



Sea levels are changing.

Climate change has accelerated the melting of glaciers and sea ice around the world, including in Alaska. This rapid melting has contributed to sea level rise globally. However, the change in sea level in Glacier Bay National Park and Preserve tells a different story. Although some data indicates that sea levels at Glacier Bay are currently rising, the land in the area is rising faster than the sea, resulting in a net decrease in sea level. This is due to a geologic phenomenon called *isostatic or glacial rebound*.

What is isostatic rebound?

Isostatic rebound follows a major loss of pressure on the Earth's crust due to the melting of large, heavy glaciers. Underneath the Earth's crust lies the upper mantle, which contains the rigid lithosphere and the malleable asthenosphere (Figure 1). The massive, ancient glaciers that once covered Glacier Bay's landscape exerted tremendous pressure on the flexible mantle, causing the land to sink. Over 250 years ago, when these glaciers began to retreat, the reduced weight caused the land to "rebound" and gradually rise over time as the asthenosphere returned to its original elevation (Figure 2).

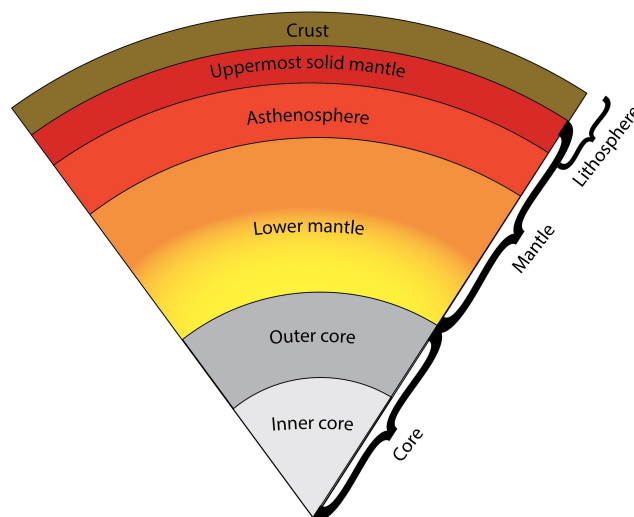


Figure 1. Layers of the Earth. Not to scale.

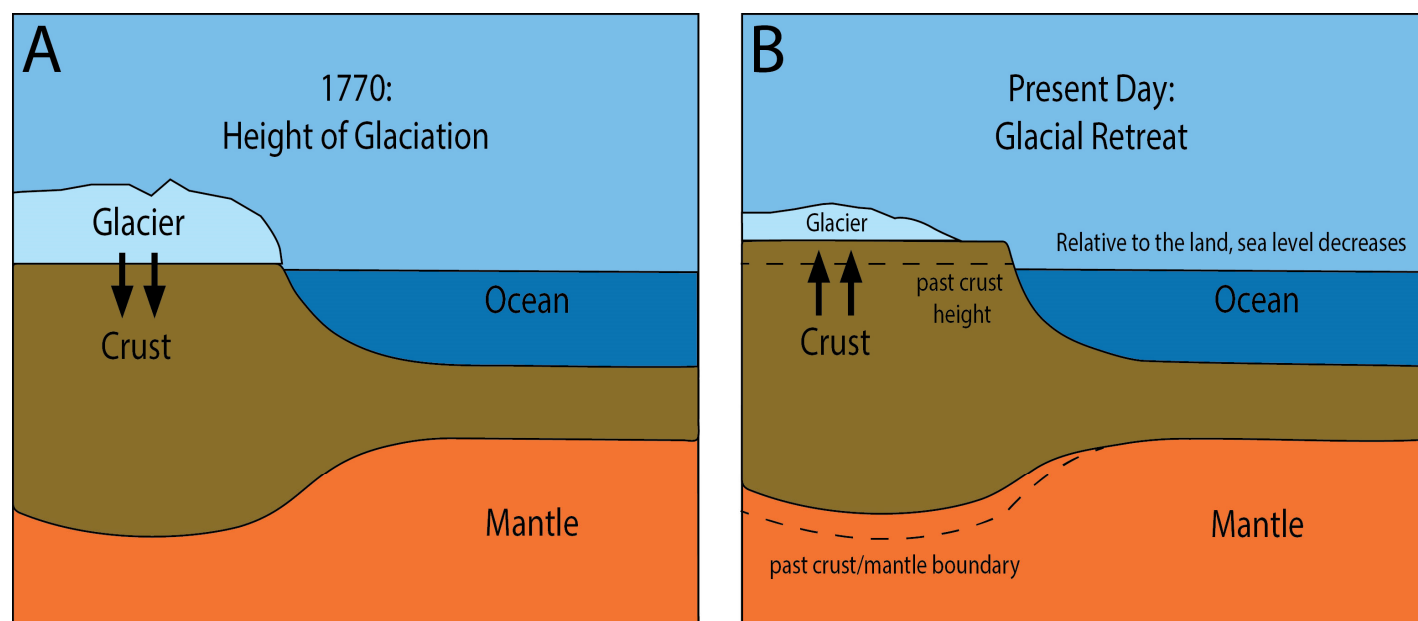


Figure 2. (A) Massive glaciers once exerted tremendous pressure on the mantle below, causing the land to sink. (B) As glaciers retreat, the reduced weight on the mantle causes the land to rise – a process known as *isostatic rebound* – resulting in a relative drop in local sea level.



Why did the glaciers in Glacier Bay retreat?

The most recent regional “ice age” is known as the Little Ice Age. During this relatively short period of cool temperatures, mountain glaciers grew in Alaska, including at Glacier Bay. Little Ice Age glaciation reached its peak around 1770, and the glaciers have been slowly melting ever since as temperatures rise.

As the glaciers melted, the weight they exerted on the land decreased causing the land to slowly uplift as is seen in the park today. Areas of the park where visitors now frequent to view glacier faces had almost a mile high glacier when the Revolutionary War was being fought (Figure 3).

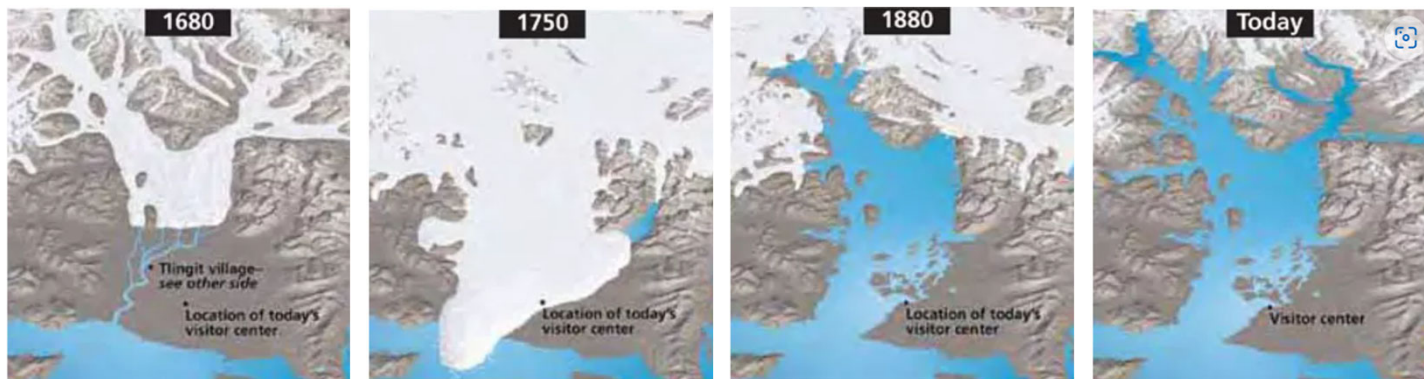


Figure 3. Aerial extent of glaciers in Glacier Bay from 1680 until present highlighting the rapid advance then retreat of the ice. [NPS]

Glaciers can still be found in the park today. However, they do not occupy the same spatial extent as the glaciers that formed during the Little Ice Age. Around 95% of the park’s glaciers are stagnating or retreating, partly due to climate change.

How is isostatic rebound measured?

Isostatic rebound, measured as vertical land uplift, is tracked using GPS data, tide gauge data, or by dating tree rings along raised shorelines. Uplift rates as high as 32 millimeters (~1.3 inches) per year have been recorded in Glacier Bay, however the rate of uplift is not uniform across the region. Glacier Bay is estimated to have experienced around 5.5 meters (18 feet) of uplift since glacial retreat began roughly 250 years ago during the post Little Ice Age de-glaciation (Figure 4). Glacier Bay currently has the fastest rate of isostatic rebound in the United States.

Motion rate 29.6 +- 0.0 (mm/yr) Repeatability 14.5 (mm)

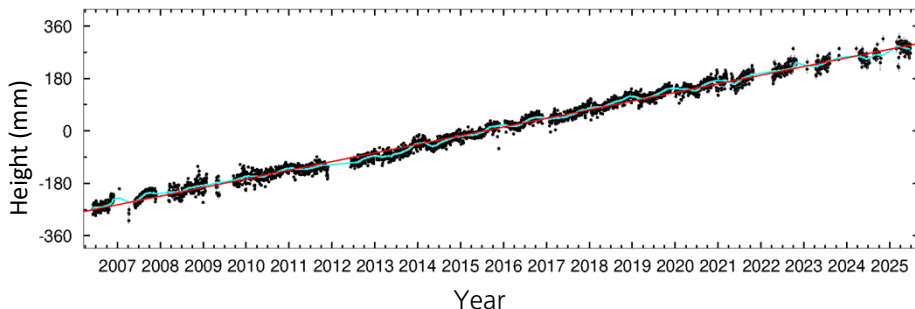


Figure 4. Change in land height over time for a continuous GPS site in Blue Mouse Cove in Glacier Bay. The upward trend is due to isostatic rebound; annual fluctuations are due to seasonal cycles of snow accumulation and melt. [Dr. Freymueller, Michigan State University and University of Alaska, Fairbanks]



Glacier calving in front of harbor seals on the ice. [NPS photo]



Why is it so hard to determine sea level in Glacier Bay?

Tracking sea level change in Glacier Bay is challenging. Authoritative sources for shoreline mapping are outdated due to the park's extensive and complex shoreline, remote location, and constantly changing landscape. Accurate shorelines also depend on connecting tide gauges with permanent GPS stations that track land movement, but Alaska's remote landscape makes these instruments sparser than in the Lower 48.

To support future analysis of sea level trends, a tide gauge was installed in the park at Bartlett Cove in 2022. Data collected in 2023 showed that mean sea level at Bartlett Cove had dropped by approximately 1.0 meter (~3.3 feet) since 1967, which is an average rate of about 2 centimeters (~0.8 inches) per year.

How does sea level change and glacial retreat affect the ecosystem?

Glacier Bay's widely varied topography contributes to the differences in sea level change throughout the park. In areas with steep shoreline slopes, the apparent change in sea level is minimal. In contrast, low-slope areas show much more pronounced change (Figure 5). In these low-slope areas, hundreds of acres of former marine habitat have transitioned to terrestrial habitat.

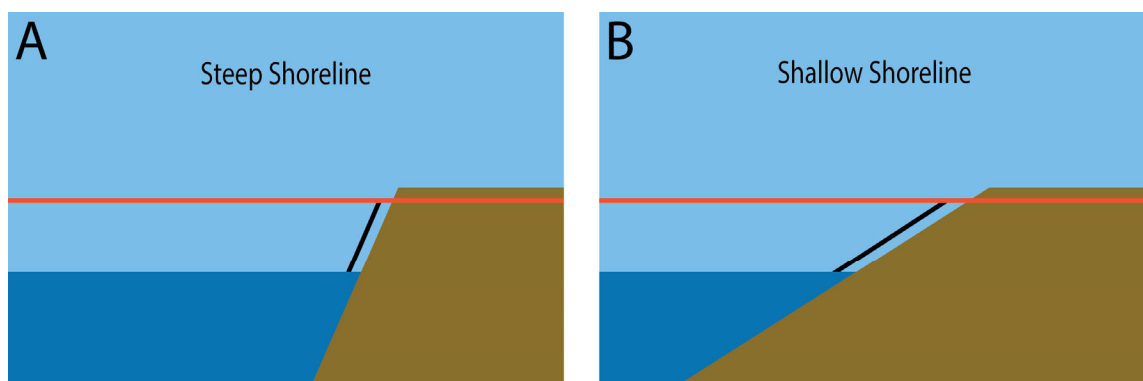


Figure 5. When sea level falls from the orange line, it exposes (A) a small amount of land on a steep shoreline and (B) a larger amount of land on a low-slope shoreline.

As the sea level decreases in the park, the ecosystem must adapt. For example, salt-tolerant beach meadow species, such as American dune grass, that thrive close to the shoreline will shift seaward with lowland forest often following close behind. Marine ecosystems are impacted as well, particularly by freshwater runoff from melting glaciers which affects the productivity and circulation of nutrients in marine ecosystems. Changes in these dynamics can impact food webs, which include phytoplankton, zooplankton, forage fish, seabirds, and marine mammals (e.g., sea lions, seals, and whales).



Aerial image of coastal habitat in Glacier Bay National Park. [NPS Photo]

Additional Resources

1. <https://tidesandcurrents.noaa.gov>: Access water levels, tide predictions, and other conditions along coasts.
2. [NOAA Coastal Flood Exposure Mapper](#): A tool to visualize coastal hazards as well as societal, infrastructure, and ecosystems exposure to those hazards.

Note: The sea level rise projections, storm surge projections, and other information presented here are for general educational and awareness purposes only. They should not be used for site-specific analysis, navigation, permitting, or legally binding activities.