

Current Ocean
Study
3:

ARCTIC SEA ICE: DECADES OF MELTING

1. Print this file. Also answer the "Concept of the Week" questions in the *Weekly Ocean News* File. (Check for additional *News* updates during the week.)
2. Complete the Investigation by responding to the *Chapter Progress Questions* (*Study Guide* binder), the Investigations 3A and 3B from the *Ocean Studies Investigations Manual*, and this *Current Ocean Study*.

Introduction:

The extent of Arctic sea ice has major climate implications. Because it reflects most of the incoming sunlight falling on its surface, sea ice keeps the polar region cool. When sea ice melts, the area of open Arctic Ocean water increases and so does the amount of solar radiation absorbed by the surface waters. The heated sea water in turn warms the overlying atmosphere. In addition, sea ice insulates warmer ocean water from the overlying colder atmosphere so that less ice cover increases heat flow from ocean to air.

The Arctic Ocean's summer melt season typically begins in March and ends in mid-September. The end of the melting season is marked by the occurrence of the year's minimum sea ice extent. The Arctic's annual minimum sea ice extent reached in early September 2011 provides further evidence of climate change affecting the Northern Hemisphere's higher latitudes.

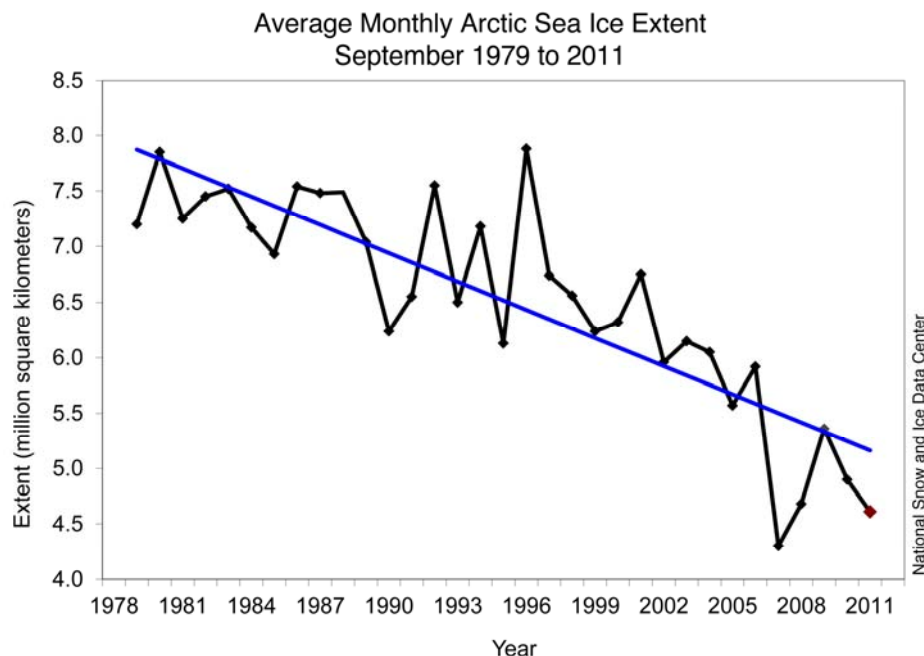


Figure 1. Arctic monthly September sea ice extent from 1979 to 2011. [NSIDC]

1. **Figure 1**, provided by the U.S. National Snow and Ice Data Center (NSIDC), shows the Northern Hemisphere September sea ice extent (areas covered by 15% or more ice) from 1979 to 2011. The graphed data indicate the lowest September average sea ice extent was observed in [(1995)(2007)(2011)].
2. The Figure 1 graph shows that the second lowest September average sea ice extent was observed in [(1995)(2007)(2011)].

The blue straight line of “best fit” on the graph highlights the overall downward trend in the Arctic sea ice extent. The monthly August sea ice extent over the 1979 to 2011 time period shows a decline of 12.0% per decade. This is consistent with the observed warming at higher northern latitudes over the same time period.

Optional: View an animation of the annual Arctic sea ice extent minimum from 1979 to 2011: http://nsidc.org/sotc/sea_ice_animation.html. The magenta lines in the images place the 1979-2000 median position of the ice edge. A NASA animation of the 2011 melt season is located at: <http://earthobservatory.nasa.gov/IOTD/view.php?id=52230>.

Figure 2 depicts Arctic Ocean and Greenland ice on 13 September 2011. Light blue shows ocean surfaces essentially ice free. [Satellite data were unavailable in gray areas.]

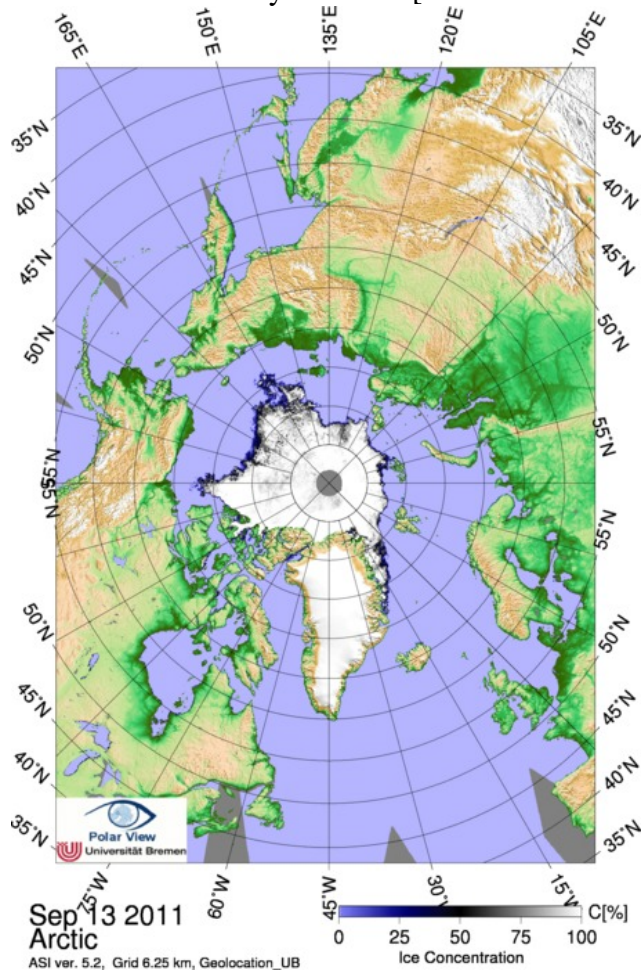


Figure 2. Satellite view depiction of ice in the Arctic Ocean on 13 September 2011. [University of Bremen Institute of Environmental Physics, Germany]

3. Figure 2 shows ice covering the Arctic Ocean in a broad area roughly centered on the North Pole and affixed to Greenland. It also shows [*some ocean ice bridging to the North American mainland*]*(some ocean ice extending to the Russian mainland)**(no ocean ice bridging to either the Russian or North American mainlands)*. [If your knowledge of the Arctic is a little rusty, go to: <http://geology.com/world/arctic-ocean-map.shtml>.]

The Arctic Northwest Passage and the Northern Sea Route:

Enhanced melting of Arctic ice in recent decades has numerous impacts, including those on navigation. For hundreds of years, commodity traders have been trying to conquer the treacherous waters of the Arctic Ocean—aware of its potential as a lucrative northern shortcut between the Atlantic and Pacific Oceans, even if only for a few weeks each year. Figure 3 depicts the two navigation routes through the Arctic Ocean if adequate sea ice melting occurs.



Figure 3. Northwest Passage and Northern Sea Route open in 2011.
[Hugo Ahlenius, UNEP/GRID-Arendal]

The Northern Sea Route (also called the Northeast Passage) on the Russian side of the Arctic Ocean was first navigated in 1878 and the Northwest Passage through the Canadian Arctic Archipelago was first traversed in a single season in 1944 (although along a route where the water depth was not sufficient for commercial shipping). For the first time in hundreds, and perhaps thousands, of years, it was possible beginning in 2007 to travel between the two major oceans through open waters in the Arctic Ocean by one or both of the two different routes. From 2007 through 2011 both routes were open for at least a few days in late summer, except for 2009 when the Northern Sea Route did not completely open.

August 2010 marked the first time ever that a large commercial vessel traversed the Arctic Ocean. The Russian supertanker *Baltica* navigated the Northern Sea Route as it carried 70,000 tons of gas condensate from Murmansk (in extreme northwest Russia near the

Russian borders with Norway and Finland on the Barents Sea) to Ningbo, China. Reducing the distance travelled by 40%, the cost was estimated to be four times cheaper in terms of fuel and charter time than the conventional route to China.

August 2011 saw the large-capacity cargo ship *Bladimir Tikhonov*, shown in **Figure 4**, travelling the 2,200 nautical-mile Northern Sea Route from Murmansk to Cape Dezhnev at the easternmost tip of mainland Eurasia in 7.5 days. The ship carried over 120,000 tons of gas condensate. It was escorted by two Russian nuclear-powered icebreakers to ensure safety.



Figure 4. Tanker *Vladimir Tikhonov* completed Northern Sea Route transit on 30 August 2011. [The Maritime Executive, 1 September 2011]

The Northern Sea Route passage cut the time from port of departure to port of discharge (Thailand on this voyage) by half compared to the traditional route through the Suez Canal. The significant economic advantage confirmed the potential and strategic importance of using the high-latitude route.

If present ice-melt trends continue, navigation of the Arctic Ocean during summer is likely to become a common occurrence because ship routes between Europe and locations such as China, Japan, and Korea would be as much as 4000 km (2500 miles) shorter. Russia is showing its intent to make the Northern Sea Route a more attractive shipping choice by establishing emergency centers along its northern coast to service commercial traffic. By doing so, it is demonstrating that climate change is being taken seriously.

4. The first large commercial vessels to cross the Arctic Ocean have followed the [(Northwest Passage)](Northern Sea Route)].

Arctic Sea Ice Extent Melt Seasons Over the Years:

Figure 5 shows Arctic sea ice extent during August through December. The thick gray curve in the graph indicates the 1979 to 2000 average extent. The dashed line represents the record

year (2007) of minimum Arctic sea ice extent. The solid light blue line shows 2011 data from August up to 6 November.

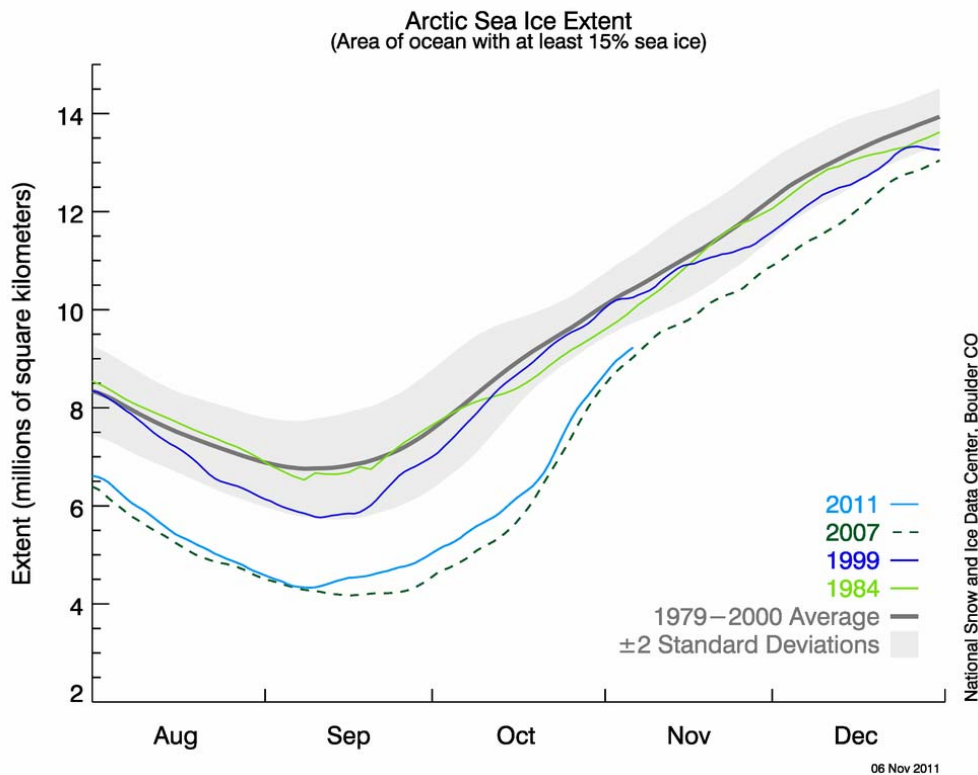


Figure 5. Arctic sea ice extent, August through December. [NSIDC]

5. According to Figure 5, [~~July~~](~~August~~)(~~September~~) is the month during which the lowest annual minimum Arctic sea ice extent occurs.
6. According to the 1979-2000 Average curve in Figure 5, the smallest area of sea ice extent during the Arctic melt seasons from 1979 through 2000 averaged [~~4.3~~](~~4.7~~)(~~6.8~~) millions of square kilometers.
7. During the time period covered by the graph, the record minimum Arctic sea ice extent occurred in 2007. This minimum extent was approximately [~~4.3~~](~~4.7~~)(~~6.8~~) millions of square kilometers.
8. The light blue curve representing 2011 data reached its lowest value on about 9 September. This indicated a minimum Arctic sea ice extent during 2011 [~~(near the 1979-2000 average)~~](~~very near the record minimum extent~~).

Note: The NSIDC concluded that minimum ice cover in 2011 occurred on 9 September. Its analysis placed the 2011 minimum ice cover to be slightly greater than the 2007 minimum. The University of Bremen Institute of Environmental Physics announced that its analysis indicated 2011 became the year with the lowest Arctic sea ice extent on record. The slight

differences in NSIDC and University of Bremen ice extent values arise from the different satellite sensors and sea ice algorithms employed in their determinations.

Summary:

The Arctic Ocean sea ice extent has major weather, climate, and marine ecosystem implications. A major component contributing to climate change involves changes in the character of Earth's surface. When the Arctic Ocean surface changes from ice to liquid, there are dramatic impacts on absorption of incident solar radiation and the interactions between ocean water and the atmosphere (e.g., storms, evaporation, clouds, wind).

The widely recognized Fourth Assessment of the International Panel on Climate Change (IPCC), *Climate Change 2007*, reported that the mean annual Arctic sea ice extent had decreased by 2.7% per decade since 1978, with the minimum annual Arctic sea ice extent decreasing by 7.4% per decade. As stated earlier, NSIDC and the University of Bremen report even greater rates of decline in Arctic sea ice extent based on observational data acquired into 2011. Also, the central Arctic sea ice thickness has decreased since the 1950s. Observations have confirmed that as the sea ice thickness decreases, the total mass of Arctic sea ice decreases even more drastically than the sea ice extent. There are various predictions indicating that the Arctic Ocean could be ice free in summer within decades, perhaps within a decade or two. Such a change will have profound effects on ocean conditions and circulation, weather, and climate, felt on local, regional, and global scales. These changes will impact societies (including more economical shipping routes) and ecosystems. Welcome to the future.

Instructions for Communications with Mentor:

Transmit this week's work to your LIT mentor by Monday, 13 February 2012, or as coordinated with your mentor. Include:

1. **Chapter Progress Response Form** from the *Study Guide* or the course website.
2. **Investigations Answer Form** for 3A and 3B from the *Study Guide* or course website.
3. **Current Ocean Studies Answer Form** from course website.

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