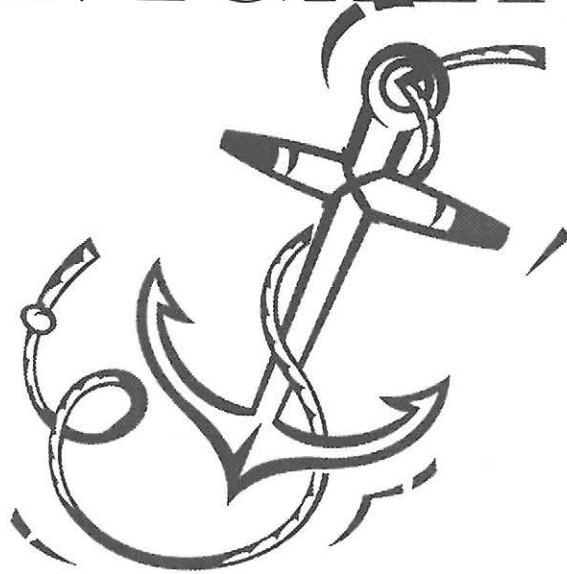


UNIT 8:

NAVIGATION



OVERVIEW FOR TEACHERS

Unit Outline

Part of the lore of Nathaniel Bowditch is the story of his remarkable navigation through fog and rock into Salem Harbor on December 25, 1803. Nathaniel's ship, *The Putnam*, encountered severe fog off of Nantucket Island. At 4 PM on Christmas Day, the fog lifted only briefly, allowing Bowditch to sight Cape Ann. A glimpse of Baker's Island several days before and one sextant sighting of the sun were enough knowledge for Bowditch to successfully navigate the treacherous Middle Ground, and finally home to Salem, still shrouded by its infamous "pea soup" fog.

Introduction

Nathaniel Bowditch and navigation are synonymous. The renowned author of the still-published *New American Practical Navigator* is also synonymous with self-education. When one reviews Nathaniel's life accomplishments in navigation, astronomy, and mathematics, it is humbling to recount his early years indentured to the chandlery of Ropes and Hodges. Nat's encounters with Dr. Bentley and Dr. Prince, members of the Salem Philosophical Society, and their invitation to use the Society's outstanding scientific library, were a direct result of this indentureship. Nat had opportunities to experience the greatest minds and writings available at that time; opportunities not necessarily afforded Harvard men. The indentureship also placed Nat with his

Every seaman knew the necessity for accurate navigation. For a mind like Bowditch, the study of navigation was the perfect marriage between his favorite subjects, mathematics and astronomy. Thus, the indentured twelve-year old, confined to a busy ship chandlery in the worldly port of Salem, fed his inquisitive mind and mathematical genius with knowledge from an outstanding library, daily encounters with the nautical world, and a natural perseverance for self-betterment.

The following unit on Navigation highlights several topics important to successful navigation. The lessons introduce contour mapping, plotting a course, using triangulation, and using ratio and proportion to determine measurement. Students will also simulate the use of chains for determining water depth. Finally, students will create an essential instrument to navigators, the quadrant. They will determine their home latitude using their measurements of *Polaris*, the North Star.

Objectives:

- Students will be able to use standard and non-standard units.
- Students will be able to use a contour map to plot a course.
- Students will be able to find location by triangulation.
- Students will use ratio and proportion to determine measurement.
- Students will construct a quadrant and estimate their home latitude.

Skills:

- Students will understand how to use ratio/proportion to convert depth readings.
- Students will be able to use geometry to triangulate their location and determine their latitude.

Vocabulary

- Depth
- Fathom
- Triangulation
- Quadrant

Frameworks Connections:

History and Social Science:

Strand 2: Geography

Standard 7: Physical Space of the Earth

- Student will be able to visualize and map oceans and continents (p. 94).

Standard 8: Places and Regions of the World

- Identify and explain features (p. 96).

English Language Arts:

Composition

- Write a composition with clear focus (19.6, p. 48)

Mathematics:

Strand 1: Number Sense

Standard 1.8

- Estimate to solve problems (p. 42).
- Apply ratio and proportion (p. 40).

Strand 3: Geometry

Standard 3.4

- Select appropriate unit (p. 76).

Unit 8 Lesson Plans



Lesson 1: Non-standard Measurements

Objectives:

- Students will use standard and non-standard units.

Skills:

- Students will be able to use ratio/proportion to convert depth readings

Vocabulary:

- mean
- median
- mode
- fathoms
- meters
- non-standard measurement
- standard measurement

Materials:

- Adding machine tape

Procedure:

Activity:

1. Discuss with the students "non standard measurement" / history connection.
2. Each student should measure 5 "hands" across a piece of adding tape.
3. Each student should measure the same length in the classroom (a window, a desk, etc).
4. Represent that length in "hands". Write the values on the board.
5. Graph the data (line plot, bar graph).
6. Extension: Find the mean, median, mode of the data.

Writing Activity:

1. What are the advantages/disadvantages of using a non-standard measurement like a "hand"?
2. Why is it important to know what standard of measurement is used on a chart?
3. Show how to convert:
 - a. 20 fathoms into feet;
 - b. 13 feet into fathoms,
 - c. 100 meters into fathoms



Lesson 2: Contour Mapping

[*Reference/ *Charting Our Course*, "Contour Mapping Activity" p 7]

Objectives:

- Students will use a contour map to plot a course.
- Students will find location by triangulation.
- Students will use ratio and proportion to determine measurement

Skills:

- Students will be able to use ratio/proportion to convert depth readings

Vocabulary

- Depth
- Fathom
- Triangulation

Materials:

- map of Salem Sound/Salem Harbor or map of Gulf of Maine
- foam board or layers of cardboard
- scissors
- glue

Procedures:

1. Before class: For each group, make 4 photocopies of the chosen map: one of each in white, blue, yellow, green for each group
2. See Activity #2 sheet
3. Field trip possibility: Peabody Essex Museum/ Bowditch Room
4. Sources for the reading of *The Putnam's* return in a snowstorm:
 - i. Berry, Robert. *Yankee Stargazer: The Life of Nathaniel Bowditch*
 - ii. Latham, Jean. *Carry on Mr. Bowditch*.
 - iii. Rink, Paul. *To Steer by the Stars: The Story of Nathaniel Bowditch*.
 - iv. Stanford, Alfred. *Navigator: The Story of Nathaniel Bowditch*.
5. Source for the contour mapping activity:
 - i. *Charting Our Course: The Massachusetts Coast at an Environmental Crossroads. Massachusetts Coastal Zone Management/ Massachusetts Marine Educators*



ACTIVITY #2 CONTOUR MAPPING

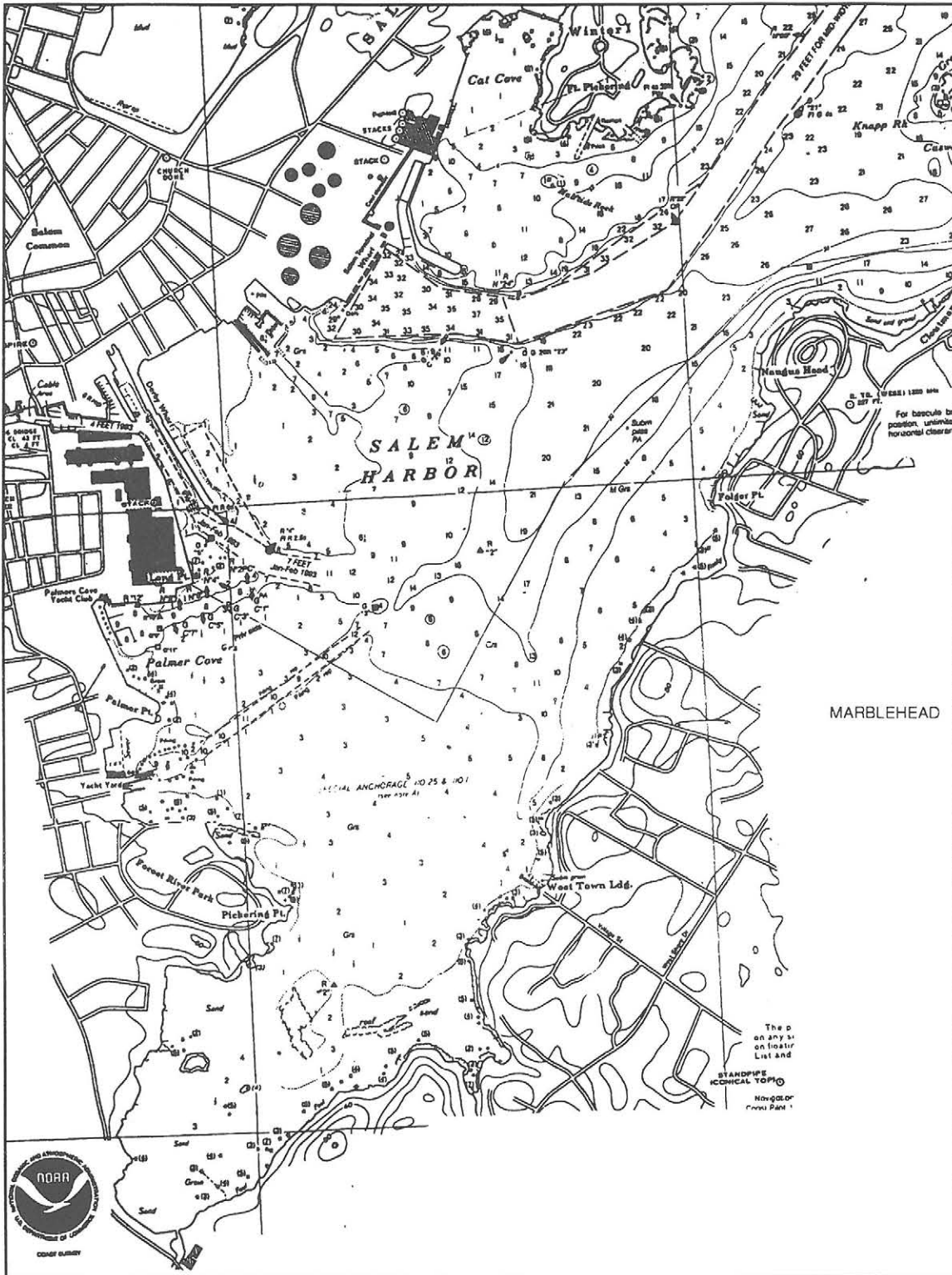
Materials for each group:

- 4 copies of Salem Sound, each on a different color paper
- scissors
- glue
- foam board (or cardboard)
- A nautical chart of Salem Sound
- X-acto knife

Procedure:

1. Study the white copy. This is your base map. Glue it to the foam board. Cut the whole map out carefully.
2. Use the blue copy to cut along all the 30 feet contour lines. Throw away the sections representing areas deeper than 30 feet. Glue the blue pieces onto the foam board. Cut the blue pieces out and glue onto the matching part of the white base map.
3. Repeat the procedure using the green paper and the 20 feet contour. Throw away areas deeper than 20 feet. Glue the green to the foam board, cut out carefully and glue onto the blue.
4. Repeat a final time with the yellow paper. Cut along the edge of the land and the 10 foot contour line. Throw away anything deeper than 10 feet. Glue this carefully in place.
5. On the land, note any navigational landmarks such as the stacks at the power plant or the lighthouse at Fort Pickering.
6. Listen to a selection that describes the arrival of *The Putnam* on Christmas Day in the fog.
7. Write a descriptive paragraph about the sail into Salem Harbor as seen by a member of the crew of *The Putnam*. Use adjectives and adverbs to describe the experience.

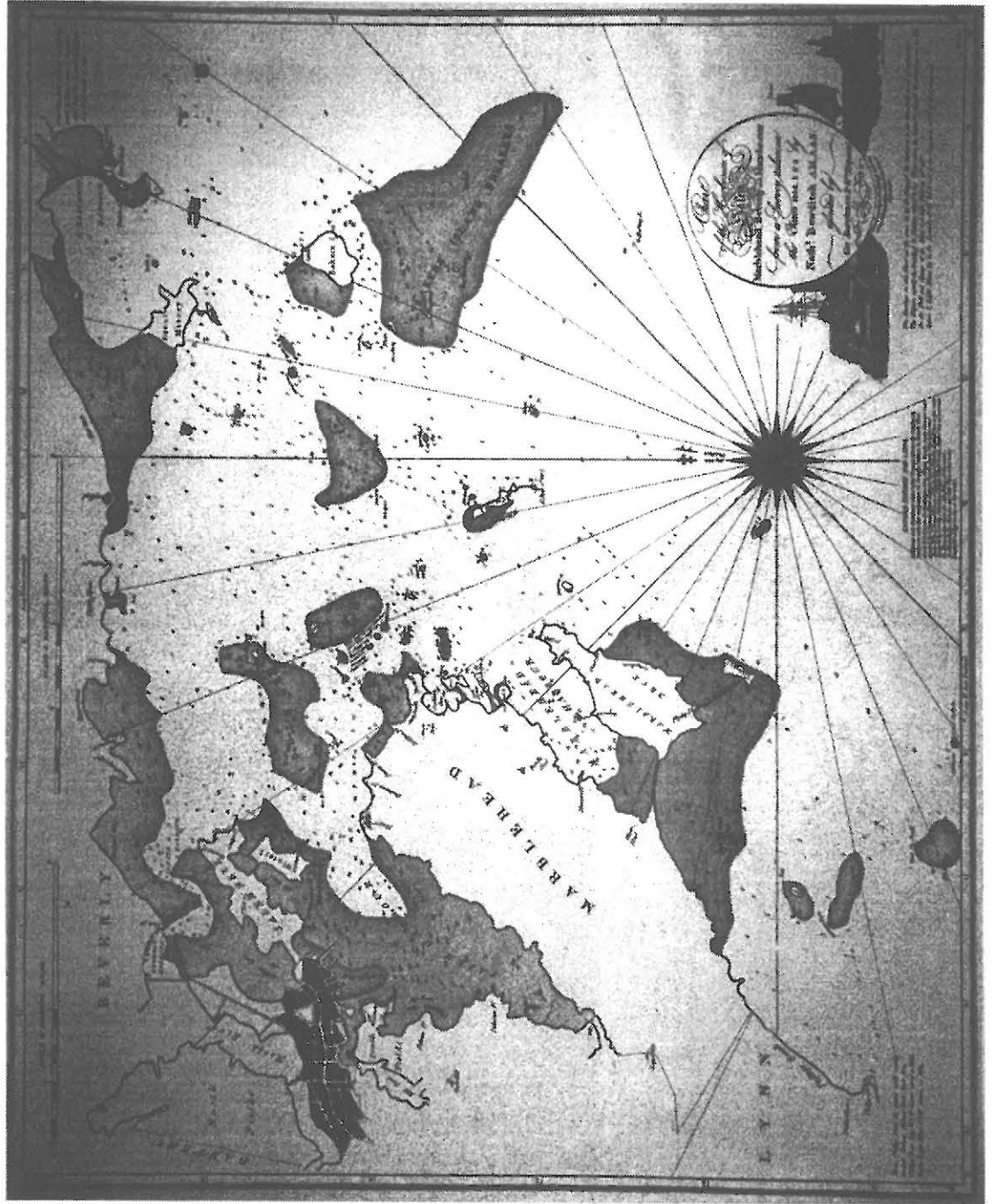
**UNIT
8
STUDENT
HANDOUT**



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ORIGINAL BOWDITCH MAP



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Courtesy of and copyright of the Peabody Essex Museum, Salem, MA



Lesson 3: Triangulation

Objectives:

- Students will use geometry to triangulate their location and determine their latitude.

Skills:

- Geometry of angles

Vocabulary:

- Triangulation

Materials:

- a model of a large compass to put on the floor
- a navigational chart of Salem Sound (Chart 13276 from NOAA is recommended)
- rulers
- pencils
- activity worksheets

Procedure:

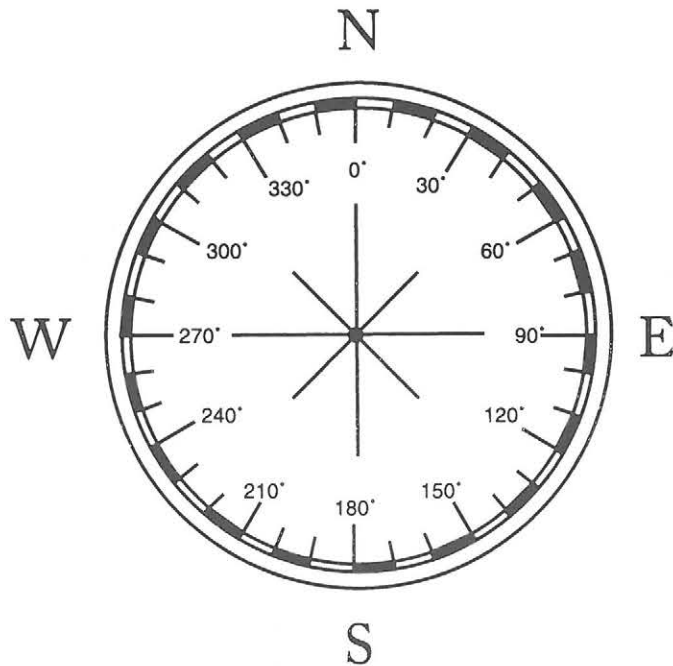
Background: Triangulation is a navigational method of locating your position on a nautical chart if you are able to sight two other landmarks. To find your location, you must first use your ship's compass to sight two landmarks (lighthouses, marked buoys, an island, etc.) These readings are then transferred to the compass rose on the navigational chart. Parallel lines are drawn and your location is at the intersection of the lines. A good introductory activity is *The Voyage of the Mimi: Maps and Navigation* (Sunburst Communications, Inc, 1985).

1. Introduce students to the bearings on a compass with the group activity "Getting Your Bearings."
2. Students practice using the compass rose and parallel lines on a map: "Chart Activity #1".
3. Students use the map of Salem Sound to locate position by triangulation: "Chart Activity #2".
4. Extension: Have students list the navigational hazards in Salem Sound.
5. Compare the location of the Salem and Marblehead Channels to these hazards.



GETTING YOUR BEARINGS

Background: A compass is a large circle marked off in degrees. There are 360 degrees in a circle and there are 360 degrees on a compass' face. The compass rose on a navigational chart looks like the face of a compass and shows where north is. The major directions are north (N), south (S), east (E), and west (W). These can be broken down into smaller units like northeast (NE) or north northeast (NNE). Look at the diagram below of a compass rose.

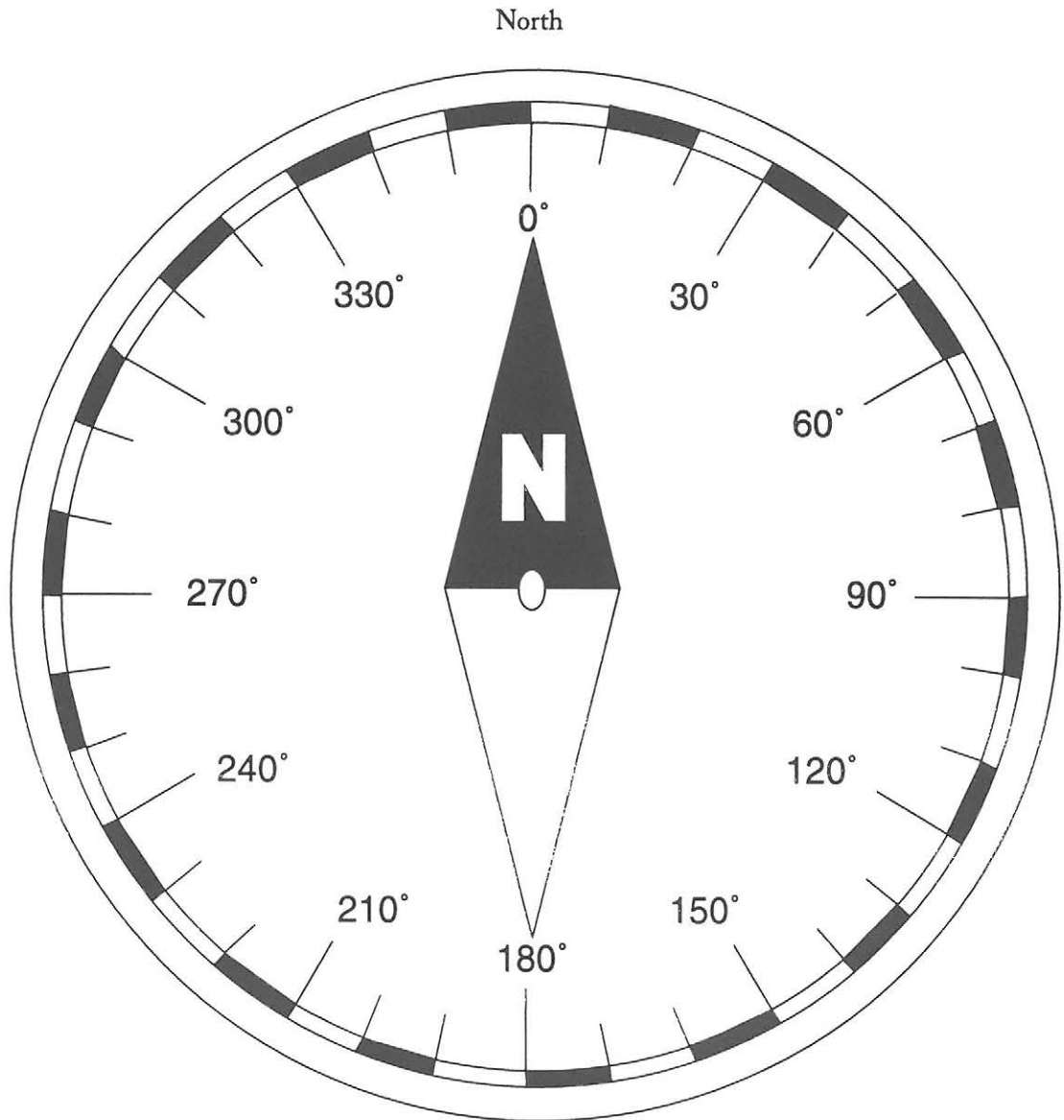


Procedure: In a large area, make a circle around the compass rose on the floor. Choose small objects to put around the circumference of the circle (A book, a wastebasket, a plant, etc) One student should stand in the middle of the compass rose holding one end of a long piece of string. Students should practice sighting along the tautly stretched string.

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GETTING YOUR BEARINGS WITH COMPASS



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CHART ACTIVITY #1

Use what you have learned about sighting on the compass and a chart of Salem Sound to answer the following questions.

1. If you are on Bakers Island, in what direction will you look to see Bowditch Ledge?
2. You are at the summer camp on Cat (Children's) Island. Your boat requires 10 feet of water at all times. Would you motor north to Bakers Island? Explain.
3. Your sailboat requires 4 feet of water at all times. You are located at Green can #3 off Chappel Ledge to the northwest of Cat Island. Describe the safest route to Mackerel Cove in Beverly.
4. Many local Salem sailors avoid the South Channel when sailing to Marblehead at low tide. Is this "local legend" or based on fact? Back up your opinion with details.



CHART ACTIVITY #2

Like Bowditch on *The Putnam*, you have sailed between Bakers Island and Great Misery Island into Salem Sound. You need to locate your position on the navigational chart before you head for Salem Harbor.

1. You notice the large stacks at the Salem Power Plant and see them on your chart. Your compass reading is 260° .
2. You also note a buoy, Red Nun #6. Its compass heading is 205° .
3. You will need a clear ruler and a pencil. On the chart's compass rose, place the ruler on the exact center and work out to the reading for the stacks at the power plant, 260° . Draw a faint line. Now carefully slide your ruler towards the stacks on the chart trying to keep the ruler even or parallel to the original heading. When you reach the stacks, draw a long line into the Sound that will be parallel to the line through 260° . You are located somewhere on that line.
4. The bearing to the Red Nun is 205° . Repeat the process in #3 with this new bearing. Your ship is located where the two lines intersect.
5. Using compass headings, describe the course you would order to sail safely into Salem Harbor at mean low tide.



Lesson 4: Depth Measurements

Objectives:

- Students will simulate depth soundings by chains

Skills:

- Students will learn to simulate sea-floor mapping

Vocabulary:

- Chains
- Depth Sounders
- Salem Sound

Materials:

- Several large fish tanks (no water is needed inside the tanks)
- Opaque paper or black paint
- Sand
- Rocks, balls
- Grid sheet
- Long knitting needles
- Pencils

Procedure:

1. Background: Today mariners use depth sounders to determine how deep the water is around them. In Bowditch's time, chains were thrown overboard and the water height was marked to indicate depth. Look at a navigational chart of Salem Sound and note the depth of water at mean low tide.
2. An exercise to simulate this method can be done with a large fish tank. Cover the outside of the tank with opaque paper or paint it black.
3. Cover the bottom with sand and then place objects on the sand such as tall rocks or balls. These simulate underwater hazards.
4. Cover the top of the tank with a thin, dark covering such as a black gauze curtain.
5. Give the students a grid sheet marked off in squares; the area of the grid should equal the area of the floor of the fish tank.
6. Give one student a long knitting needle and have them put the needle through the covering until it strikes a solid.
7. That depth is marked and noted on the grid.

8. This process is repeated over the entire surface area of the tank ; the students then speculate about the surface of the floor.
9. The knitting needle represents the chains the mariners used to find depth.
10. This activity is best done with several tanks. Water is not needed in the tank.

Alternative materials and procedure:

1. Gather large empty coffee cans with plastic covers - enough for every two students.
2. Create a grid on the top of each plastic cover.
3. Fill the cans in the same way that you would fill the fish tanks.
4. Using a sharp wooden skewer, pierce the plastic tops at each point on which the vertical and horizontal lines meet. Push skewer down carefully, to determine the exact place where the skewer meets an obstacle on the bottom of the coffee can.
5. Mark one of the axes on the outside of the can. Then graph the contour of the "ocean floor" on graph paper. Only after completing this task are students allowed to open the can and compare their graph to the actual contours.