FROM ICEFIELD TO OCEAN

EXPLORE THE MANY WAYS THAT GLACIERS INFLUENCE ALASKA'S COASTAL ECOSYSTEMS


Photo: K. Timm

Glaciers cover over 33,000 square miles (about 5%) of the state of Alaska. The glaciated area of Alaska is larger than 13 of the smallest U.S. states!

Glaciers are a major feature of Alaska's coastal ecosystems. They impact people, fish, and wildlife near and far.

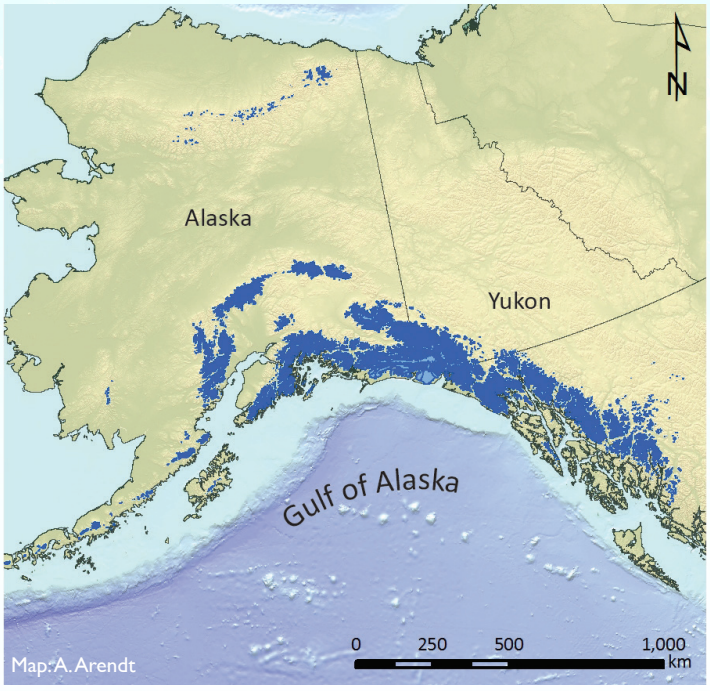
IT ALL BEGINS WITH **SNOWFLAKES**

Each winter, hundreds of feet of snow falls high in the mountains surrounding the Gulf of Alaska. Not all of this snow melts during the summer months. The snow that remains until the following winter is compressed into a coarse, dense snow-like material known as firn. As time goes by, water percolates in and new overlying layers of snow add pressure and transform the firn. The firn eventually becomes blue glacier ice.

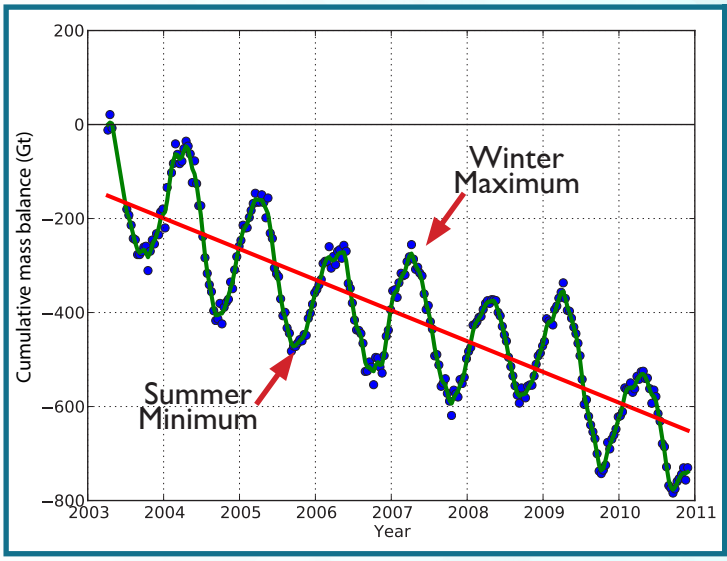
Like rivers, glaciers respond to gravity and flow downslope from the mountains to lower elevations. At low elevations where air temperatures are warmer, glaciers lose mass to melting. Some glaciers also lose mass from calving—when ice breaks off the front of the glacier into a lake or fjord.

The process of gaining ice through snowfall each winter and losing ice through melt in the summer is like a bank account—it can have a positive or negative balance. If a glacier gains more ice than it losses through melt, it has a positive mass balance and grows larger. If a glacier loses more ice than it gains, it has a negative mass balance.

A glacier's mass can vary in response to subtle changes in



▲ Many of Alaska's glaciers (blue) are concentrated in the area surrounding the Gulf of Alaska; they cover about 20% of this region. About 50% of the freshwater that drains into the Gulf of Alaska comes from glaciers.



The overall mass of Alaska glaciers can be measured using satellites.

Seasonal differences in glacier mass account for the peaks and valleys on the graph. Mass is higher in the winter when snow accumulates but decreases in the summer as it melts.

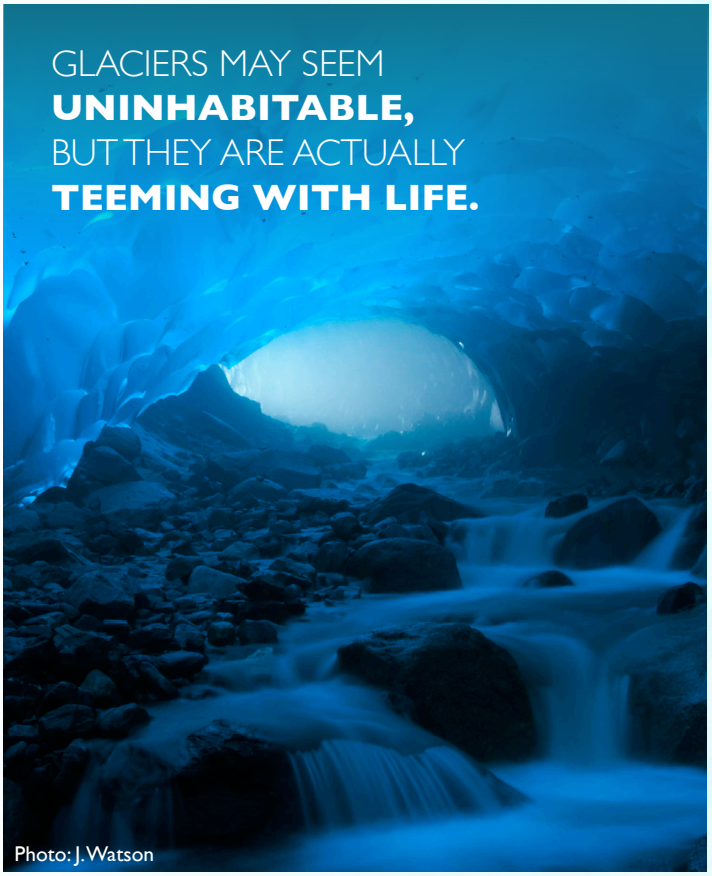
Despite the seasonal variation, in the past decade the mass of Alaska glaciers has had a declining trend (red line).

(Figure: Arendt, Luthcke, Gardner, O'Neel, Hill, Moholdt, & Abdalati, 2013)

temperature and precipitation. Several years of warmer temperatures and/or less snowfall can lead to a negative mass balance. A glacier with a negative mass balance for many years may become noticeably thinner or may recede.

In order to see if long-term climate trends are causing glaciers to loss mass, scientists have to look beyond these seasonal or yearly variations. One way that scientists are able to do this is with satellites. A satellite called GRACE, circles the earth 15 times a day and measures tiny changes in mass. When all of these tiny changes in mass are added up from hundreds of glaciers over several years of time, scientists can see of if glaciers within a region are losing or gaining mass.

During the past decade, Gulf of Alaska glaciers lost about 50 gigatons (Gt) of mass each year. The amount of freshwater that has been added to the ocean as a result of this mass loss in Alaska glaciers is equal to a .14 mm (.006 in) increase in the global ocean level each year. It is very likely that Alaska's glaciers will continue to lose more mass than they gain. This will cause global sea level to continue to rise. It may also impact the natural systems that are closely connected to glaciers.



WELCOME TO THE **GLACIER BIOME**

Where water exists, there is life—and glaciers are no exception. During the summer, glacial meltwater flows down through cracks and tunnels to the base of the glacier. The meltwater interacts with bedrock, soil, and ancient organic matter that has been overrun by the glacier creating a habitat for a variety of microorganisms.

Bacteria, protozoa, fungi, and algae live on, within, and beneath glaciers. Similar to organisms that live in the deep sea or in caves, these organisms have unique adaptations to survive in this extreme environment. They have anti-freeze-like proteins in their bodies that protect their cells from freezing. They are able to survive with very limited amounts of nutrients.

Some microorganisms that live on glaciers are photosynthetic like plants. These organisms are able to turn sunlight into energy and carbon dioxide from the atmosphere into biomass. Other microbes survive by consuming the organic matter that blows or falls onto the glacier surface.

◀ This subglacial stream under the Mendenhall Glacier is cold and dark, yet it is home to a community of uniquely adapted microorganisms.

Although they are microscopic, these tiny organisms make valuable contributions to Earth's systems. They affect the movement and cycling of nutrients, such as carbon, nitrogen and phosphorus. These nutrients are cycled on and beneath glaciers and end up in drainage streams which carry them away from the glacier.

A biome is a unique ecosystem characterized by distinct types of plants and animals that are specially adapted to a unique place and climate. These little communities of microbes make up the *glacier biome*.

Developing a better understanding of the glacier biome is important because the amount of glacier ice worldwide is decreasing. There are still many uncertainties about the structure and function of this system, including the ways that runoff from glacier biomes affects downstream ecosystems in streams, estuaries, fjords, and the ocean.

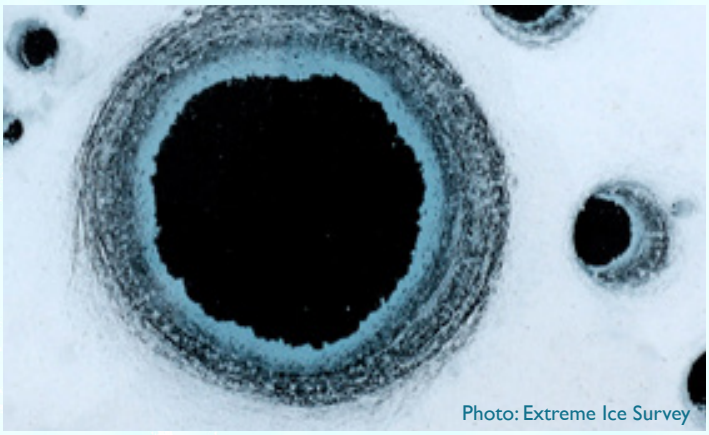


Photo: Extreme Ice Survey

▲ These tiny pools of water are formed when sunlight is absorbed by dark colored, wind-blown material called cryoconite. One of the many unique habitats on the surface of a glacier, this pool may be just inches in diameter, but contain many species of microorganisms.

Photo: K. Timm

GLACIERS **TALK** TO THE **OCEAN**

Glacier-fed streams have unique biological, chemical, and physical traits. These traits are carried and passed on to aquatic systems downstream, including the ocean. Glacier runoff adds rock derived elements such as phosphorus and iron to marine ecosystems, which fuels phytoplankton growth at the bottom of the food chain. In addition, glaciers and their runoff provide bioavailable—or easy to use—organic matter for microbes living in streams and the ocean.

Glacier runoff also helps maintain cool water temperatures in streams during the warm summer months. This is important because cold water holds more oxygen than warm water, and dissolved oxygen is required by spawning salmon as well as other fish and aquatic organisms.

The difference in temperature and density between glacier runoff and ocean water also helps drive the Alaska Coastal Current (ACC). Like a giant conveyor belt, the ACC carries nutrients and organisms throughout the Gulf of Alaska and into the Arctic.

Glacier runoff carries a unique suite of nutrients and organic matter to near-shore marine ecosystems. Understanding how glacier runoff interacts with marine food webs is critical for predicting the ecological effects of glacier change in Alaska.

◀ The surface of a glacier has streams of meltwater that carry anything that accumulates on the surface—including minerals, organic matter, or contaminants—downstream to rivers, fjords, and eventually to the ocean.

▲ Silty, gray, glacier stream water mixes with the ocean in Berner's Bay north of Juneau, Alaska.

IT'S ALL **CONNECTED**

The Gulf of Alaska is one of the most productive marine ecosystems on Earth. Humans have found many ways to utilize the wealth of resources it produces. Animals and fish provide food, jobs, recreation, and scenic value. The incredible beauty of the glaciers and glacier-influenced landscapes attract tourists who bring economic benefits to Alaska communities. Some of the benefits of glaciers, such as steady streamflow for hydropower, are yet to be fully realized.

The complete loss of glaciers in Alaska is not imminent, but the current rates of ice loss are likely to continue and perhaps accelerate. The Gulf of Alaska region is heavily influenced by glaciers and the runoff that they deliver to the ocean. Understanding how changes in regional climate will affect glaciers and closely linked systems is a goal among scientists and resource managers in Alaska and beyond.

Organic matter and nutrients from glacier runoff may provide sustenance to near-shore marine food webs.

The krill upon which humpback whales feed can be abundant in glacial fjords.

Glaciers are a significant tourist attraction, and tourism is a major part of Alaska's economy.

Seals find safety from predators in the thick icebergs near the calving face of glaciers.

Kittlitz's murrelets, which often nest near glaciers, find small fish to feed to their chicks in silty glacier river plumes.

Fish are an important food source and economic resource in Alaska. Glaciers help maintain healthy water temperatures.

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