Sea Level

This indicator describes how sea level has changed over time. The indicator describes two types of sea level trends: absolute and relative.

Background

As the temperature of the ocean changes (see the Sea Surface Temperature indicator on p. 38), so does sea level. Temperature and sea level are linked for two main reasons:

1. Changes in the volume of water and ice on land (namely glaciers and ice sheets) can increase or decrease the volume of water in the ocean.
2. As water warms, it expands slightly—an effect that is magnified over the entire surface and depth of the oceans.

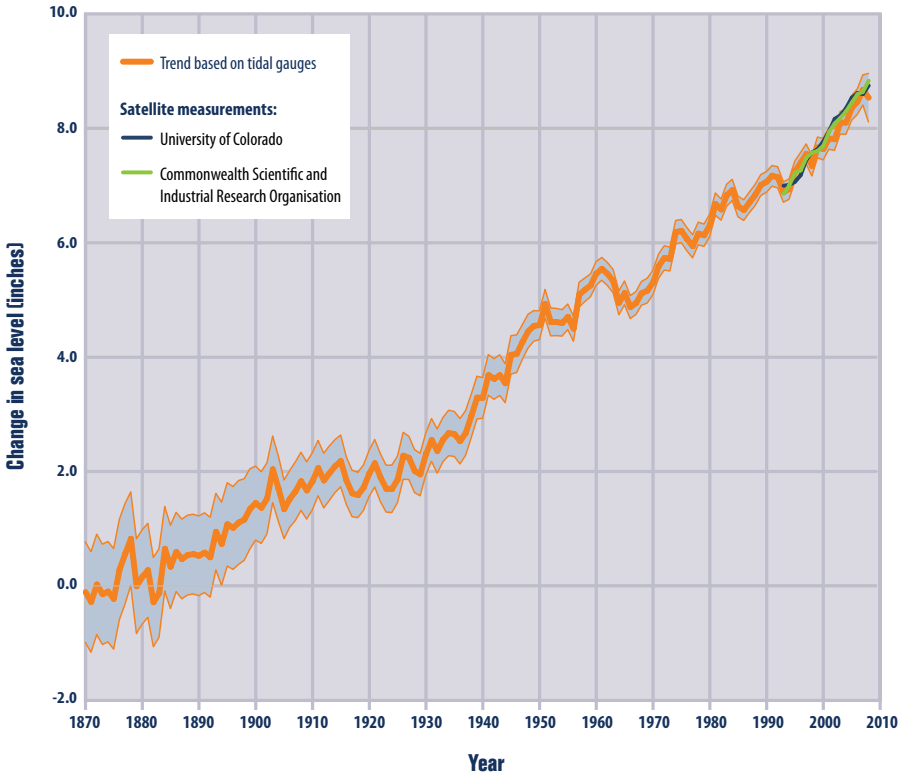
Changing sea levels can affect human activities in coastal areas. For example, rising sea levels can lead to increased flooding and erosion, which is a particular concern in low-lying areas. Sea level rise also can alter ecosystems, transforming marshes and other wetlands into open waters and freshwater systems to salt water.

The sea level changes that affect coastal systems involve more than just expanding oceans, however, because the Earth's continents can also rise and fall relative to the oceans. Land can rise through processes such as sediment accumulation (the process that built the Mississippi Delta) and geological uplift (for example, over long timeframes as tectonic plates collide and build mountain ranges, and over shorter timeframes as glaciers melt and the land below is no longer weighed down by heavy ice). In other areas, land can sink because of erosion, sediment compaction, natural subsidence (sinking due to geologic changes), or engineering projects that prevent rivers from naturally depositing sediments along their banks. Changes in ocean currents such as the Gulf Stream can also affect sea levels by pushing more water against some coastlines and pulling it away from others, raising or lowering sea levels accordingly.

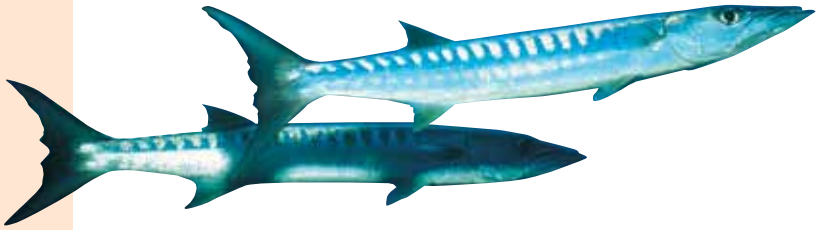
Scientists account for these types of changes by measuring sea level in two different ways. *Relative* sea level is the height of the ocean relative to the land elevation at a particular location. In contrast, *absolute* sea level strictly measures the height of the ocean surface above the center of the earth, without regard to whether nearby land is also rising or falling.

Figure 1. Trends in Global Average Absolute Sea Level, 1870–2008

This graph shows how the average absolute sea level of the world's oceans has changed since 1870, based on a combination of long-term tidal gauge measurements and recent satellite measurements. Absolute sea level does not account for changes in land elevation. The shaded band shows the likely range of values, based on the number of measurements collected and the precision of the methods used.



Data sources: CSIRO, 2009;[14] University of Colorado at Boulder, 2009[15]

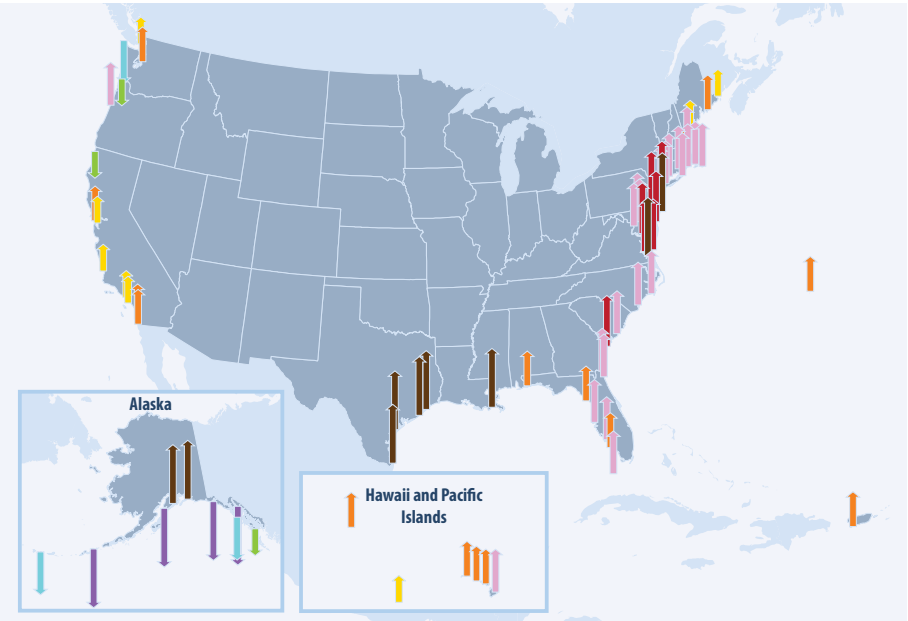


Key Points

- After a period of approximately 2,000 years of little change, average sea levels rose worldwide throughout the 20th century, and the rate of change has accelerated in recent years.[16] When averaged over all the world's oceans, absolute sea level increased at an average rate of 0.06 inches per year from 1870 to 2008 (see Figure 1). From 1993 to 2008, however, average sea level rose at a rate of 0.11 to 0.13 inches per year—roughly twice as fast as the long-term trend.
- Relative sea level rose along much of the U.S. coastline between 1958 and 2008, particularly the Mid-Atlantic coast and parts of the Gulf coast, where some stations registered increases of more than 8 inches (see Figure 2). Meanwhile, relative sea level fell at some locations in Alaska and the Pacific Northwest. At those sites, even if absolute sea level has risen, land elevation has apparently risen faster.
- While absolute sea level has increased steadily overall, particularly in recent decades, regional trends vary, and absolute sea level has decreased in some places.[17] Relative sea level also has not risen uniformly because of regional and local changes in land movement and long-term changes in coastal circulation patterns.

Figure 2. Trends in Relative Sea Level Along U.S. Coasts, 1958–2008

This map shows changes in relative sea level from 1958 to 2008 at tidal gauge stations along U.S. coasts. Relative sea level accounts for changes in sea level as well as land elevation.



Data source: NOAA, 2009[18]

About the Indicator

This indicator presents trends in sea level based on measurements from tidal gauges and from satellites that orbit the Earth. Tidal gauges measure relative sea level at points along the coast, while satellite instruments measure absolute sea level over nearly the entire ocean surface. Many tidal gauges have collected data for more than 100 years, while satellites have collected data since the early 1990s.

Figure 1 shows trends in absolute sea levels averaged over the entire Earth's ocean surface. The long-term trend is based on tidal gauge data that have been adjusted to show absolute global trends through calibration with recent satellite data. Figure 2 shows trends at a more local scale, highlighting the 1958 to 2008 change in relative sea level at 76 tidal gauges along the Atlantic, Pacific, and Gulf coasts of the United States.

Indicator Limitations

Relative sea level trends represent a combination of absolute sea level change and any local land movement. Tidal gauge measurements such as those in Figure 2 generally cannot distinguish between these two different influences without an accurate measurement of vertical land motion nearby.

Some changes in relative and absolute sea level can be due to multi-year cycles such as El Niño, which affect coastal ocean temperatures; salt content; winds; atmospheric pressure; and currents. Obtaining a reliable trend can require many years of data, which is why the satellite record in Figure 1 has been supplemented with a longer-term reconstruction based on tidal gauge measurements.

Data Sources

Absolute sea level trends were provided by Australia's Commonwealth Scientific and Industrial Research Organisation and the University of Colorado. These data are based on measurements collected by satellites and tidal gauges. Relative sea level data are available from the National Oceanic and Atmospheric Administration, which publishes an interactive online map (http://tidesandcurrents.noaa.gov/sltrends/slrmap.html) with links to detailed data for each tidal gauge.