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Energy and Natural Resources

Hearing on
United States Artic Opportunities

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Thank you Chairman Murkowski, Ranking Member Cantwell, and Members of the Committee. I appreciate the opportunity to be here today to discuss Arctic climate change and new frontiers in Arctic climate research.

I am a professor in the Atmospheric Sciences Department in the College of the Environment of University of Washington. I am also faculty in the Program on Climate Change. My research focus is on climate and climate change in the high latitudes, especially involving ice. I use a variety of observations and models for my research, including sophisticated earth-system models. I have done fieldwork in the Arctic on land and sea ice and in the Antarctic on sea ice. I received the 2013 Rosenstiel Award for Oceanography and Meteorology and the 2013 Ascent award of the American Geophysical Union. I am a fellow of the American Meteorological Society. Last year, I was a Fulbright Scholar in New Zealand.

Recent Arctic Climate Change

Our climate has changed in many ways across the globe since pre industrial times. Global mean surface temperature has warmed about 1.5 F (IPCC, 2013). The oceans have also warmed substantially, especially the upper ocean at most latitudes

(Levitus et al, 2014; Abraham et al, 2013). The pace and characteristics of climate change are consistent with the scientific understanding of climate drivers due to human activities.

For a region of its size, the Arctic has experienced the fastest surface warming on Earth, particularly in winter (see Figure 1). In addition, the subsurface of the Arctic Ocean is warming faster than anywhere else on Earth.

Based on satellite observations for the 1979-2012 period, sea ice cover in the month of September has receded at a rate of 13% per decade, relative to the 1979-2000 average (Stroeve et al, 2012; see Figure 2). The area decrease in winter is smaller, at about 3% per decade. The thickness of sea ice has been monitored more sporadically, but observations show an overwhelming decline of a similar magnitude to the summer sea ice cover (Kwok and Rothrock, 2009). Arctic winters are still sufficiently cold to cause seawater to freeze and snow to fall. However, the ocean freeze-up is later, sea ice is younger (see Figure 3) and thinner, and more snow is falling into the open water (Hezel et al, 2012). Consequently, the sea ice does not insulate the atmosphere from the relatively warm ocean as well as it did in the past, especially in fall and winter before the higher ocean heat loss results in partial regrowth. This interplay explains why sea ice is retreating faster in summer than winter.

I have emphasized the loss of Arctic sea ice because it is an amplifier of climate change (Screen and Simmonds, 2010). Air warmed over the sea ice is transported towards the surrounding land masses, including Greenland, other ice caps, and regions with permafrost (Lawrence et al, 2008). The dominant contribution to global sea level rise today is from land ice mass loss (glaciers, ice sheets, and small ice caps) (Church et al., 2011), and sea level rise impacts humans at all latitudes. Loss of snow-covered area on land is an amplifier of change as well, though less so than is sea ice.

Arctic Climate Change Impacts

Warmer air masses over the Arctic in winter increase the likelihood of freezing rain and rain on snow, both can significantly disrupt transportation by automobile, snow machine, and by foot (McAfee et al, 2014). Caribou and musk oxen have difficulty walking and pawing through snow to reach food in winter, and large die-offs have occurred after rain on snow events (Grenfell and Putkonen, 2008; Rennert et al., 2009). Subsistence hunters suffer twice with difficulty traveling and a diminished population to hunt.

Thawing permafrost can damage roads, houses, buildings, and pipelines. Arctic tundra overlying permafrost has unique features, such as braided rivers and temporary thaw ponds and lakes known as thermokarsts. Thawing permafrost can at once make lakes more common and then cause them to disappear when the permafrost melts entirely (Smith et al 2005). Thawing permafrost leads to greater particulate runoff into rivers and into the Arctic Ocean, changing the mineral and nutrient cycle in the Arctic Ocean and affecting fish and marine mammals.

Arctic coastlines are experiencing rapid coastal erosion from a combination of thawing permafrost and greater wave heights and worse storm surges due to reduced sea ice (Barnhart et al, 2014). Regions with high ground ice content and low-lying coastlines, which are frequent along the north shore of Alaska, are particularly vulnerable. At Drew Point, Alaska, the duration of the sea ice-free season increased from 45 to 95 days between 1979 and 2009 (Barnhart et al, 2014; see Figure 3). Storms are particularly treacherous in autumn, where the offshore waters are now much more often sea ice free. Just east of Drew Point, the coast eroded over 60 feet in 2012 compared to an average of 22 feet in a year for 1955-1979 (Barnhart et al, 2014).

Sea ice loss is tied to greater absorption of sunlight, especially over continental shelves where loss of sea ice coverage in summer has been greatest. Some areas of the continental shelves have ice in the sediments that contain methane. Some studies have argued that methane is released at a greater rate when permafrost on land and/or ocean sediments thaw (Kort et al, 2012).

Sea ice is host to an array of organisms that are integral to Arctic ecology (see Figure 4). Most people realize it is a platform for polar bear foraging and seals to haul out and raise their young. Yet, in reality it is a much more holistic player (Post et al, 2013). When it melts, organisms living within the ice are released into the ocean precisely when light levels are highest and the ocean is most stable, so the released materials effectively seed the ocean bloom. Many fish and whale populations, important to human, are tied to the sea ice edge.

Arctic Research Program Examples and Gaps

Given the importance of sea ice today for transportation, shipping, and industry, there has been a concerted effort to forecast the sea ice conditions each summer since 2007. Researchers and operation forecast centers have been developing the forecasting systems to predict sea ice from a few weeks to a few years in advance. These systems are a blend of the methods used to predict atmospheric weather and longer-term climate signals. A few forecast systems have published retrospective forecasts, and they show skill at predicting Arctic-wide sea ice extent for at least four-month lead times. Drivers of sea ice conditions in the near term include the starting point of sea ice thickness and concentration and ocean heat content.

I co-lead a community effort known as the Sea Ice Prediction Network, which coordinates and leads scientists worldwide to improve sea ice prediction (Bitz and Stroeve, 2014). Many of us at the University of Washington are active participants. Weather forecasting has a half-century lead on sea ice prediction. There is much more we need to do to make these systems realize their full potential. An important component of our work is to find out what information is needed by stakeholders, including members of the public, industry, and governments. Our leadership team incudes experts on science communication and stakeholder engagement. With continued investments in observations and research, we could forecast optimal shipping routes and give coastal communities advanced notice of offshore sea ice type and the potential for damaging waves.

Arctic climate has a clear impact on the lower latitude ocean and atmospheric circulation. Researchers are actively exploring the extent to which a changing Arctic can influence the lower latitudes, with longer lasting cold air outbreaks as one possibility (Francis and Vavrus, 2012). In any case, when global forecast models include more realistic Arctic sea ice and other variables, forecasts improve in lower latitudes (Scaife et all, 2014; Jung et al, 2014).

Because the Arctic is highly responsive, human influences on atmospheric warming are a very important driver for Arctic environment predictions in the future after about 3 years. Environment outlooks in the 3-20 year range are valuable for preparing for new opportunities and challenges in the changing Arctic environment. Outlooks can also help us make decisions about what we want to avoid. The information could be used to plan for military vessel investments, economic opportunities, and resource management. While climate models have been used to predict multi-decade and century long Arctic change, they can be used to make more detailed predictions in the nearer term too (see Figure 5). New efforts should target this 3-20 year lead time and present information in all seasons. Investment are needed in model development and high-performance computing to predict a greater range of environmental factors, such as chemical cycling, near-shore sea ice conditions, biologic productivity, wave heights, and other small-scale processes.

Observations are essential to our ability to predict the Arctic environment. Observations at a process level and across the Arctic from remote sensing and in place are needed. An observing network of the Arctic Ocean, sea ice, and surrounding land is challenging to construct, but the pay off is clear.

University of Washington researchers have a history of developing innovative instruments to make measurements less difficult in the Arctic. Our scientists are developing robotic instruments such as seagliders (see Figure 6), an autonomous underwater vehicle (AUV) that can travel under ice for many days collecting and storing data taken down to about 3000 feet in ocean depth. Seagliders are reusable, propeller free, and use very low power.

University of Washington also has lead long-term ocean and ice monitor efforts at the North Pole and Bering Strait using ocean moorings to make hourly measurements at a fixed point from the surface to full ocean depth. The Bering Strait is a gateway of heat transport into the Arctic from the Pacific Ocean. Ocean heat content and sea ice immediately north of the strait respond sensitively to the ocean heat flow (see Figure 7). Our instruments monitor currents that are important to shipping in the strait. We also observe nutrients and ocean chemistry so we can understand factors that influence Arctic fisheries and marine mammals. These data are being used to validate models of the Arctic to improve our understanding of the Arctic environment and make better predictions.

Investments in Higher Education

The University of Washington has taken a leadership position in Arctic research, building exceptional depth and breadth in the natural and social sciences and policy. We are investing in an even stronger program with our Future of Ice Initiative, through new investments in faculty and facilities to accelerate research. A signature of the initiative is to create new opportunities that bridge disciplines. We have a new Arctic Studies minor and a graduate seminar that introduces students to interdisciplinary, policy-relevant themes. Our program is a model for investments that could be made in Arctic Studies in other universities. Learn more at http://ice.uw.edu

Investment in Arctic research is essential to a safe and productive future. Universities are a key player in Arctic research because they offer scientific excellence and expertise in wide ranging areas that are essential to new discoveries and progress in Arctic science. University scientists are uniquely able to include undergraduate students in the research program and educate a large population about the Arctic. In addition, universities and industry have an excellent history of collaborating to solve problems and develop new technology. However, the proportion of Arctic scientists in academic positions is small compared to other sciences owing to the high demands of field work in the Arctic. Investments in universities are particularly important to train the next generation of students and post-doctoral researchers in Arctic studies. It is important for universities to educate the next generation who will inherit the environment that we oversee today.

Figures

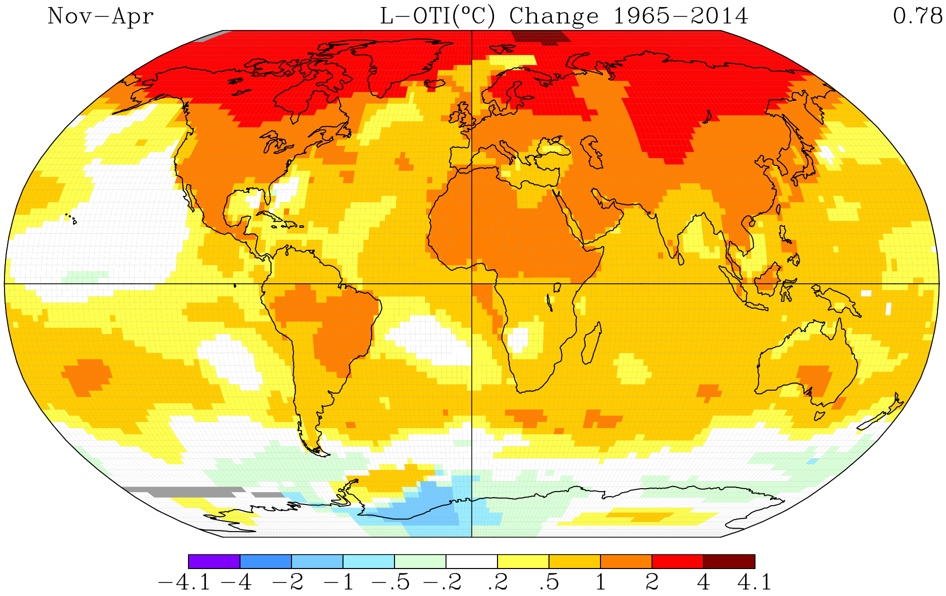

Figure 1. Surface temperature trends in degrees Celsius from 1965-2014 for November to April from the NASA GISSTEMP analysis. Generated on 26 Feb. 2015 from http://data.giss.nasa.gov/gistemp/maps/

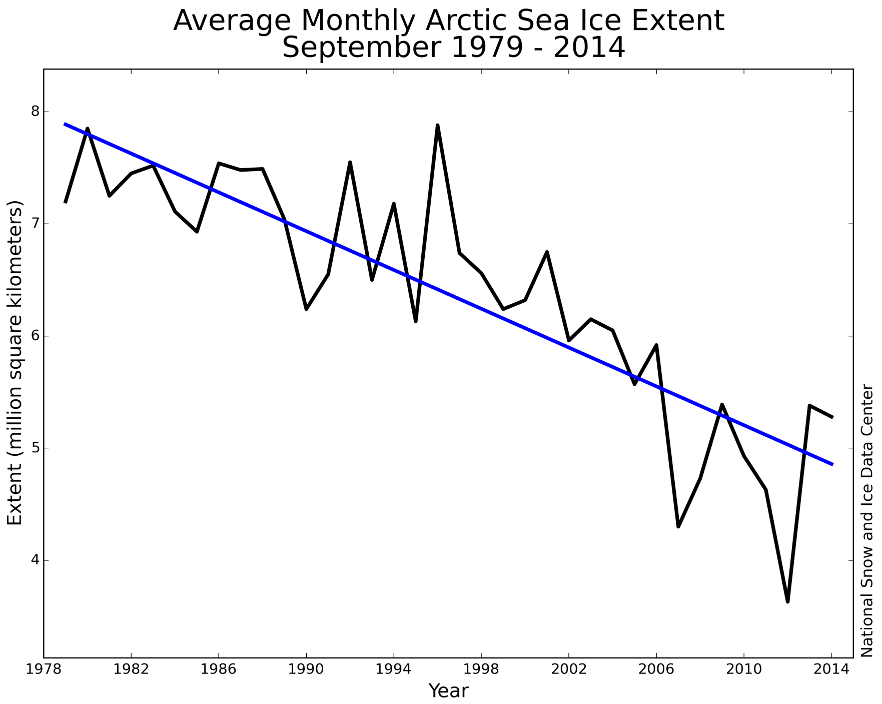

Figure 2. Arctic sea ice extent in September from 1979 to 2014. Data are from passive microwave satellite using the NASA team algorithm. Each of the lowest 10 years in this recard occured in the last decade. Figure downloaded from the National Snow Ice Data Center, retrieved 2 March 2015 from http://nsidc.org/arcticseaicenews/2014/10/.

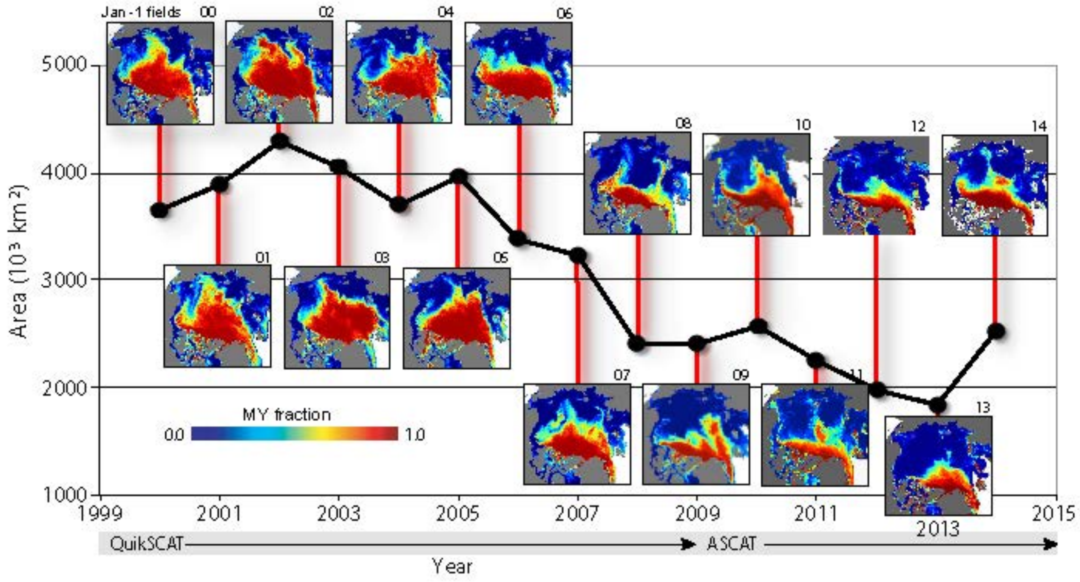

Figure 3. Fraction of Arctic sea ice in January that has survived the previous melt season. Data are from QuikScat (NASA) and ASCAT (EUMETSAT) satellites. Figure courtesy of Ron Kwok, updated from Polyakov et al (2011).

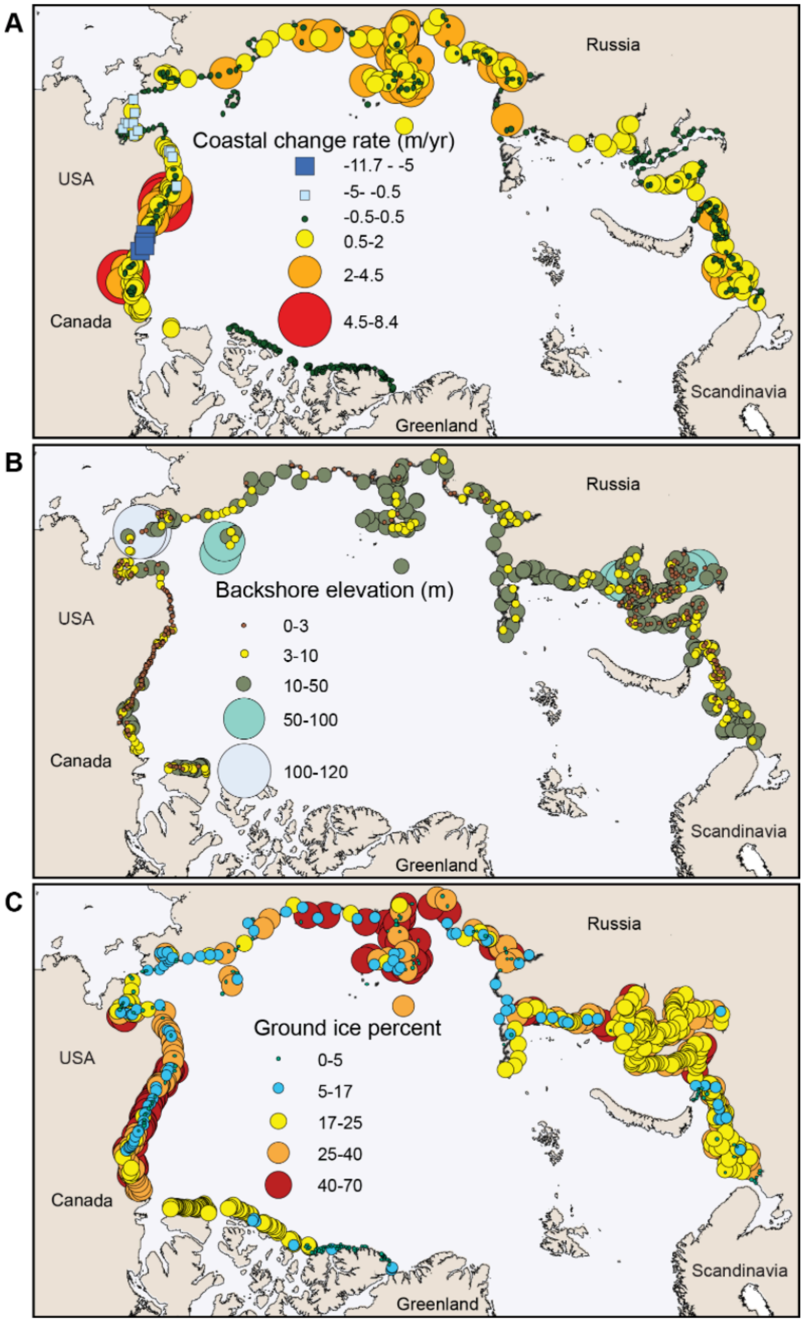

Figure 3. Coastal position change from erosion (positive numbers) and deposition (negative numbers) (a), backshore elevation (b), and ground-ice concentration (c) from Barnhart et al. (2014). Deposition occurs in northern Alaska near the Colville and Mackenzie River deltas. High backshore elevation or low ground ice content can reduce coastal vulnerability. Much of Northern Alaska has low backshore elevation and high ground ice content.

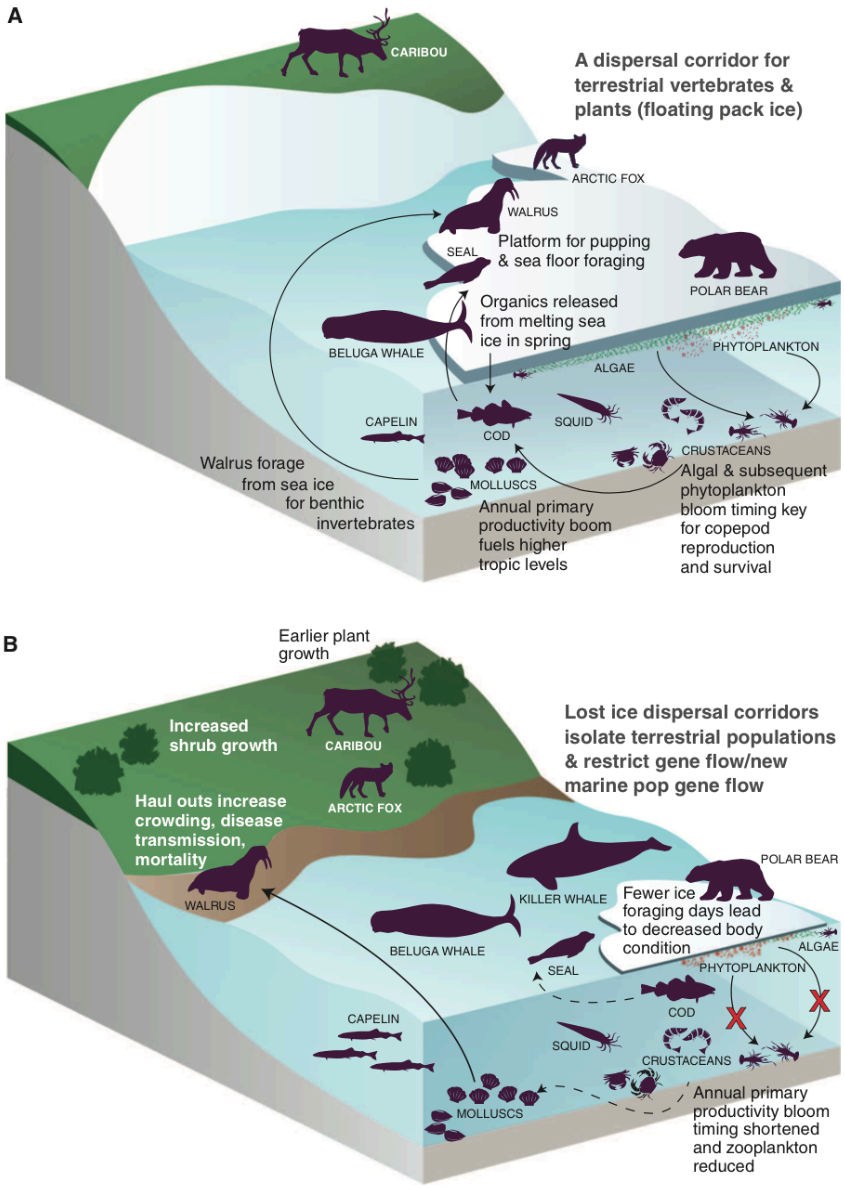

Figure 4. Ecological distribution of marine and terrestrial species influenced by sea ice (a). Outlook of distribution change in a warmer Arctic with diminished sea ice (b). From Post et al (2013).

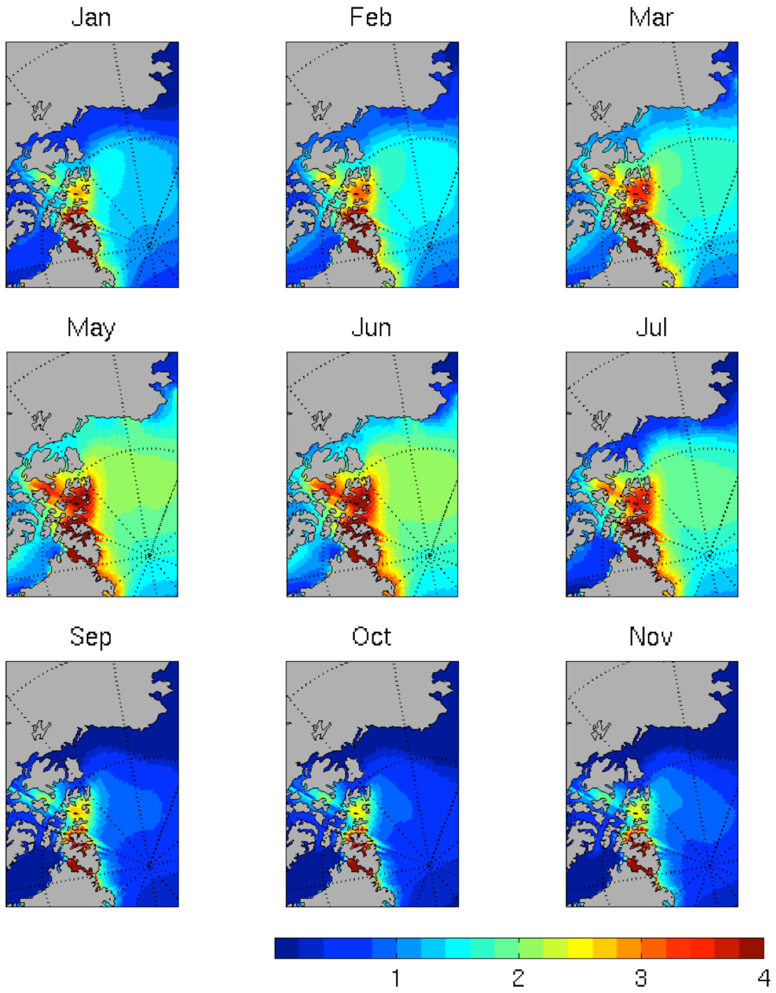

Figure 5. Sea ice thickness in meters along the Alaskan coast and Canadian Archipelago by month for 2023-2028. Predictions are averaged across a subset of models from global climate models from the Fifth Coupled Model Intercomparison Project that compare well with observations (Massonnet et al, 2012).

Figure 6. Sea glider tested under sea ice in the Davis Strait. Robotic instruments like these are making observations under ice that were previously impossible to gather. Photo courtesy of Craig Lee.

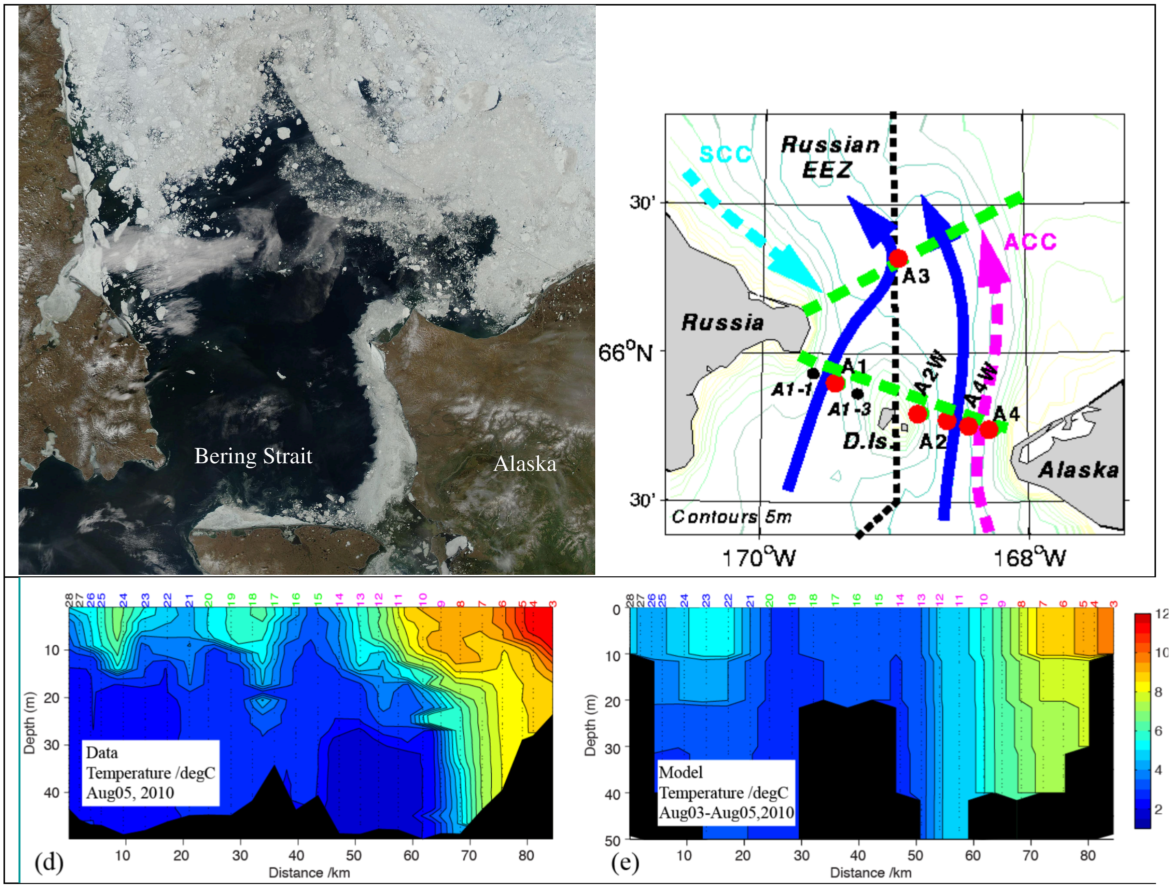

Figure 7. Bering Strait network of moorings (red dots in upper right panel) monitor temperature, salinity, and other parameters of seawater flowing through the strait. Heat transported into the Arctic through the Bering Strait is an important control on the sea ice extent to the north (upper left panel, 17 June 2013 from Modis, NASA Worldview). Temerature measured by the moorings is compared with a model in lower panels. Figure courtesy of Rebecca Woodgate.

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