ANTARCTIC SEA ICE

Nilas is an early stage of sea ice that forms under calm conditions.

Pancake ice forms under turbulent conditions.

Ice floes may be pushed together forming ridges and blocks.

Photos courtesy of the ACE CRC Sea Ice Project.

Key Points

- Antarctic sea ice is highly seasonal, covering about 19 million square kilometres near Antarctica each winter. Approximately 80% of this ice melts in the summer.
- Sea ice plays a critical role in both global climate and Southern Ocean ecosystems.
- It increases the Earth's surface reflectivity and reduces the amount of solar radiation absorbed by the ocean.
- Sea ice is an insulator that greatly reduces the exchange of heat between the ocean and the atmosphere. Open areas in the sea ice and areas of thin ice allow greater heat exchange and are very important in regulating local and regional climate.
- The formation and melting of sea ice plays a major role in the global overturning ocean circulation that helps distribute heat around the Earth.
- Changes in the amount of sea ice may slow the overturning circulation, decreasing the ocean's ability to absorb atmospheric carbon dioxide and affecting the distribution of heat around the globe.
- Algae that grow in brine trapped in sea ice are a critical food source for krill larvae in winter. Changes in sea ice extent or thickness may affect the abundance and distribution of krill.
- Changes in krill populations may impact organisms higher up on the food chain because krill are a major food source, directly or indirectly, for other animals such as seals, whales, penguins, fish and squid.
- Sea ice extent in the Arctic has been declining rapidly over the past few decades. Although there are currently no clear trends in the extent of Antarctic sea ice, numerous climate models agree that Antarctic sea ice will decline in the future.

What is sea ice and how does it form?

The freezing temperature of water depends on the amount of dissolved salts (salinity). Normal ocean water, with a salinity of about 3.4%, begins to freeze when temperatures reach about -1.9°C. The ice may have very different characteristics depending on its stage of development and the conditions under which it evolves.

Tiny ice crystals, known as ***frazil***, begin to form in the surface waters when the freezing temperature is reached. These ice crystals are mixed through the top few meters of water, forming slicks of ***grease ice*** that give the sea surface an oily sheen. Under calm water conditions, the grease ice will develop into smooth uniform sheets called ***nilas***. If the water is turbulent, grease ice aggregates into irregularly shaped ice patties called ***pancake ice*** that may be up to several metres across. As the ice continues to develop, the pancakes are pushed into and on top of each other by wind, waves and currents, eventually resulting in large solid ***ice floes*** known as ***pack ice***.

The pack ice is a dynamic, constantly changing environment. It is constantly moved about by wind and currents, sometimes over distances of thousands of kilometres. The ice may be stretched and broken, forming features such as ***leads*** (long linear gaps) or ***polynyas*** (large persistent patches of open water). Pieces of ice are also pushed together and piled up, creating ridges of jumbled ice blocks.

About 80% of Antarctic sea ice melts each summer, from a winter maximum of around 19 million square kilometres to a summer minimum of about 3 million square kilometres. This seasonal change is extremely important to both global climate and marine ecosystems.

Why is sea ice important?

Influence on the global climate system

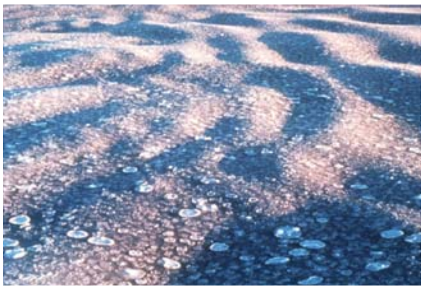
The Earth's global average surface temperature is regulated through the amount of radiation received from the sun, the amount reflected back to space (***albedo***) and the ability of atmospheric gases such as water vapour and carbon dioxide to absorb heat (the ***greenhouse effect***). Sea ice reflects from 50% to 95% of the solar radiation that reaches it, depending on the age and the snow cover on it. Open water only reflects about 8%.

Changes in the extent of sea ice can lead to a positive feedback loop: More ice = more reflection = lower temperature = more ice formation. Conversely, less ice cover means more solar energy is absorbed by the ocean, leading to further melting and more open water. Water is very effective at storing heat, so massive melting in one season can add enough heat to the system to prevent ice formation the next season.

Sea ice moderates local climate extremes because it releases heat when it freezes and absorbs heat when it melts. This effect is especially pronounced at the edges of the ice. Sea ice also affects the regional climate when it drifts away from the area where it formed, redistributing heat and fresh water.

Sea ice functions as a physical barrier to the exchange of heat, gases and particulate matter between the ocean and the atmosphere. It prevents the exchange of heat from the ocean water to the surrounding air. Open areas in the sea ice and areas of thin ice allow greater heat exchange and are also very important in regulating local and regional climate.

The seasonal formation and melt of sea ice is the dominant factor controlling the salinity and density of surface ocean waters in the polar regions. As sea ice forms, salt is discharged into the water and heat is given off to the air. The addition of salt to the water underlying the ice increases its density, allowing it to sink and contributing to the global ocean circulation pattern known as the 'overturning circulation' or the 'global conveyor belt'. This circulation is critical in the distribution of heat, gases and nutrients needed by marine ecosystems around the Earth.



Pancake ice dampening swells in the Southern Ocean

Influence on marine ecosystems

Sea ice starts to form in autumn, when there are still substantial concentrations of microorganisms in Antarctic surface waters. Some of these organisms become trapped within the ice matrix and start growing, forming ice-associated communities that are dominated by algae. The algae and other organisms are released to the water column in the spring as the ice melts. These contribute to algal blooms along the ice edges.

Sea ice microbial communities provide an important food source for marine herbivores during winter and early spring, when there is little other food in the water. In certain areas, researchers have noted a close relationship between the extent of winter sea ice and the subsequent recruitment and abundance of Antarctic krill (*Euphausia superba*). Krill, especially larvae and juveniles, have been observed feeding on the sea ice communities on the underside of the ice, particularly in late winter.

Krill are small shrimp-like animals that are a major food source, directly or indirectly, for other animals such as seals, whales, penguins, fish and squid. Changes in sea ice thickness or extent could have a significant effect on krill populations or distribution that could, in turn, affect organisms higher on the food chain.

What is happening to Antarctic sea ice?

Satellite records show that mean winter sea ice cover has declined by about 2.6% per decade over the past 27 years in the Arctic, while the minimum summer extent has decreased even faster. In Antarctica, no discernable trends have been documented for the continent as a whole, although there have been noticeable decreases in sea ice extent around the Antarctic Peninsula.

It is possible, however, that Antarctic sea ice may be changing more in thickness than in extent. To date, there are few broad-scale data about sea ice thickness and this is a key area of research for the ACE CRC and others. In addition, a summary of climate models from the Intergovernmental Panel on Climate Change indicates that sea ice extent in Antarctica will decrease in the future, perhaps by as much as 50% by the end of the 21st century.