ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

FACT SHEET

OUR CURRENT KNOWLEDGE OF Sea ice

What is sea ice?

Floating ice that forms from freezing ocean water is called sea ice. That distinguishes it from other kinds of ice, such as ice sheets, ice shelves and glacier ice, which form on land from freezing precipitation. Nowadays seasonal and multi-year ice can be found in areas at high latitudes, i.e. in polar regions.

The extent and thickness of sea ice vary with the seasons. In austral winter, when an extensive sea ice cover spreads over the Southern Ocean (Antarctica), up to ten per cent of the global oceans are covered with sea ice. In the course of the subsequent summer, however, this ice cover melts almost completely.

This photo shows young Arctic sea ice in the Northern Fram Strait. The ice floes had been formed during winter. On average they are 0.9 metre thick. (Photo: S. Menze, AWI)

In the northern hemisphere (Arctic) the extent of sea ice normally reaches its maximum towards the end of winter, in March. Part of the sea ice melts in the following summer months; and the Arctic ice cover shrinks to a minimum, which it normally reaches in September.

How has the Arctic sea ice changed in recent decades?

- The extent of Arctic sea ice reached its all-time observed minimum in September 2012. Overall, since 2007 the extent of summer sea ice has been less than in all previous years since the beginning of satellite observations.

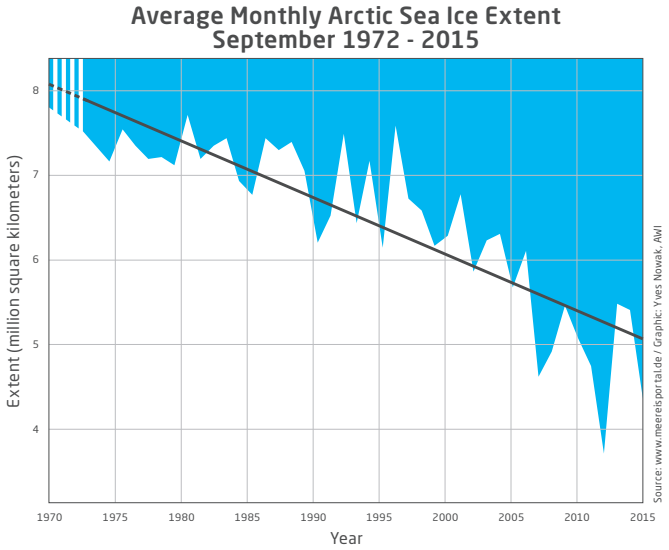
- The thickness of sea ice has declined significantly. The most frequently occurring sea ice thickness during the summer was approx. 3.0 metres in the 1960s, over 2.0 metres in the 1990s and about 0.9 metres in the last two years.

- Sea ice thickness and extent indicate a substantial decline in the ice volume in the Arctic. According to the latest estimates, this decline is approx. 4,300 cubic kilometres in autumn and about 1,500 cubic kilometres in winter if one compares 2011 with the

years 2003 to 2008. In the winter of 2013/2014 the European research satellite CryoSat-2, however, observed an increase in ice volume. There are various explanations for this observed increase: a generally cold winter in the year 2013 in the Arctic, a higher compression of the sea ice, or a potentially falsifying influence of the snow cover on the measurements of CryoSat-2. Undisputed is, however, that the sea ice volume increased in the winter of 2013/2014 compared to the previous years. The various explanations merely differ in the dimensions they attribute to the increase in ice volume.

- The proportion of old, multi-year sea ice is declining rapidly. At the end of 2012 this previously dominating part had dropped to less than 50 per cent. Consequently there is now significantly more seasonal ice that forms in winter and does not survive melting in the following summer. In addition to the mere age of the ice, this development shows a substantial change in other physical properties of the sea ice.

- First-year sea ice is covered with melt ponds to a greater extent in summer than multi-year ice. For this reason the amount of sea ice that is covered with melt ponds over the summer is increasing because there is more melt water and it spreads in area to a greater degree. As a result, the ability of the ice to reflect solar energy (albedo) diminishes. At the same time, the amount of energy that is absorbed inside or transmitted into the ocean rises. This feedback reinforces melting.



This graph is based on the most recent sea ice data. However, the final data for the sea ice minimum of September 2015 was not yet available at the editorial deadline of this fact sheet, which is why the minimum is indicated as a range of values.

The development in the southern hemisphere: What do we know about the status of Antarctic sea ice?

- The extent of sea ice in the Antarctic varies greatly from region to region. While the sea ice cover in the Amundsen / Bellingshausen Sea is declining considerably, other regions display an increase. Overall, the extent of sea ice in the Antarctic is currently rising slightly so that new maxima of sea ice extent (since the beginning of satellite observations) are observed.

- Even though there are still no large-scale, long-term measurements of sea-ice thickness in the Antarctic, we conclude from different studies that the total volume of Antarctic sea ice has increased in recent years.

- The reasons for these sometimes surprising observations are still the subject of various research projects. A substantial natural variability and changes in the wind are currently considered the main reasons. A further potential explanation that is discussed is the increased occurrence of melt water from the Antarctic continent, which freezes faster than sea water.

- Antarctic sea ice is still characterised by a very thick and heterogeneous snow cover. This is in contrast to the Arctic. The snow cover and complex processes in sea ice formation and melt on the top surface of sea ice make large-scale measurements (e.g. from satellites) of the thickness and other physical properties of Antarctic sea ice difficult.

For large scale measurements of sea ice, AWI scientists apply their sea ice thickness sensor EM-Bird. It is tied to a helicopter or research aircraft, which tows the device across the ice. Since the sensor has to fly 15 meters above the ice floes, these measurement flights are a big challenge for the pilots. (Photo: S. Hendricks, AWI)

What are the consequences of the changing Arctic sea ice?

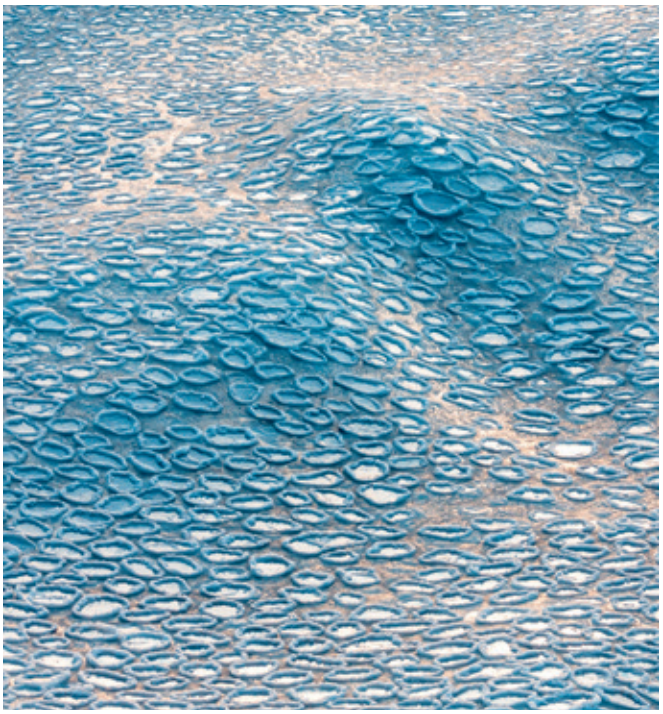
- Thinner and less compact sea ice is subject to higher dynamics. For instance, it is carried away faster and more easily by wind and ocean currents. As a result, transport

processes accelerate in most regions of the Arctic.

• The decline and changing properties of sea ice have a direct impact on the ecosystem since both sea ice and the ocean underneath represent a major habitat. But it is still subject of various research projects to study the impact of these changes for different organisms and the productivity of the system as whole: How do more open water, a greater supply of light in and under sea ice, and changes in ocean temperature and salinity influence the habitat?

• As sea ice diminishes, the Arctic Ocean increasingly opens itself to economic use. A rise in shipping traffic and extraction of resources are expected. This is extremely risky for the ecosystem, however. There are numerous open questions with regard to the ecological and climatic impacts, safety aspects and disaster management, and the predictability of such activities.

Paradoxes / surprising features



Before Antarctic sea ice forms big heavy ice floes, one can see this so called pancake ice. Step one in the process of sea ice forming in the Southern Ocean. (Photo: S. Hendricks, AWI)

• The area covered by sea ice in the Southern Ocean (Antarctic sea ice) has expanded in recent years although the Polar Regions are warming to a considerable extent.

• Antarctic sea ice is covered with snow throughout the whole year while snow on Arctic sea ice melts completely every summer.

• Melt ponds characterise Arctic sea ice in summer while they occur rarely in the Antarctic. These ponds were always a characteristic of Arctic sea ice in summer, but now they occur earlier, longer and cover larger areas.

• Arctic and Antarctic sea ice differ in terms of properties and interactions with the atmosphere and ocean. Thus, they react very differently at present.

• The extent of Arctic sea ice in winter is also declining as compared to the previous years, but slower than in summer. However, it is important to mention that the Arctic Ocean will be completely covered with sea ice in winter in the future as well.

• Sea ice and snow on sea ice usually warm and melt faster on cloudy days than on days with clear sky.

What contribution does AWI make to an understanding of sea ice as a central element of climate and ecosystem research?

• Bipolar (Arctic and Antarctic) sea ice research has been one of the core topics and competencies of the Alfred Wegener Institute since the institute's existence. Our current sea ice research primarily stands out by its diverse methodology and inter-disciplinary aspects. It involves observations and model calculations on different spatial scales and is conducted in close cooperation with biologists, physicists, geochemists and geologists.

• The Alfred Wegener Institute has unique time series from the Arctic and Antarctic sea ice regions. At present AWI's main topics in the field of sea ice physics are studies on the thickness of sea ice and its snow cover as well as the physical properties of snow and sea ice. In particular, we are currently engaged in conducting ice thickness and radiation measurements.

• An outstanding and, to a certain extent, unique

AWI sea ice physicists unload a Polarstern helicopter to investigate an Arctic ice floe and its snow cover. (Photo: M. Schiller, AWI)

research infrastructure allows us to implement extensive, regular observational programmes that examine the entire interaction of ocean, sea ice and atmosphere. The use of modern research equipment and research platforms, such as aircraft and helicopters, towed sensors, underwater vehicles and autonomous measuring stations plays a major role.

- Our model simulations focus on seasonal and decadal investigations aimed at enabling better forecasting of the state of sea ice.

The German research vessel Polarstern has stopped next to a huge ice floe during one of its expeditions into the central Arctic. In the foreground one can see a melt pond, which has formed from melt water. (Photo: S. Hendricks, AWI)

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