How Much Land Has Been Lost?

We might wonder exactly how much land is lost with erosion. It is easier to see surface changes than to perceive actual amounts in terms of volume. Analytical techniques allow us to calculate the amount of land lost through erosion.

Objectives

You will use aerial photos to:

- Calculate the amount of material eroded from a portion of shoreline.
- Estimate an average rate of recession for a section of shoreline.
- Consider possible economic effects associated with changing shorelines.

Procedure

In this investigation, you will actually calculate the amount of land surface lost to erosion and the volume of material that made up that land. You will measure the change from 1954-73 and then 1973-81.

1. Use your map of the three shorelines from the activity "How fast can a shoreline change?" and begin with the years 1954 and 1973. With the following scale measure the distance between the two shorelines along each of the lines A through H. Enter your measurements in Line Q of the worksheet.

0 ——— 400

1 inch = 400 feet

2. Lines A through D are west of the groins. Average the distances for these four lines and enter them in line R. Now determine the average distance between shorelines for the remaining four lines and enter it in the worksheet.

You are now ready to determine the **recession rate** for this section of shorelines. The recession rate is the average distance the shoreline has been eroded away per year.

3. Divide each average distance in Line R by 19 years, the length of time between the taking of the two photos for 1954 and 1973. For the difference between 1973 and 1981, divide by 8. Enter in line S.

Source

Modified from OEAGLS EP-6, "Erosion along the Great Lakes," by Beth A. Kennedy, Newark Public Schools, Ohio, and Victor J. Mayer, The Ohio State University.

Earth Systems Understandings

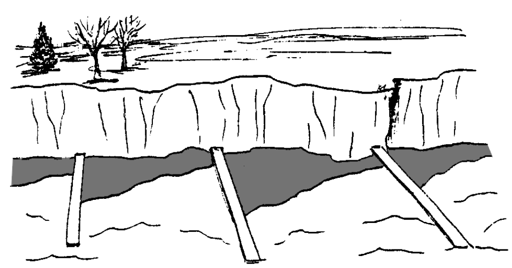
This activity uses scientific methods to calculate the amount of land lost by erosion. It addresses ESU 2 (stewardship), 3 (science methods and technology), 4 (interactions), and 5 (change through time).

Materials

- The chart traced from the photos in the activity "How fast can a shoreline change? (Appendix A)
- Graph paper (10 squares per inch).
- Topographic map of Perry, Ohio.

Answers

1-3. See Appendix A, completed worksheet. Use the top of the bluff line, which gives you a more accurate idea of the recession rate.



Answers

4. The eastern part has the higher recession rate. This means that the bluffs retreat southward more rapidly in this area. The best place to own shoreline property would be behind the groins, because that is where the recession rate is the least. Again, students might not get the expected results because of the presence of the clay pit (refer to question 13 in the activity "How fast can a shoreline change?").

5. Students will have to use their judgment in counting the squares. It is easiest if they align the shoreline with a line of the graph paper.

6. See Appendix B.

9. On the 1992 revised map, the approximate mean lake elevation is 571 feet.

10. To the west of Hardy Road, the contour lines at the top of the bluff are confusing. However, it appears that the elevation of the top of the bluff is 610 or 620 feet. The answers your students give on lines V and W will vary according to the elevation that they select for the bluffs.

11. The elevation is 600 feet.

4. Which part of the shoreline, western or eastern, has a higher recession rate? Describe what this means. Where would you prefer to own shoreline property?

5. Place your map over the piece of graph paper provided by your teacher. Locate the easternmost of the two prominent groins appearing on the 1973 photo. Count the number of squares in the shaded area to the east of the groin and enter in line T. Also, count the number of squares to the west of the groin and enter on line T.

6. Each square represents 160 square feet of surface area. Calculate the total surface area eroded away and enter in line U.

To determine the total volume of material removed, you will need to know its depth as well as its surface area. The depth of material will be roughly equivalent to the average height of the bluffs. To determine this, you will need a copy of the Perry, Ohio, quadrangle.

7. Determine the area of a typical lot on the air photo. Divide that into the value on line U. This is the number of lots or yards that have been removed.

8. Locate Painesville-on-the Lake. This is the same area represented on the air photos. Note that the contour lines are closely spaced along the shore at Painesville-on-the-Lake. They represent the bluffs. The highest close-spaced contour represents the top of the bluff.

9. Determine the elevation of the lake. Record it on your worksheet.

10. Determine the elevation of the bluff just west of Hardy Road.

Subtract the elevation of the lake from that of the bluff and enter the difference on line V of the worksheet.

11. Now determine the elevation of the bluff to the east of Hardy Road.

Subtract the elevation of the lake and enter the difference on Line V.

12. Calculate the total volume of material removed by erosion by multiplying the average height of the bluffs times the total surface area removed. Enter in Line W.

13. Determine the volume of your classroom. Divide this value into the value on Line W. The result will be the number of volumes equal to your classroom removed by erosion.

14. Determine the average yearly loss of material by dividing the total volume removed by 19 or 8 years as appropriate. Enter on Line X.

15. Repeat the procedure for 1973-1981.

From this investigation, you have learned that a portion of the Great Lakes shoreline, specifically on Lake Erie, is retreating southward at a fairly rapid rate. It may surprise you to find out that this is occurring throughout the lake.

What evidence of erosion can you find on your section of the Great Lakes?

The rate of recession will vary according to the hardness of the materials. Near Marblehead in Lake Erie, for example, the rate is barely noticeable. Marblehead has limestone exposed in the bluffs along the lake. The shoreline on the northern side of Lake Erie is retreating at a more rapid rate than in the Perry area, but northward. In a sense, then, Lake Erie is getting bigger. What happens to all the material that has eroded? Most of it eventually ends up filling in the deeper basins of the lake.

Lake shorelines are not the only shores that erode. The seacoast also erodes. The same processes, wind, and currents are involved, and the same protective structures are used. As you have seen, groins are effective in treating some local problems on a temporary basis. Although they do not offer a permanent solution to erosion problems, they may provide the extra time needed for other measures to be taken.

Extension

Observe the following shoreline changes of Racine County, Wisconsin on Lake Michigan. Determine a method to measure the amount of shoreline removed by erosion.

Answer

12. See Appendix B.

The following paragraph from Willard Bascom's *Waves and Beaches* describes how groins may be helpful in preventing seacoast erosion.

There is an instance in which a ship saved a lighthouse, instead of vice-versa. In 1883, the Cape Henlopen light on the Delaware coast was in imminent danger of being undermined by the sea. The high-water mark reached around the base and various emergency protective actions were being considered. Then, in a storm the Minnie Hunter was driven ashore, grounding about 500 feet north of the lighthouse. The wrecked ship immediately acted as a groin which dammed the coastal flow of sand and replaced the beach in front of the light so that the structure survived for many more years.

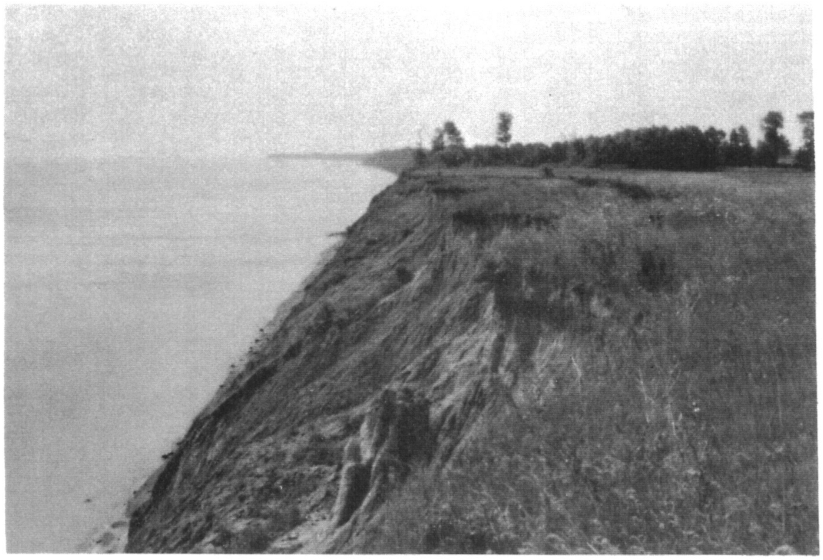
Site 2D-North

12/3/81

4/1/82

Site 2D – North: "Note the large slump that is broken into three major pieces in photo 12/3/81. . . Photo 4/1/82 shows the remains of the slump failure. It is evident that the supporting soil of the slump block partially disintegrated, resulting in the downward movement of the slump. Also note the development of bluff overhang above the slump in photo 4/1/82. This overhang is not significant in photo 12/03/81. The remaining loose soil material above the slump is a remnant of the supporting soil structure before crumbling away, resulting in bluff overhang. . . (T)he scalloped shaped bluff edge in photo 12/3/81 is becoming more bowl-shaped in photo 4/1/82. Several slump events ranging from 4 feet by 2 feet to 75 feet by 10 feet have been observed at this location. In general, the bluff slope shown in photo 4/1/82 is becoming steeper." (Racine County Coast Watch Program Final Report, 1982, p. 85)

Site 1C-South 8/1/80



5-14-82

Site 1C – South: "Photo 8/1/80 shows that the bluff edge was "scalloped" shaped and the bluff slope was steep. This site is subjected to wave attack that erodes the solid material from the bluff toe. . . . Photo 5/14/82 shows large slumps that detached from the bluff edge and slid down the bluff face. Recorded observations indicated that slump pieces vary greatly in size and range from 1 x 1 foot to 50+ feet long and 12 feet wide. The bluff edge has changed from the scalloped shaped to a bowl-shaped retreat. . . . The major slumps occurred over a 4-month time period in 1982." (Racine County Coast Watch Program Final Report, 1982, p. 83)

The above photographs are examples of remote video monitoring of the shorelines you have examined in this activity. Investigate more images of Lake Erie and at other sites by exploring the Internet address http://stimpy.er.usgs.gov.

Additional Suggestion: A similar "video" can be designed with a site near your school. Find a place where you can observe shoreline changes or sand bar movement or stream level changes. Take photographs at successive times over several months. Display the photographs on a poster or digitize them to make a movie.

Additional Background Information

The techniques used in this activity to determine the rate of recession and the amount of materials lost through beach processes are adapted from the techniques used by professional geologists.

Painesville (on-the-Lake) is located along the shore of the central basin of Lake Erie. Here the prevailing southwesterly winds have a fetch (straight-line distance crossing a body of water) over the lake and, therefore, cause longshore currents that have a net easterly movement. In the western part of the Lake Erie Basin, however, such as in the area of Sandusky, these winds at the shore blow only from over the land, and there is little if any fetch. The occasional northeasterly storms, then, are the major cause of longshore currents, especially because of the long fetch that they have over the lake. As a result, the net movement of longshore currents on the southern shore in the western basin is in a westerly direction.

Review Questions

1. Describe how you would determine the recession rate of a section of the Atlantic Coast?

2. How would you determine the amount of material removed from a section of the Atlantic coast?

3. Describe what is likely to happen when a groin is built along a section of shoreline.

References

Carter, Charles H. 1993. Coastal Processes on the Great Lakes. In: Rosanne W. Fortner and Victor J. Mayer, eds., *The Great Lake Erie*. Columbus, OH: The Ohio State University.

Carter, Charles H., et. al. 1987. *Living with the Lake Erie Shore*. Durham: Duke University Press. Sponsored by the National Audubon Society. This is a reference book with photographs, diagrams, and relevant information about coastal processes, shoreline protection, and coastal zone management.

Carter, C.H. and W.S. Haras. 1985. Great Lakes. In: E.C. Bird and M.L. Schwarz, eds., *The world's coastline*. New York: Van Nostrand Reinhold.

Carter, C.H., D.E. Guy, Jr., and J.A. Fuller. 1981. *Coastal geomorphology and geology of the Ohio shore of Lake Erie: Geological Society of America Guidebook*, Annual Meeting Field Trip, Cincinnati.

Racine County Planning and Zoning Department and Wisconsin Coastal Management Program. 1982. *Racine County Coastwatch Program Final Report*. Financial assistance provided by the State of Wisconsin, Department of Administration, Office of State Planning and Energy, and the Coastal Zone Management Act of 1972 as amended, administered by the Office of Coastal Zone Management, NOAA.

U.S. Army Corps of Engineers. 1981. *Low Cost Shore Protection: A Property Owner's Guide*. Philadephia, PA: Rogers, Golden and Halpern, Inc. Contact: Section 54 Program, U.S. Army Corps of Engineers, USACE (DAEN-CWP-F), Washington D.C. 20314

Worksheet

Names in Group:

Shoreline Changes 1954-73

	West A	B	C	D	East E	F	G	H
Q: Distance								
R: Average Distance Q/4								
S: Recession Rate R/19								
T: Squares								
U: Surface Area T x 160 sq ft								
V: Cliff Height								
W: Volume U x V								
X: Yearly Loss W/19 yr								

Shoreline Changes 1973-81

	West A	B	C	D	East E	F	G	H
Q: Distance								
R: Average Distance Q/4								
S: Recession Rate R/8								
T: Squares								
U: Surface Area T x 160 sq ft								
V: Cliff Height								
W: Volume U x V								
X: Yearly Loss W/19 yr								

Appendix B. Completed worksheet example.

	West A B C D	East E F G H
Q: Distance	90 ft + 75 ft + 0 + 0 = 165 ft	0 + 100 ft + 120 ft +125 ft = 345 ft
R: Average Distance Q/4	41.25 ft	86.25 ft
S: Recession Rate R/19	2.2 ft/yr	4.5 ft/yr
T: Squares	25	90
U: Surface Area T x 160 sq ft	4,000 sq ft	14,400 sq ft
V: Cliff Height	40 or 50 ft	30 ft
W: Volume U x V	160,000 cu ft	432,000 cu ft
X: Yearly Loss W/19 yr	8,421 cu ft/yr	22,737 cu ft/yr