

The Arctic and Climate Change

The bottom line is that the top of the world will play a decisive role in determining how Earth's climate changes.

Despite its remoteness, the Arctic Ocean is a critical component in the interconnected “machine” that regulates Earth's climate. Global warming already may be tipping the [Arctic's delicately balanced system](#) of air, ice, and ocean—and posing it to trigger a cascade of changes whose impacts will be felt far beyond the Arctic region.

Will the Arctic retain its ice?

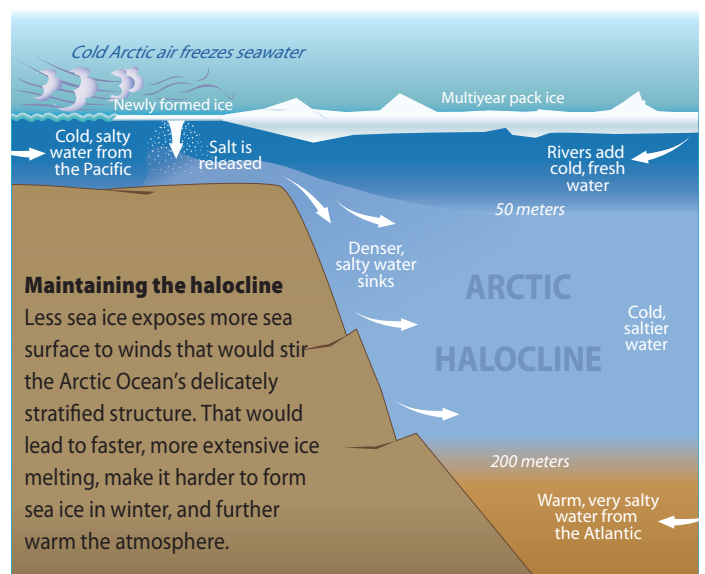
Both the extent and thickness of [Arctic sea ice has decreased](#) steadily and significantly over the last 50 years. In 2007, the extent of sea ice in summer was 490,000 square miles (roughly the size of Texas and California) less than the previous record low in 2005 and about 1 million square miles smaller than the average ([National Snow and Ice Data Center](#)). NASA recently reported that only about 30% of the Arctic Ocean has “[multiyear](#)” sea ice (which has survived and thickened through several summer melting seasons)—down from about 60% in the 1980s. Several [Greenland Ice Sheet](#) glaciers are flowing faster to the coast since 1995, calving more ice into the ocean (NASA, NSIDC). Numerous studies predict accelerated [thawing of the Arctic permafrost](#).

The ocean plays a critical role in how sea ice forms and melts.

Surrounded by continents, the Arctic Ocean is like a big, deep bowl, ideally set up to make ice. Cold, salty water enters from the Pacific through the narrow spigot of the [Bering Strait](#). It circulates in the [Beaufort Gyre](#), the “flywheel of the Arctic,” a wind-driven circular current that periodically weakens and releases fresher water toward the North Atlantic. Fresher water exits into the Atlantic via [narrow gateways](#), while warmer, saltier water enters from the Atlantic through the Fram Strait. Meanwhile, six of Earth's largest [rivers](#) drain into the Arctic Ocean—nearly one tenth of the planet's annual freshwater river flow into the oceans. The fresh water, less dense than salty seawater, lies in a thin lens on the surface, atop a saltier, denser water layer known as a halocline (from the Greek words for “salt” and “slope”). The halocline acts as a barrier shielding sea ice from warmer, yet denser waters incoming from the Atlantic. In the deep Arctic “bowl,” waters don't mix up and down much, helping to maintain the halocline.

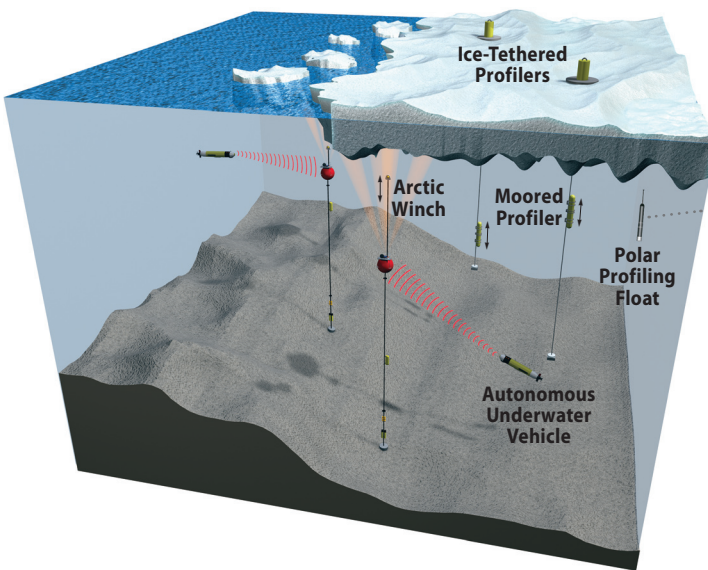
Diminished Arctic ice has far-reaching impacts.

- Ice acts as an “air conditioner” for the planet, [reflecting about 70 percent of incoming solar radiation](#); a dark, ice-free ocean absorbs about 90 percent, which further accelerates warming.
- An [ice-free Arctic Ocean](#) opens possibilities for increased shipping, oil and gas exploration, and [fisheries](#).
- An ice-free Arctic Ocean will intensify [military operations](#) in this strategic part of the globe.
- Decreased ice has major impacts on the Arctic ecosystem, from algae growing on sea ice at the base of the food chain to [whales and Inupiaq](#) people at the top. Ice also provides hunting platforms critical for the survival of [walrus](#) and [polar bear](#).
- Melting ice adds fresh water that can flow into the [North Atlantic](#), shifting the density of its waters, and potentially leading to ocean circulation shifts and further climate change.
- Accelerated input of [Greenland ice](#) into the ocean means higher, faster sea-level rises.
- [Thawing permafrost](#) increases coastal erosion and damage to roads, buildings, and pipelines. It releases the greenhouse gas methane, and toxic and other materials into the environment, according to the Intergovernmental Panel on Climate Change.



What do we need to do?

- Understand the oceanographic processes that might [weaken the halocline](#) and [monitor stratification](#) across the Arctic Ocean to see if the halocline is eroding.
- Understand the air-sea interactions that cause “flywheel of the Arctic,” the [Beaufort Gyre](#), to alternately accumulate fresh water and release it to the rest of the oceans, and monitor how the system may be changing.
- Monitor the extent of [fresh water exiting the Arctic](#) into the



Overcoming the ice barrier

Accomplishing these tasks requires fundamental and sustained observations of the ocean-atmosphere system, above and below the ice, with real-time networks for distributing data and assimilating them into ocean-climate models. Historically, the Arctic region’s ice cover, remoteness, seasonal darkness, and extreme weather has deterred researchers from bringing instruments to the Arctic, leaving them there, or getting them back. Over the last decade, scientists and engineers at Woods Hole Oceanographic Institution (WHOI) have developed and successfully deployed several different instruments and systems for long-term monitoring in ice-covered oceans.

The Moored Profiler

Moorings anchored to the seafloor monitor single, strategic locations over long times. A “profiler” device equipped with sensors, slowly moves up and down a wireline, measuring seawater temperature and salinity, the direction and speed of currents, and in the near future, chlorophyll, particles, solar radiation, and other important ocean properties that provide evidence of changes in the ocean’s ecosystem.

The Arctic Winch

To reach up and take measurements in the thin Arctic surface layers critical to the halocline—while minimizing the risk of the mooring getting smashed or dragged away by ice—WHOI engineers developed the Arctic Winch. At regular intervals,

- North Atlantic, which could [disrupt Atlantic and global circulation](#) and lead to more extensive climate change.
- Learn how changes in the Arctic ice cover are affecting the ecosystem from [algae](#), to [copepods](#), [whales](#), and [humans](#).
- Monitor and analyze [melting patterns on Greenland](#) to determine the stability of the ice sheet and its susceptibility to rapid disintegration.
- Determine the extent and effects of [melting permafrost](#).

the mooring’s top float releases a buoyant sensor package that rises on a tether toward the surface. If the package encounters ice, a pressure sensor triggers a winch to immediately reel it back down, out of harm’s way.

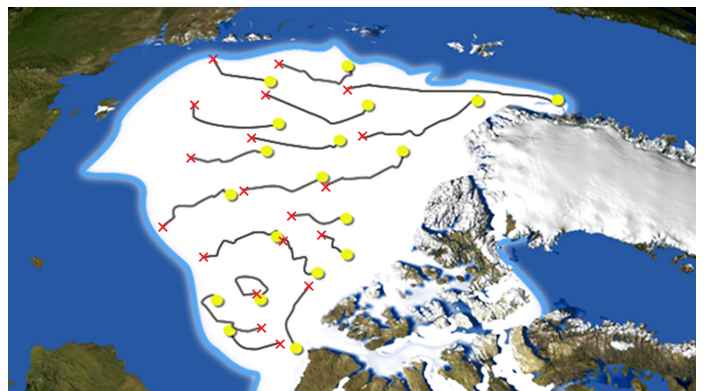
Polar Profiling Float

In the late 1990s, scientists developed floats that drift through the depths, programmed to rise slowly every few days, measuring water temperature and salinity on the way up. At the surface, they transmit data via satellite to shore-based labs. For an ocean with an icy lid, WHOI scientists developed a float with a hard antenna to withstand bumps against the bottom of ice floes. If they rise and hit ice, they are programmed to sink down and try again, until they find open water.

[Autonomous Underwater Vehicles](#) are being developed for under-ice operations to make observations between moorings.

Ice-Tethered Profilers (ITPs)

Anchored to ice floes, ITPs dangle a long wireline through an ice hole. A Moored Profiler device equipped with sensors, slowly moves up and down the wireline, measuring seawater temperature and salinity and other important ocean properties that provide evidence of changes in the ocean’s ecosystem. Data is relayed up the wireline to a transmitter atop the ice and then via satellite, in near-real time to a publicly accessible [Web site](#).



Ice-Tethered Profilers (●) drift with the ice from the points where they are deployed (×). They are designed to last three years, about the lifespan of the floes supporting them. Since 2004, WHOI has built and deployed 10 ITPs, along with eight others in 2007 with international colleagues. The team is working toward a goal of spreading and sustaining a [network of as many as 20 ITPs](#) distributed over the Arctic Ocean. A model simulation (above) shows how a strategically deployed ITP network would provide Arctic coverage.