Scenarios for Energy and Resource Development on the North Slope and Adjacent Seas

Research and Monitoring Prioritization for the NSSI

Sea ice | Seasonal cycle and extent

Summary

The Beaufort and Chukchi Seas have experienced some of the greatest reductions in summer ice extent, reducing ice cover in the region by well over one half as part of an Arctic-wide reduction in summer ice over the past three decades. These trends are projected to continue, with a near-ice free summer Arctic Ocean by the second half of the century. Feedbacks and natural variability may temporarily halt this trend, adding uncertainty. Similarly, ice hazards will continue to persist in the Alaska offshore throughout the year as a result of pack-ice movement continuing to bring old, thick ice and icebergs. As a major climate regulator, important habitat, geologic agent along Arctic coasts and constraint on human activities and ecosystems, sea ice will likely gain in importance as a driver and key uncertainty throughout the century.

Changes in the extent and seasonal cycle of sea ice acts a driver affecting the duration and location of shipping activities, offshore exploration, and hazard risks for coastal and marine infrastructure. It also affects emergency and oil-spill response.

Overview

Sea ice is an important component of the Arctic and it is an important driver in regulating climate, maintaining healthy ecosystems, and impacting shoreline change. It also has major influence on people, both as a hazard and as a platform for different activities. The Chukchi and Beaufort Sea have experienced the largest reductions in summer ice extent and loss of multi-year ice in the Arctic over the past three decades (Fig. 1). Model projections indicate that this trend will continue, with little to no summer ice present in the Arctic by mid-century. Reconstructions of sea ice extent using proxy paleo records indicate that warmer temperatures and greatly reduced Arctic ice cover have occurred in the past. However, the current, accelerated rate of sea-ice loss exceeds past records and cannot be explained by natural variability alone (1).

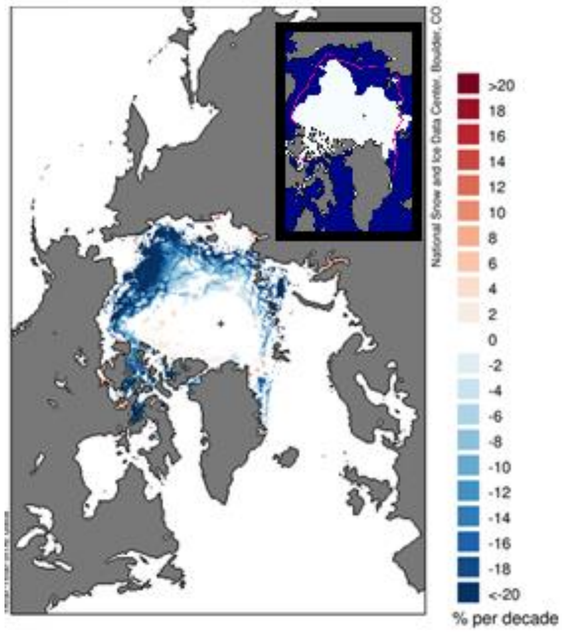

Figure 1. Sea-ice concentration trend for September (1979-2014; corresponding to summer minimum ice extent). Inset shows median ice edge (pink). Source: NSIDC, 2014.

Reductions in summer ice extent are more pronounced than winter ice extent, and are accompanied by a thinning of the Arctic ice pack, loss of multiyear ice and a speeding up of ice movement (2).

Ice conditions in Alaska waters

Summer ice extent is greatly reduced in the Chukchi and Beaufort Seas, with open water season length increased by several weeks, and an ice edge several hundred km to the North of the coast. While the presence of old, thick and strong multiyear ice has decreased, such heavy ice and glacier ice from the High Canadian Arctic still drifts into Alaska waters, with the potential of hampering offshore maritime operations. Winter ice extent (but not thickness) has increased slightly in the Bering Sea over the past three decades, mostly driven by a different wind regime in the North Pacific. Shorefast ice, lining the coast in winter, forms several weeks later in the year compared to three decades ago. Moreover, it is substantially less stable, with frequent break-outs and shifts that can impact a range of human activities (2).

Trends

Current trends for Arctic Sea ice show a consistent reduction in ice volume, age and sea ice extent (3). The September sea-ice extent has been declining at 13% per decade relative to the average extent from 1981-2010 (4). Sea-ice thickness has also been decreasing as observed by satellite and direct measurements (3), and documented in local observations of thinner sea ice (5). The proportion of multi-year ice and mean ice age are predicted to continue their decline in conjunction with the overall reduction in summer ice extent (3, 6). Climate models project near-complete disappearance of summer ice in the second half of the century (Fig. 2). Models deemed more accurate in representing Arctic Ocean conditions suggest a near-complete removal of summer (and hence multiyear) ice by mid-century (6).

Regional long-term predictions of ice conditions in the Alaskan Arctic are challenging because of greater uncertainty in simulations at a finer scale (7). However, even with a greatly reduced Arctic ice pack, remnants of heavy ice are expected to persist in the High Canadian Arctic and continue to drift into Alaska waters. Similarly, icebergs and ice islands from the disintegration of ice shelves and glacial ice in Canada's North will continue to pose a threat to maritime activities in the Chukchi and Beaufort Seas (2).

Uncertainties

A mostly ice-free summer Arctic Ocean is expected in the second half of the century. However, uncertainties inherent in the modeling approach and limitations in the predictability of the Arctic ice pack have a significant role in determining how soon this may occur, with estimates ranging from the 2030s through the 2080s for models that perform well in simulating Arctic processes (6, 8). Natural variability may both reinforce or counteract anthropogenic warming trends. Models suggest that until mid-century there is a 35% chance of a 10-year cooling episode due to natural variations overwhelming a global warming trend at the Arctic regional level (8). Uncertainties related to the impacts of sea-ice reductions include a lack of pan-Arctic local observations to extrapolate to ecosystem-level impacts and limited understanding of the role of feedbacks and complex interaction between ice, ocean, atmosphere and the biosphere. Uncertainties in the regulatory and economic environment and future technology also influence our understanding of sea ice as a driver of human-related activities such as future shipping activity, subsistence hunting, development of offshore infrastructure and the fate of oil spills in the marine environment.

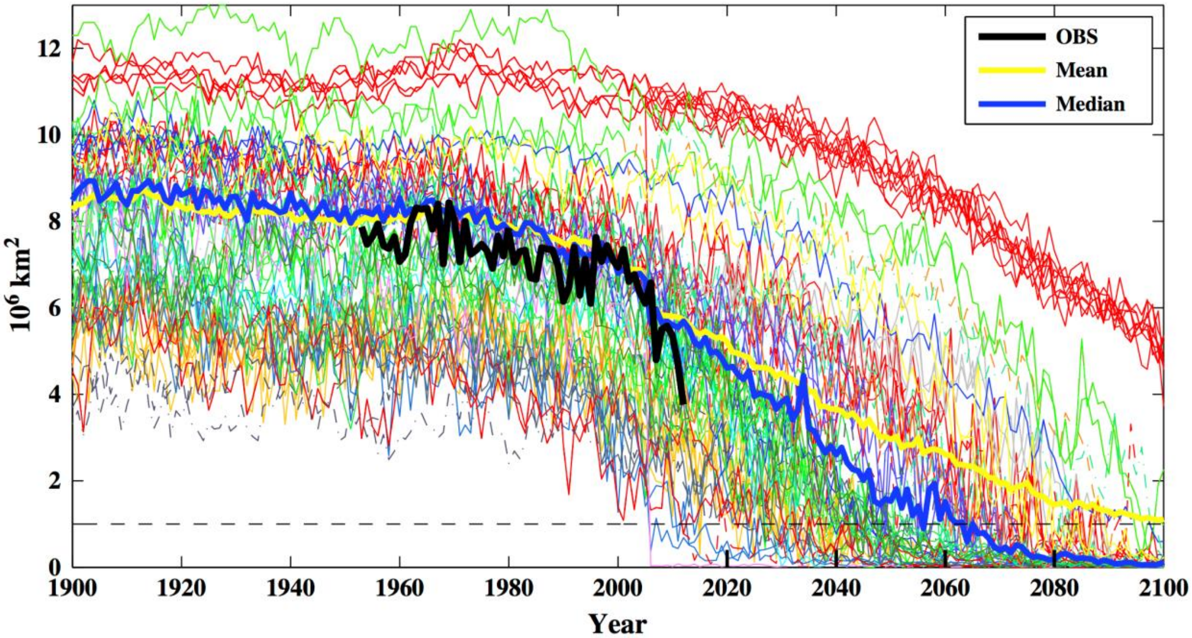

Figure 2. Projections of Arctic summer minimum ice extent (September) by a range of different climate models. Observations are shown as bold black line. Source: Overland & Wang, 2013 (6).

Driver interactions

Resource development and support activities

Impacts on human activities are mostly related to risks associated with sea-ice hazards. Shipping (including cargo, tourism, research, enforcement and potentially fisheries) and offshore resource exploration is mostly limited to the open-water season. However, pack-ice incursions will continue to pose risks even in summer (2). Similarly, coastal and offshore infrastructure may be damaged by impact from drifting ice, ice gouging and ice-push events. Activities conducted directly on the ice require stable sea-ice conditions to prevent loss of equipment and minimize risk to personnel. Sea-ice conditions are also an important constraint for emergency and oil-spill response, as well as subsistence hunting activities (2, 5). Reduced ice cover increases the vulnerability of exposed coastlines to storms and flooding events.

Other driver interactions

Ice-associated primary production plays an important role in marine ecosystems. A reduced ice cover with a shorter ice season directly affects marine productivity and carbon cycling. Further impacts include altered food-web dynamics and threats to ice-associated biota ranging from plankton to top predators. Ice-associated species such as walrus or polar bears may experience shrinking dispersal corridors, potentially isolating populations. At the same time, invasive species and diseases may displace resident species where ice used to act as a barrier. Terrestrial ecosystems may also be affected and observed trends for longer growing seasons, increased primary productivity and increased shrub abundance may continue into the future (9).

Monitoring efforts

Basin-scale remote sensing of ice extent and movement helps track evolution of the ice pack in response to climate change. Sea ice monitoring data from NOAA and NASA are available from the National Snow and Ice Data Center. Ice thickness and energy budget measurements are more challenging and generally lacking, as are measurements of ice hazards at the local and regional scale.

Community-based monitoring and observations can help link changes in the ice cover to impacts on people and ecosystems. In addition, a significant amount of ongoing ice hazard monitoring is associated with measurements of strudel scour, over flood, and ice gouging but not much is getting consolidated in a comprehensive database.

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For more information please contact:

Dr. Olivia Lee | UAF - PI
olivia@gi.alaska.edu
(907) 474-6832
http://accap.uaf.edu/?q=projects

Dr. John Payne | Director, NSSI
jpayne@blm.gov
(907) 271-3431
www.northslope.org

Dr. Denny Lassuy | Deputy Director, NSSI
dlassuy@blm.gov
(907) 271-3212

Dr. Juan Carlos Vargas | GeoAdaptive Principal
jcvargas@geoadaptive.com
(617) 227-8885
www.geoadaptive.com