LAB AND FIELD ACTIVITIES AND IMPROVISED EQUIPMENT

Massachusetts Marine Educators

New England
Marine Resources
Information Program

New England Aquarium

Suffolk University

Contents

This publication is available through the New England Marine Resources Information Program, Narragansett Bay Campus, University of Rhode Island, Narragansett, Rhode Island 02882 and through the New England Aquarium, Boston.

An Evaluation

1. General response to contents.
2. Specific comments, corrections, or additions.
3. Any specific areas or activities on which you would like more emphasis.
4. Any additional *specific* information on exercises or equipment that would be of value to teachers.
5. Any additional comments.
6. Any new material in the format of this book.

Return to Education Specialist, NEMRIP, University of Rhode Island, Narragansett Bay Campus, Narragansett, Rhode Island 02882.

DESIGN IN NATURE

Discussion

This lesson was designed to stimulate a keener visual sensitivity to the natural world around us. A meaningful art education program springs from the heart of each subject in the child's curriculum. Therefore, this exercise has not been labeled for art or for science, but rather should be planned as a unit for these two disciplines to carry out together. A synergetic relationship evolves naturally when the scientist and the artist "interthink." Look at this lesson as an open-ended investigation into the "nature of things."

The sorting and organizing of sensory impressions from the visual field is basic to all learning. Yet, how often do we rely on visual aides in which the material received has been sorted and organized by someone else. The use of visual materials does not automatically produce visual thinking.

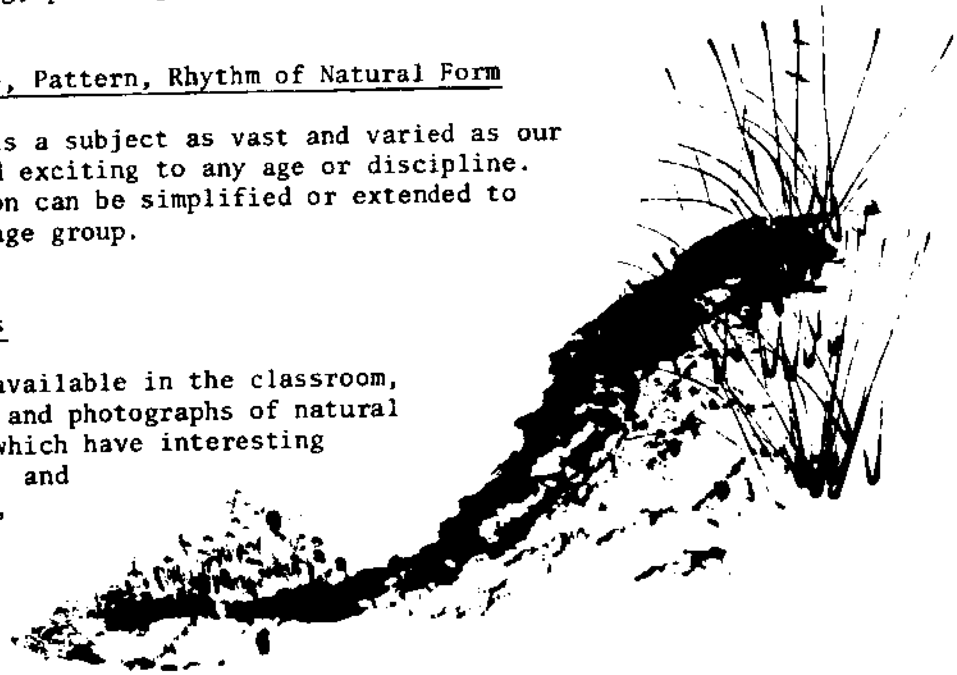
Since the most meaningful visual education comes from direct experience, these exercises have been designed to actively involve the student with a visual problem. The idea is to invite visual participation without requiring the conventional standards of drawing, painting and sculpture.

Structure, Pattern, Rhythm of Natural Form

This is a subject as vast and varied as our world and exciting to any age or discipline. The lesson can be simplified or extended to fit the age group.

Materials

Have available in the classroom, examples and photographs of natural objects which have interesting textures and patterns,



i.e. bark, stones, shells. Explore these surfaces with magnifying glasses. How does the pattern or structure relate to the history or life style of the object? Does the structure show how the form grows? Stimulate discussion of the differences and similarities.

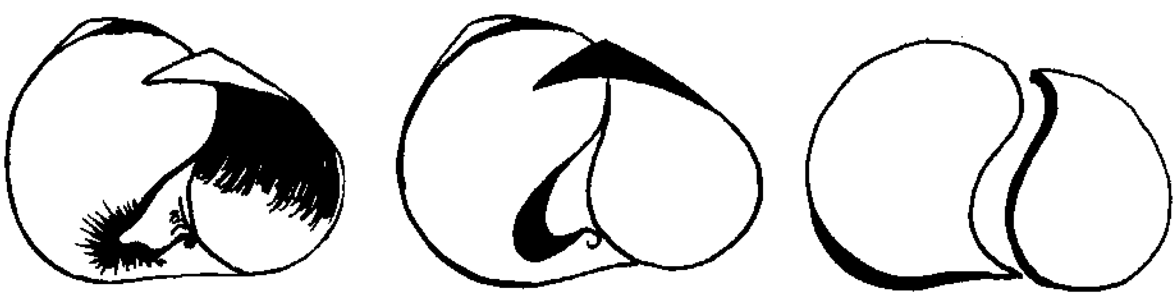
Also have on hand these: magnifying glasses, drawing boards and paper, soft pencils, Cray-Pas or marking pens, viewing frames.

Field Procedure

Send students out in the field in search of texture, pattern, structure as found in nature. Students will no doubt begin to try to draw a whole form. Direct their eye rather to the pattern, i.e. the bark of the tree, rather than the whole tree. Have them visualize their subject in this way: How would this tree appear to a woodpecker? How would this shell look through the eyes of a sea gull? Suggest examining the forms with their eyes closed, using all the senses to explore the natural world. Encourage free, large visual notations, ones that look for the most basic elements in the form. Objects of special interest that are no longer living, such as a branch or fish bone, may be collected for the classroom. Alert the students to note whether or not the area surrounding the object of interest is related to its form or pattern.

Afterward

This is a time to share the discoveries and notations found in the field experiences. Cover the points mentioned in the discussion.



Moon snail -- a study of form.

More Action

The student will now choose his favorite study from the field or, if he hasn't found one to his liking, one from the classroom selection. The challenge is to reinterpret his visual notation, blowing up his design to fill the paper (suggested size - 12" x 18").

A variety of media should be available. The art teacher in your school will no doubt become interested and involved in this area. Don't worry if your choice of materials is limited to paint, crayon, or paper collage. If you can convince your students that they are free to explore and experiment, they will invent exciting variations with whatever materials you have on hand. The student may want to repeat his idea in a different media. Present this activity as an ongoing study, encouraging students to bring in natural forms from their own environment.

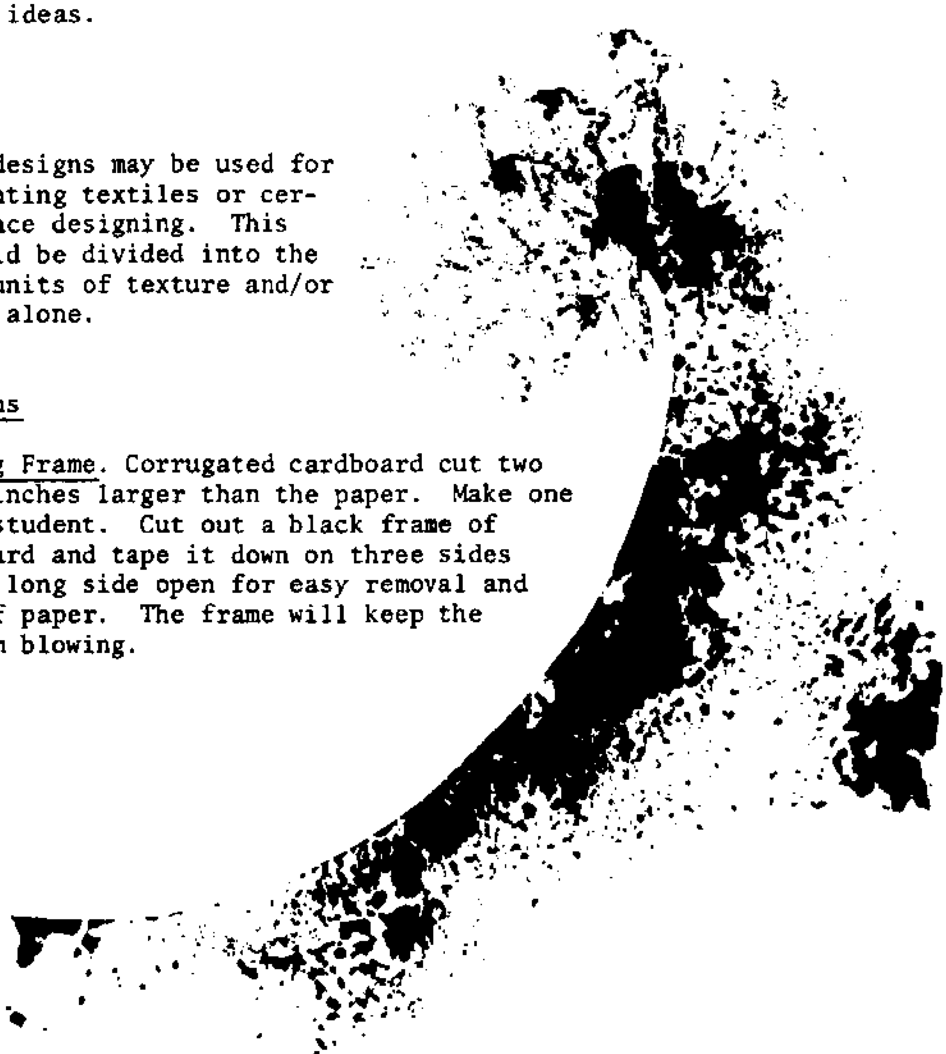
The resulting work should relate in essence to the original object, but one might need some help in understanding the relationship. If the student has truly wrestled with the problem, it doesn't matter how he has represented nature. His capacity to clarify and integrate in visual terms will increase with practice. The goal is to educate the eye, not develop talent or skill in drawing. Mat the flatwork and display the sculpture. Living with the creations will prompt discussion and stimulate new ideas.

Extension

Final designs may be used for block-printing textiles or ceramic surface designing. This study could be divided into the separate units of texture and/or structure alone.

Definitions

Drawing Frame. Corrugated cardboard cut two to three inches larger than the paper. Make one for each student. Cut out a black frame of poster board and tape it down on three sides leaving a long side open for easy removal and storage of paper. The frame will keep the paper from blowing.



Viewing Frame. A black cardboard frame for viewing and isolating subjects in a given field as with a camera. Cut in varying sizes, but small enough to frame detail.

References

Biederman, Charles. Art and the Evolution of Visual Knowledge.

Guyler, Vivian Varney. Design in Nature, Art Resource Publications.

Hurwitz, Elizabeth. Search for Essentials.

Jameson, Kenneth. 1968. Art and the Young Child, The Viking Press, New York.

Lacey. Nature and Seeing. Available in paperback.

Lowenfeld, Victor. 1965. Your Child and Hid Art, The Macmillan Company, New York.

Wolf, Robert Jay. On Art and Learning, Grossman Publishers, New York.

-- submitted by Susan Latham

THE MAGNETIC COMPASS (for secondary students)

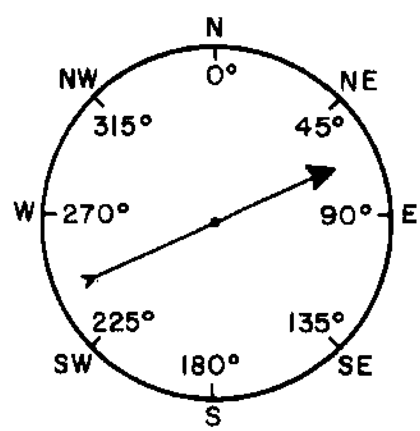
Discussion

One of the oldest and yet one of the most useful tools of the modern navigator is the magnetic compass. No boat which will ever be out of sight of its originating point whether due to distance or poor visibility should be without one.

Traditionally sailors had to learn to "box the compass" or, in other words, be able to name all the Cardinal Points (North, East, South, and West) as well as the many intermediate points (Northeast, North by Northeast, etc.).

In our own time, however, this practice has given way to the much simpler method of describing directions in terms of degrees based upon the 360 degrees of the circle. Thus:

360° (or 0°)	=	North
90°	=	East
180°	=	South
270°	=	West



The compass depends upon the attractive force exerted by the magnetic north and south poles for its direction-seeking action. However, these magnetic poles are not located in the same positions as their corresponding geographic or "true" poles. Since the longitude lines used on charts and maps are laid out in terms of the geographic poles it can be seen that a line drawn on such a chart from a direction indicated by a compass will show this discrepancy. The difference between these "true" and "magnetic" directions is called variation. Variation is the angle between "true north" and "magnetic north" and is expressed in degrees. Variation is different all around the earth and is changing very slowly. In the area of New England variation is about 15°W. This means that the compass is pulled away from "true north" in the amount of 15° to the west. If variation is west you must add the appropriate number of degrees to any magnetic or compass reading in order to determine the "true" direction. (If variation is east you must subtract the appropriate number of degrees from compass readings).

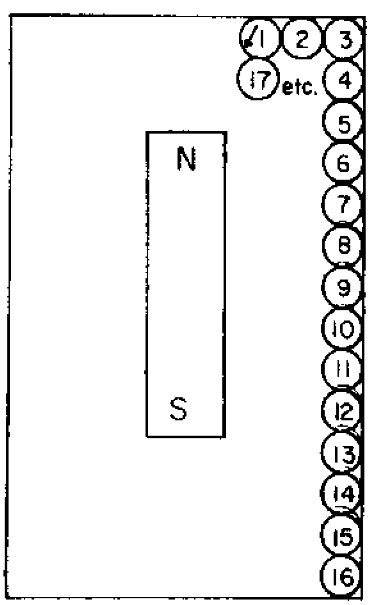
Work Sheet: The Magnetic Compass

1. Place a bar magnet on top of a sheet of plain white paper as shown in the diagram. Position your small compass in the locations indicated and in the order suggested. After the compass needle has come to rest, make a mark at either end. After removing the compass, connect the marks. After all the marks have been connected as pairs, see if you can find a pattern in which several of the marks can be connected head-to-tail in order to form an overall geometric pattern.

2. Now place your magnet under your sheet of paper as shown in the diagram. Carefully sprinkle a small quantity of iron filings on the paper. Compare the pattern that they form with the lines you drew in No. 1.

1

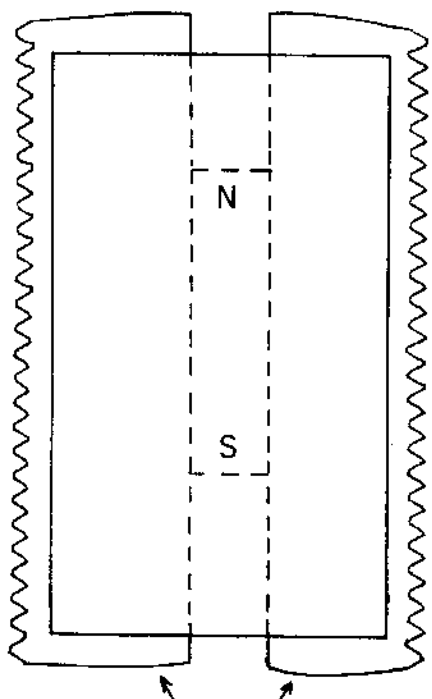
(Magnet on top)



(Note! You will probably not be able to fit your compass in as many locations as indicated. Follow the pattern none the less.)

2

(Magnet Under)



Notebooks for support

Procedure - Materials

This activity will be more meaningful if the students are able to have some small compasses to examine, perhaps a magnet with which to influence the compass and, if possible, a marine compass with its rotating card. To make this lab even more meaningful it is recommended that it be followed up by field work where students must take bearings and actually fix their own position on a shoreline.

Method

On the basis of the above information fill in the following:

TRUE BEARING	VARIATION	MAGNETIC BEARING
150°	15° W	
	15° W	270°
75°		90°
	5° E	180°
220°	5° E	
65°		72°

References

"Modern Geodetic Survey." Navy film No. MN10203. Write to Assistant for Public Affairs of your local Naval District Office (check listing in phone book under U.S. Government).

"The Shape of the Earth." 16 mm, 28 minute, color film from McGraw-Hill, 330 West 42nd Street, New York, N.Y. 10036.

--submitted by J. Crowley and J. Stouffer, Hingham High School

BOSTON HARBOR: "NEW" VS. "OLD" (for secondary students)

Discussion

In this activity ask students to compare the present shoreline of Boston with that from a map from 1775. Particular emphasis should be placed on landfill and real estate operations, their relation to the saltmarsh greenbelt and to efforts of groups such as Save Our Shores (S.O.S.).

Materials

Coast and Geodetic Chart 246.
Student copies of map of Boston 1775 (see enclosed copy).

Method

Acquaint yourself with Boston via Chart No. 246.

A. Can you locate latitude and longitude of your home? ________ school? ________. If these are not on the chart, then locate the following:

B. What historical navigation aid can be found at Lat. 42° 20' 20" North, Long. 70° 45' 30" West? ________

C. What structure is found at Lat. 42° 21', Long. 71° 03' 35"? ________

D. What do Deer Island, Winthrop; Worlds End and Otis Hill, Hingham, have in common? ________

Using Chart No. 246 of Boston as a guide, shade in the 1775 map of Boston to show how the city has expanded through landfill projects into the harbor.

A. If possible, color-code the new fill areas: Red = Logan Airport; Green = South Boston and Dorchester; Black = Prudential Center and Back Bay; Yellow = Miscellaneous. (Each 1-inch square block = 1 square mile.)

B. Using a 1/2" grid overlay or drawing on the map, first estimate the approximate number of square miles of inner harbor on the original 1775 map.

Next determine how many square miles have been filled; i.e., count the colored blocks.

C. What percent of the original harbor has been filled in:

$$\frac{\text{TOTAL NO. OF BLOCKS FILLED (COLORED BLOCKS)}}{\text{TOTAL NO. OF BLOCKS OF ORIGINAL HARBOR}} \times 100 =$$

% OF OLD HARBOR NOW FILLED

What effect does this have on the total volume of water exchanged in Boston Harbor each day? ______

How does this relate to sewage outflow? ______

What do you think has happened to the average depth of Boston Harbor? ______. How might this affect marine life? ______

References

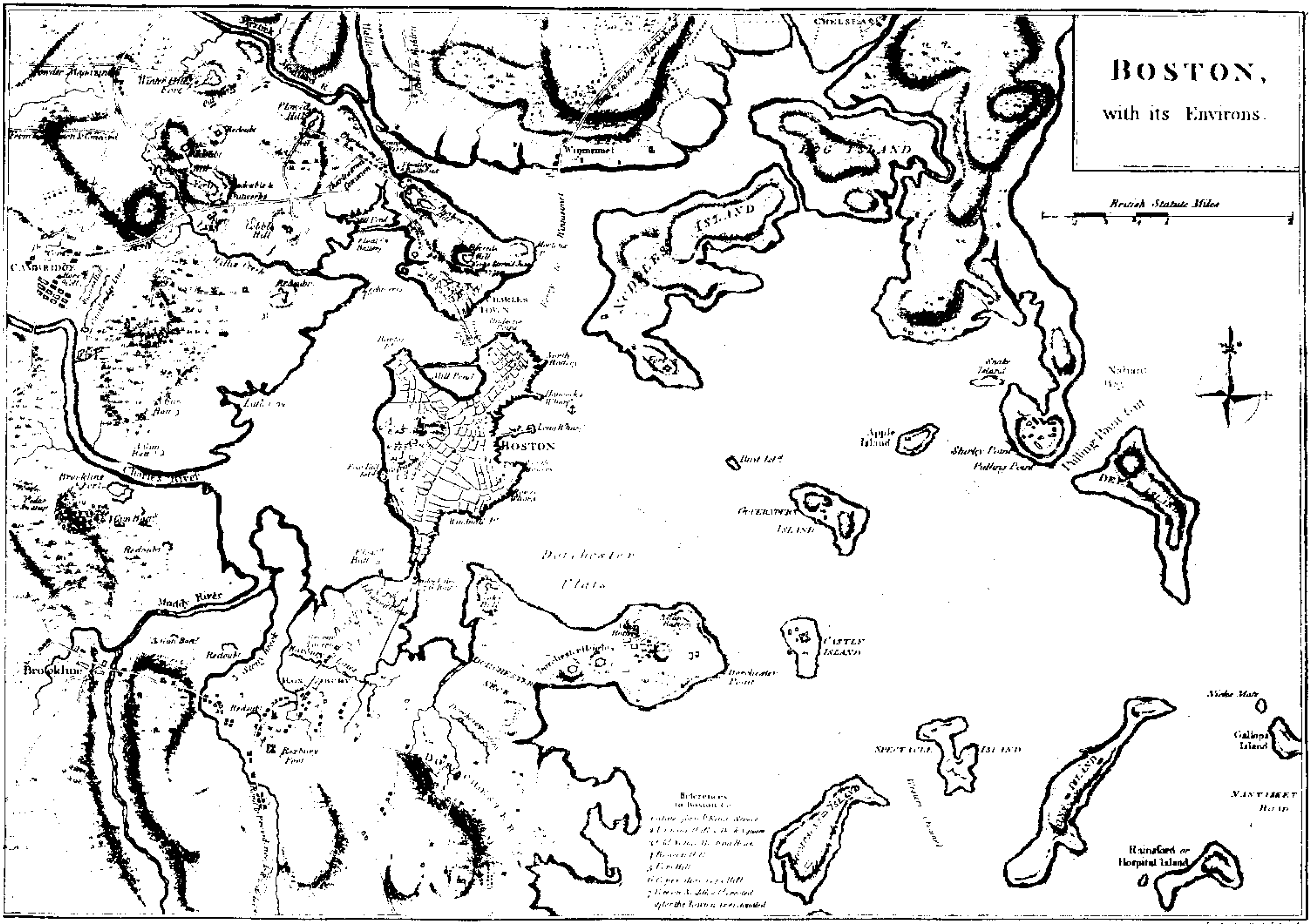
Snow, Edward Rowe. Several books on Boston Harbor and its history.

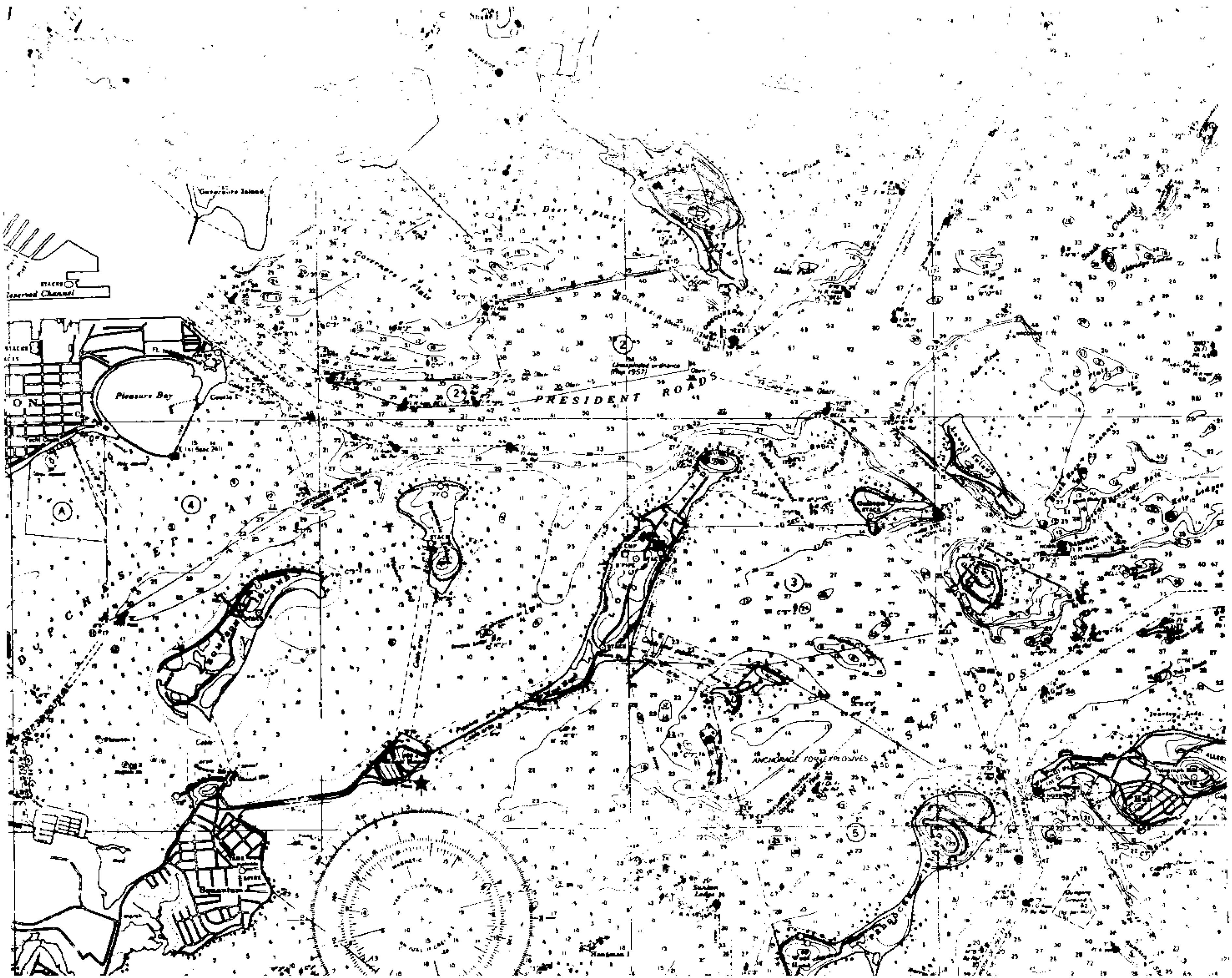
Teal, John and Mildred. 1969. Life and Death of a Salt Marsh, Ballantine Press, $1.25. (Note chapter 11 on "Marsh Productivity.")

1775 map is copy of the Debar Chart for the British government, available in antique shops for 75¢.

New England Aquarium special programs are 75¢ per student.

--Submitted by J. Crowley and J. Stouffer, Hingham High School


BOSTON,
with its Environs.
British Statute Miles
BOSTON
CHARLES TOWN
CAMBRIDGE
Brookline
Charles River
Muddy River
Dorchester
Flats
Apple Island
Snake Island
Castle Island
Governors Island
Spectacle Island
Noddles Island
Hog Island
Deer Island
Gallops Island
Nantasket Road
Rainsford or Hospital Island
Dorchester Point
Roxbury Fort
Winnesimet
Chelsea
Shirley Point
Pulling Point
Pulling Point Gut
Nick's Mate
Long Wharf
Mill Pond
Western Channel



PRESIDENT ROADS
Pleasure Bay
Reserved Channel
Governors Island
Deer Island Flats
Unexploded ordnance (Rep 1957)
ANCHORAGE FOR EXPLOSIVES
NANTASKET ROADS

SEA BOTTOM CONTOURS (for secondary students)

Discussion

Bathymetric data or ocean soundings tell us something about the changes in depth and configuration of the ocean bottom. Studying the sounding notations on navigational charts can aid us in visualizing the outline or slope of the bottom features. Connecting all points having the same depth by contour lines and drawing these contour lines at different depth intervals can help us picture the sea in graphic form. Contour lines show the shape of underwater ridges, mountains and valleys, as well as their depth. Successive contour lines that are far apart on the map indicate a gentle slope; lines that are close together indicate a steep slope, and lines that run together indicate a cliff.

Procedure

The method described below suggests the technique which might be used with the soundings data from an extensive area of sea bottom and with a large range of depths. For the purposes of this activity the teacher might find it expedient to transcribe the data from a chart showing local waters. This can be done by placing a piece of tracing paper over an appropriate section of the desired chart, copying the position and values of the soundings and transferring this information to a duplicating master. After the contours have been drawn, the students might use colored pencils to distinguish the various depths.

Method

The selection of a proper contour interval for this exercise is the first step. Choose a contour interval that will show the bottom features in accordance with the amount of available data. The details of an area with numerous soundings and low relief may be shown by choosing a small contour interval. If detail cannot be shown, as in areas of great relief and scattered soundings, a large contour interval may be desirable. A combination may be useful, that is, a small contour interval in shallow waters and a larger interval in progressively deeper water (see suggested contour interval below). Too many contours can be confusing; too few may be misleading.

Suggested contours (in feet) for Chart No. 246, Nantasket Beach include 18 (already done - color in), 25, 50, 75, 100 and 150.

A contour is a line connecting all points at the same elevation which closes upon itself. The contours of the smaller features will close within the area of the chart. But the contours of the larger features may not close in the chart area.

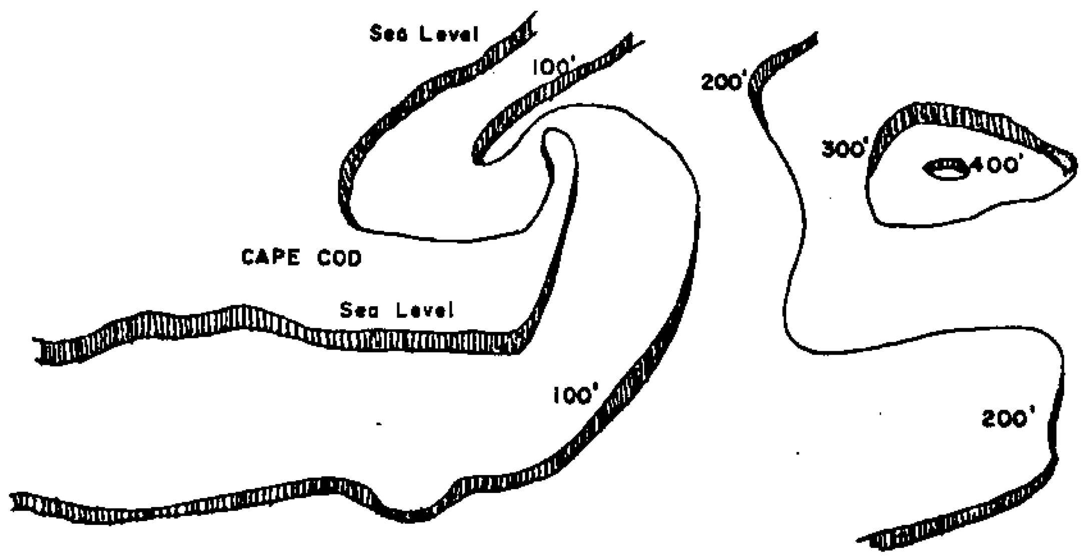
Contouring is based on the assumption that there is a constant slope between points on a surface. This is not always true but is useful for study purposes. The shape of the contour is controlled by the sounding notations. The drawing of the contour can be done fairly accurately by approximation which is commonly done by geologists.

The approximation method requires the plotter to be skilled in recognizing and imagining the bottom shape from the sounding notations. While imagining the type of feature described by the soundings, on a trial basis lightly pencil in dashes to represent the path of certain essential contours, such as those at 100, 1,000, and 2,000 fathoms.

Once enough dashes, or control points, have been drawn to outline the feature, sketch in a smooth flowing line connecting the points or dashes. On the bathymetric analysis exercise a portion of the 18-foot contour line has been drawn to assist the student in getting started. Try to keep your lines free from wiggles or right-angle turns. Number each contour as it is drawn to avoid joining contours of different depths. As you draw, various features will become visible, such as seamounts, depressions, troughs, ridges, island shelves and slopes, submarine canyons and reefs.

Suggested Student Activity

To get an in-depth view of our coastline build a three-dimensional contour model. To do this get a local marine chart or even better Chart No. 70, United States Coast and Geodetic Survey (now National Ocean Survey), "West Quoddy Head to New York," ($1.00) from Long Island to Nova Scotia. Cut out along the shoreline and trace this outline onto a piece of 1/4-inch or 1/2-inch cardboard or homosote. Select a proper depth interval (30 feet for local charts or 100 feet for offshore charts) and cut along these contour lines. Glue these onto 1/2-inch stock and cut to the contour lines. When you have finished you should have a "wedding cake" effect with the land on the top layer and deepest points at the bottom. This model can be coated with water repellent and filled with water to serve as a three-dimensional wave tank or can be used for other classroom demonstrations.



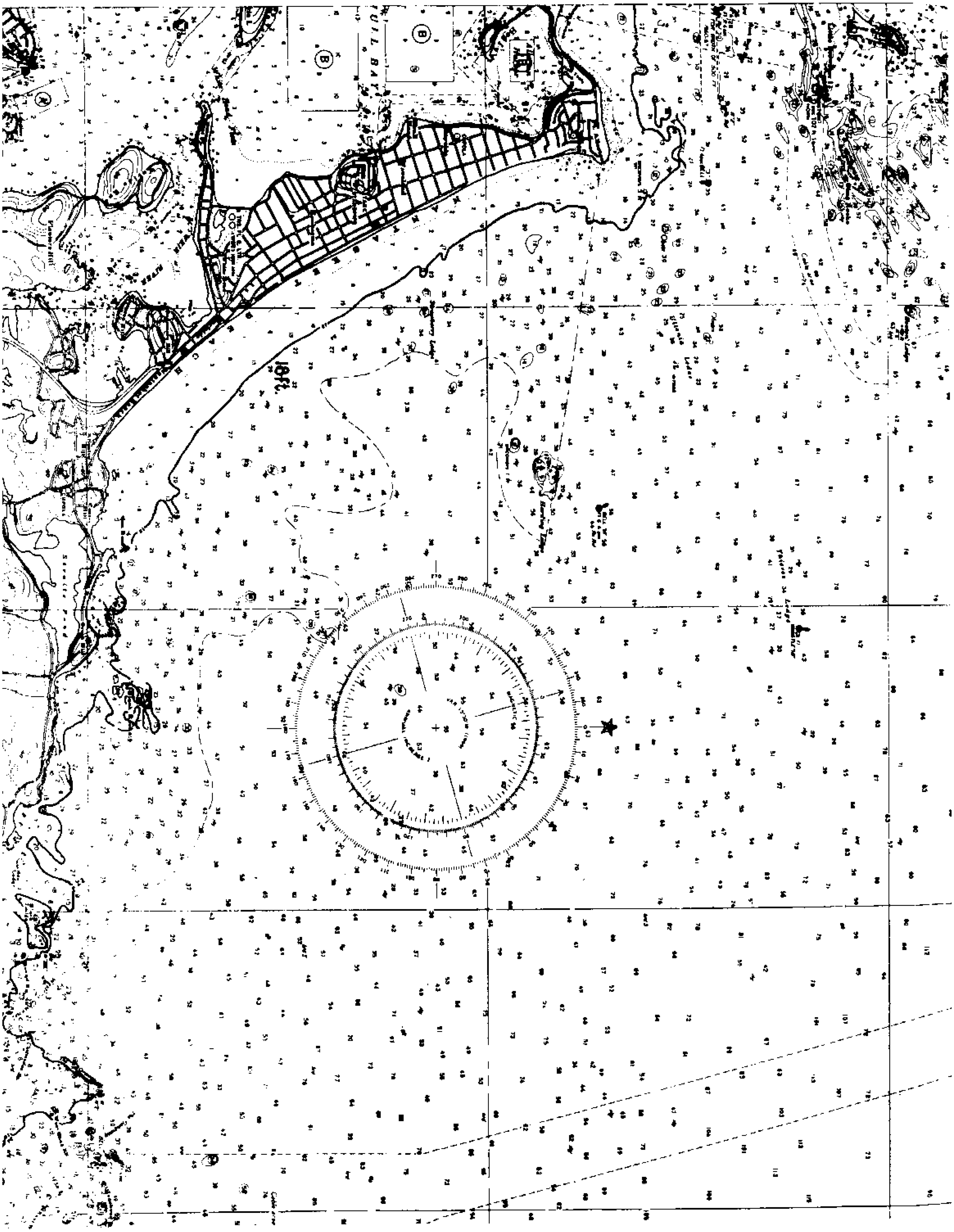
References

Straphler, A. 1966. A Geologist's View of Cape Cod. Natural History Press, Garden City, N.Y.

Hall, J. and P. Farb. 1966. The Atlantic Shore. Harper and Row, New York, N.Y. $6.00.

Coast and Geodetic Survey Maps. Marine supply stores.

--submitted by J. Crowley and J. Stouffer, Hingham High School



SIMPLE COURSE PLOTTING

Discussion

One necessary skill that a marine biologist or oceanographer should possess is the ability to "find his way" on the ocean where there are no streets and numbers, and familiar landmarks are scarce. The visible landmarks on the ocean are buoys and shore-based structures, such as lighthouses and other prominent features. The buoys have special characteristics (shape, color, number, and light or sound) that give the navigator information as to how to proceed relative to them. This unit assumes a familiarity with buoy characteristics. (See Chapman or other similar reference for this information.)

Materials

Marine charts (Xeroxed portions of of charts serve well for classroom work. See teacher references for sources of charts.)

Equipment

Sharp pencil
Ruler
Protractor (Course plotters of various types normally used by navigators are not necessary, but may speed up calculations when their use is understood.)

Method

1. Course Direction. A line must be drawn on the chart from the point of departure to the destination. (Needless to say, you must know where you are,to begin with.)

The direction of this course line must be determined with reference to the chart north, called true north. This may be done as follows. (A) Extend the course line until it crosses a meridian or a parallel. (B) Measure the angle the course line makes with the meridian or the parallel. (C) Calculate the angle the course line makes with true north. (NOTE: The meridians are oriented from true north, 0°, to south, 180°. The parallels are oriented from east, 90°, to west, 270°.)

Correct the course from true north to magnetic north so that you can follow it with the ship's compass. (The compass north, called magnetic north, is not the same as the chart north and, in this general area, is 16° west of true north.) The correction is made as follows. (A) Find the compass rose on the chart; the magnetic variation is printed in the middle. The variation can also be seen as the difference between true north and magnetic north on the compass rose. (B) There are some rules that can be used in changing from chart to compass and vice versa. They are listed below. However, by inspecting the difference on the compass rose, the process can be reasoned out. When going from chart to compass, if the variation is west, add; if the variation is east, subtract. When going from compass to chart, if the variation is west, subtract; if the variation is east, add. (C) In this case, since the variation is west and we are going from chart to compass, the variation is added to the figure for the course based on true north. The resultant figure is the course in degrees magnetic and is the course to be followed on the vessel's compass. (NOTE: The compass may have a deviation that must be corrected for and there may need to be a correction for current, but at this stage we will assume that the compass is correct and there is no current.)

2. Course Distance. Lay the edge of a piece of paper along the course line on the chart. Mark off the distance from start to finish. Lay this out on the mileage scale on the chart and determine the total mileage. (NOTE: One minute of latitude equals one nautical mile. This relationship is often used as a scale to measure mileage.)

Example

You have come out of Rockport Harbor to the R"2" bell at Avery's Ledge and you wish to go out to the ledge at the day beacon called the Londoner off Thatch's Island to do some diving. Plot a course from Avery's Ledge to the Londoner and determine the distance. (See the attached chart.)

1. Draw a line on the chart from the dot that represents the Avery's Ledge bell to the Londoner.

2. Lay the protractor along the parallel of $42^{\circ}40'$ and measure the angle from this parallel to your course line. This angle is measured at 64° (see chart).

3. Add 90° to your measured figure because the parallel pointing east was already at 90° from true north. This gives you 154°, which is your course in degrees true. (An alternate method would be to extend the course line through the $70^{\circ}36'$ meridian and measure the total angle (see chart).)

4. Find the compass rose and look up the variation, which is 16° west.

5. Add the variation of 16° to the true north course of 154°, giving you a course of 170° magnetic. This is the course to be followed on the compass.

6. Lay the edge of a piece of paper along the course line and mark the start and finish. Lay this out on the scale of nautical miles and determine the mileage. It is 2.2 nautical miles.

Problems

1. What is the course and distance from the Londoner to the lighted bell "1" to the east of the Dry Salvages? (Answer: 23° magnetic, 2.6 nautical miles)

2. What is the course and distance from the bell off the Dry Salvages to the "IAHP" gong off Halibut Point ? (Answer: 312° magnetic, 3.3 nautical miles)

3. What is the course and distance from the Halibut Point gong to the "3" quick flashing gong at the NW end of the breakwater? (Answer: 156° magnetic, 1.6 nautical miles)

4. What is the course and distance from the gong at the NW end of the breakwater to the N"4" buoy at Harbor Rock? (Answer: 217° magnetic, 1.2 nautical miles)

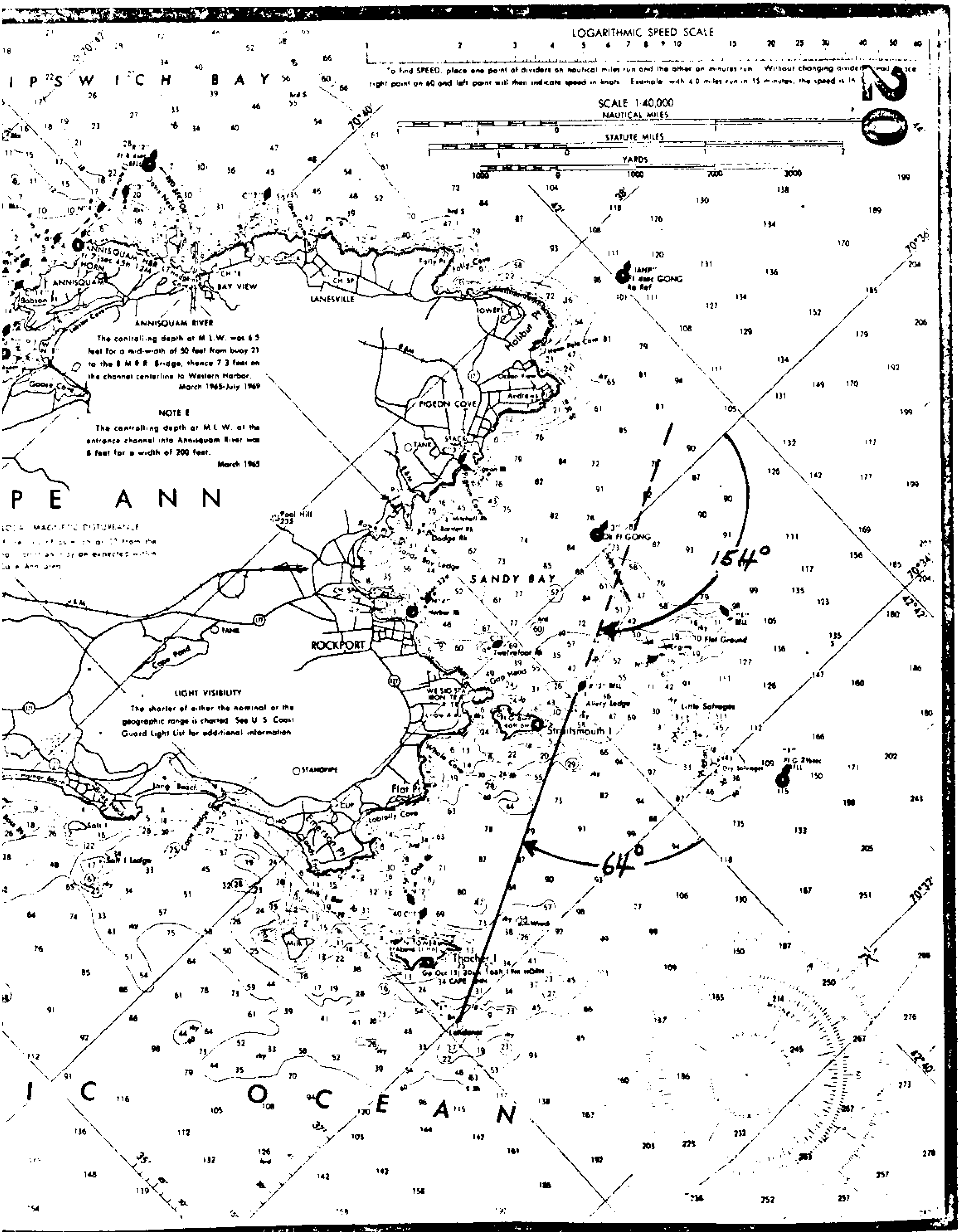
References

Chapman, Charles F., Piloting, Seamanship and Small Boat Handling, Motor Boating, New York. (latest edition).

Motte, G. A., Chartwork for Fishermen and Boat Operators, Marine Bulletin Number 7, Marine Advisory Service, University of Rhode Island, Narragansett, Rhode Island.

Sources of Marine Charts. There is usually one or more chart dealers in each coastal community. Some local chart suppliers are James Bliss and Co., Boston and Dedham; The Building Center Stores, Gloucester; and Jaynes Marine, Salem.

--Submitted by J. Lake, Andover High School



LOGARITHMIC SPEED SCALE
To find SPEED, place one point of dividers on nautical miles run and the other on minutes run. Without changing dividers, place right point on 60 and left point will then indicate speed in knots. Example: with 4.0 miles run in 15 minutes, the speed is 16
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
20
IPSWICH BAY
ANNISQUAM RIVER
The controlling depth at M.L.W. was 6.5 feet for a mid-width of 50 feet from buoy 21 to the B.M.R.R. Bridge, thence 7.3 feet on the channel centerline to Western Harbor.
March 1965-July 1969
NOTE E
The controlling depth at M.L.W. at the entrance channel into Annisquam River was 8 feet for a width of 200 feet.
March 1965
ANNISQUAM
BAY VIEW
LANESVILLE
Halibut Pt
PIGEON COVE
CAPE ANN
Pool Hill
SANDY BAY
ROCKPORT
Cape Pond
LIGHT VISIBILITY
The shorter of either the nominal or the geographic range is charted. See U.S. Coast Guard Light List for additional information.
STANDPIPE
Straitsmouth I
Flat Ground
Little Salvages
Avery Ledge
Dry Salvages
Whale Cove
Flat Pt
Long Beach
Emerson Pt
Loblolly Cove
Salt I
Salt I Ledge
Milk I
Thacher I
Londoner
154°
64°
ATLANTIC OCEAN

CHART SYMBOLS---USING A MARINE CHART (for secondary students)

Discussion

Marine charts have become indispensable to oceanographers, fishermen, professional seamen, and pleasure boat operators alike. Their history most likely goes back to the day that the first mariner, using a floating log, scratched the pictured description of a hidden harbor or underwater reef into the beach sand for the edification of a fellow voyager. Since that time, they have evolved into our modern-day Coast and Geodetic Survey (now, National Ocean Survey) charts which are based on accurate surveys, show extremely detailed information, and are beautifully printed.

Procedure

In this activity you will work with a training chart. On the back of the chart you will find an explanation of the symbols used, and these will enable you to answer the questions.

Methods

Using a Coast and Geodetic Survey chart, answer the following questions:

1. What color is land which is permanently above water?________________

2. What color is land which is exposed at low tide?____________________

3. What color is used to indicate relatively shallow water?____________

4. What color is used to indicate deeper water?________________________

5. In what units is the depth of water shown?__________________________

6. What is the scale used in making this chart?________________________

7. Explain what scale means. ____

8. What map projection was used to produce this chart?________________

9. At each of the following locations, designated by latitude and longitude, describe the object found. Include the following information: the kind and number of the object (e.g., buoy); its color, if any; size; characteristics of light(s), if any; type of sound produced; electronic aids (e.g., radio beacon); and any special characteristics indicated.

A suggested list of headings:

Lat.	Long.	Obj. #	Color	Light Char.	Sound	Electr. Aid	Spec. Char.

Teacher's Note: List various objects on charts you are using. You can get information about obtaining training charts from any local Power Squadron officer or Coast Guard Station. It is suggested that you ask the students to locate about six to eight aids as described by your directions.

10. What is the usual color of nun buoys?__________. How are they numbered?_______________

11. What is the usual color of can buoys?__________. How are they numbered?_______________

12. Examine the entrance to a harbor. What do you notice about the arrangement of the buoys which mark the channel?___________________________

13. On the end of this sheet, make a sketch showing the actual appearance of nun and can buoys.

References

Chapman, Charles F. 1971. Piloting, Seamanship and Small Boat Handling, Hearst Corporation, New York, New York.

Hamlyn, C. 1962. Seas, Maps and Men. Atlas History of Man's Exploration of the Oceans, Geographical Projects Limited, London. $3.97.

"To Help Man Find His Way," 28-minute, color film, Modern Talking Pictures, 1212 Avenue of the Americas, New York, New York 10036.

--submitted by J. Crowley and J. Stouffer, Hingham High School

BEACH, BAR, COASTAL MODELS USING A STREAM TABLE (for secondary students)

Discussion

Before the unit begins, familiarize yourself with how the stream table works. It is an excellent investigatory device, mainly because it does not lend itself to "providing" preconceived ideas. For example, bars and beaches will be formed, but exactly where and when cannot be predicted. Specific suggestions for successful use of the stream table follows.

1. Avoid presenting your own ideas and predictions to the class for any of the exercises. Instead, ask leading questions which will guide students to the formulation of hypotheses which may be used to answer the introductory questions on the laboratory sheets.

2. Be alert to what is happening on the table. Point out to the students how water and soil particles are moving at various points. Capitalize on the phenomena which appear on the table, regardless of whether or not they apply directly to the particular laboratory sheet being used at the moment.

3. Use a reliable wave-generating device. A fan operating at approximately 3600 rpm, or a vacuum cleaner set to blow air out, are excellent since they provide choppy waves as found in nature. Experiment with the angle between the blade and water. This angle is the key to sufficient choppiness and energy to do the required work quickly.

4. In order to observe changes more easily, use toothpicks as reference points. Toothpicks are so small that they do not affect the wind or water. They will float away when the soil in which they are placed is eroded.

5. Use any type of soil for the land areas in the stream table. Each type has certain advantages and disadvantages. Sandy soil provides organic debris which gives a good imitation of driftwood, but it obscures some features by making the water muddy. Sand keeps the water clean, but limits particle size and type.

In order to show the students what waves are and how they move, demonstrate the effect of waves on a cork floating in an aquarium. Create waves with an aquarium pump hose held one-half inch below the water surface. Do not stir up currents. Ask the students the following questions.

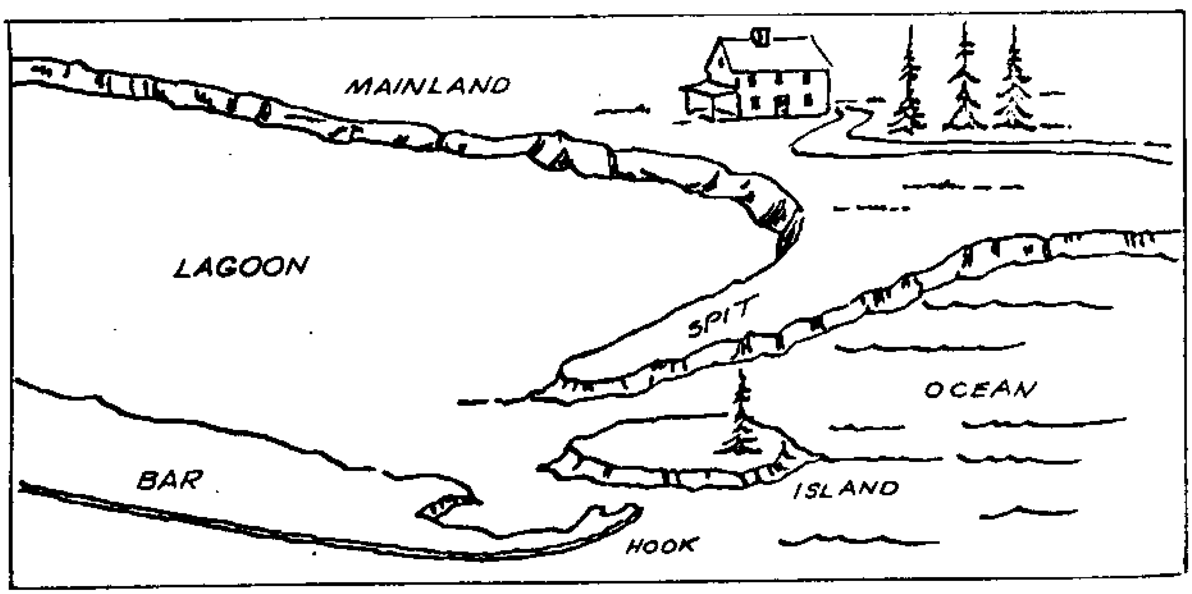
1. Is the cork moving?
2. How is it moving?
3. Are the waves moving?
4. Are the water particles moving?

Waves are caused by wind blowing over the water surface. The waves that reach the shore are called breakers. These breakers hit the shore with a strong force. This force erodes the rock and soil of the shore.

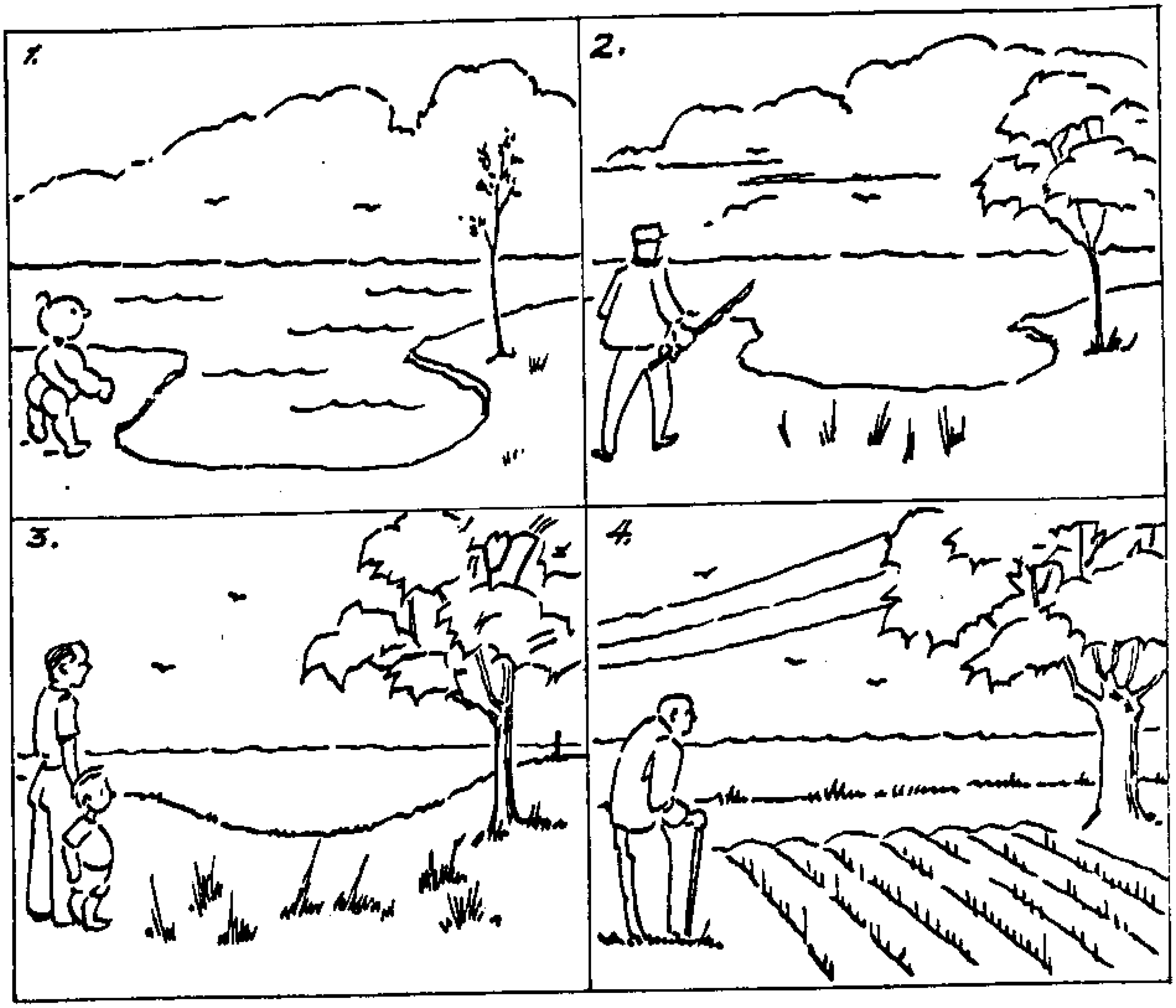
The speed of erosion depends on the materials that make up the shore and on the things carried in the water. Pieces of materials carried by the water act like sandpaper on the shore. Some of the shores of England have been cut back two miles in 2,000 years. The shore at Cape Cod, Massachusetts, gets from one to six feet smaller each year.

Currents are in the water near the shore. A current is the movement of water in a certain direction. The Gulf Stream is a large current that travels many miles. There are two currents near the shore. They are the undertow current and the longshore current. The undertow current is water that moves from the shore to the sea. It is caused by water that has been piled on the beach by the waves and must run back. The longshore currents move parallel to the shore line. They are caused by waves that strike the shore at an angle.

The action of the waves and currents causes shoreline changes. They wear away soil and rock. They also carry the pieces of soil and rock to other places. These actions make new shorelines. Have students observe some of the shoreline changes you can see in the stream table.



The tides have been a moving force for as long as waters have covered the earth. Man has used this natural force to help him in many ways. Early sailing ships used outgoing tides to start them on their trips. People who lived along rivers would block off pools at high tide to trap fish. At low tide, they could easily catch the trapped fish. Now man has found still another use for tides. He has found that they will deposit good land for farming. How can moving water build up land? We generally think of water as it erodes land.



Without further comment, have the students investigate the effects of waves and longshore currents on sloping shores as outlined in laboratory sheet.

Procedure - Materials

Obtain or make a watertight tray optimum size 3 feet x 4 feet x 4 inches or larger. Tray can be made of marine plywood and sealed on inside with fiber-glass or silicone sealant or tar.

For homemade construction, you will need: 2 lengths of 1/4" tubing, 36" x 48" x 1/2" sheet of plywood (6PX waterproof plywood), 2 strips of plywood 4" x 37" x 3/4", 2 strips of plywood 4" x 55", rectangular block of wood approximately 6" high, bucket of sand with variety of grain sizes, bucket to catch water runoff.

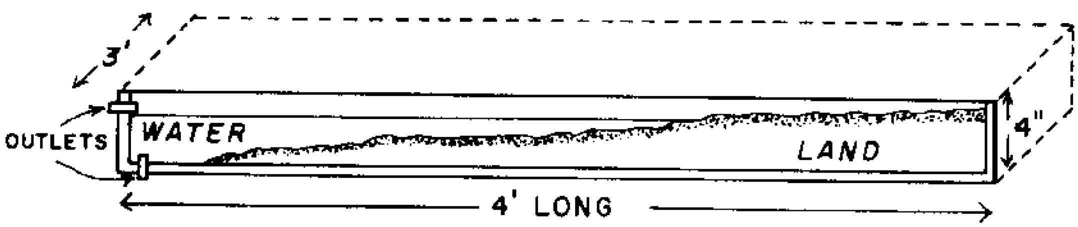
Nail 4-inch panels around edge of plywood sheet.

Drill hole in one end of stream table through 4-inch x 9-inch panel, large enough for 4-inch tubing to fit.

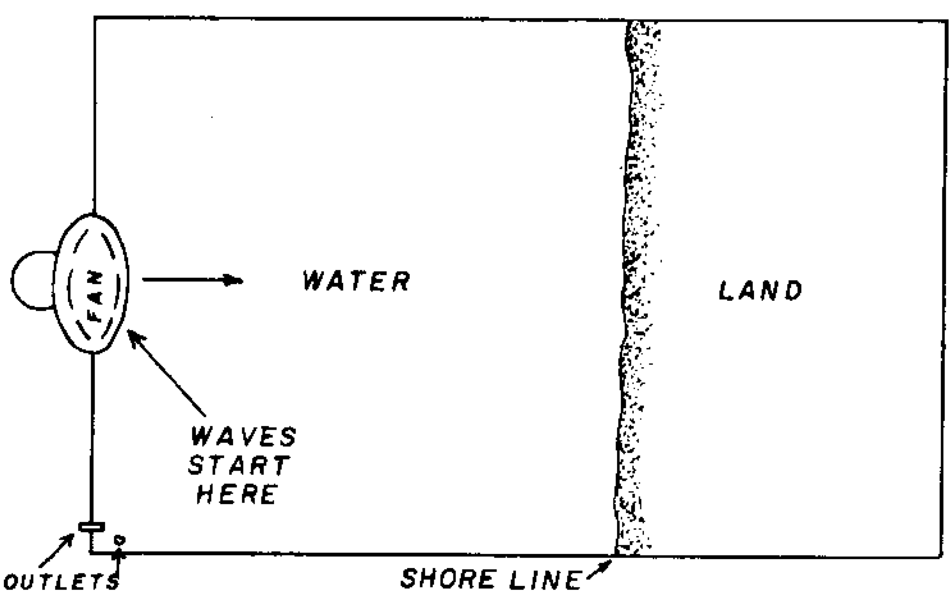
Prop up opposite end with block of wood and pour sand and water in at this end.

Method

A. Set up the stream table as shown below.



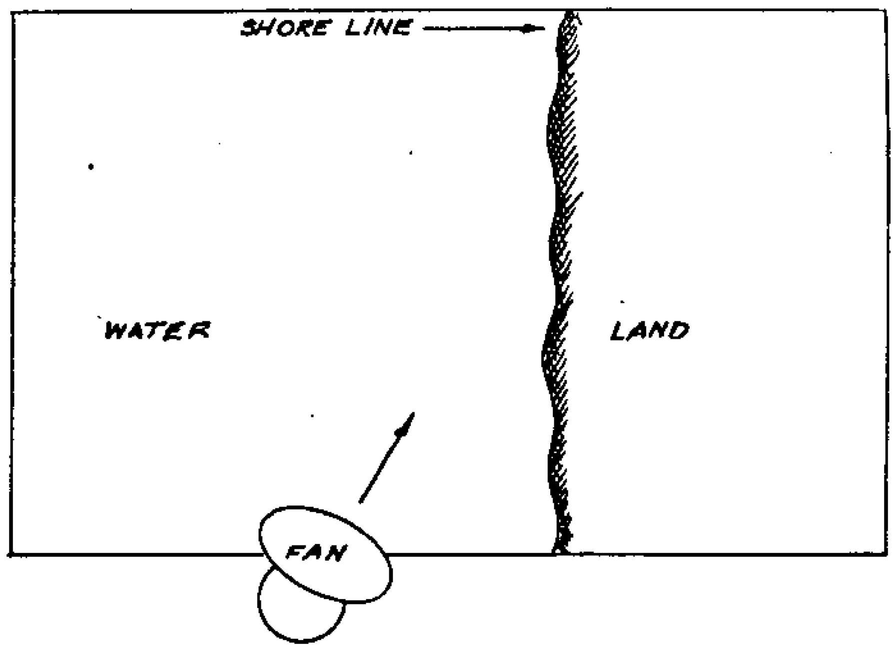
B. Make waves at the deep-water end with a fan.



Shoreline - make any way desired. Land (sand) - vary texture and show results of erosion.

Move the fan to one side of the stream table and make waves near the shore.

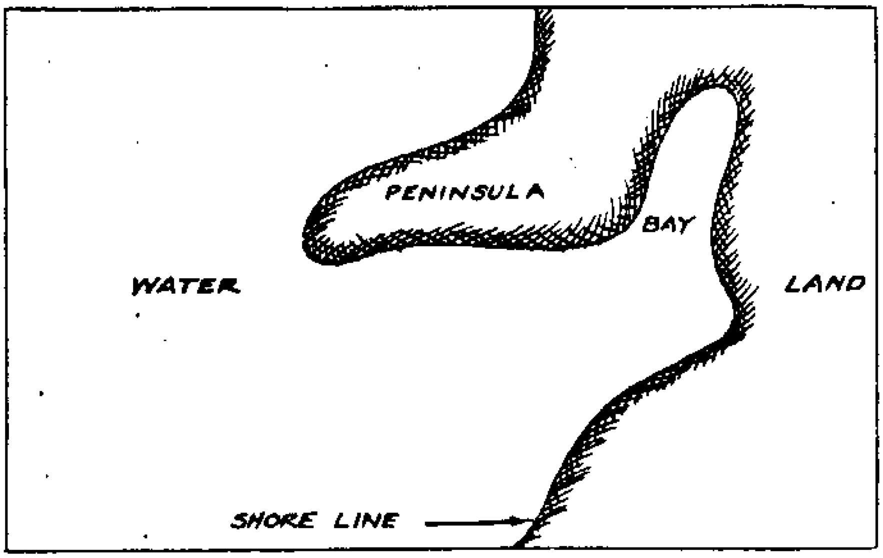
Sketch a top view of the waves approaching the shoreline.



What happened to the shoreline? In five minutes?____________________
In ten minutes?____________________ In fifteen minutes?____________________

C. Look at the grains of sand in the table. Are all the grains where the waves washed onto the shore about the same size?______Why?____________________

D. Scoop out the sand to make a bay and a peninsula in the shoreline as shown below.



E. Repeat Exercise B for 5 minutes.

How did waves affect the peninsula? ______________________________

____

Tidal Flats

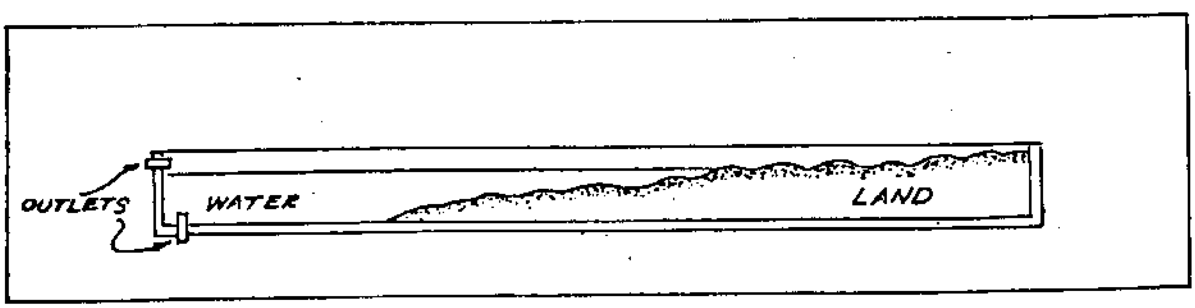
What do tides do to gently sloping shorelines? ______________________________

____

What do tides do to steep shorelines? ______________________________

____

A. Set up the stream table as shown below.

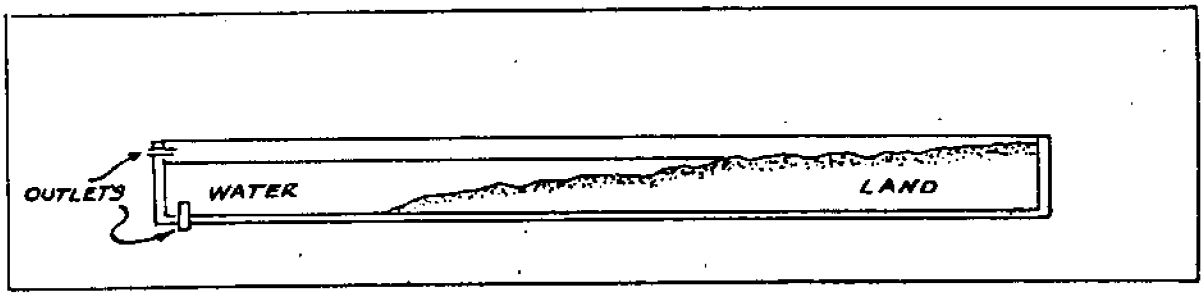


B. Slowly raise the land end of the stream table 4 inches. When the water becomes still, slowly lower the table. Repeat this raising and lowering 10 times.

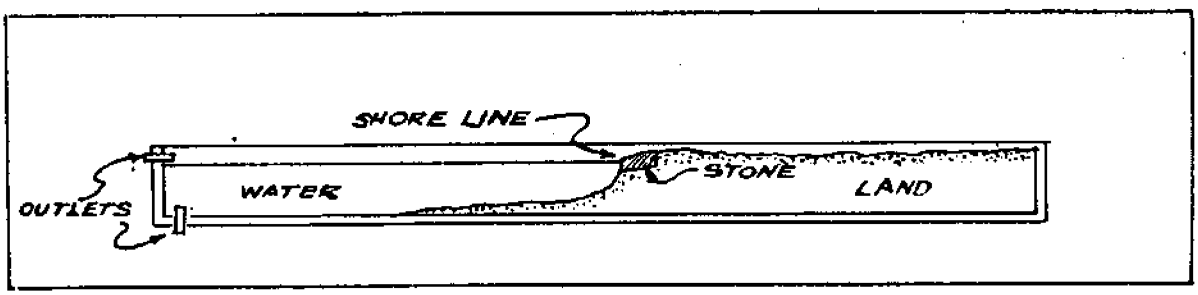
What happened to the sand when the table was **raised** and the tide went out (ebbed)?__________

What happened to the sand when the tide came in (flowed) as the table was lowered?__________

Sketch the changes in the shoreline after the 10 tides have ebbed and flowed.



C. Set up the stream table as shown below. Place some stones along the shoreline.



D. Create tides as in Exercise B.above.

What happened to the sand when the tide ebbed?__________

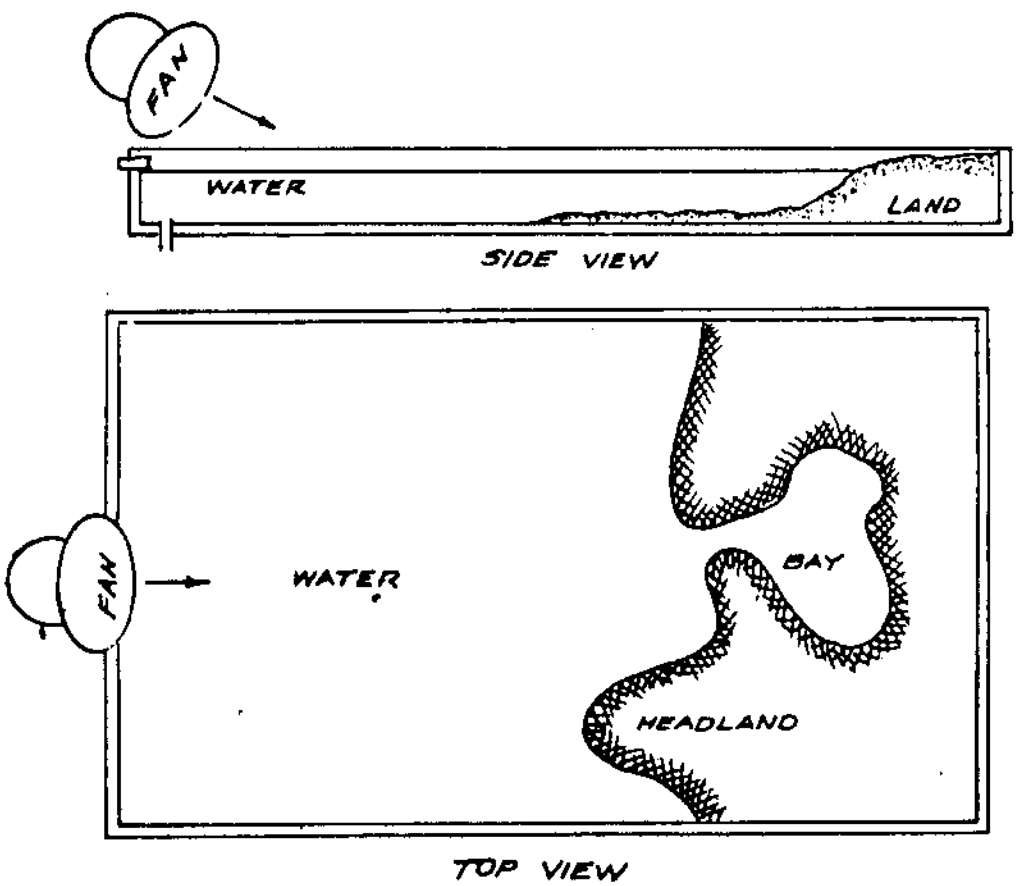
What happened to the sand when the tide flowed?__________

Describe or sketch the changes in the shoreline after the 10 tides ebbed and flowed __________

Coastal Terraces

How are coastal terraces formed?

A. Set up the stream table as shown below.



B. Observe the shoreline for 5 minutes as waves wash against it.

How did the straight section of coastline change?________________________

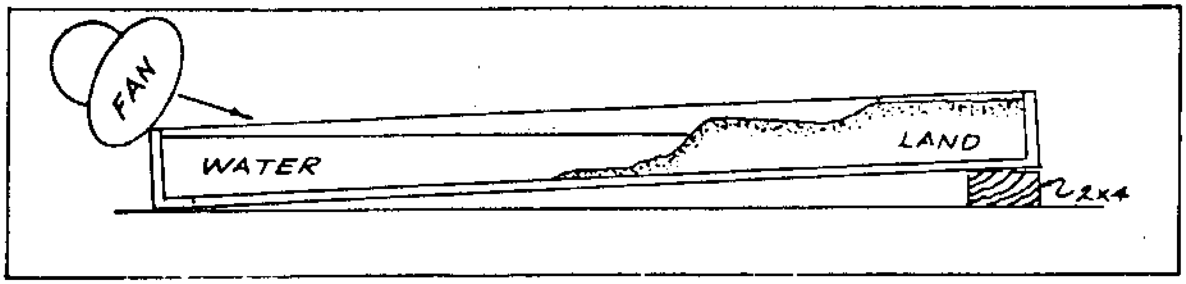
____

How did the bay coastline change?____________________________________

____

How did the headland coastline change?_______________________________

____



D. Observe the new coastline as waves wash against it for 5 minutes.

How did the straight section change?______________________________

How did the bay change?______________________________

How did the headland change?______________________________

References

For students:

Chamberlain, B. 1964. These Fragile Outposts. A geological look at Cape Cod, Martha's Vineyard, and Nantucket. Natural History Press, Garden City, N.Y. 327 pp.

Straphler, A.M. 1966. A Geologist's View of Cape Cod. Natural History Press, Garden City, N.Y. $1.95.

Usinger, Robert. 1967. The Life of Rivers and Streams. McGraw-Hill, N.Y.

"Mud." 20 minute, color, sound film from National Association of Conservation Districts, League City, Texas 77573.

"The Beach, the River of Sand." 16 mm, 20 minute film from Encyclopedia Britannica Films, 425 N. Michigan Avenue, Chicago, Illinois 60611.

"Erosion - Levelling the Land." 14 minute, color, sound film from Encyclopedia Britannica Films, Preview Rental Library, 1822 Pickwick Avenue, Glenview, Illinois 60025.

For teacher:

"Flow in Alluvial Channels." 35 minute, color, sound film from U.S. Geological Survey, Visual Services, Washington, D.C. 20242.

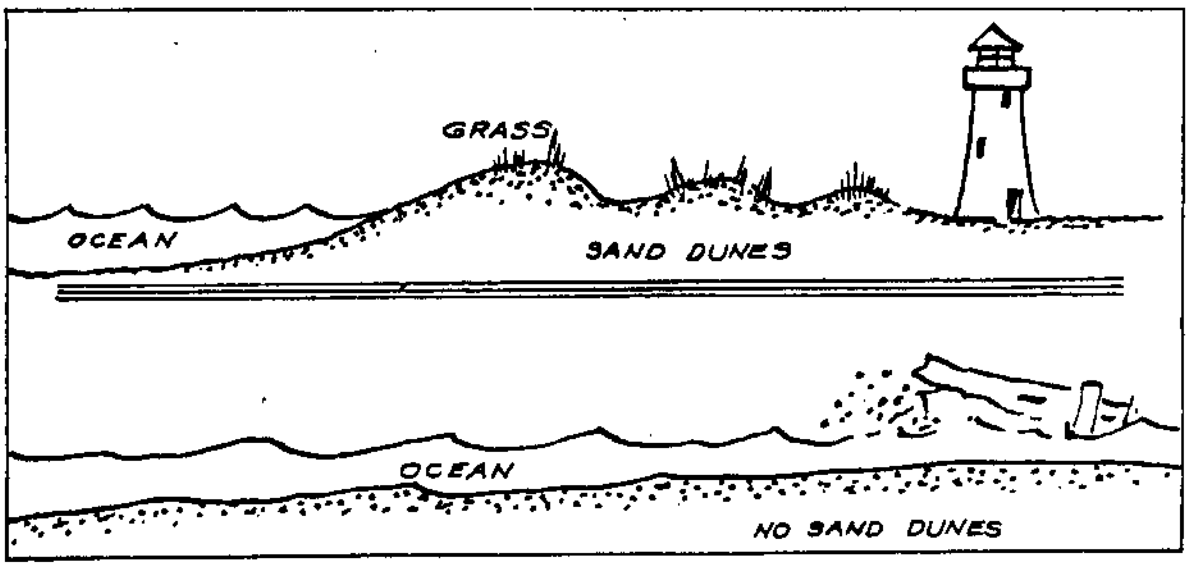
--submitted by J. Crowley and J. Stouffer, Hingham High School

MOVING DUNES ON A STREAM TABLE (for secondary students)

Discussion

The great storm of 1962 that hit Ocean City, caused great damage. Houses were torn apart. Large buildings were weakened by water washing the ground from under them. Roads were destroyed.

Why was damage from this storm so great? Many engineers said that man had removed some of the natural protection from Ocean City. This natural protection was in the form of sand dunes. When the sand dunes were smoothed out, the wind and high water had nothing to stop them. This caused more damage to property than there should have been.



What are sand dunes? How are they formed? These are questions man has to answer if he is to understand the oceans and their shores.

Sand is made up of small chips of rock. These chips are so small that they are easily carried by both wind and water. As the wind blows across the sand it picks up pieces of sand. A strong wind can carry a lot of sand. If the wind slows down it drops the sand. A dune may be formed in this manner.

Materials

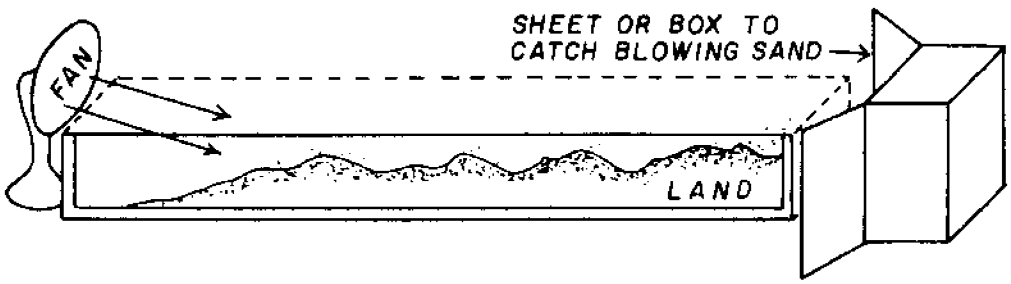
Large stream table or sand box

Large box or sheet to catch sand

Fan or vacuum cleaner (reversed) for wind source

Method

Make a number of hills and valleys in the stream table, keeping the land sloping as shown below.



Place a large cardboard box, open at one end, on the land portion of the stream table. Use fine, dry sand to represent sand dunes. Place a stone and a small bushy plant on the sand. Create wind by locating a fan at the end of the stream table, facing the open end of the box. Have students observe how the wind affects the dune shapes and locations. Ask the following questions:

What is happening to the sand on the front of the dune?

What is happening to the sand at the top of the dune?

What is happening to the sand on the far side of the dune?

What is happening to the sand around the stone?

What is happening to the sand around the bush?

Do sand dunes move?

Sketch a cross-section of a coastal terrace on the chalkboard. Ask students how such a coastal line might have been formed. Summarize all suggestions on the chalkboard and ask the class which suggestions seem most logical.

Have students use knowledge of wave action and dune movement to explain past, present and future of Cape Cod.

References

Chamberlain, Barbara. 1964. These Fragile Outposts - A Geologist View of Cape Cod. Natural History Press, N.Y.

"The Beach, the River of Sand." 16 mm, 20 minute film from Encyclopedia Britannica Films, 415 N. Michigan Avenue, Chicago, Illinois 60611.

--submitted by J. Crowley and J. Stouffer, Hingham High School

WAVES AND SURF (for secondary students)

Discussion

Refraction. Wave speed is slowed in shallow water as the waves tend to align themselves with the bottom contours. This results in a "bending" (refraction) of the wave train.

Convergence. The bending of a wave(s) inward toward a point, ridge or shallow region. This is accompanied by an increase in wave or breaker height.

Divergence. The bending of a wave(s) outward as a result of crossing a deeper region (e.g., a submarine canyon) or as the wave approaches a concave shoreline. This is accompanied by a decrease in wave or breaker height.

Currents. At the entrances of tidal estuaries and bays, when waves encounter a current running in the opposite direction they become higher and shorter. (A good example is at Hull Gut.)

Breakers and Surf. In deep water, swell generally moves across the surface as somewhat regular, smooth undulations. When shoal water is reached, the wave period remains the same but the speed decreases. The amount of decrease is negligible until the depth of water becomes about half the wavelength at which point the waves begin to "feel" the bottom. As the waves become higher and shorter, they also become steeper, and the crest becomes narrower. The process continues at an accelerating rate as the depth of water decreases. At some point the wave may become unstable, toppling forward to form a breaker.

There are three general classes of breakers: (1) spilling breakers, which break gradually over a considerable distance; (2) plunging breakers, which tend to curl over and break with a single crash, and (3) surging breakers, which peak up but surge up the beach without spilling or plunging (these are classed as breakers although they actually do not break).

Longer waves break in deeper water and have a greater breaker height. (This accounts, in part, for the large surf of the Pacific Ocean.) The effect of a steeper beach is also to increase breaker height. With a steeper beach slope, there is a greater tendency for the breaker to plunge or surge. The still-water depth point of breaker action is approximately 1.3 times the average breaker height. For example: if waves are running 3 feet high, they will break in water which is somewhat less than 4 feet deep. Surf varies with both position and time. A change in position along the beach often means a change in bottom contour, with the refraction effects described above. At the same point, the height and period of waves vary considerably from wave to wave. A group of high waves is usually followed by several lower ones. Therefore, passage through surf (in a boat) can usually be made most easily immediately following a series of higher waves. Or conversely, a series of lower waves will be followed by higher ones more suitable for catching with a surfboard.

Materials

Most any coastal chart will serve for this activity; however, it will be more interesting if it presents a coastline of considerable variety. Check with the local Power Squadron or Coast Guard on the availability of training charts.

Method

In this activity you will work with Nautical Chart #__________. Based on the information contained in the discussion above, answer the following questions.

1. Indicate the location of a beach where you would expect to find divergent waves. Lat.__________ Long.__________. Explain why this would be the case. ____________________.

2. Locate a spot where you would expect to find convergent waves. Lat.__________ Long.__________. Explain why..... ____________________.

3. With a considerable swell running, indicate a beach where you would expect the surf to be composed of either spilling breakers or plunging breakers. Lat.__________ Long.__________. Explain why..... ____________________.

4. How high would seas have to run in order to produce breaking seas at ____________________ (some shallow region away from the immediate coast). ____________________

5. Where is there a spot upon which you would find seas of 4 to 6 feet producing breaking water (other than along a beach)? ____________

References

Bascom, W. 1964. Waves and Beaches, Anchor Science Study Series, Doubleday, New York, New York. $1.45.

---submitted by J. Crowley and J. Stouffer, Hingham High School

PARTICLE DISTRIBUTION ON SANDY BEACHES (for secondary students)

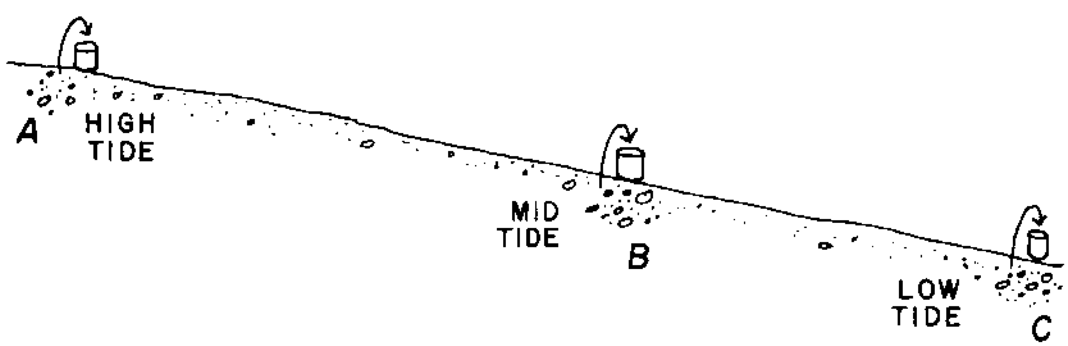
Discussion

In the development of a sandy beach the natural sorting out of the material which forms the beach causes certain sized particles to be left at the top of the slope (farthest from the water) while other sizes are moved toward the bottom (closest to the water). But, because of the constant movement of the material by tide and surf action of varying heights and force, there will be some material of virtually all sizes at any level along the slope of the beach.

In this exercise students will go to various beaches and sample sand from at least three spots--high tide, mid tide, and low tide levels. They will sort them by particle size and determine if there is any relation between elevation on a beach and percent particle sizes found there. If so, why?

Procedure - Materials

Collect sand samples from three elevations on selected beaches. Note the slope of the beaches you work on. Use about a pint-sized can for each sample and try two - three beaches with slopes of different angles.



For this activity it is not necessary to purchase a set of graduated sieves. All that is required are four or five pieces of screen (which can be purchased at a hardware store) tacked onto simple wooden frames about eight inches across. The mesh of the screen should range from approximately 1/2 inch down to 1/32 inch. The precise sizes of the screen are not so important, but there must be a distinct graduation from larger to smaller. You will also need five plain sheets of paper, numbered one through five.

Methods

Place a moderate quantity of the sample in the top of the stack of sieves (do not attempt to fill the top sieve). Be sure the sieves are stacked in order of decreasing size of screen, the largest being on the top. Be sure the sand is dry.

Shake the sample through the sieves. Remove the material from each sieve (be careful to get all of it out of each) and place it on a piece of paper. Number the papers from one through five, with No. 1 being the largest and No. 5 the smallest.

Weigh each size sample carefully.

Add the weights of the size samples in order to get the total weight.

Calculate the percentage of the total sample represented by each size sample as indicated on the accompanying data sheet.

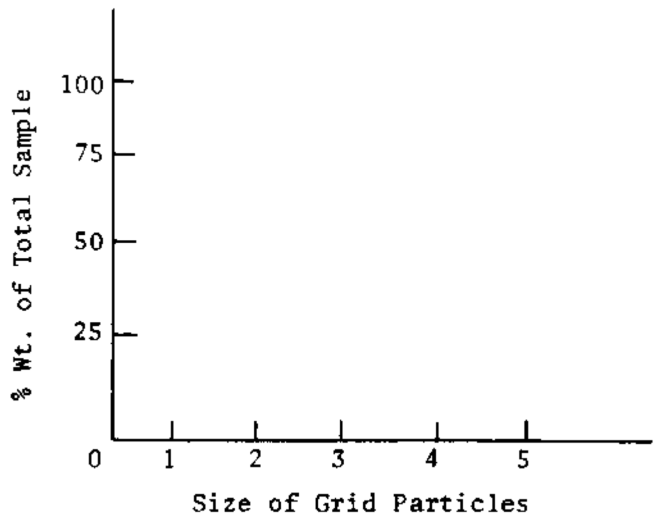
Data Sheet

	Sample 1	Sample 2	Sample 3
1. Total weight of particles size 1	______	______	______
Total weight of particles size 2	______	______	______
Total weight of particles size 3	______	______	______
Total weight of particles size 4	______	______	______
Total weight of particles size 5	______	______	______
2. Percentage of the weight of the total sample represented by the weight of:			
Particle size 1	______	______	______
Particle size 2	______	______	______
Particle size 3	______	______	______
Particle size 4	______	______	______
Particle size 5	______	______	______
Total Percentage	______	______	______

The method for calculating the percentage of the total weight represented by each particle size is as follows:

$$\%\text{ of wt. of total sample} = \frac{\text{wt. of particle size}}{\text{wt. of the total sample}}$$

3. Plot your results on a graph with the percent of total sample on the verticle axis and the particle size on the horizontal axis.



References

Bascom, W. 1964. Waves and Beaches. Anchor Science Study Series, Doubleday, New York, N.Y. $1.45.

"The Beach, the River of Sand." 16 mm, 20 minute film from Encyclopedia Britannica Films, 415 N. Michigan Avenue, Chicago, Illinois 60611.

--submitted by J. Crowley and J. Stouffer, Hingham High School

CHARTING LOCAL CURRENT SYSTEMS

Discussion

In the charting of local current systems, we must first define a few terms and describe the types of currents which we might encounter near shore. We shall not consider the movements of large masses of water such as the rotation of the water of the North Atlantic Ocean (the North Atlantic gyre). The study of these local current systems is important from both a civilian and military point of view. Commercial and sport fishermen, swimmers, beach erosion experts, chart makers, and others are interested in current studies, during the daily normal changes, the changes with seasons, and the unusual changes due to storms of varying intensities. The currents and waves caused by hurricanes often change an entire coastline.

Now for a few definitions: Tide is the rise and fall of a large body of water, such as an ocean, due to changes in the gravitational pull of the moon and the sun on the water mass. A tidal current is the horizontal movement of the water. As the tide rises and falls, the currents of water move toward the shore and away from shore so we say the tidal current floods and ebbs. A nontidal current is any current not due to the tidal movement. Near-shore currents are the sum of tidal and nontidal effects and are most complicated. They are the result of many different agents acting on the water: the direction, force and duration of the wind; the rise and fall of tides; the constantly changing shape of the bottom of the near-shore water; and the sediment brought down by rivers which in turn affects bottom currents. Estuaries are bodies of water, salt or brackish, mostly surrounded by land, but with a connection with the sea--they also have current systems which are very difficult to study.

Many methods are in use to determine local current systems. The oldest and still the most widely-used method is the use of drift bottles. This method has been extremely valuable in measuring offshore ocean currents, but is not too satisfactory near shore. In charting nearshore and estuarine currents, dyes of various colors are dropped into the water and visual observations are made. Another indirect way of measuring bottom currents is to dye sand and determine its drift. With the increase in surfing all over the world, personal observations of local currents have been made. As waves and currents cause beach erosion, specialists in this field,(U.S. Army Corps of Engineers, Scripps Institution in

California and others) have made valuable contributions to our knowledge of currents. Changes in the shape of the beach often give very accurate indications of current velocity and direction.

Procedures

1. Use floats outside the breaker zone. Floats can be made by students. The sketches give some suggestions on their construction. The effect of the wind should be reduced by having as little of the float above the water as possible. Currents beyond the breaker zone are often weak, so there should be a large float surface for water reaction. Floats should be released along the entire length of the area to be studied. Each float should have an identifying flag or marker. Measurements should be made through several tidal cycles and for as long as a one-year period.

2. Use of fluorescein dye for the measurement of currents inside the breaker zone. Fluorescein is a yellowish-red dye which receives its name from the brilliant yellowish-green fluorescence of its alkaline solutions. A cup of sand with a teaspoonful of dye is wrapped in a paper towel, bound with a rubber band and tossed into the breaker zone. The direction of movement of a patch of colored water is then traced from shore, from a pier if one is nearby, or from a boat.

3. Ordinary rubber balloons filled with fresh water may also be used. They are put into the water beyond the surf zone where they float, due to the fresh water's having less density than the salt water.

Answer these questions?

1. Why are currents near shore more difficult to study than currents in the deeper parts of the ocean?

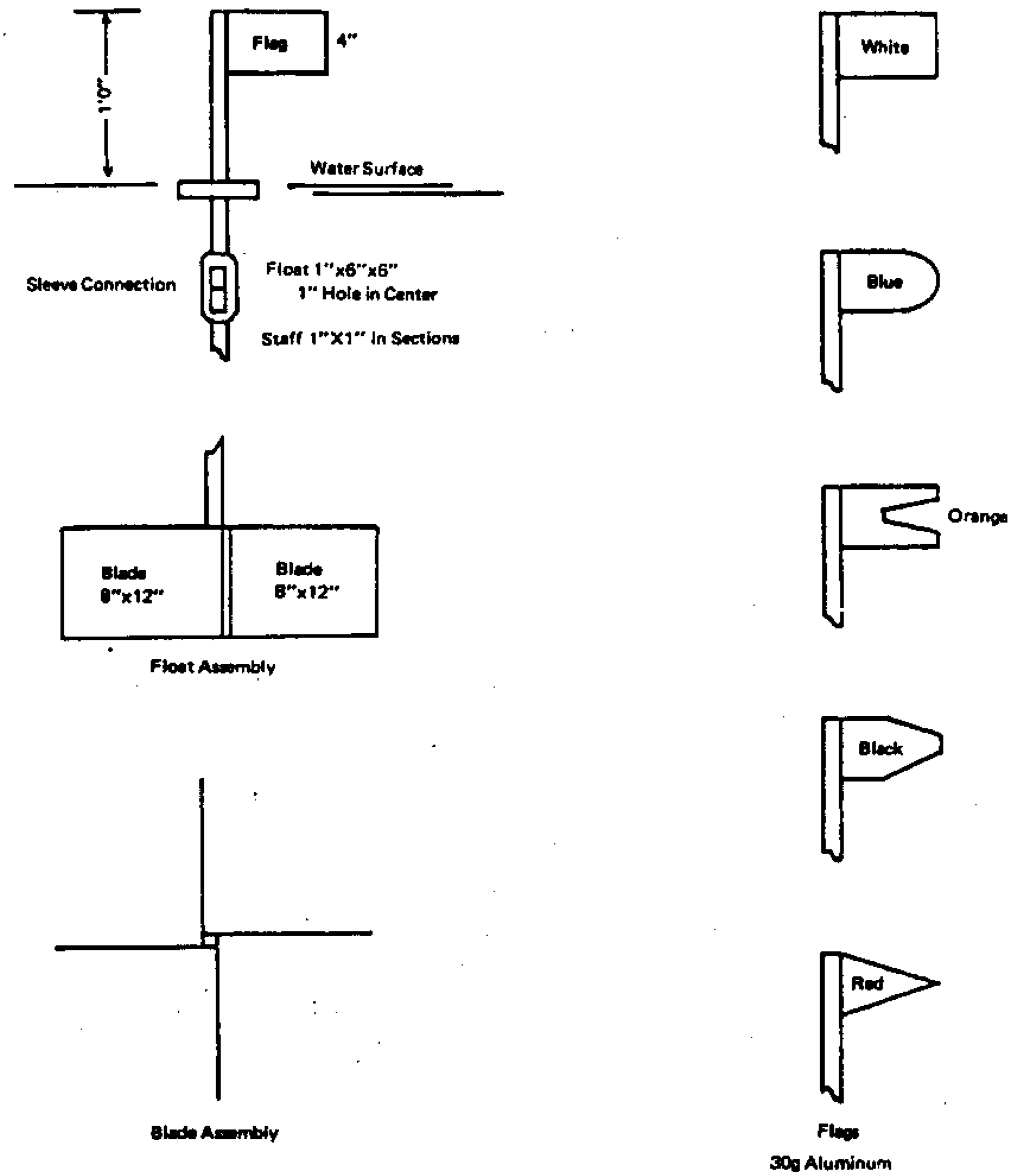
2. What causes a "run-out"?

3. Why would the surface currents near shore be different from the bottom currents?

4. What is the difference between a tidal and a nontidal current?

5. What is an estuary?

It is easy to see that the measurement of near-shore currents is very difficult. Much work of a quantitative, statistical nature needs to be done. Every marine science education group should have a master chart of their own coastal area and as current studies are made, this should be put on the chart. The knowledge of currents which surfers, swimmers and fishermen gain from experience should be recorded for the benefit of everyone. For a group wishing to make a really serious study of the beaches, monthly charts should be prepared showing changes in the beach topography due to current, wave, and wind action. The study of sand transport along the beach is most interesting and could be a real contribution to the community.



VANE FLOAT – SUGGESTED CONSTRUCTION DETAILS

--Submitted by J. Crowley and J. Stouffer from Hingham High School, Sourcebook of Marine Science, Bureau of Curriculum and Instruction, Florida Department of Education, Tallahassee, Florida.

OCEAN FLOOR SPREADING (for secondary students)

Discussion

The ocean floors are known to be moving slowly away from ridges like the one that bisects the Atlantic Ocean (the Mid-Atlantic Ridge) as molten rock rises into the ridges to fill the gaps. When looking at the ridges, one observes they are not continuous; they are repeatedly offset to one side or the other. Furthermore, these offsets are joined by faults that lie parallel to the directions of sea floor motion. This exercise helps to explain the formation of these cracks in the earth's crust. The wax-tray method is taken to be an analogue of the earth's crust that floats on a relatively plastic region immediately beneath it.

Materials

Paraffin
Variable-speed fan
Tray, metal
Paddle

Method

Melt paraffin (candle wax) in the tray. Place paddle in pan, about one-third of the way from the front (fan side). Turn on fan to cool wax. When surface film becomes solidified, draw paddle through it. This will compress the crust on one side of the pan and stretch it on the other. Watch the stretched side carefully. The crust will break into cracks perpendicular to the direction of stretching, and molten wax will well up into these cracks from below to form a new crust. Note that the cracks do not occur in one continuous line but in segments. The dragging created transform faults, linking offset segments and continuing well beyond them (see drawing).

References

For teacher:

"Continents Adrift," Scientific American.

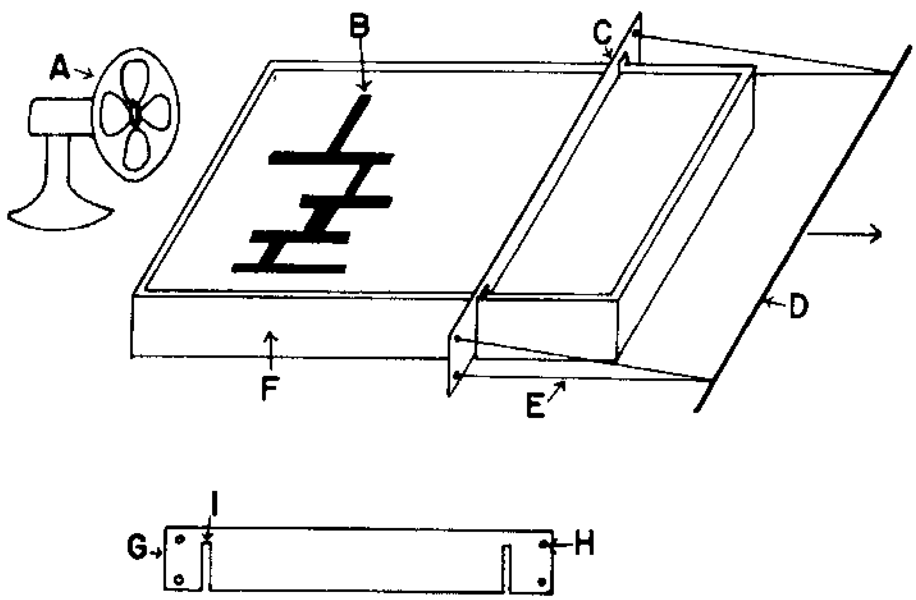
Heezen, Bruce, and Ian MacGregor. 1972. "Riddles Chalked on the Ocean Floor," Saturday Review, Feb. 19.

For student:

Matthews, Samuel W. 1973. "This Changing Earth," National Geographic, January.

Canby, Thomas Y., and James P. Blair. 1973. "California's San Andreas Fault," National Geographic, January.

-- submitted by H. Wiper, Newton High School, Newtonville



A Variable speedfan

B Wax breaks into ridge and fault pattern

C Movable paddle

D Handle to pull paddle

E Rope

F Wax tray

G Paddle

H Holes for rope

I Cut to fit frame

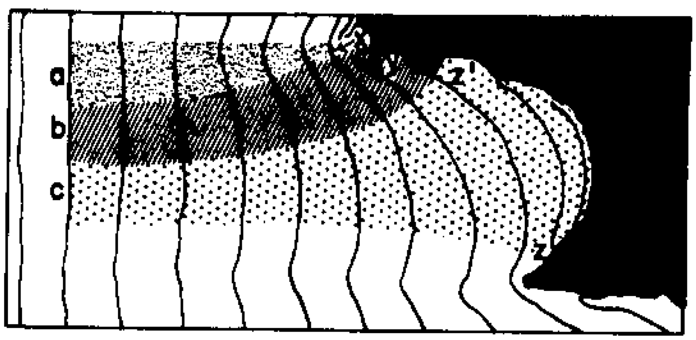
WAVE REFRACTION AND SHORE EFFECTS ON WAVE ENERGY (for secondary students)

Demonstration of Wave Refraction and Concentration or Dissipation of Wave Energy on the Shore

Discussion

An explanation of how waves are formed is in order. It is not sufficient to say by the wind. Just how does the wind form waves? Consider the velocity of the wind, its duration, and the distance over which the wind blows (fetch). This can be illustrated by actual data from wave heights in storms at sea versus the heights during calm weather. Fetch can be illustrated by comparing bay waves to ocean waves. Define such wave terminology as wave height, wavelength, period, and frequency.

Explain the development of waves of oscillation and waves of translation, and the particle movement in each case (see figure).



Two changes are commonly developed.

1. Oscillatory wave motion extends downwards to a depth equal to one-half the wavelength. As the wave approaches land its character is affected by interference of the shallowing bottom with the orbital motion of the water. Due to the traction between the wave motion and the bottom, the forward advance of the wave is retarded. This causes a shortening of the wavelength and an increase in wave height. Ultimately, the wave breaks. Explain and demonstrate this feature by using a ripple tank.

2. Waves are refracted (or bent) upon approaching the shore, and are especially refracted toward places of shallower, rather than deeper, near-shore bottom. This is found to be true of coastal areas with straight shorelines as well as for coastal zones more embayed between headlands, particularly where the longshore bottom is correspondingly shallower off the headlands (compare figures). Explain and demonstrate this by diagrams and by using a ripple tank.

Procedure--Materials

A ripple tank; or any 20-inch square or larger clear flat container (such as a clear plastic freezer container or a homemade glass-bottom box) which can be placed over one (or a series of) overhead projectors. By using overhead projectors, large images can be projected on walls, etc., making activity easier to follow. In addition, a fan, flat wood sticks, or other wave makers are needed as well as various objects (modeling clay) to simulate shorelines.

Method

Place a few drops of ink in the water on one end of the tray. Then, blow air with a fan or straw across the surface to show the effect of wind on wave formation and water movement.

1. Explain how waves are refracted as they approach the shore.

2. Demonstrate the refraction of waves with the ripple tank. Place the simulated smooth shore at the opposite end of the tank from the ripple generator. Generate ripples and observe the bending of the ripples. Do the same for a simulated headland and bay.

3. Show how the wave is bent and what it means by diagrams. Use a copy of figures below (A for headland and D for bay).

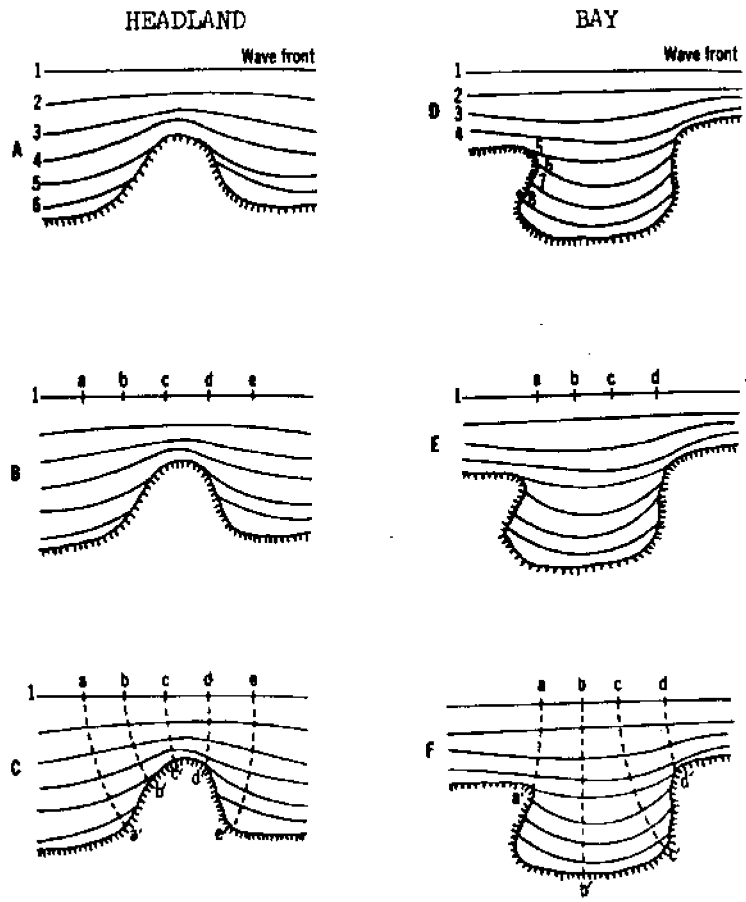
a. As the wave front approaches the headland (A) it is refracted; numbers 1—6 represent the same wave as it moves toward shore. Upon entering a bay the wave is also refracted (D). Numbers 1—8 represent the same wave as it enters and spreads out in the bay.

b. Plot 5 points (a—e) on wave front 1 as shown in B (or the students can do this individually). Plot 4 points (a—d) on wave front 1 as shown in E.

c. From each of their points (a—e) on wave front 1 (B) draw lines perpendicular to the wave front. Do this for each location of the wave front (1—6) and connect these lines as in C. Measure the line abcde and a'b'c'd'e'. Do the same for the bay and measure lines abcd and a'b'c'd' (F).

d. The line abcde represents the energy in the wave as it approaches the headland. The line a'b'c'd'e' is the same wave. Is the energy concentrated or spread out? The line abcd represents the wave energy as the wave approaches the bay. The line a'b'c'd' is the same wave. Is the energy concentrated or spread out?

e. Wave refraction occurs whenever the wave meets the bottom; thus bottom topography can cause refraction. What shape would a wave take as it came in over a submarine canyon? A submarine ridge? The military services took advantage of this during World War II. Aerial photographs could be used to determine the depth of water prior to sending in landing craft.



Reference

Bascom, W. 1964. Waves and Beaches, Anchor Science Study Series, Doubleday, New York, New York. $1.45.

---submitted by J. Crowley and J. Stouffer, Hingham High School

TURBIDITY

Discussion (teacher)

"Turbidity in water is caused by the presence of suspended matter, such as clay, silt, finely divided organic matter, plankton, and other microscopic organisms." (Standard Methods 12th Ed. 1965) Turbidity is caused by the optical property of water where light is absorbed and scattered rather than transmitted.

Of all the parameters of water analysis, turbidity determination is perhaps one of the most difficult to establish a satisfactory procedure. D.D. Jackson and G.D. Whipple compared the turbidimetric methods in 1900 in a paper printed in the MIT Quarterly. The outgrowth was that the candle turbidimeter became the laboratory standard method (Jackson Turbidimetric). Later methods of limited acceptability are photo-electic and sample comparison devioes.

For field studies the Secchi disc and photometrics have been used successfully. A Secchi disc may be produced locally or purchased from suppliers.

The disc varies in diameter between 8 inches (20cm) and 7 1/2 feet (237 cm). Many commercially produced ones are about 12 inches (30-33 cm) in diameter. One side is white while the other side is either black or black-white marked in quadrants.

A smaller Secchi disc of about 8 inches diameter (22 cm) in now being marketed by the General Biological Supply House (Turtox), Chicago, Ill., and also by Gilson Slide Rule Co. of Stuart, Florida.

The Secchi disc is also used by comparing the white disc at a standard depth (1M) to a color chart. The color chart is in two parts: The Forel Scale I-X and The Ule Scale XI-XXII.

The Forel Scale is primarily for offshore blue to green waters. The yellowish to brown inshore waters match the Ule scale. These scales can be bought from Braincon Corp., Marion, Mass., and other suppliers of oceanographic instruments. They may be made from chemicals available in most high school laboratories according to the following table and directions:

Prepare 1210 ml of solution 1;660 ml of solution 2; 330 ml of solution 3. This is enough to prepare 4 sets of vials of 25 ml each.

Solution 1:
--Measure 6.05 g of $CuSo_4.5H_2O$
--Dissolve $CuSo_4.5H_2O$ in one liter of distilled H_2O
--Add concentrated NH_4OH until deep blue color indicates the complete dissolving of the white precipitate. Add NH_4OH* to 1210 ml.

Solution 2:
--Measure 3.3g of $K_2CrO_4.5H_2O$
--Measure 33 ml of NH_4OH* (The NH_4OH required is made by adding 50 ml of concentrated NH_4OH to 75 ml of distilled H_2O.)
--Dissolve $K_2CrO_4.5H_2O$ in 1/2 liter of distilled H_2O.
--Add NH_4OH. Add H_2O to a total volume of 660 ml.

Solution 3:
--Measure 1.65 g of $CoSO_4$-$7H_2O$
--Dissolve $CoSO_4$ $7H_2O$ in 300 ml of distilled H_2).
--Add H_2O to a total volume of 330 ml.

Make 100 ml of each Roman-numeraled mixture as directed by the table. Divide the 100 ml of mixture into four 25 ml vials. Seal each vial. Number each vial with appropriate Roman numeral. The Turtox #315A57-D is an adequate vial size and type. Compile four sets of the vials.

In order that the continuity of a set will not be broken, it is suggested that a wooden rack be fabricated so that the entire set of vials is visible while reading one. Place in the order of ascending Roman numerals, two racks of eleven vials to make one set. Be sure that the Secchi disc is visible while seeing each vial.

Discussion (student)

Turbidity is antithetical to transparency. These are physical properties of water. When light enters water from air it is reflected, refracted, absorbed, scattered and transmitted. A beam of light passing through pure H_2O has almost total transmittance. In order to detect this light, the beam needs to be pointed toward the receiver (you). The same is true for true solutions although the beam of one light may now appear colored. This selective absorption by color is called filtering. The colorimeter is a laboratory instrument that measures this factor. Why do underwater color photographs always seem to appear blue? Why do marine animals, who normally dwell in deep water, soon die in shallow containers?

Table of Composition of each Solution in ml

Solution	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1	100	98	95	91	86	80	73	65	56	46	35
2	0	2	5	9	14	20	27	35	44	54	65
3	0	0	0	0	0	0	0	0	0	0	0
	Blue		Greenish blue		Bluish green				Green		

Solution	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
1	35	35	35	35	35	35	35	35	35	35	35
2	60	55	50	45	40	35	30	25	20	15	10
3	5	10	15	20	25	30	35	40	45	50	55
	Greenish yellow					Yellow				Brown	

To prepare the mixtures, put solution 1 in first; then 2; and then, 3; as indicated.

Both questions can have the same answer. The infrared, red, orange and yellow light frequencies are filtered (absorbed) in the upper water levels. Thus, an animal from the "blue" deep is in a red to yellow environment. The animal may be partially blinded by the amount and color of light. His enemies now find him an easy prey.

Materials in the water that are not dissolved, but are held in suspension, produce a milky appearance. A light beam is scattered so that it can be seen from any angle. Each tiny particle reflects a minute bit of light. Since the particles are randomly oriented, the beam shows from every angle. Light that is apparent at the side angles is therefore subtracted from the light arriving at the aimed destination.

When enough suspended particles are between the source of light and the receiver of light, the object is no longer seen. If an object is lowered underwater until it can no longer be seen, the depth at which this takes place is related to the turbidity of the H_2O (vanishing point).

Such a device was developed and first used in 1865. This is the Secchi disc. Even today it is in use for measurements by oceanographers around the world.

Is there a biological significance to turbidity? An emphatic YES! Egg-laying species depend upon the waters to remove CO_2 (diffusion) and to provide O_2 for absorption by the developing embryos. If these eggs are covered with a layer of silt, clay or industrial waste, the embryo development is arrested. Benthic invertebrates that feed by "pumping" water have retarded growth rates or they may die en masse.

Turbidity caused by a high plankton count is an indicator of a favorable environment. Plankton are the foundation of the marine food chain. Ultra-clear waters are often referred to as "marine deserts" (Bahamian waters).

The problem

Measure the turbidity of water
Perform a color analysis of water with the Forel-Ule Scale and the Secchi disc.

Materials

Secchi disc
Forel-Ule color scale
Maps
Field notebook

Procedure

A. To measure the turbidity of water, the point of entry of the Secchi disc into H_2O should be in a shadow during a sunny day. Reflected sunlight on the surface obscures the vanishing point of the Secchi disc. There are those who can see a "sharper" vanishing point with the alternate white and black quadrants up. There are others who can do better with the white side uppermost. Try both.

1. Read and record the length of chain under water.
2. Move to next site. Repeat readings of underwater chain length (caution: The Secchi disc tends to "hydroplane" when the current is strong. Make all readings when the chain is vertical).
3. If other analysis is to be done back at the lab, a bottled sample should be taken at each Secchi-reading site.

B. To perform a color analysis with the Forel-Ule Scale and the Secchi disc, immerse the Secchi disc with the white side up. Lower the disc to a total depth of one (1) meter below the water's surface. Again, direct light reflections are to be avoided. Hold the scale at arm's length so as to see both the Secchi disc and the Forel-Ule scale.

1. Read and record the color closest to the color of H_2O over the disc.
2. Move to next site.

Statistical and Mathematical Analysis

1. Plot Secchi readings on area chart. A continuing study of this can be expecially meaningful. If both chain length and color are read, a plot is made in the form of an ordered pair: (7.4,XX). This indicates that the disc "disappeared" at 7.5 meters and the water was a shade XX of brown--an unlikely occurrence. Why?

2. Connect similar readings with a continuous line similar to the contour line of a relief map.
3. Take readings at a single spot every hour during a day. Plot the hour (24-hour clock) against the depth.

Questions

1. Could a photographic light meter be used on bottled H_2O samples? How could a comparison be made with the Secchi disc field readings? (Did you ever candle an egg?)
2. Can you account for the multitudes of specimens in a shallow water biome?
3. Is there a conspicuous color change of fishes with an increase of depth? How do you account for this?
4. How deep does light penetrate into the ocean depths? What technique(s) can be used to verify the presence of light at a given depth?
5. In which bodies of water would you expect to find the greatest degree of turbidity? The least?

References

Booda, Lary L. 1967. "Special Report: Underwater Photography," Under Sea Technology, 8:5, 35-41.

Coker, R. E. The Great and Wide Sea, Harper and Row, New York.

Fairbridge, Rhodes W. 1966. The Chemistry and Fertility of Sea Waters, Reinhold Publishing Co., New York.

Harvey, H. W. 1963. The Chemistry and Fertility of Sea Waters, Cambridge University Press, New York.

Orland, H. P. 1965. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WPCF, New York.

Rodhe, Wilhelm. 1965. "Standard Correlations Between Pelagic Photosynthesis and Light," C. R. Goldman, Primary Productivity in Aquatic Environments, University of California Press, Berkley, California.

Sverdrup, Harold V., et al. 1964. The Oceans, Prentic Hall, Englewood Cliffs, New Jersey.

Stephens, William M. 1967. "Sophisticated Underwater Cameras to Bring Depths into Sharp Focus," Oceanology, 2:3 7-40.

Twenhofel, William H. 1950. Principles of Sedimentation, McGraw-Hill Book Co., New York.

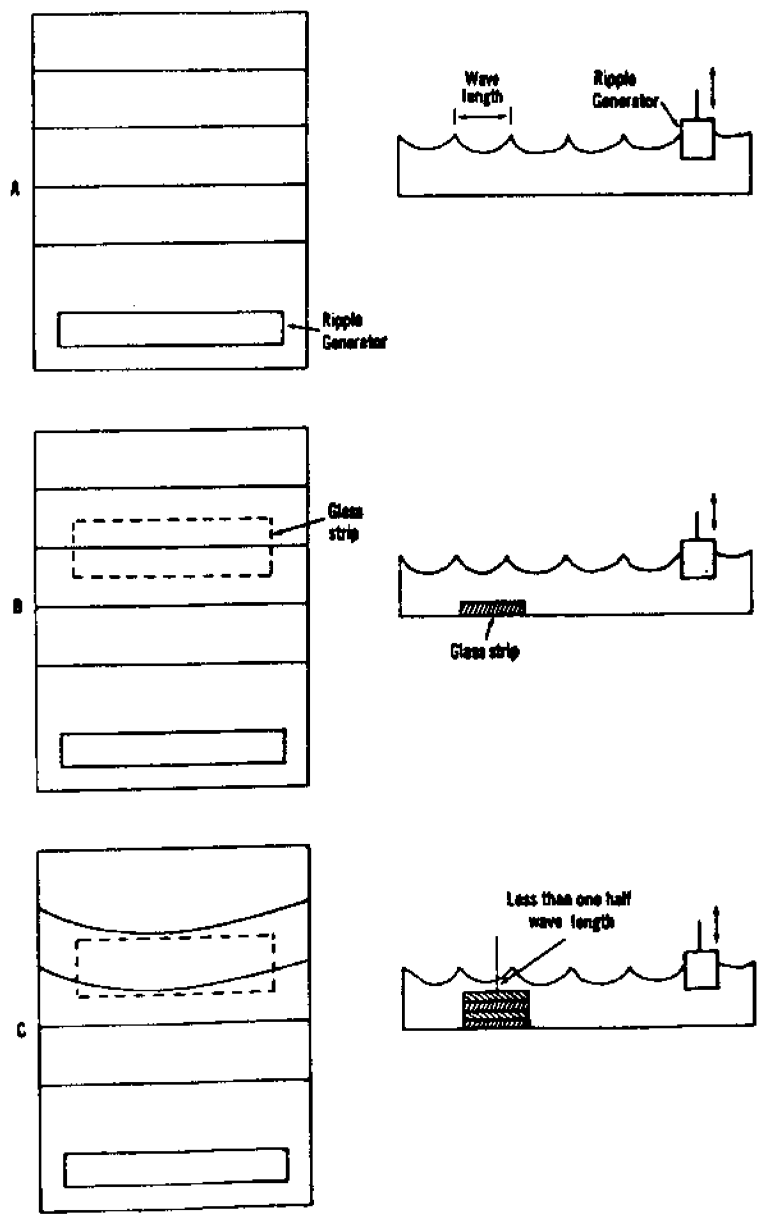
--Submitted by J. Crowley and J. Stouffer from Hingham High School, Source book of Marine Science, Bureau of Curriculum and Instruction, Florida Department of Education, Tallahassee, Florida.

DEPTH OF WAVE MOTION

Demonstration of Depth of Wave Motion

<u>Materials</u>

ripple tank	paper
ripple generator	pencil
water	strips of glass 6 inches long, 1 inch wide and about 1/4 inch thick
lamp	



Procedure

1. Generate ripples and measure their length by marking the paper simultaneously at the crest of two or more wave reflections (A).

2. Place one strip of glass on the bottom of the tank at the opposite end (B). The 6-inch length should be parallel to the crest of the ripples. Continue to place the glass strips one on top of the other until the reflection of the ripple pattern is interfered with (C)(refracted around the ends of the glass strips).

3. Measure the depth of the water over the glass strips. It should be approximately one-half the length of the ripples. This demonstration shows that wave motion does not "touch the bottom" in the deeper water but does as the wave approaches shore.

Reference

Bascom, W. 1964. Waves and Beaches, Anchor Science Study Series, Doubleday, New York, New York. $1.45

---submitted by J. Crowley and J. Stouffer, Hingham High School

THE DETERMINATION OF SALINITY OF SEA WATER BY TITRATION TECHNIQUE (for secondary students)

Discussion

In this method of chemical analysis of sea water, we shall use silver nitrate ($AgNO_3$) solution to precipitate (cause to settle out) the various chlorides in the water. The problem is to know exactly how much silver nitrate it takes to combine with all of the chlorides in the water. In order to determine this, we will use an indicator. The indicator in this case is potassium chromate ($KCrO_4$). The manner in which this indicator works is as follows: (1) The addition of the potassium chromate to the sea water will give it a yellow color. (2) As the silver nitrate is added to the solution, it will react with the chlorides and cause a white precipitate to settle out. As long as there are chlorides in the solution, the addition of more silver nitrate will cause this reaction to continue. (3) However, at the point when all the chlorides are removed from the solution, the potassium chromate will begin to react with the silver nitrate to form a new compound, silver chromate which is a red precipitate. At the same time, the remaining solution will take on a reddish or orange hue. You must stop adding silver nitrate precisely at this moment.

Materials

25-cc graduated cylinders
2 sets of dropping bottles plus glass stirring rods

Reagents

silver nitrate (.5 molar), 85 grams in 1,000 cc distilled water (a must)
potassium chromate, 5 cc in 95 cc distilled water

Method

All measurements must be made accurately.

1. Place a suitable volume of the sample (preferably 10 cc) into a 25-cc graduated cylinder.

2. Add 1 ml of potassium chromate.

3. Using dropper, slowly add silver nitrate to the solution. Shake or stir the solution as you add more silver nitrate. Calculate silver nitrate

used by subtracting volume of sample plus 1 cc from total volume in cylinder.

4. Record the volume of silver nitrate used. __________ ml.

$$\text{salinity in parts per thousand } 0/00 = \frac{\text{volume of silver nitrate}}{\text{volume of sample}} \times 32$$

How can you change answer to parts per hundred (%)?

Data

Test samples from various locations. What must be done to test drinking water?

Sample	Your Data	Averages of Other Groups	Overall Averages
1.			
2.			
3.			
4.			

Room temperature of 20°C results in a 2% error. Procedure should be done at 4°C. Correct data if time allows.

---Submitted by J. Crowley and J. Stouffer, Hingham High School

TIDES AND THE TIDE CURVE

Discussion

Nearly everyone has heard about the rise and fall of the tide every day, and nearly everyone has heard that the tides are caused by gravitational forces of the sun and moon. Information about the tides has always been of great importance to navigators, especially in guiding ships in and out of harbors and operating in shoal waters near shore and around islands. In time of war, a knowledge of the tides of a particular area is essential before an amphibious operation can be planned where boats, men, and materials have to be landed along a shore. Another way in which tidal information can be used is in the designing of power plants which use tidal energy to generate electricity.

In order to study the tides, we must take observations of the time of rise and fall and the amount of rise and fall of the tide each day over a long period. These observations are usually taken automatically in a tide station by an instrument that rises and falls with the tide and makes a recording. An example of such a recording is the typical tide curve shown below. After a number of recordings are collected for various places around the world, certain characteristics of the tide can be discovered and predictions made for the future.

Tides are classified into three types:

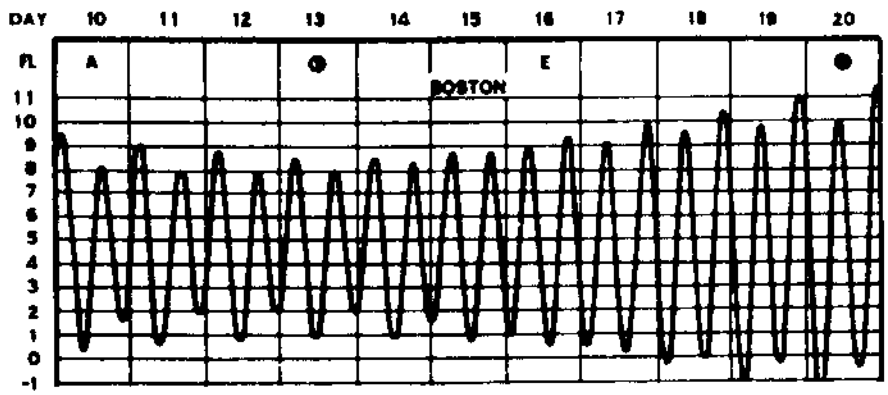
1. The semidiurnal type has two high waters and two low waters each day with little or no difference between consecutive high or low water heights. Tides along the east coast of the United States are semidiurnal.

2. The diurnal type has only one high water and one low water each day. The tides along the Vietnam-China coast are diurnal.

3. The mixed type has both diurnal and semidiurnal characteristics; that is, there are two high waters and two low waters each day but with considerable difference between heights of successive high waters or successive low waters. These differences are called diurnal (daily) inequalities. The tides along the Pacific coast of the United States are mixed.

When the moon and sun are in a straight line with the earth (new or full moon every two weeks), they pull together and the tides are greatest. These are spring tides that occur when the water "springs" up (the term spring has nothing to do with the season of the year).

When the moon, sun, and earth form a right angle (first and last quarters), the pulls oppose each other and the water is "nipped," or lowered; these are neap tides. The accompanying figure shows a typical tide curve related to the phases of the moon for an 11-day period; the changes in the moon's position with respect to the sun and earth are called phases.



A graphical representation of the rise and fall of the tide can be shown by plotting a curve from predictions of times in hours and minutes, and heights in feet, for specific days. Predictions of tides occurring in the future are made mathematically from past tide observations and from knowledge of the motions of the earth, moon, and sun in space.

Tide Predictions			
Days	Time*		Heights*
	Hours	Minutes	Feet
1	01	15	1.0
	07	30	4.1
	16	00	1.0
	20	15	4.0
2	02	00	1.0
	08	30	6.5
	14	15	2.0
	21	00	5.0
3	04	15	0.0
	16	00	7.0
4	04	30	1.0
	10	00	3.0
	16	00	1.0
	22	00	2.9

*The days are divided into 24 hours (0 to 24), midnight to midnight. Heights are measured from the zero reference line.

QUESTIONS

1) During what day is the tide diurnal? ____________________

2) During what day is the tide mixed? ____________________

3) During what days is the tide semidiurnal? ____________________

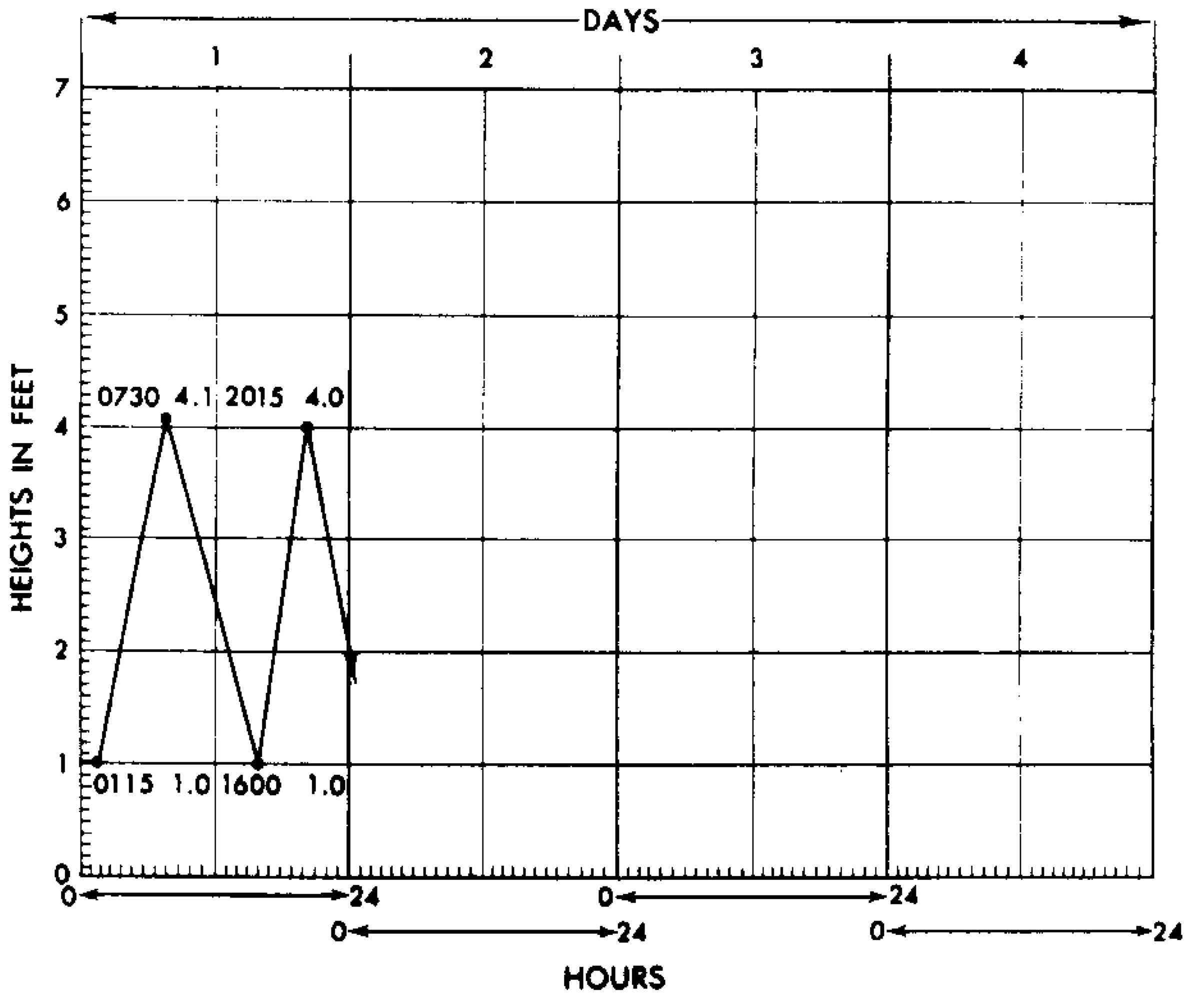
4) During what day is the range largest? ____________________

5) What is the smallest range and on what day? ______ft. ________day

6) What is the largest diurnal inequality shown? ______ft. On what days? ____________________
and ____________________

Exercise

Plot a tide curve from the tide predictions given on the previous page. The first day has been plotted on the accompanying graph. Complete the tide curves for days 2, 3, and 4 by plotting the times and heights and connecting all points. Then try to answer the questions.



References

Bascom, Willard. 1964. Waves and Beaches, New York.

Gordon, Bernard. 1970. Man and the Sea: Classic Accounts of Marine Explorations, Garden City, New York.

"Waves on Water" 16-minute, color, sound film. Encyclopedia Brittanica, Educational Corporation, Preview-Rental Library, 1822 Pickwick Ave., Glenview, Illinois 60025.

--Submitted by J. Crowley and J. Stouffer, Hingham High School, and B. Gordon, Department of Earth Sciences, Northeastern University, Boston

MAKING A LOCAL MONTHLY TIDE GRAPH (for secondary students)

Discussion

In this activity students will make a graph on tides in their local area (or other locations) for a two-week, month or extended period. Once this data is put into graphic form, students may be able to label monthly lunar cycles on the chart and "discover" how these coincide with spring and neap tides. You may find a day with extreme high or low water; allow students to visit the shoreline during this period.

Procedure-Materials

For this activity it is suggested that 1/4-inch square graph paper be used and that on the time scale one square equals 6 hours. It is important that the times of the high and low tides are plotted accurately. In order to graph more than eight or nine days it will be necessary to tape two or more sheets of paper together. The exercise will take on greater meaning for the students if the tides of a local or nearby area are used. It is usually possible to pick up free copies of the local tide estimates from bait shops, marinas, etc. These will generally not indicate the height of low water, so you will have to provide your own interpolated information as indicated in the accompanying sample. However, the ideal source, which includes heights of low water, is the Tide Tables for the east coast of North and South America ($2 at marine stores), published by the U.S. Department of Commerce.

The activity may also be tied into phases and location of the moon (apogee or perigee). An excellent source for this information is R. Eldridge, Tide and Pilot Book.

Exercise

1. Using the data from the accompanying tide table for Boston (or your local area), construct a graph showing the tides for the month of ________, 19___. If you plot your times carefully, you will be able to construct a continuous, complete curve.

If no heights are given for low water, use the following table:

If high tide is	7.0'- 7.5',	low tide level is	2.0'
	7.6'- 8.0',		1.5'
	8.1'- 8.5',		1.0'
	8.6'- 9.0',		0.5'
	9.1'- 9.5',		0.0'
	9.6'- 10.0',		-0.5'
	10.1'- 10.5',		-1.0'
	10.6'- 11.0',		-1.5'
	11.1'- 11.5',		-2.0'

You will find, perhaps, that there are not two high tides and two low tides indicated in every calendar day.

2. Answer these questions:

   A. What type of tide (diurnal, semidiurnal, mixed) do we have in ____________________?

   B. What is the date of the greatest diurnal inequality? ____________

   C. What is the date of the least diurnal inequality? ______________

References

Eldridge, Robert. Tide and Pilot Book, Boston. ($2.50--published annually)

Tide Tables (East Coast, North and South America).

"Between the Tides," 16-mm., 22-minute, color, sound film. Contemporary Films, Inc., New York, New York 10001.

"The Grunion Story," excellent film with diagrams of biological clocks and their relationship to spring tides. Original source unknown; available from Massachusetts Co-operative Film Rentals, State Department of Education, Boston.

--Submitted by J. Crowley and J. Stouffer, Hingham High School

BOSTON, MASS., 1971

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

MOON STAGE

JULY

DAY	TIME H.M.	HT. FT.	DAY	TIME H.M.	HT. FT.
1	0506	8.2	16	0518	9.2
TH	1118	1.3	F	1124	0.2
	1736	8.7		1748	10.4
	2354	1.4			
2	0600	7.9	17	0012	-0.1
F	1206	1.5	SA	0624	8.8
	1824	9.4		1224	0.5
				1848	10.3
3	0048	1.2	18	0118	-0.1
SA	0654	7.8	SU	0724	8.6
	1254	1.6		1324	0.7
	1912	9.0		1948	10.4
4	0136	1.0	19	0218	-0.2
SU	0748	7.9	M	0830	8.6
	1348	1.5		1424	0.7
	2000	9.3		2048	10.4
5	0230	0.6	20	0312	-0.4
M	0836	8.0	TU	0930	8.7
	1436	1.4		1518	0.6
	2048	9.6		2142	10.5
6	0318	0.2	21	0406	-0.5
TU	0924	8.2	W	1018	8.8
	1524	1.1		1612	0.5
	2136	10.0		2230	10.5
7	0406	-0.2	22	0454	-0.5
W	1012	8.5	TH	1106	8.9
	1612	0.8		1700	0.5
	2224	10.4		2318	10.4
8	0454	-0.5	23	0536	-0.5
TH	1100	8.9	F	1154	9.0
	1700	0.5		1742	0.4
	2312	10.7			
9	0536	-0.9	24	0000	10.3
F	1148	9.2	SA	0618	-0.4
	1748	0.2		1230	9.1
				1830	0.5
10	0000	10.9	25	0042	10.0
SA	0624	-1.1	SU	0700	-0.2
	1236	9.6		1312	9.1
	1836	-0.1		1912	0.6
11	0048	10.9	26	0124	9.7
SU	0706	-1.2	M	0736	0.0
	1318	9.9		1354	9.1
	1924	-0.3		1954	0.7
12	0136	10.8	27	0206	9.3
M	0754	-1.1	TU	0818	0.4
	1412	10.2		1430	9.1
	2018	-0.3		2036	0.9
13	0230	10.5	28	0248	8.9
TU	0842	-0.9	W	0900	0.7
	1500	10.3		1512	9.0
	2112	-0.3		2124	1.0
14	0324	10.1	29	0336	8.5
W	0936	-0.6	TH	0942	1.1
	1554	10.4		1600	8.9
	2206	-0.2		2212	1.2
15	0418	9.6	30	0424	8.1
TH	1030	-0.2	F	1030	1.4
	1648	10.4		1648	8.8
	2312	-0.1		2306	1.3
			31	0518	7.8
			SA	1124	1.7
				1736	8.8

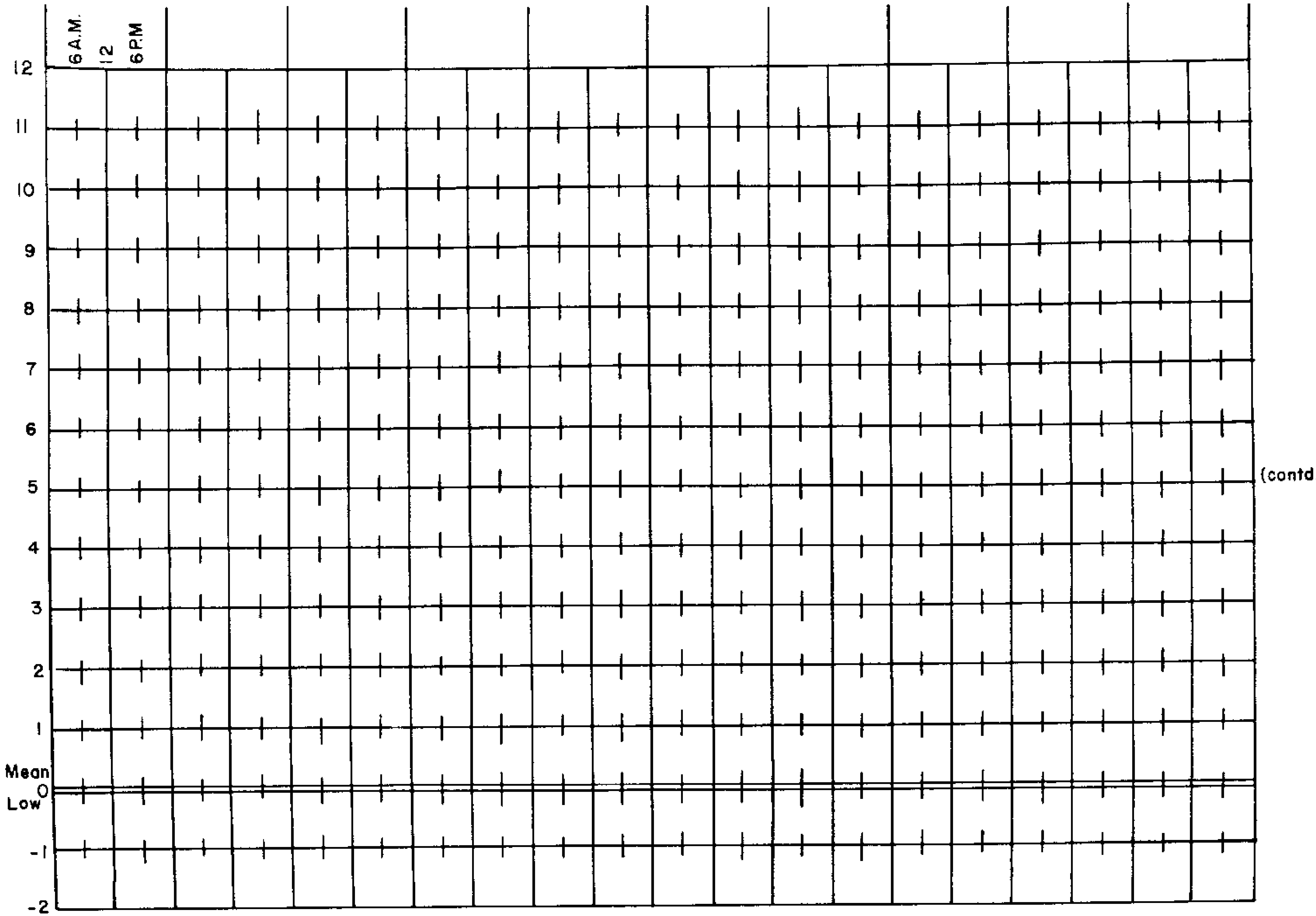
AUGUST

DAY	TIME H.M.	HT. FT.	DAY	TIME H.M.	HT. FT.
1	0000	1.3	16	0100	0.2
SU	0612	7.7	M	0712	8.3
	1212	1.8		1312	1.1
	1830	8.9		1936	9.9
2	0100	1.1	17	0206	0.2
M	0706	7.7	TU	0818	8.3
	1306	1.7		1412	1.0
	1924	9.2		2036	9.9
3	0154	0.8	18	0300	0.1
TU	0800	7.9	W	0918	8.5
	1400	1.4		1506	0.9
	2018	9.6		2130	10.0
4	0248	0.3	19	0348	0.0
W	0854	8.3	TH	1006	8.8
	1454	1.0		1600	0.6
	2112	10.1		2218	10.1
5	0336	-0.2	20	0436	-0.1
TH	0948	8.8	F	1048	9.0
	1548	0.5		1642	0.5
	2200	10.6		2300	10.1
6	0424	-0.8	21	0512	-0.2
F	1036	9.3	SA	1124	9.2
	1636	-0.1		1724	0.3
	2248	11.0		2336	10.0
7	0512	-1.2	22	0548	-0.1
SA	1124	9.9	SU	1200	9.3
	1724	-0.6		1806	0.3
	2336	11.2			
8	0554	-1.4	23	0018	9.8
SU	1206	10.4	M	0624	0.0
	1812	-0.9		1242	9.4
				1842	0.3
9	0024	11.3	24	0054	9.5
M	0642	-1.5	TU	0700	0.2
	1254	10.8		1318	9.4
	1906	-1.1		1924	0.4
10	0118	11.0	25	0136	9.2
TU	0730	-1.4	W	0742	0.5
	1342	11.0		1354	9.3
	1954	-1.1		2006	0.5
11	0206	10.6	26	0212	8.8
W	0818	-1.0	TH	0818	0.9
	1436	10.9		1430	9.2
	2048	-0.9		2048	0.8
12	0306	10.0	27	0300	8.4
TH	0912	-0.5	F	0900	1.3
	1530	10.7		1518	9.0
	2148	-0.6		2136	1.0
13	0400	9.4	28	0348	8.1
F	1006	0.1	SA	0948	1.6
	1624	10.5		1606	8.8
	2248	-0.2		2230	1.2
14	0500	8.9	29	0436	7.8
SA	1106	0.6	SU	1042	1.8
	1724	10.2		1654	8.8
	2354	0.1		2324	1.2
15	0606	8.5	30	0536	7.6
SU	1206	1.0	M	1136	1.9
	1830	9.9		1754	8.9
			31	0024	1.1
			TU	0630	7.7
				1236	1.7
				1848	9.2

SEPTEMBER

DAY	TIME H.M.	HT. FT.	DAY	TIME H.M.	HT. FT.
1	0124	0.7	16	0242	0.4
W	0730	8.0	TH	0854	8.6
	1336	1.3		1454	0.9
	1948	9.7		2112	9.6
2	0218	0.2	17	0324	0.3
TH	0824	8.6	F	0942	8.9
	1430	0.7		1542	0.6
	2042	10.2		2154	9.6
3	0312	-0.4	18	0406	0.2
F	0918	9.3	SA	1024	9.2
	1524	0.0		1618	0.4
	2136	10.7		2236	9.6
4	0354	-0.9	19	0442	0.1
SA	1006	10.1	SU	1054	9.4
	1612	-0.7		1700	0.2
	2224	11.1		2312	9.6
5	0442	-1.4	20	0518	0.2
SU	1054	10.7	M	1130	9.6
	1706	-1.3		1736	0.0
	2318	11.3		2348	9.5
6	0530	-1.6	21	0554	0.3
M	1142	11.2	TU	1206	9.6
	1754	-1.7		1812	0.0
7	0006	11.3	22	0024	9.3
TU	0618	-1.6	W	0630	0.5
	1230	11.5		1242	9.6
	1842	-1.8		1854	0.1
8	0054	11.0	23	0106	9.0
W	0706	-1.3	TH	0706	0.7
	1318	11.5		1318	9.5
	1936	-1.6		1936	0.3
9	0148	10.5	24	0142	8.7
TH	0754	-0.8	F	0748	1.1
	1412	11.3		1354	9.3
	2030	-1.2		2018	0.5
10	0242	9.9	25	0224	8.4
F	0848	-0.2	SA	0824	1.4
	1506	10.8		1442	9.1
	2124	-0.7		2100	0.8
11	0342	9.2	26	0312	8.0
SA	0942	0.5	SU	0912	1.7
	1606	10.3		1530	9.0
	2230	-0.1		2154	1.0
12	0442	8.6	27	0406	7.8
SU	1048	1.0	M	1006	1.9
	1706	9.8		1624	8.9
	2336	0.3		2254	1.0
13	0554	8.3	28	0506	7.8
M	1148	1.3	TU	1106	1.8
	1812	9.5		1724	9.0
				2348	0.9
14	0042	0.5	29	0600	8.0
TU	0700	8.2	W	1206	1.6
	1300	1.4		1818	9.3
	1918	9.4			
15	0148	0.5	30	0048	0.5
W	0806	8.4	TH	0700	8.5
	1400	1.2		1306	1.0
	2018	9.5		1924	9.7

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.
HEIGHTS ARE RECKONED FROM THE DATUM OF SOUNDINGS ON CHARTS OF THE LOCALITY WHICH IS MEAN LOW WATER.



Tape two or three together for one month; include phases and positions of moon.

OCEAN CURRENTS (for secondary students)

Discussion

Ocean currents are one of the more important environmental factors contributing to our existence. They influence availability and abundance of our commerical fishes as well as our climates. It is intended that the demonstrations described here will provoke thought among your students when they examine the distributions of ocean currents. The demonstrations deal with three physical factors influencing currents: salinity, temperature, and earth rotation.

Materials

two pint milk bottles
3x5 index cards
table salt
food coloring
warm water source

Method

Temperature and salinity influence the density of water. Difference in the distribution of density is one of the driving forces of the ocean currents. Using the data provided in Table 1, have your students determine

Table 1. Some oceanographic observations from the Gulf of Maine

Depth M.	Temp. °C	Salinity 0/00
0	14.5	31.0
10	12.0	31.0
20	7.0	32.0
30	5.5	32.0
82	5.0	32.5
0	13.0	31.0
10	11.0	31.0
20	9.5	31.0
30	8.5	31.5
0	17.0	30.5
10	12.0	31.5
20	9.5	32.0
30	7.5	32.0
92	4.7	32.2

density values and plot them at their corresponding depths. These examples are from three oceanographic stations in the coastal area of the Gulf of Maine. The curves obtained will differ as does the density of the water from the surface to a given depth, i.e., 30 meters will appear less dense at one station than at another.

The sea surface is higher at a station of lower density and water flows "downhill" to stations of higher density. Along a coast, areas near the shore are more diluted by stream discharge so that water density is less and sea surface is higher than in the offshore areas. In Figure 1, one would expect the currents to flow offshore in the vicinity of 68° west longitude, but the rotation of the earth creates a force known as Coriolis which guides the flow of ocean currents clockwise to the original direction of flow. This results in an along-shore current.

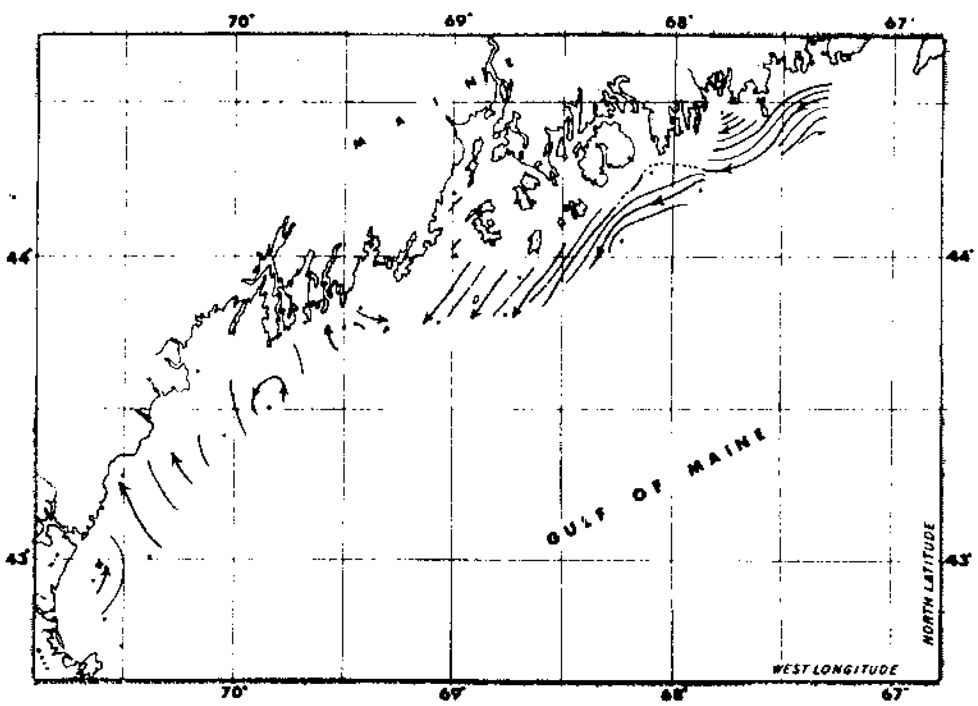


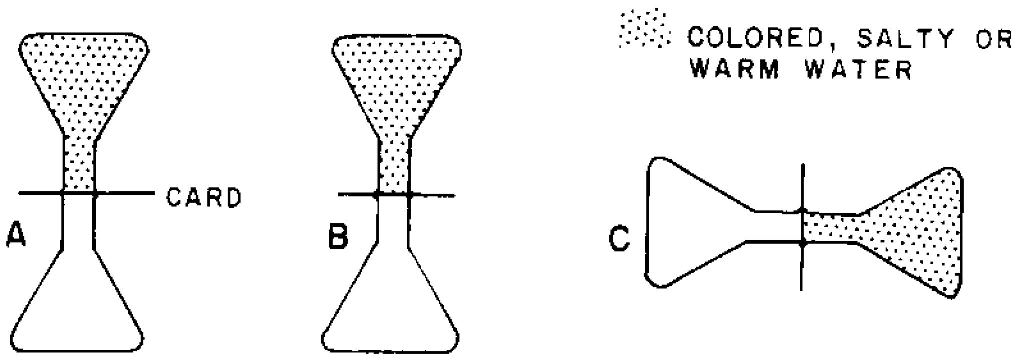
Figure 1. Relative coastal currents along the Gulf of Maine coast. Arrows indicate direction of flow; closer spacing of line indicates relatively faster currents.

Demonstration

1. Salinity currents. Is salt water heavier or lighter (of higher or lower density) than fresh water? Fill the two pint bottles with tap water. Dissolve one-half teaspoon of salt in one and add a drop of food coloring.

Place a 3x5 card on top of the salt-water container and carefully invert it; the upward pressure of air will hold the card in place. (A) Place the salt-water container on top of the fresh-water container and have someone gingerly remove the card. Observe. (B) Place the fresh-water container on top of the salt-water container, remove card and observe. (C) Place both jars horizontally, remove card and observe. Have the students record the position of the dye for a period of time at five-minute intervals.

2. Temperature currents. Is warm water heavier or lighter than cool water? Fill one bottle with warm tap water and the other with cool tap water. Add salt and a drop of coloring to the warm water. Do A, B, and C above. Have the students record dye position as before.



Now and then accidents do happen; therefore, I usually demonstrate over a plastic dish pan.

Where in the world's oceans might these factors be most noticed? Where does most heating take place? Where does most dilution of sea water occur? Is it easier for a human to swim in salty water or in fresh water? Cool water or warm water?

After observations are made and recorded, draw up some assumptions. It may be a good idea to discuss where most mass movements of water take place in the oceans and the effect they have on man's exploration of the sea.

References

Coker, R.E. 1962. This Great and Wide Sea, Harper Torch Books.

Encyclopedia Britannica World Atlas. (This volume has an excellent chart of ocean currents.)

Life. 1961. The Sea. Time, Inc. 190 pp. (Assign this publication as required reading. The coverage of oceanic features is excellent.)

McConnaughey, B.H. 1970. Marine Biology, The C.V. Mosby Company.

Stewart, Harris B., Jr. 1963. The Global Sea. Van Nostrand Searchlight Book No. 17. 126 pp. (This is an excellent paperback and should be recommended reading for your students. Particularly have them read "The Moving Waters.")

Sverdrup, H.U., Martin W. Johnson, and Richard H. Fleming. 1942. The Oceans, their Physics, Chemistry, and General Biology. Prentice-Hall, Inc. 1087 pp. (This publication is technical, but there is a general section, "The Water Masses and Currents of the Oceans," that might be of interest. In the back of the text are charts showing surface temperature, salinity, and currents of the oceans.)

U.S. Department of Agriculture. 1941. Climate and Man. Yearbook of Agriculture.

Yasso, W.E. 1965. Oceanography.

--Submitted by A.O. Bedard, Canton High School, M. Moore, New England Aquarium, and H. Wiper, Newton High School

TURBIDITY AND DENSITY CURRENT (for secondary students)

Discussion

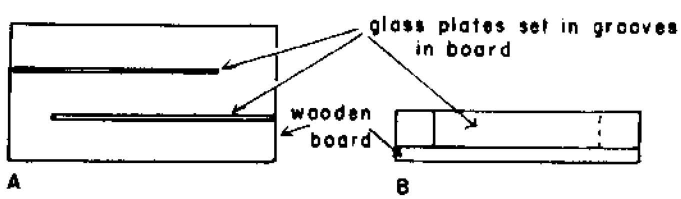
Density currents. Currents in the sea or in lakes may be formed by a density differential. This differential may be caused by a locally greater concentration of suspended material or material in solution. These currents can be demonstrated.

Procedure—Materials

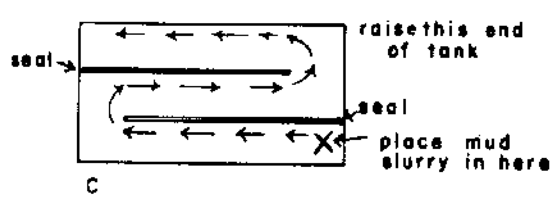
Put a set of glass baffles in an aquarium. The baffles are made by placing two sections of plate glass in grooves on a wooden board as shown in diagrams. The dimensions of the board should be the same as the dimensions of the inside of the aquarium.

After placing baffle system in aquarium, seal the margins of the wood and the edges of the glass baffles to the aquarium with ordinary window glass putty (masking tape will also work). It probably is a good idea to seal the glass baffles in the grooves in the wood as well.

Tilt the aquarium up at one end with a block and fill with water nearly to the top of the glass baffles, but not over the top.



Mix a mud slurry in a cup and pour the slurry into the compartment where the baffle is sealed against the side of the tank at the raised end. (Diagram.) A current will be set up that will flow downhill in one compartment, turn and run uphill in the middle compartment, turn again and run downhill in the last compartment.



Empty the tank and repeat the demonstration, substituting a solution of table salt for the mud slurry. Color the salt solution with food coloring so the current can be observed.

---submitted by J. Crowley and J. Stouffer, Hingham High School

SALINITY DETERMINATION BY DENSITY (for secondary students)

Discussion

The purpose of this lab is to relate students' density and salinity findings to one common concept.

Materials

graduated cylinder (500-ml) or similar container
hydrometer with range of 1.000 to 1.028 (may be homemade)
thermometer
temperature-density-salinity graph

Reagents

water samples of varying salinities

Method

1. Use samples collected for the titration.

2. Pour approximately 400 ml of the sample into the graduate.

3. Carefully float the hydrometer in the sample and read the density at the bottom of the meniscus.

4. Remove the hydrometer and insert the thermometer. If necessary, convert the temperature of the water sample from $^{\circ}C$ to $^{\circ}F$.

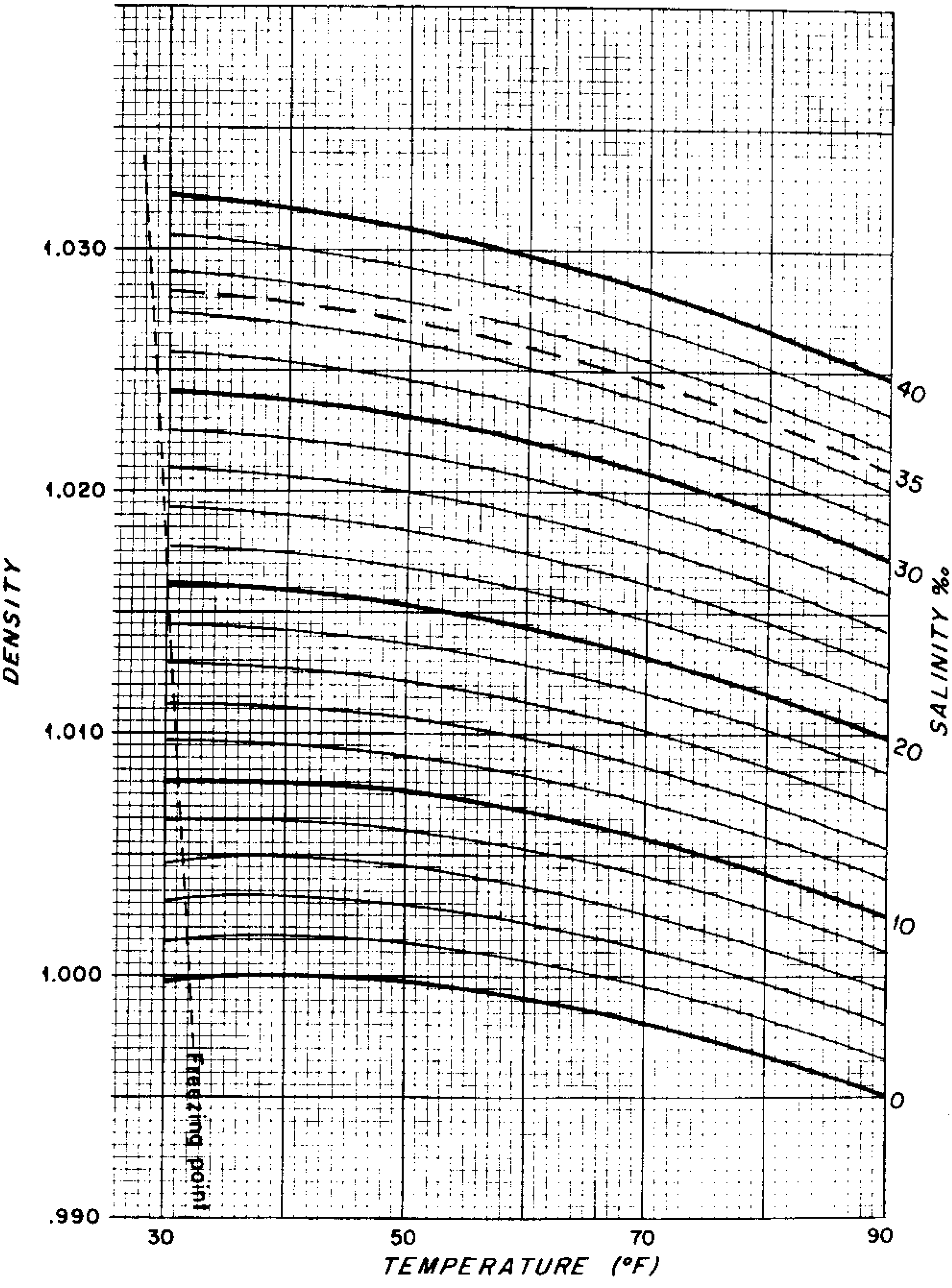
5. Using the graph, find the intersection of the density and temperature coordinates and, interpolating between the curved lines, read the salinity at the right.

Example: temperature = $70^{\circ}F$; density = 1.015; salinity = 22.5 0/00.

Reference

Coker, R. D. 1947. This Great and Wide Sea, Harper and Row, New York, New York. $2.25.

--- submitted by J. Crowley and J. Stouffer, Hingham High School


DENSITY
1.030
1.020
1.010
1.000
.990
30
50
70
90
TEMPERATURE (°F)
SALINITY ‰
40
35
30
20
10
0
Freezing point

CURRENT BOTTLES

Materials

soda bottles - preferably the 10—12-ounce, thick-walled returnable type with screw-on caps
3 x 5 cards
wax

Procedure

Bottle preparation. First the cards must be marked. Be sure to use a soft pencil. Ink will rapidly fade in sunlight and these bottles are frequently exposed to weeks of direct light. A typical card is diagrammed below.

Name High School Address	Drift Bottle Experiment Where found ____________ Date ______________ Drop site + Date

Be sure there are identifying marks for cards that are thrown from different locations. Nothing is more frustrating than to get a card back in the mail and not be able to find out where it was dropped off.

After the cards are marked and placed in the bottles, put the caps on as tightly as possible. The cap should then be dipped in hot wax and allowed to cool. CAUTION: hot wax is flammable and can also cause severe burns. It should be handled with extreme caution and under direct supervision of a teacher. After the wax has cooled, second, third, and fourth dippings are suggested. Be sure to make them brief, or else you will simply melt off the wax from the previous time. Allow the wax to cool between each dipping. If the wax you use is too brittle for a good waterproof seal, add a small amount of petroleum jelly to soften it up. After the bottles are sealed (you can spot check with a bucket of water), they are ready to be used.

When selecting a spot to throw your bottles, a few things should be kept in mind. (1) Try to select a place where there are definite currents, preferably headed offshore. If there is a mixture of local constantly shifting eddies and wind currents, it will be difficult to get any meaningful results. (2) Try to avoid throwing the bottles during a strong incoming tide. This usually results in your bottles being washed up very close to where they were thrown in. (3) Bottles thrown off during the outgoing tide, particularly near a river, can often be carried a long way offshore. If you have access to a boat, your problems are greatly simplified because you can be selective in your drop site. (4) Throw off at least ten bottles from any given spot. Your chance of multiple returns is much better.

Results of One Experiment

Fourteen bottles thrown off Cape Ann; seven notes returned. All were found on the outer shore of Cape Cod near Wellfleet. Bottles were found about two weeks after being thrown in.

Ten bottles thrown off at the mouth of the Merrimac River; six were found north along the coast of New Hampshire.

Fourteen bottles thrown off the coast of Maine three months ago; no returns to date. In the Gulf Stream maybe?????

The letters we got with the drift cards were half the fun of this experiment. Most people are very interested in knowing what we are doing and often request more information about the experiment. This gets the students involved with the public, and our local newspaper publishes the results of our returns. Our next step is to try to make bottles that will be carried by sub-surface currents. We have filled bottles with sand until they just begin to sink. Hopefully in the ocean they will reach a density equilibrium and not sink to the bottom. We have thrown some bottles off, but have gotten no results thus far.

--Submitted by D. Taylor, Triton Regional High School, Byfield.

AN AMERICA'S CUP RACE

Discussion

Tides, winds, and currents affect all of man's activities on the sea. Success in the America's Cup Race depends on using these factors to the best advantage.

Materials

nautical chart of Point Judith, Rhode Island
America's Cup Races Spectator Craft Regulations

Method

Determine answers to following questions by referring to nautical chart and attached diagram.

1. What is the deepest, and shallowest, depth of water in fathoms on the race course of the "America's Cup" sailboats?

2. What effects do the tides have on the racing sailboats?

3. If during the second race the wind is blowing from the north, into what direction is the second leg of the race sailed?

4. If the winning sailboat completes the race in $1\frac{1}{2}$ hours, what was its average speed for the race?

5. How far is the start of the race from Boston in nautical miles?

6. What is the latitude and longitude of the place where the race starts?

7. What is the probable temperature of the water in which the race is held?

8. What is the name of the body of water in which the race is held?

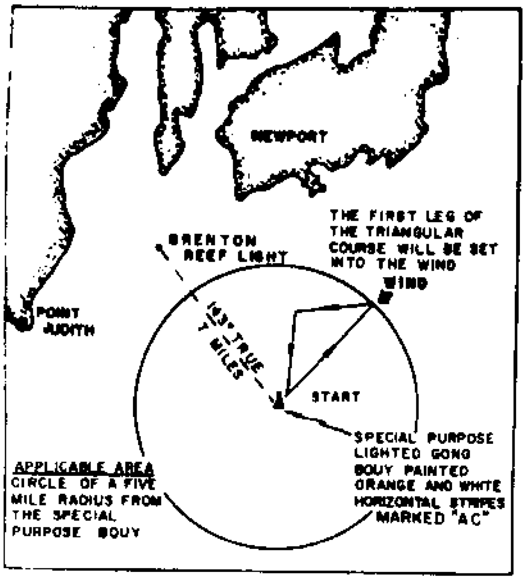
9. What government agencies are involved with the America's Cup races?

Reference

Gordon, Bernard. 1970. Man and the Sea, Garden City, New York.

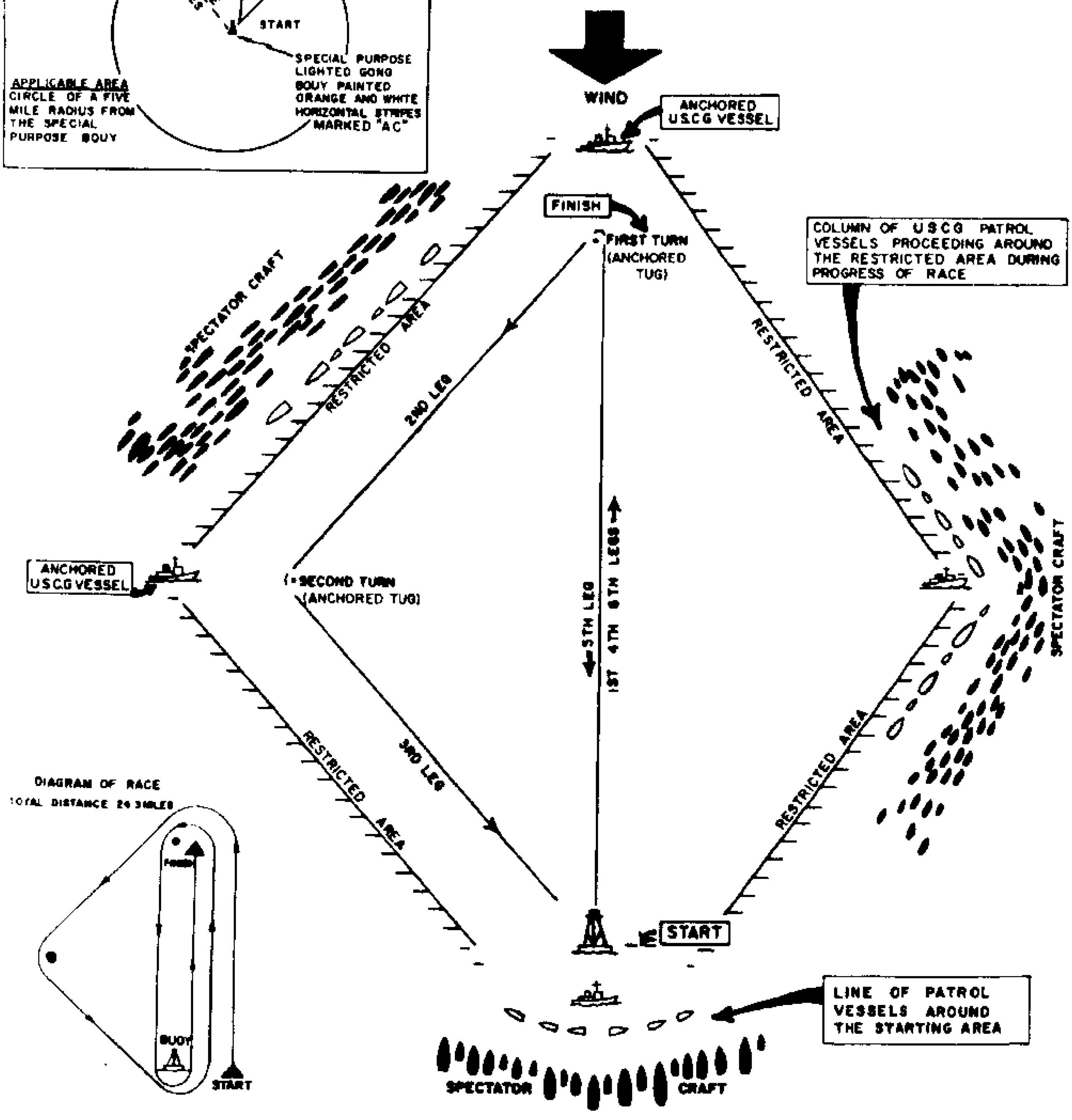
---submitted by B. Gordon, Department of Earth Sciences, Northeastern University, Boston

1970 AMERICA'S CUP RACES



SPECTATOR CRAFT REGULATIONS

A. KEEP CLEAR OF THE RESTRICTED AREA.
B. REMAIN AT LEAST 100YARDS OUTSIDE THE LINE OF PATROL VESSELS IN THE STARTING AREA
C. REMAIN AT LEAST 100 YARDS OUTSIDE THE COLUMN OF PATROL VESSELS WHEN PROCEEDING AROUND THE RESTRICTED AREA.
D. COMPLY WITH THE INSTRUCTIONS OF THE U.S.COAST GUARD PATROL VESSELS AND HELICOPTERS.
E. BE ALERT FOR DISABLED CRAFT AND PERSONS FALLING OVERBOARD.
F. EXERCISE CAUTION WHEN OPERATING IN CONGESTED AREAS.
G. VESSELS OVER 100 FEET IN LENGTH MUST REMAIN 500 YARDS OUTSIDE OF THE RESTRICTED AREA EXCEPT FOR THE PURPOSE OF ANCHORING



MEASURING DENSITY USING HOMEMADE HYDROMETERS (for secondary students)

Discussion

Hydrometers are instruments used to compare the density of various liquids to that of distilled water at 4° C. which is given at a global standard of 1. From this point the density and temperature of a water sample can be used to determine salinity (see graph).

Materials

A small test tube
Wooden-handled probe with point cut off (length of remaining metal should not exceed the depth of the cork)
Small beaker of water
One cork suitable for closing the mouth of the test tube
Small quantity of sand
Graduate cylinder of cold, fresh water (ideally this will be distilled water)

Reagents (note to teacher)

Various solutions of salt water (brackish, ocean, and "homemade" high saline water - add 50 g/1000 H_2O add 75, etc.). You might also like to try to use alcohol, karo syrup, liquid soap, mercury, etc.

Method

Insert the cork into the test tube (see diagram).

Insert the probe into the center of the cork so that it is at right angles to the surface of the cork.

Remove the cork and, using either sand or water, ballast the tube so that it will float with the surface of the cork beneath the surface of the water in the graduate cylinder deep enough to expose about half the length of the handle of the probe. This will take some time by means of trial and error. Don't give up!

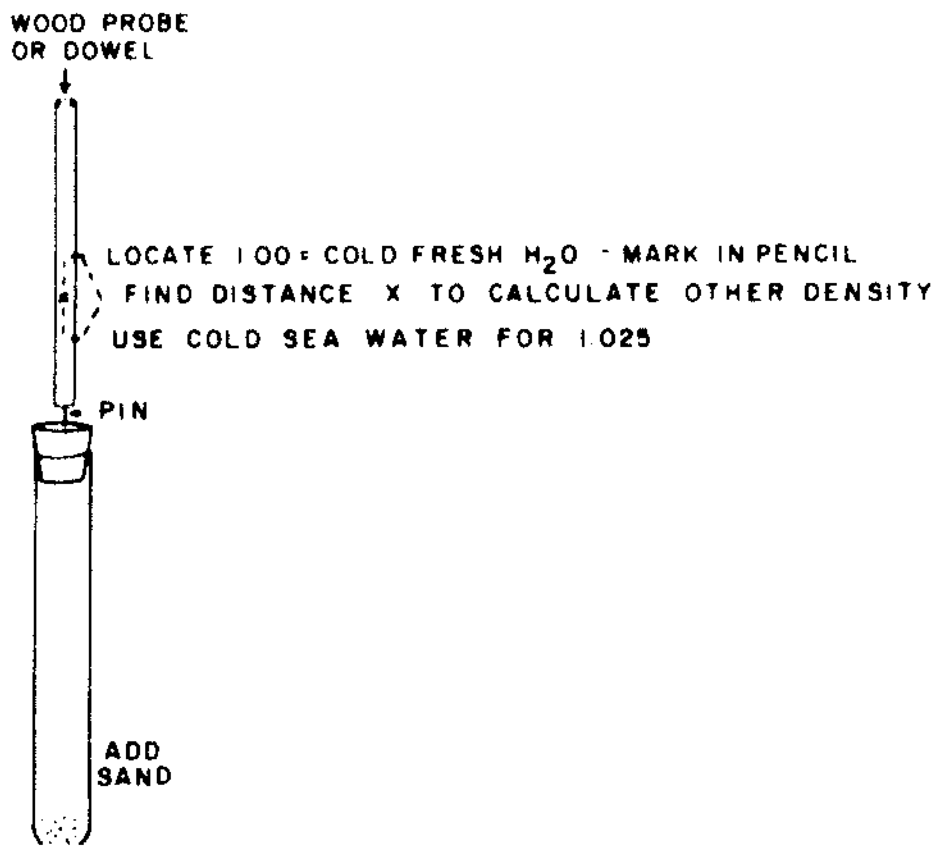
When you have got the apparatus floating at the proper depth, carefully mark the probe as 1.0 at the point reached by the surface of the water.

Place a quantity of cold saltwater (35‰) in the graduate cylinder and place the hydrometer in it. Mark the point where the surface of the water reaches the probe, and label it 1.025.

Now use your hydrometer to test the various liquids supplied. Record your results below.

Solution	Floats higher or lower than cold freshwater	More or less dense than cold fresh-water	More or less dense than seawater	Calculate actual density (see note)
1				
2				
3				

To calculate density: Use ruler to determine distance "x" on wood stick. If this represents change of .025, determine density of other liquids by measuring how far they are from the 1.00 line (can be + or - 1.00).



Submitted by J. Crowley and J. Stouffer, Hingham High School

PHYSICAL AND BIOLOGICAL PROPERTIES OF LIGHT IN OCEAN WATER

Discussion

The slogan for recent increased interest in the study of the oceans could well be "Man in the Sea." In the past man has operated from the surface of the sea. Now we are determined to see and work beneath the surface. We do this with cameras (still, movie, and TV) and with our own eyes by getting man into various depths of the hostile undersea environment. The study of the behavior of light as it penetrates water can be divided into three general areas:

1. Descriptive oceanography--this area is largely in the field of physics and is concerned with the behavior of light as it hits the air-water interface, and as it penetrates the water. This penetration of water by light is quite complex and involves reflection, refraction, diffraction, absorption, scattering and polarization. Add to this the constant changing of the intensity of the light due to changes in the position of the sun and variation in cloud cover and you can see how complex the study of light in water can be under natural conditions.

2. Biological aspects--photosynthesis one factor affecting the population of micro-organisms in the oceans is the optical properties of water (plus naturally available food and water temperature). Many marine species, shrimp, etc., have diurnal migrations of considerable vertical distances. (The word diurnal means changes due to the position of sun.) The factors causing these migrations are still little known. A decrease in the surface temperature of the water near the surface at night might be a factor influencing vertical migration just as much as light. Not too many years ago the majority of marine biologists thought that most of the life in the oceans was near the surface where the light was most intense. As the result of a great deal of deep-sea research it is now known that planktonic organisms are found at all depths. Russell and Yonge (1936) and Nicol (1964) have excellent discussions of vertical distribution of marine animals.

3. The effect of light penetration through seawater as it relates to undersea photography, TV, and human vision--the limiting factors of underwater visibility are due to two general factors--seawater is about a thousand times more dense than air and usually there is considerable organic and inorganic material suspended in the water. Recognition for distances of 100 feet underwater is possible only under ideal circumstances and sharp photographs are not

possible beyond 30 feet. Special film, lens system, and lights have had to be developed. Dr. Harold Edgerton of the Massachusetts Institute of Technology was a pioneer in the development of deep sea photography.

To the teacher

The study of light and its influence on marine organisms shows how biology and other sciences are related. This is an example of the use of basic physics in a biological problem. The lab exercises suggested are open-ended. With simple basic apparatus, a wide variety of experiments may be conducted.

To the student

The experiment outlined gives ideas on how to build the apparatus. Use imagination to develop other ideas. What effect does light of varying intensities have on the vertical migration of marine animals? Most have read about some species of shrimp coming up near the surface at night. Do they do this because there is less light near the surface at night, or is the temperature lower at night, or is the food of the shrimp more abundant near the surface at night?

Materials needed

100 ml. graduated cylinder

Enough black paper to cover the cylinder and to make a cover.

The live specimens to be used will depend on the local supply: If near the ocean, collect several pints of plankton. If not near the ocean, use the water flea (Daphnia) which can be collected in almost any clean pond.

Brine shrimp (Artemia) can be reared in the lab. If a vertebrate specimen is needed, use guppies or any small fish which can be obtained in quantity.

If a plankton net is not available, make one. Cut the top 10 or 12 inches from an old nylon stocking and sew it to a round piece of wire, tie a small plastic jar on the bottom of the net. Tie a string to the upper part of the net and it is ready.

Procedure

Wrap the 1000-ml. graduated cylinder with the black paper and hold in place with rubber bands. At each 100 ml. mark cut out a flap in the paper which can be opened and shut. Make a light-proof cover of the black paper for the cylinder.

Use a light source such as a microscope light; attach it to a ringstand so that it may be raised or lowered.

Fill the cylinder with salt or fresh water depending on the type of specimens being used.

Add organisms--use enough so you may easily see the action of your experiment. Make sure that organisms are evenly distributed throughout the water.

Put the cover on.

Turn on the light and open the flap at the 1000 ml. mark of cylinder. Let the light shine through for 10 minutes.

Open the top. Is there a concentration of animals in the lighted area? Try the same experiment at each level and make a record of observations. Vary the time that the light was at each opening. Is there any difference in the distribution of the animals?

References

Clarke, G. L. and E. J. Denton. 1962. "Light and Animal Life," Chapter 10 in The Sea, Ed. M N. Hill, Interscience Publishers, John Wiley & Sons New York.

Nicol, J. A. Colin. 1964. The Biology of Marine Fishes, Pitman, London.

Russell, F. S. and C. M. Yonge. 1936. The Seas, Frederick Warne and Co., Ltd., London.

Stephens, William M. 1967. Oceanology International. May/June, Industrial Research Publications Co. Beverly Shores, Indiana.

--Submitted by J. Crowley and J. Stouffer, Sourcebook of Marine Science, Board of Curriculum and Instruction, Florida Department of Education, Tallahassee, Florida. Hingham High School.

CORROSION RESISTANCE OF THERMAL COATINGS TO ENVIRONMENT (for junior high and senior high students)

Discussion

The behavior of materials in a highly corrosive environment is well understood. The behavior of materials (coatings, specifically) in the environment of space is much more subtle. The action of water vapor, trace amounts of various chemicals, ultraviolet radiation, and various gases can play a part in the degradation of a thermal coating. The properties of these materials may change drastically after prolonged exposure. This laboratory exercise is open-ended and goes on for an extended period of time. Periodic inspection is required.

Materials

corrosion test chambers (see drawing)
materials to be tested
salt water to be tested

Method

Put salt water in jar. Attach to stopper several strips of metal or rods. These may be coated with various test materials. Suspend the strips or rods in the water. Microbial activity can be simulated by a solution which is 5% acetic acid and 3% NaCl. Store jars in areas with different temperatures.

Students should be allowed to make their own combinations. They should note any changes which have occurred. Stress to them that this experiment takes time.

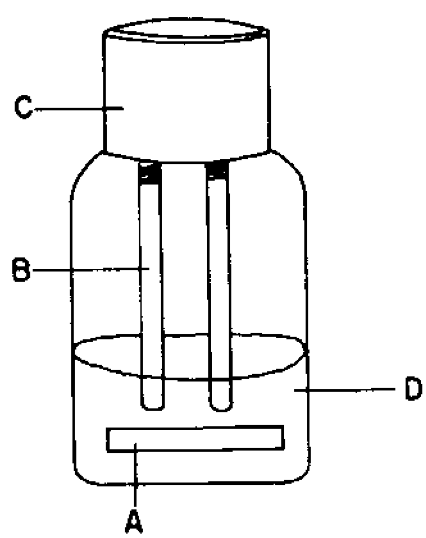
Key: Corrosion Test Jar

A. Label--include nature of the test material, the corrosive environment (salt H_2O), and date experiment began.

B. Material being tested--it may be coated.

C. Rubber stopper or cork

D. Salt water



THE LIGHT AND DARK BOTTLE METHOD FOR DETERMINING GROSS PRIMARY PRODUCTION

Discussion

In order to study the energetic relationships in any ecosystem, an accurate estimate of the amount of solar energy fixed by green plants must be known. It is this energy that supports all other organisms in the community. The light and dark bottle method utilizes the one-to-one relationship between oxygen production and carbon fixation in photosynthesis to predict the amount of energy stored as energy-rich carbon compounds by the producers in an aquatic ecosystem.

Procedure—Materials

2—3-liter collecting bottle
calibrated lines or bridle
250-ml ground-glass-stoppered bottles (paint one black)
all those materials and reagents needed for a standard dissolved oxygen determination

Collecting the sample. It is essential that the sample be representative of the given depth in the water column and that all atmospheric oxygen be excluded from the collecting and sample bottles.

Lower the collecting bottle to depth and secure at least a two-liter sample. Bring the bottle to the surface and fill three 250-ml ground-glass sample bottles (two clear and the other black) by overflowing each several times to exclude water that was in contact with the air in the bottle.

Return one "light" and one "dark" bottle to the depth from which the original sample was taken by suspending them from a calibrated line. (A bridle designed for this purpose is handy but not necessary.) Immediately "fix" the remaining sample according to the directions given for dissolved oxygen determination (D.O.D.)[1].

Leave the light and dark bottles at depth for two to three hours and return to the lab to determine the oxygen content of the original sample (the D.O. of the third sample bottle). After two to three hours, collect the remaining bottles and determine their dissolved oxygen content.

Calculations

The first bottle that you analysed represented the amount of oxygen present in the water column at the beginning of your study. By comparison of this value with the data obtained from the light and dark bottles you can determine the amount of oxygen produced by the photosynthetic organisms in your sample over the time of the test period.

Let us refer to the first sample as Bottle "O" and the light and dark bottles as "L" and "D" respectively. The light bottle should show an increase in D.O. due to the action of photosynthetic organisms. This value, however, must be corrected for the oxygen consumed by the organisms present in the bottle. The D.O. of the dark bottle should decrease over the test period. No photosynthesis is occuring in this bottle and theoretically the same amount of respiration is taking place here as in the light bottle. Based on this assumption then we can see that the amount of oxygen consumed in the dark bottle should be equal to that consumed in the light bottle. Thus we can calculate the total amount of oxygen produced by the producers in the light bottle by adding the decrease in D.O. of the bark bottle to the increase in D.O. in the light bottle. This value is the gross primary production in the sample.

$$L - O = X$$

$$O - D = Y$$

$$X + Y = P \text{ or gross primary production}$$

This value, in mg O_2/l or in ppm, can be used directly to compare productivity -- at different depths, of different water columns, of the same water column at different times of the day or year.

In the literature, production is generally given in mg C/m^3. The following chemical relationship between fixed carbon and molecular oxygen can be used to convert mg O_2/l to mg C/m^3:

PHOTOSYNTHESIS

$$6\ CO_2 + 6\ H_2O + E \qquad C_6H_{12}O_6 + 6\ O_2$$

Assuming a one liter sample at standard temperature and pressure

$$\text{mg C} = (\text{mg } O_2)\ \frac{(1 \text{ mole } O_2)}{(32X10^3 \text{mg} O_2)}\ \frac{(6 \text{ mole } CO_2)}{(6 \text{ mole } O_2)}\ \frac{(12X10^3 \text{mg C})}{(1 \text{ mole } CO_2)}$$

$$= (\text{mg } O_2)\ \frac{(12X10^3 \text{mg C})}{(32X10^3 \text{mg } O_2)}$$

$$= .375(\text{mg of } O_2)$$

Since one cubic meter contains approximately $10^6$1 we can convert mgC/1 to mg C/m^3 by knowing that mgC/m^3 = (mg C/1) ($10^6$1/m^3).

Additional Projects

1. Determine the effect of light intensity on production.
2. Determine the effect of light quality on production.
3. Determine the effect of CO_2 concentration on production.
4. Determine the effect of temperature on production.
5. Determine the relative production efficiency of various phytoplankters under similar environmental conditions.

References

Heister, R.D. 1972. "Measuring Dissolved Oxygen in Water," Environmental Activities New Bulletin, C.E. Merrill, Columbus, Ohio. 1:1.

Macan, T.T. 1963. Fresh Water Ecology, Longman Group Ltd., London.

Nygarrd, G. 1955. "On the Productivity of Five Danish Waters," Verh. int. Ver. Limnology, 12:123-133.

RELATIVE HUMIDITY AND DEW POINT (for secondary students)

Discussion

Absolute humidity is the actual amount of water which one cubic foot of air holds. It is measured in grains of moisture per cubic foot. When air contains all the moisture it can hold, it is said to be saturated. But the moisture-holding capacity of air depends upon its temperature. See table below.

MAXIMUM MOISTURE CAPACITY OF ONE CUBIC FOOT OF AIR

Temp. ($^{\circ}$F)	Grains of Moisture	Temp. ($^{\circ}$F)	Grains of Moisture
0	0.5	55	4.8
5	0.6	60	5.7
10	0.8	65	6.8
15	1.0	70	8.0
20	1.2	75	9.4
25	1.6	80	10.9
30	1.9	85	12.7
35	2.4	90	14.8
40	2.8	95	17.1
45	3.4	100	19.8
50	4.1		

How many grains will 1 cubic foot of saturated air hold at 70°F________, 85°F________, 90°F________?

Relative humidity is the ratio of the quantity of water vapor actually present (absolute humidity) in the air to the quantity necessary for saturation at the same temperature.

$$RH = \frac{\text{absolute humidity}}{\text{quantity necessary for saturation}}$$

What is the RH of 1 cubic foot of air which contains 1.7 gr. of water vapor at 45°F__________, of 6.6 gr. of water vapor at 100°F__________?

Materials

a useful source of "shiny containers" is ordinary tin cans from which the labels have been removed
thermometers

lots of ice
salt
stirring rods

Method

Dew point is the temperature at which a given sample of air is saturated.

Using the table above, what is the dew point of air whose absolute humidity is 4.1 gr. per cubic foot and whose temperature is 80°F?________. How much moisture would this cubic foot of air contain if it were saturated?_____________. What would be the relative humidity of the air?_____.

Dew Point Determination

1. Partially fill a shiny metal container with water at room temperature.

2. Slowly drop small pieces of ice into the water, while stirring it with a thermometer.

3. When a film of moisture appears on the outside of the container, note and record the temperature. Watch carefully. The film may not be noticed. _______°F.

4. Allow the water to warm up until the film disappears. (You may find it helpful to use warm water to bring the temperature up. Do this carefully.) Note and record the temperature. _______°F.

5. The average of the two temperatures is the dew point. _______°F (dew point)

If the amount of moisture in the air is very small, you may find it necessary to add some salt to the water in the container for steps 2 and 3 in order to cause a film to appear. This will be particularly true for your outside calculation.

	Inside Air	Outside Air
Temp. film appears	________	________
Temp. film disappears	________	________
Average (dew point)	________	________

Using the values you get for the dew points of the inside and outside air, determine the absolute humidity and relative humidity.

	inside	outside
absolute humidity	______	______
relative humidity	______	______

Reference

Chapman, Charles F. 1971. Piloting, Seamanship and Small Boat Handling, Hearst Corp., New York, New York

---submitted by J. Crowley and J. Stouffer, Hingham High School