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USGS Science for the Nation's Changing Coasts: Shoreline Change Research

The demands of increasing human population in the coastal zone create competition with coastal habitat preservation and with recreational and commercial uses of the coast and nearshore waters. As climate changes over the coming century, these problems facing coastal communities will likely worsen. Good management and policy decision-making require baseline information on the rates, trends, and scientific understanding of the processes of coastal change on a regional to national scale. To address this need, the U.S. Geological Survey (USGS) is engaged in a research project of national scope to measure, report, and interpret historical shoreline change along open-ocean coasts of the United States. One of the primary goals of this project is to understand shoreline change hazards using methods that are comparable from one area of the country to another and that will allow for future, repeatable analyses of shoreline movement, coastal erosion, and land loss.

Around the United States, coastal erosion is a common problem. At Cobb Island, Virginia (top), shoreline retreat on a sandy coast has left these houses in the surf zone (photograph by Karen Morgan, USGS). The retreat of coastal cliffs can be a significant hazard to development, as seen in Pacifica, California (bottom), during the El Niño winter of 1997–98 (photograph by Monty Hampton, USGS).

Why Do Beaches Change?

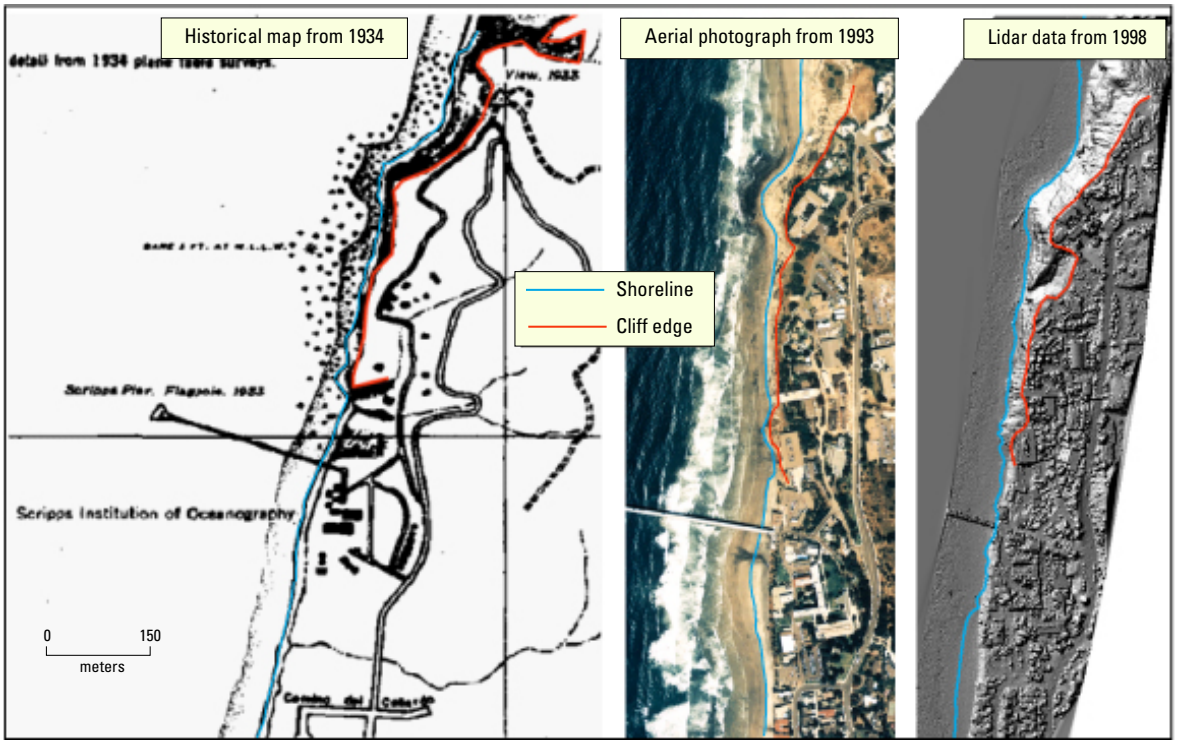
Beaches change in response to a variety of factors, including type of coastline, changes in the amount of available sand, storms, sea-level rise, and human activities. Natural changes are most often associated with storm activity, including hurricanes along the U.S. Mid-Atlantic, Southeast, and Gulf of Mexico coastlines, northeaster storms along the New England and Mid-Atlantic coasts, and strong Pacific storms, especially during El Niño years, on the West coast. Over longer time scales, sea-level rise will likely add to the amount of change. In addition, global climate models indicate that storms may increase in intensity, which will heighten their ability to cause beach change. The type of coastline also plays a role in how fast beaches change—for instance, beaches along rocky coastlines (like much of the New England and West coasts) generally change more slowly than beaches on barrier islands and mainland beaches because of differences in exposure to wave energy and the types of materials that form the beaches.

Human activities, particularly those that impound sand, can cause beaches to change. These include sand being obstructed from reaching the coast by damming rivers, as well as coastal engineering structures (for example, groins and jetties) that can trap sand moving along the coastline, depriving other areas from receiving sand. Other human activities that change beaches include beach-nourishment projects and structures such as seawalls, breakwaters, and artificial reefs.

The complex interplay of the different natural and human factors that influence how and why beaches change makes it challenging to measure changes and to understand the patterns and trends of shoreline change, especially on regional and national scales. The USGS has taken a lead role in undertaking the complex scientific issue of understanding coastal change on a national scale.

Measuring Coastal Change

In most areas of the country, coastal change is measured by comparing the position of the sandy shoreline through time. A variety of data sources are used to derive past shoreline positions so that the analyses can extend as far back as the historical record allows, which is about 150 years. However, the feature identified as the shoreline on sources such as historical maps



The U.S. Geological Survey assessment of long-term coastal change includes a variety of data sources, such as historical maps (left), aerial photographs (middle), and airborne lidar (right) of the area around Scripps Oceanographic Institution in Southern California. The sandy shoreline (blue line) and the cliff edge (red line) can be identified on these data and compared to estimate the rate of coastal change. (Map courtesy of National Oceanic and Atmospheric Administration Coastal Services Center; aerial photograph Copyright© 2004–2010 Kenneth & Gabrielle Adelman, California Coastal Records Project, http://www.californiacoastline.org/; lidar hillshade created by Cheryl Hapke, USGS).

from the 19th century may be slightly different from the feature derived from maps and aerial photographs in the 20th century. The most recent shoreline data are derived from data collected with modern state-of-the-art technology (lidar, or LIght Detection And Ranging). The USGS has developed specialized, quantitative approaches to be able to merge the historical and modern datasets to allow us to move forward in the 21st century using the best available data while still retaining valuable historical information.

Along some of the Nation's coasts, such as in California and the Great Lakes, erosion of coastal cliffs is as much of a coastal hazard as erosion of beaches. To address this hazard, the USGS measures the rates of historical cliff retreat for California and parts of Alaska in addition to the rates of sandy shoreline change. This effort requires the development of new, innovative methods to measure and interpret trends of coastal cliff retreat on a regional scale.

The Digital Shoreline Analysis System (DSAS) is used to calculate shoreline change at regular intervals along the coast. This software, created by USGS scientists, allows the user to define the along-coast intervals in which to measure coastal change, input information regarding confidence in data sources, and choose from a variety of statistics that describe the rates of change. The software is available at no cost from the USGS, which also maintains and updates it. The DSAS is now used worldwide and is considered one of the standard approaches for measuring coastal change.

The USGS is a scientific leader in the development of tools and methodologies for measuring coastal change and in the interpretation and dissemination of scientific results of coastal-change analyses. It is the only government agency that has a dedicated program to continue monitoring coastal change into the future. The research described here provides baseline information to assist both Federal and state decisionmakers in understanding how shoreline change varies along the coast and over time.

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For More Information

The National Assessment of Coastal Change Hazards Project Web site: http://coastal.er.usgs.gov/national-assessment/.

USGS science for the Nation's changing coasts: shoreline change assessment: U.S. Geological Survey Fact Sheet 2011-3074 (http://pubs.usgs.gov/fs/2011/3074/).

National assessment of shoreline change: historical shoreline change along the New England and Mid-Atlantic coasts: U.S. Geological Survey Open-File Report 2010–1118 (http://pubs.usgs.gov/of/2010/1118/).

National assessment of shoreline change; part 4, historical coastal cliff retreat along the California coast: U.S. Geological Survey Open-File Report 2007–1133 (http://pubs.usgs.gov/of/2007/1133).

National assessment of shoreline change; part 3, historical shoreline change and associated coastal land loss along sandy shorelines of the California coast: U.S. Geological Survey Open-File Report 2006–1219 (http://pubs.usgs.gov/of/2006/1219/).