Predicting and Preparing for a Changing Arctic

SUMMARY REPORT
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The U.S. is an Arctic nation, where significant economic, social and national security interests collide. The opening of the northern sea passage, the migration of species, the influx of fresh water and the changing ocean currents are the tip of the iceberg of Arctic change. On March 4th, Ocean Leadership convened a forum on Capitol Hill to discuss the state of knowledge, the information that is needed and how we can achieve the capacity to more accurately predict these changes.

The Forum featured distinguished speakers including:
- Fran Ulmer of the Arctic Research Commission
- NSF Director France Cordova
- Senator Lisa Murkowski (R-AK)
- Senator Angus King (I-ME)
- The President's Science Advisor, John Holdren
- Jack Omelak from the Alaska Nannuq Commission
225 participants including more than 25 members of the military, more than 65 congressional staff, and more than 100 federal agency representatives, in addition to leaders from the academic and industrial oceanographic community.

Panel Topics Included:

Forecasting a Changing Arctic
Scientists discussed the major physical phenomena such as sea-ice content, glacial melting, and the cycling of freshwater, carbon and nutrients that are essential to predict Arctic change.

Science Needs for Arctic Operations
The featured industry and military officials that operate in the Arctic spoke about the predictive tools needed to operate safely in a rapidly changing and unforgiving environment and about nation’s capacity to respond to emergencies and disasters in the Arctic.

Why the Arctic Matters to the Lower 48
Investigated how changes in the Arctic may impact those living in the lower latitudes including extreme weather events, coastal erosion and migration of species.

Throughout out the day, there was robust discussion and debate about what is known, what needs to be known and how can we garner this information and translate it in terms meaningful for government and the commercial sector.

Forum presentations, video, and summary on our website: www.oceanleadership.org
As Chair of the U.S. Arctic Research Commission, Hon. Fran Ulmer regards the Arctic as a complex geopolitical space. Most of the difficulty in regulating this area is due to the fact that the Arctic is an ocean surrounded by land; there are five coastlines that belong to eight different nations (Canada, Denmark, Finland, Greenland, Iceland, Russia, Norway, and the U.S.), who all have different ideas about how their Arctic should be used and managed. Hon. Ulmer stressed that the Arctic Council is not a treaty based organization and it does not issue executive orders, regulate a body, or make decisions. Instead, it simply acts as a forum that permits for a conversation to take place between the eight Arctic nations, six permanent participants (consisting of the indigenous people of the north), and 20 observers. The theme for the chairmanship of the Arctic Council is to “share challenges, opportunities, and responsibilities; one Arctic,” Hon. Ulmer emphasized. Also, the Arctic Council formed around two fundamental themes: protecting the environment of the Arctic and promoting sustainable development of the region. Hon. Ulmer admitted that the working group of the Arctic Council is where most of the crucial work of the Council is conducted.

Melting Arctic sea ice and thawing permafrost are some of the issues associated with a warming climate. However, change is not only environmental, “it’s also about changing economics,” Hon. Ulmer elucidated. The combination of globalization; an exponential increase in the Earth’s population; the demand for oil and gas; and the opening of the Northwest Passage have awakened people’s interest in the Arctic. Countries are plagued with the challenge of planning and preparing for these environmental and economic changes. Warming and changing ecosystems may create additional opportunities for fisheries in the Arctic. There are vibrant fisheries in areas of the Arctic, such as Norway and Alaska, but in many cases there is not enough research available to allow for responsible fishing to take place in the Arctic. To safeguard its fishing resources until further research is available, the U.S. placed a moratorium on fishing in the Arctic. Other economic issues are of worry for the Arctic region; “the elephant in the room,” as Hon. Ulmer put it, “is oil and gas.” A few years ago the U.S. Geological Survey (USGS) announced that 13 percent of the world’s undiscovered reserves of oil and 30...
percent of its natural gas remain in the Arctic. "This captured a lot of attention... where there is oil, there is opportunity that isn’t going to go away,” she warned. People are now concerned about how to best exploit these resources in a safe and responsible manner.

Hon. Ulmer also commented on the U.S. National Strategy for the Arctic Region, which has recently seen a tremendous “step-up” in activity and focus by the federal government of the U.S. Most interestingly, all of the Arctic nations have a national strategy similar to that of the U.S.; their main themes are to advance national security interests, pursue responsible stewardship, and strengthen international cooperation. Additionally, this year, Obama issued an executive order on Arctic coordination. In the U.S., federal agencies that possess federal Arctic research capacity or funding have been organized under the Interagency Arctic Research Policy Committee (IARPC). IARPC recently developed a five-year research plan that outlines what federal agencies need and plan to do to support their decision-making. Seven major research themes emerged from this plan: sea ice and marine ecosystems; terrestrial ice and ecosystems; atmospheric studies of surface heat, energy, and mass balances; observing systems; regional climate models; adaptation tools for sustaining communities; and human health. While much work still needs to be done at the national level, vast progress has already occurred in an attempt to coordinate the U.S. Arctic.

Hon. Ulmer also gave a brief overview of the two-year U.S. chairmanship of the Arctic Council. The U.S. Arctic chairmanship will focus on Arctic Ocean safety, security, and stewardship; improving the living conditions of the people of the Arctic; and addressing the impacts of climate change. Public diplomacy will also form part of Secretary Kerry’s goal for the U.S. chairmanship. “America is the only [country] of the Arctic eight that does not self-identify as an Arctic nation,” Hon. Ulmer explained. Most Americans are very detached from the Arctic; they associate the Arctic with Alaska, so it is “out of sight” and therefore, “out of mind.” However, Hon. Ulmer believes that today there is an opportunity for a teachable moment. People have to be taught that a melting Arctic will also directly impact the rest of
the world, including Americans. Public diplomacy is one step forward to helping Americans understand and care about the changes taking place in the Arctic.

“There’s a lot going on at every level, but what ties it together?” she asked. “There are a lot of shared opportunities, challenges, and responsibilities,” continued Hon. Ulmer. People at the national and international levels are putting systems in place to deal with safety issues and there is a shared interest in scientific research since gain of knowledge through research is important at every level for the Arctic. In closing, Hon. Ulmer advertised the Arctic Research Commission’s daily report as a way to stay informed on issues pertaining to the Arctic.
“Polar science matters to people everywhere on our planet,” Dr. France Córdova began, “and for this reason the NSF has been committed to supporting basic research in and about the Arctic for more than 40 years.” As part of their Arctic portfolio, NSF funds marine facilities, such as ships and submersibles, which permit scientists to conduct research in the Arctic. The NSF has recently purchased the Research Vessel (RV) *Sikuliaq* to specifically serve the marine science community in the Arctic. However, even with this new ship the NSF cannot fulfill all research needs in the Arctic and will continue to work with the U.S. Coast Guard and other agencies to ensure that the science community has cost effective vessels to access the Arctic. The Division of Polar Programs is responsible for coordinating NSF’s efforts in the polar region and the Division of Arctic Science conducts interdisciplinary research that requires international collaboration. This section expends about $100 million annually; $60 million of this amount is directly awarded to investigators, and $40 million towards logistics to enable their research.

The complexity of NSF programs lies in the variability of sites and projects available to scientists. To look at the breadth of NSF’s Arctic science programs, Dr. Córdova displayed an annual map of NSF’s Arctic field support sites. Field support at these sites entails ships, aircrafts, surface vehicles, and activities at fixed contemporary stations. NSF owns and maintains stations in Alaska, Russia, and Greenland and also partners with other agencies to support permanent research facilities elsewhere. Also, the Foundation’s sites are periodically altered to accommodate changing research priorities. For example, some sites support people in field stations while others are autonomous. “A broad geographic scope is needed to understand a rapidly changing Arctic system, but managing that within logistics and budget constraints is of course challenging,” she added.
In closing, Dr. Córdova spoke about NSF’s involvement in IARPC and the Distributed Biological Observatory (DBO). IARPC, which consists of principals from 16 agencies, departments, and offices across the Federal government, is charged with enhancing both the scientific monitoring of, and research on, local, regional, and global environmental issues in the Arctic. The DBO is comprised of several nations and U.S. agencies who have established a change detection array along a latitudinal gradient from the northern Bering Sea to the Barrow Arc. According to Córdova, this project is a perfect example of how different nations can come together under the IARPC umbrella to overcome the immense task of researching the Arctic Ocean and surrounding seas.


Featured Speaker

Senator Lisa Murkowski – United States Senate, Alaska

“Predicting and preparing for a changing Arctic...there is no question in my mind that we are seeing a change in the Arctic,” began Senator Murkowski. “How do you predict it? How do you prepare for it? And how do you deal with the reality of a changing Arctic?” she continued. The Arctic’s resources, increased shipping and maritime activity can bring benefits to America, however, there are many more aspects that still need to be understood for this region, such as basic atmospheric and climate interactions to understand the impacts of ocean acidification, and research into the technology and development that might help transform the region and its economies. Anthropogenic carbon dioxide is not the only process that will affect the acidity of the ocean; the Arctic will also have to face issues with river run off and melting ice. Ice retreat may permit for the introduction of invasive species into the Arctic. The Bering Strait is the only oceanic gateway between the Pacific and the Arctic, providing a corridor for northward bound invasive species. Additionally, new observations of ocean currents may bring pollutants up north, Sen. Murkowski warned.

Sen. Murkowski recognized the benefits and threats of the increased activity in the Arctic and admitted that America is underprepared to tackle the challenges (such as an oil spill) that this activity might bring. Alaskans understand the value of the ocean, “for those of us in Alaska, the ocean sustains us, it nurtures us, it feeds us, and it drives our economy. And we must manage our oceans with the environmental stewardship that is inherent on those who rely on its bounty,” said Sen. Murkowski. However, she stressed, “caring for the environment is not inconsistent with other goals to develop resources and create jobs.” Like the U.S., Canadian and Russian governments are also pursuing these ambitions to develop Arctic resources “and are aggressively moving in to achieve these goals.” The level of development activities and maritime commerce is active in the Arctic. Even non-Arctic nations are embracing opportunities that the Arctic has to offer with diminished sea ice. What’s worse is that non-Arctic nations, like Great Britain, had a larger presence at the Arctic Circle meeting than the U.S. did, Sen. Murkowski exclaimed. She hopes that the U.S. will begin to engage more seriously in the Arctic and will commit the necessary resources and infrastructure to make the Arctic a
national priority. At present, data about the Arctic is lacking; the U.S. will require accurate navigational charts, buoys, and ice monitoring systems to fill these gaps. “From the mapping perspective, I find it phenomenal that we have more detailed maps of the surface of Mars than we do of the Arctic,” she noted. As a first step towards mitigating these data gaps, Sen. Murkowski plans on introducing a piece of legislation that will develop an investment and solid building block to create charts for the Arctic. Investment in icebreaking capabilities is also a critical national asset. The U.S. Coast Guard requires a total of six (three heavy and three medium sized) icebreakers to fulfill its statutory mission in the Arctic, but it currently consists of two aging vessels, the USCGC Healy and USCGC Polar Star. “The Russians have 27 icebreakers. China has their second icebreaker under construction and have another six planned. Even India is considering building an icebreaker. We’re the richest and most powerful country in the world and yet we send a very poor signal when it comes to how we view our role in the Arctic,” Sen. Murkowski added.

Lastly, Sen. Murkowski spoke of the people who live and depend on the Arctic. A changing Arctic threatens the lives and property of people who live in the region. Winter storms that were once diminished by sea ice protecting the coast are now eroding the shoreline and causing damage to infrastructure. Energy and transportation costs are high in the Arctic, so relocation of Arctic communities can be challenging and costly. “More importantly,” Sen. Murkowski concluded, “we are dealing with a people who are resilient, proud, and strong and want to find ways to continue to live in a land that they and their families have inhabited for thousands of years. And they want economies that will allow them to continue to live there.”
Senator Angus King – United States Senate, Maine

Senator King kicked off his presentation with a NOAA video animation, entitled *Arctic ice age, 1987-2014*, about the movement and melting of old ice (or persistent ice). “The reduction of the sea ice has opened up an area [in the Arctic] about the size of the Mediterranean Sea,” said Sen. King. Among other political problems, countries still need to work out jurisdictional boundaries. Sen. King suggests that America prepare and invest in physical, social, and political infrastructure for the Arctic. Political infrastructure, such as the Arctic Council and the United Nations Law of the Sea (UNCLOS), will hopefully guide international decisions and norms so that nations may work in a “peaceful and non-competitive” way in the Arctic. Investing in physical infrastructure, such as icebreakers, is also a priority. Sen. King reiterated what Sen. Murkowski said about America’s poor icebreaking capabilities; the U.S. only has one operational icebreaker, which will not suffice to maintain transit routes through the Arctic.

Sen. King expressed concerns about climate change since it is an important component of the Arctic’s current and future state, and is also causing problems elsewhere in the world. “Climate change is abrupt,” Sen. King said worryingly, “the history of ice ages is not at all gradual. It is abrupt. It is a matter of a couple of decades... Maine was under 10,000 feet of ice 10,000 years ago.” A large proportion of the Earth’s freshwater is stored in Greenland’s ice sheet. If this ice sheet was to melt, Sen. King explained, the sea level would be expected to rise by 1-3 feet, which would annihilate most cities on the coast. Given these facts, Sen. King underlined the need for a collective effort to slow this process down by first developing green energy and moving away from the oil and gas industry. However, the changes currently taking place in the environment are due to persist for several decades so “the world has to adapt to the changes that are beyond our control.” This ability to adapt will be especially crucial for the Arctic where change hits the hardest. Several steps are necessary to move forward. First, “we have to raise the profile of the Arctic as an important region of the world, that’s why we have meetings like this,” Sen. King offered. Second, we have to build infrastructure, like...
icebreakers, and the Arctic will also need to be mapped. Third, UNCLOS will be
important. Fourth, we also need to develop a security strategy.

Sen. King remains hopeful that countries like Russia and the U.S. will be able to
work in the Arctic together, in a cooperative manner. A lot of countries have direct
interest in this region so nations need to initiate a conversation and raise
awareness about the Arctic. He ended with a profound statement by Abraham
Lincoln about how to deal with changed circumstances: “The dogmas of the quiet
past are inadequate to the stormy present. The occasion is piled high with difficulty,
and we must therefore rise with the occasion. As our case is new, so we must think
anew, and act anew. We must disenthral ourselves and then we shall save our
country.”
Dr. John Holdren summarized the U.S. national interests in the Arctic and reminded participants that the rights and cultures of indigenous peoples need to be accepted as an important part of this picture. “Everybody in the country recognizes that national defense, maritime safety, energy and economic benefits, environmental stewardship, and scientific research are important, but not everybody understands that we have an important set of peoples and cultures up there,” said Dr. Holdren. “From the stand point of cultural diversity and human rights it is important to preserve their existence and engagement in decisions that affect them.” Several Arctic policy and coordination efforts have been put in place over the past decade, explained Dr. Holdren. The U.S. Arctic Research Commission, IARPC, and the eight nation Arctic Council emerged in the 90’s. In more recent times, the National Security Policy Directive 66 and Homeland Policy Directive 25 established a regional Arctic policy. Also, National Ocean Policy and National Ocean Council were created by an Executive Order of President Obama in 2010. In an effort to further organize Arctic activities, the Office of Science and Technology Policy (OSTP) has been generating several reports on Arctic strategy. Notably, OSTP’s Arctic Research Plan will be released at five year increments. Arctic research has many dimensions, but Dr. Holdren noted that observing systems are most crucial stating, “we need more data, we need better monitoring systems, we need a denser network of sensors, and we need big data analytics to understand everything that is being measured.”

Dr. Holdren briefly discussed the implications of a rapidly warming Arctic before applauding the international Arctic GEOTRACES program, which uses the chemistry of the ocean to elucidate changes taking place in the Arctic. Through this program, scientists have discovered vital information about the distribution of trace elements that provide information about ocean circulation patterns, as well as changes in the ecosystem. This program is shedding new light on key oceanic processes and illuminating areas for future targeted studies.
Dr. Holdren wrapped up his address by focusing on Obama’s recent Executive Order on *Enhancing Coordination of National Efforts in the Arctic* (EO 13689) that led to the development of the Arctic Executive Steering Committee (AESC). The AESC is set out to improve communication, coordination, and effectiveness within federal agencies and departments with respect to the Arctic. More specifically, AESC is expected to help shape and reconcile priorities across all federal agencies; promote coordinated implementation and evaluation; and improve coherence of engagement with the state of Alaska and Alaskan native communities. AESC is tasked with supporting the U.S. chairmanship of the Arctic Council. “The challenges we face are too big and our resources too limited to have the option of not cooperating,” concluded Dr. Holdren by quoting a statement made by President Obama during his first address to OSTP.
Mr. Jack Omelak recalled the words that his “great leader” once told him, “you’re not going to get very far if you fight for issues that are important to Alaska natives and indigenous people...at times we’re going to have to work behind the scenes and we’re going to have to turn other people’s issues into our issues.” Many Alaskan leaders have to think on a macro-level and then try to implement on a micro-level, he explained. There exists a difference of perspective between policymakers at higher levels versus those at local levels. For example, policymakers are now talking about relocating coastal communities in Alaska, but these communities—who were once nomadic—settled in these locations because of forced federal policies.

In the field of resource management, Mr. Omelak must continuously remind people that “it’s not about managing the resource; it’s about managing the people.” Mr. Omelak understands that science results in conclusions that are objective and repeatable, but believes that aspects of the human element are lacking during consideration of regulations and need to be integrated in the science as well. Today, domestic and international policies are still being developed, but these will impact Arctic people without considering the past and present challenges that Alaskan’s face. He again stressed the lack of human perspective in resource management. There is “a disconnect” between the ideals of conservationists and resource managers. With polar bear populations diminishing due to the loss of sea ice, several domestic and international policies now protect polar bears. However, while creating these guidelines policymakers forget to consider the effect of such regulations on the people who are hunting and gathering in this same environment. Without considering the human aspect of the environment, policymakers and scientists do not have a clear understanding of the ecosystems that they are trying to influence.

To bring a local perspective to Arctic issues, Mr. Omelak related a story of his visit to St-Morris Island. Mr. Omelak met with the community to solicit comments about the polar bear conservation plan. Rightly so, the community was more concerned about the fact that they hadn’t had access to a hospital in three weeks and had
diesel in their drinking water, than conserving polar bears. There is a common perception in these communities that few studies are relevant to Alaskans. The studies that scientists are conducting are beneficial to these people, but this benefit needs to be communicated in a manner easily understood by the impacted people. Research in Alaska has often been called “the next great gold rush” because the information is extracted, but does not result in local benefits to the communities. Finally, Mr. Omelak reminded participants that the gap between federal agencies have real implications for the people on the ground, and expressed desire for people to work together and be mindful of the people of Alaska “who will be affected by these decisions.”
Dr. Larry Mayer opened the panel with a compelling story about his experience with “a changing Arctic.” “The climate it is a-changing,” he began, paraphrasing a famous poet, “and nowhere is this change more evident than in the Arctic. I have had the opportunity to work in the high Arctic...I’ve witnessed firsthand this climate change.” He displayed plots and images that illustrated a remarkable trend in melting Arctic ice; the plots showed a 12-13 percent reduction in Arctic ice minimum over the past 35 years, but it was the images taken during the northern deployment of the U.S. Coast Guard (USCG) Healy that revealed the drastic changes in Arctic ice minimum. The USGS Healy used to reach the ice margin at 75 degrees north, Dr. Mayer explained, but in 2012, the Coast Guard had not yet run into the ice margin at 80 degrees north. He made a second point to remind participants that there is always annual variability in weather patterns. For example, in 2013 the ice came back at 75 degrees north and it made news headlines, but the press forgot to mention that even with this return of the ice that year was still the sixth lowest ice extent in recorded history. With this, Dr. Mayer urged Senators and Congressmen to listen to the science, not the news, and asked the general public to “not criticize what they don’t understand.” Upon completion of his recollections in the Arctic, Dr. Mayer briefly introduced the panel.
Cecilia Bitz, Ph.D. – Professor, Atmospheric Sciences Department, University of Washington

Dr. Cecilia Bitz discussed sea ice and its effects on the Arctic and on global climate change. She first gave a brief overview of the role of sea ice in the Arctic; sea ice plays an important role in regulating wave action, thus changes in sea ice affect coastal erosion and storm surge. Also, as sea ice retreats and thins, it contributes to global warming. The greatest global warming is occurring over Arctic sea ice, at a rate 2-3 times that of the global mean. This warming effect also impacts sea salinity. “There’s a greater amount of salt being rejected causing more dense plumes to sink off the continental shelf,” Dr. Bitz explained. “There is also a relationship between warmer waters and the release of salt that could change in the future.”

Dr. Bitz described recorded changes in sea ice cover, long-term global climate modelling scenarios generated from National Snow and Ice Data Center data reveal intense sea ice loss. Dr. Bitz explained that in the past, intense sea ice loss was very rare, but in the first half of the century such events were frequent (with a 20-30 percent probability of occurring). Also, since 1999 scientists have seen a greater loss in multiyear ice, which is sea ice that has survived more than one year. The current ice cover has transitioned from very thick and stable to a less concentrated, thinner, and younger type of ice, which has major implications for the climate, and hence people. According to Dr. Bitz, anthropogenic forcing of climate has been a significant factor impacting these trends.

To clarify the relationship between sea ice and global warming, she proceeded to discuss the feedback loops associated with sea ice retreat. “Warming causes the sea ice to retreat and reduces the reflectivity of the planet, so there is more absorption in the ocean, and that gives rise to further warming, and greater amounts of retreat,” she explained. “So, we have an accelerating effect.” Feedback resulting from interactions between Arctic sea ice and the ocean influence the Arctic climate. By understanding these feedback patterns, scientists will improve their seasonal prediction capabilities to better forecast the changes taking place in the Arctic.

In conclusion, Dr. Bitz acknowledged that much still remains to be understood about melting sea ice. To improve sea ice forecasting capabilities she suggested development of short-term models that could predict sea ice cover at a shorter time
scale (from months to a few weeks). These models would help in the planning of shipping routes, for example. Also, more sophisticated long-term models and additional observations from the field and from space are vital in gaining a better understanding of the coupling between Arctic sea ice and the ocean.

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**Fiamma Straneo, Ph.D.** – *Senior Scientist, Physical Oceanography Department, Woods Hole Oceanographic Institution*

Dr. Fiamma Straneo spoke of the significant changes in land ice. This ice, unlike the sea ice previously discussed by Dr. Cecilia Bitz, resides on land and is primarily stored in Greenland. It directly impacts the marine environment via glaciers that drain parts of the ice sheet into the ocean. Changes in Arctic land ice are not only important for sea level rise, but also for the freshening of the Arctic Ocean. Greenland is becoming a major contributor of freshwater in the Arctic. Plumes are also a problem; surface melt at the top of the ice sheet is transported to its margins via crevices resulting in turbulent muddy waters that transport large amounts of nutrients, such as carbon and minerals, into the ocean. Icebergs are also of concern since they are large, occurring more frequently in the ocean, and pose a danger for navigation and infrastructure around the Arctic.

Dr. Straneo explained that scientists measure land ice melt by calculating the volume discharged into the ocean. Calculations are obtained using forecasting tools, such as regional atmospheric models, which are connected to large scale climate models. These models need to be validated by measurements on the ice. For this, scientists use weather stations that measure melt and albedo, which are essential components of land ice models.

Over the past two decades, significant land ice change has been recorded worldwide, not only in the Arctic. Dr. Straneo demonstrated changes in land ice by displaying images of the shrinking Greenland ice sheet over time. She also stressed, “not only is there change, the change is accelerating...the rate of increase is speeding up.” Changes in land ice can take place via two mechanisms. First, it can melt by increasing air temperature. Much of the shrinking Greenland ice sheet is associated with a rapid rise in air temperature over the Arctic. The second kind of
change relates to glaciers that are terminating in the ocean via ice streams. Normally, melting takes place at the edges of the ice sheet, but in 2012 melting extended all the way to the middle of the ice sheet. She explained that this is worrying, “ice moves, it doesn’t just sit there, but what should be striking is that the fast flow is concentrated in some really tiny features, rivers of ice and ice streams, which then discharge into the ocean...and some of these extend all the way to the middle of the ice sheet.” It is clear that this observed retreat and melting of the ice sheet does not only occur due to warming air temperatures, but also to ice melt speeding up and ice streams dumping more ice into the ocean. Scientists do not have a reliable forecasting tool to model ice stream behavior, but they suspect that this increased velocity is triggered by changes taking place at the margin of ice and ocean.

Scientists have recently begun measuring the extent of warm waters at the margin of glaciers. From these measurements, scientists are now aware that warm waters from the Gulf Stream can reach the Greenland ice edge, but they do not yet understand the relationship between warm waters and glaciers. To clarify this relationship, Dr. Straneo emphasized the need to link an ocean model to an ice sheet model. However, before such coupling can take place, scientists will require further information about the drainage of lakes at the base of ice sheets, ice and plume dynamics, as well as fjord circulation patterns. “We need this kind of information to feed into the model; we need to understand the physics before we can start to make the forecast,” she explained. To obtain measurements on these particular items, Dr. Straneo and her team must undertake perilous missions to the ice edge. The ice’s margin is a dangerous environment, so to access this area her team uses ice breakers, helicopters, marine mammals (fixed with trackers), and sometimes must develop new technologies, such as underwater vehicles and autonomous surface vehicles, that can safely gather data at the edge of the sea ice.
Sustained measurements are needed to inform models that will improve predictions, but scientists need dedicated resources to obtain these. “We have a lot of strategic plans in the Arctic, we have a lot of implementation plans, but it hasn’t really translated into new resources. The federal agencies that fund my work, the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA), are really overstretched in their ability to fund this work.” Furthermore, understanding the changes taking place in the Arctic is a complex and cross-boundary problem that will require scientific and international collaboration and coordination. “What happens in the Arctic doesn’t really stay in the Arctic. The glacial changes that we see in the Arctic, including in Greenland, is really a global issue...so as an international community we all need to deal with it,” she concluded.

**Jackie Grebmeier, Ph.D. – Research Professor, University of Maryland Center for Environmental Science**

Previous speakers informed participants about the physical changes observed in the Arctic, but Dr. Jackie Grebmeier discussed changes in the biological system of the Arctic, with a focus on the Pacific-Arctic sector. She initially presented four questions that would structure the rest of her presentation: “What do we know about the changing Arctic? What can we forecast? What are the gaps in knowledge? And what types of opportunities -and with what types of observations- do we need to fill the gaps?” Grebmeier and her team collaborate with Russian and Canadian colleagues to gather the necessary data to answer these questions. “[International collaboration] is the only way we will fully be able to understand this changing system,” she said, reiterating Dr. Straneo’s concluding remark.

Dr. Grebmeier reminded the audience that the huge influx of nutrients into the Bering Sea is not from the rivers, as previously thought, but rather from the Pacific Ocean itself. Deep and old Pacific water that is high in nutrients enters the Bering Sea on the western side of the Pacific Ocean, and freshwater flows into the system from the eastern side. Research has also shown that while the Bering Strait is Pacific water, in reality it is 40 percent freshwater. Additionally, there is interannual
variability taking place in the Bering Strait that is mostly seen as an increase in volume of water coming through the Bering Strait.

Today, the Strait is undergoing changes, namely increased heat transfer and freshwater transport. These changes affect the melt of sea ice and the amount of salt and nutrients in the water, which in turn, impact the chemical and biological systems. Grebmeier tracks sea ice melt using oxygen (O) isotope signatures. As sea ice forms, salt is rejected from the ice, but it maintains the water type that it uses to form this ice, so melted sea ice has a different $^{18}$O signature than that generated from river water. The isotope data of the water column has revealed a shift in the early 2000’s; prior to this period most freshwater originated from rivers flowing into the system, but nowadays, more of it originates from melted sea ice due to the rapid sea ice retreat. Another problem associated with ice melt is the algae that grow under the sea ice. This biomass is very high in chlorophyll, so the release of this material acts as a carbon input that affects the composition of organic matter in the system.

![Image](image.png)

**Figure 2.** The image portrays season-long composites of ocean chlorophyll concentrations derived from visible radiometric measurements made by NASA satellites. The purple and blue colors represent lower chlorophyll concentrations. The oranges and reds represent higher chlorophyll concentrations. These differences in color indicate areas with lesser or greater phytoplankton biomass. (Credit: NASA/Suomi NPP/Norman Kuring)

To forecast changes in the biological system, Grebmeier and her team utilize satellite measurements of surface chlorophyll. With NASA’s satellite products, Grebmeier can track the surface values of chlorophyll over time. However, to determine subsurface populations the team must collect samples of the biomass in the ocean to identify which organisms are present in the water. To facilitate data collections, Grebmeier has joined the DBO, and can join the research cruises of her international colleagues to look at the nutrients, and plant and animal life that are in the water column. Grebmeier also considered sea ice persistence since its rapid retreat changes the
seasonality of the biological activity. With these measurements in place, DBO scientists can determine the biological response and track how the system is setting up as the sea ice retreats and waters warm. Understanding the biomass changes of organisms that are lower in the food web is crucial for predicting subsequent changes to fish populations that prey on them. By tracking this biomass, scientists at DBO can predict the potential northern shift in fish species and other organisms higher in the food chain.

Biological systems are also affected by ocean acidification since seawater becomes corrosive to animals such as clams, snails, and pteropods in the water column due to changes in the water’s pH. There is seasonal variability and an east to west gradient of carbon dioxide uptake by the ocean. Understanding the concentration of carbon dioxide over space and in time can help scientists determine the corrosive nature of the ocean. Grebmeier also discussed the indirect effects of ocean acidification and melting sea ice on upper trophic organisms. Specifically, the threatened diving sea duck feeds on clam populations that are directly affected by ocean acidification. As prey species shift depth range, the birds cannot alter their diving depth to capture prey that have moved outside of their diving range, so they must adapt and change their food source. Also, diving sea duck populations are only found in Alaska and Russia; its habitat range is established by the presence of sea ice. The ice provides a platform on which the birds can feed and rest to save energy between dives, so melting sea ice may threaten their existence as their range contracts. Sea ice offers a similar resting platform for marine mammal benthivores, such as walruses. In this case, if walruses can’t haul out on sea ice, then they must haul out on shore (which means that they take longer to get to their prey and thus expend more energy). Grebmeier is currently collaborating with other scientists to try to measure the caloric change of walruses as sea ice melts. Obtaining such information will help scientists model energy budgets in the presence and absence of sea ice to better understand the fate of seabirds and mammals residing in the Arctic.

To summarize, Grebmeier returned to the questions that she posed at the beginning of her presentation. Seasonal and interannual changes in the sea ice extent, duration, and seawater temperature influence biological processes from the lower trophic levels of the food chain to organisms in the higher trophic levels, such as birds and marine mammals. These changes can be forecasted by tracking physical, chemical, and biological patterns, as well as measuring the response at selected locations in the Pacific-Arctic that are part of DBO and other observing systems. However, there are still gaps in time series transects, leaving questions regarding how phenology (timing of events) will impact the system.
“Permafrost is permanently frozen ground,” began Dr. Schaefer, “it covers roughly a quarter of the Northern Hemisphere’s land surface.” He went on to further describe permafrost in the northern versus southern latitudes; it is deeper (700 m-1500 m in depth) in the north and thins as one moves south because of the natural north to south temperature gradient. Dr. Schaefer uses bore holes to measure permafrost temperatures to study this frozen layer of the ground. Increases in permafrost temperatures have been observed in these bore holes in Alaska, but what is most worrying is that the greatest increase in temperature has taken place over the northern most bore holes of Dr. Schaefer’s transect (a two degree increase in the top layers of permafrost at this location over the past 30 years). Dr. Schaefer stressed the importance of this increase in temperature, “nothing happens fast for permafrost, down at depths of 200m, the temperature is still responding to the little ice age that took place 400 years ago, so when we see a two degree temperature increase at 20 m depth we find this quite alarming.”

Dr. Schaefer illustrated the effect of climate change on permafrost with images of future thawing projections. These simulations suggest that over time permafrost thaw deepens as air temperature warms. Permafrost was shown to degrade over time from north to south and top to bottom. This has huge implications for Arctic communities and ecosystems that that depend on this concrete-like permafrost. Buildings collapse as permafrost thaws, and after the ice melts an ecosystem is very vulnerable to erosion.

Thawing permafrost can also impact the global climate due to carbon emissions released. There is roughly 1700 Gt of carbon frozen in permafrost today, which is a large amount considering that the atmosphere presently holds only 700 Gt of carbon. “There is twice as much carbon frozen in permafrost than there is in the atmosphere today,” he noted. Questions still remain regarding when and how much carbon will be released in this thawing process. Published estimates predict that by
2100 there will be 120 Gt of carbon released from permafrost (which is not enormous but not negligible either), resulting in an increase of the global temperature by 0.23 ± 16 degrees Celsius. However, projections also estimate 60 percent of total emissions from thawing permafrost will occur after 2100. This has long-term effects. “This whole process is essentially irreversible,” he warned. “Once you thaw out the permafrost, you really can’t refreeze it. Once the organic matter thaws out and decays away, there’s no way to put it back into the permafrost. Once you turn on these emissions, you really can’t turn them off and they persist for centuries.” For the United Nations Environment Programme’s (UNEP) Policy Implications of Warming Permafrost report, Dr. Schaefer and his colleagues proposed recommendations to address the potential economic, social, and environmental impacts of permafrost degradation. The UNEP report commissions a special report on permafrost emissions, creation of a national permafrost monitoring network, and a national plan for adaptation.

In conclusion, Dr. Schaefer gave his thoughts on the bigger picture of climate change. “What are we going to do about [climate change]?” he questioned. “We need to reduce emissions...as a nation, I think we need to invest in reducing the cost of renewable energy. We need to invest in reducing the cost of energy conservation. We need to foster innovation with basic public policy, like cost breaks. This will create an environment where the average consumer will pick the low carbon emission option because this is the best economic option.”

Figure 3. Coastal erosion reveals the extent of ice-rich permafrost underlying active layer on the Arctic Coastal Plain in the Teshekpuk Lake Special Area of the National Petroleum Reserve - Alaska. (Credit: Brandt Meixell, USGS)
Mr. Kolo Rathburn, who is also a scientist by trade, spoke of his role on the Senate Appropriations Committee and that of Sen. Richard C. Shelby’s (R-AL) role as Chairman of the Subcommittee on Commerce, Justice, Science, and Related Agencies (CJS). He started by painting a picture of the Committee’s role in the programs that are of interest to participants of the Forum. “Last month the Committee received the President’s budget,” he began. “But there are a number of challenges that Congress faces at the moment. Without an act of Congress, we are back under sequestration,” he explained. The President’s budget is $4 million over what sequestration has limited federal spending to be. The Committee has to work in a more realistic budget environment. “I personally don’t foresee anything happening to change that,” stated Mr. Rathburn.

The Senate CJS Subcommittee reviews budgets for the NSF, NASA, NOAA, OSTP, the Department of Commerce, and Department of Justice. In the following weeks, the Subcommittee will examine the spending priorities of these agencies for the Fiscal Year 2016 budget. Mr. Rathburn specifically discussed the President’s budget request for NOAA. In this budget proposal, Mr. Rathburn noticed an increase in funds requested for Arctic spill response, as well as regional and coastal resiliency grants. Within NOAA’s Oceanic and Atmospheric Research (OAR) division there was also a requested increase for an Arctic research program and for ocean acidification research. What was most astounding to the Subcommittee was that a large increase of funds were requested for these relatively new programs, while long standing programs (like hydrographic surveys, mapping, and charting) remained flat-funded and in some cases do not account for the inflation rates of 2016. As the Subcommittee prepares to write their Appropriations Bill for FY16 they will try to manage expectations for these agencies and constituents, but they must still work under constrained and tough financial times.
He ended with an important message to participants who wish to make their science and concerns heard, “keep doing what you’re doing, which is coming up to D.C., attending events like this, giving talks, and communicating the message as to why programs that support Arctic research help to better understand the changes that are happening up there and why members should care.” Forecasting Arctic change should be in the best interest of all Americans as the changes taking place in the North are not just an environmental and ecological problem, it is potentially a massive economic problem and there are huge ramifications for national security.

Click here to watch the discussion portion of Forecasting a Changing Arctic
Click here to see the PowerPoint presentation for Forecasting a Changing Arctic
Panel 2: Science Needs for Arctic Operations

Randall Luthi – President, National Ocean Industries Association
Moderator

“As you learned from this morning’s panel, the only thing constant about the Arctic and the world itself is change,” Mr. Randall Luthi reminded participants before introducing the panel on science needs for Arctic operations. For many reasons, the Arctic remains important to the rest of the world since it is thought to contain 25 percent of the world’s undiscovered oil and gas resources; changes in the ice cover is enabling shipping to access the Northwest Passage for trade; fishing remains a vital industry in the Arctic as it contributes to the world’s ever growing need for food; and finally, the Arctic remains home to significant native populations. Before passing the microphone to the panel’s first speaker, Mr. Luthi added, “much is on the horizon for this frontier region, yet much remains to be understood as well...there have been a lot of scientific studies done, but today’s battle touches on other aspects; on what is going to be necessary in the future.”
Erik Milito – Director of Upstream and Industry Operations, American Petroleum Institute

The U.S. is currently recognized as an energy superpower. Mr. Erik Milito began by stating, “we are now the world’s largest producer of natural gas and we are set to become the world’s largest producer of crude oil.” However, the U.S. will need 12 percent more energy by 2040 and fundamentally, 60 percent of that will come from oil and gas. “It is important for our industry to look at places where they can get the supply to meet the demand,” noted Mr. Milito, which is why the oil industry has expanded its search for oil in offshore locations and the Arctic. The U.S. Arctic region holds tremendous opportunities for the oil industry as it is expected to hold $90 billion barrels of oil.

According to Mr. Milito, the industry has a balanced approach to energy production so that it can secure and harvest the benefits in a safe and environmentally responsible manner. Also, the benefits of this industry are plentiful for Alaska as its development could create 50,000 well paid jobs for Alaskans. Strategically, the U.S. is in a much different position today than it was in the past due to the oil and gas production; the supplies that the U.S. produces and then places on the global market create excellent national and economic security, explained Mr. Milito. The U.S. oil and gas industry also contributes to the lower prices of gas at the pump, which are only possible due to oil and gas production in the U.S.

America has the “technological know-how” for growth in this industry and this has allowed the industry to find and extract oil and gas from new rocks, as well as in 10,000 ft of water (30,000 ft of seabed) on the continental shelf of the Gulf of Mexico. Despite extreme environmental conditions in the Arctic, the industry has also found ways to exploit such resources in the region. While oil exploitation in Arctic conditions can be achieved, the drilling window in Alaska is short and it is difficult to drill wells in the region. There are also several regulations in place to make sure that a company has the ability to operate safely in Arctic conditions. Planning, gathering the research, environmental impacts assessments, and socioeconomic impact studies on local communities and indigenous populations is
an important part of the federal leasing process of land for oil and gas exploitation. The government requires individual oil and gas companies to have a safety and environmental system in place to reduce the risk of accidents from happening. Additionally, there are many layers of regulations for the equipment used. For example, there must be multiple redundant barriers in the well design to prevent leakage from occurring in any flow path. Once the lease sale is made, the sale equates to great financial revenues for the government.

Mr. Milito closed his remarks by touching on the oil and gas industry’s need to expand research efforts to help harness opportunities, but at the same time make sure that workers and the public, as well as the marine environment, are protected.

Gary C. Rasicot – Director, Marine Transportations Systems for the U.S. Coast Guard

The U.S. Coast Guard has been in the Arctic since the early 1800s, Mr. Gary Rasicot announced proudly. Very few people have had the opportunity to visit the Arctic, but as the ice continues to melt, he warned that more human Arctic activity would occur. The USCG is thus taking steps to prepare for this increased traffic in the Arctic. The USCG is tasked with search and rescue, law enforcement, as well as environmental response in American waters (including the U.S. waters of the Arctic). However, he noted operations north of the Arctic Circle can be more challenging as radios do not work effectively in Arctic temperatures, and collecting oil in cold water might be slightly different than in warmer waters (like the Gulf of Mexico). Oil spill operations are very difficult in the Arctic because the weather may prevent response ships from accessing the location where the spill took place. Mr. Rasicot listed a few questions that still remain troublesome to the USCG: “What are the anomalies associated with being that close to the poles? Do radars work that close to the poles? Can we use dispersants in cold temperatures? And does it have an impact on the marine environment? On subsistence fisheries?” At present, the logistics have not been put in place to respond to disasters in the Arctic. In the case of an oil spill, the closest port to drilling areas is Dutch Harbor, several days away. These are the types of problems that the USCG must try to manage. Science could play a critical role in improving operations, data management, and enhancing the USCG’s ability to aid in logistics and prevention of disasters, as well as respond to other needs of people in the Arctic. “That is where we really need the science...we need to better understand how the environment affects our operations,” he urged. For this reason, the USCG is trying to better understand the Arctic environment to help prepare for future eventualities that might arise in the region, and the USCG’s Center for Arctic Studies and Policy (CASP) is studying the effects climate change could have on Coast Guard operations.
In closing, Mr. Rasicot highlighted a key point made in the *USCG Arctic Strategy*, which focuses on improving awareness, modernizing governance, and broadening partnerships. There are very few single agency problems in the Arctic. “No one can do it on their own up there [in the Arctic],” he explained. “We need to find a single structure that we can work on.” The eight Arctic nations all have the same goal in mind, “to be able to keep people and oil out of the water.” In a final plea, Mr. Rasicot reiterated the USCG’s need for scientific research in aspects relating to Arctic operations, “There’s a lot of help we need on learning how to operate up there [in the Arctic] because we only see our operations increasing and not decreasing.”
"Just recently, Admiral Greenert [Chief of Naval Operations] testified before the House Appropriations Committee and he talked about the Arctic and the Navy's efforts in the Arctic,” began RADM Jonathan White. “The Navy is serious about the Arctic.” In agreement with Mr. Rasicot, RADM White described a need to develop science in the Arctic. The Navy is constantly looking at sensing and processing capacities in the Arctic. As shipping routes open in the Arctic, the Navy is tasked with outlining new shipping routes that will enable ships to navigate safely in the Arctic. Sensing, forecasting, and predicting environmental conditions are critically important for working in the Arctic. Improving models and forecasting abilities, as well as new technology for hydrographic operations and unmanned vehicles will enable the Navy to safely operate in the Arctic.

The Navy has a national role in the Arctic (outlined in the Implementation Plan for the National Strategy for the Arctic Region), including maritime forecasting. “We have a unique role in the Arctic,” said RADM White. “Because of our maritime forecasting capability, we are responsible if asked to produce weather support to ships on the high seas... and we want to be able to do this in the Arctic as well.” For these forecasts, the Navy needs Arctic coupled models. It will also require regional predictions that can be reduced to a local level. These models would facilitate short-term (two week) and longer (30-90 day) term sea ice forecasts (including its location, thickness, age, and movement). These can be done in other regions and basins of the world, but due to the gaps in data they have yet to be modelled for the Arctic. There is natural variability in the Arctic that we don’t yet understand, he continued, understanding this interannual variation would help plan the Navy’s strategic and operational tasks. The Navy also needs to obtain a time series across months of what the ice dynamics in the Arctic are so that the fleet can stay ahead of the ice and can better understand the acoustics for the submarine force. Arctic-specific infrastructure and ship design and construction were also raised as necessary considerations.
The Navy is considering the development of Arctic maritime capability requirements, engagement with Arctic partners, and updating fleet guidance for Arctic operations to gain experience and training in that environment. Training exercises such as Ice Exercise (ICEX) are already taking place bi-annually to train members of the U.S. Navy in the Arctic environment, as well as to refine and validate procedures and required equipment. To further illustrate the Navy’s commitment to the Arctic, RADM White spoke of the Office of Naval Research’s (ONR) Science and Technology Plan, and a five-year Departmental Research Initiative (DRI) called Stratified Ocean Dynamics in the Arctic (SODA).

In his concluding remarks, RADM White reflected on the USS Jeannette’s final journey through to the Arctic. In the 1870s, USS Jeannette was tasked with a one-year deployment to the Arctic, but it never returned due to severe sea ice conditions. In a normal year, the ice would melt in the summer and freeze over in the winter, but that year the ice did not melt over the summer. “Our ability to predict seasonal ice conditions is no better now than it was in the 1870s,” he announced sadly, but it is for this reason the Navy is very serious and is investing millions of dollars in Arctic research.

Figure 4. USS Jeannette at Le Havre, France, in 1878, prior to her departure for San Francisco, California. (Credit: U.S. Naval Historical Center)
As with the U.S. Navy and Coast Guard, the American Bureau of Shipping (ABS) has had a long history in the Arctic. “The first commercial vessel to ever cross the Northwest Passage, the SS Manhattan built in 1962, was ABS classed,” stated RADM Bone. ABS is not a shipping company; it was founded in 1962 as a non-for-profit independent third party inspectional arm of the U.S. Maritime Agency. Its purpose is to promote the security of life and property, and to protect the natural environment. ABS developed its own standards and rules for the design, construction, and maintenance of ships and off-shore structures. The Bureau is primarily concerned with the Arctic challenges that affect ships, structures, and the people operating on these. “We are not involved in response,” RADM (ret.) Bone explained. “We are involved in prevention.”

The dynamics of sea ice and rapidly changing weather conditions are a major obstacle for ships operating in the Arctic. The ice that coats these ships affects their stability, as well as the functional ability of the machinery and people operating on these vessels. Sea ice and Arctic weather conditions are so much more demanding for a ship’s structure than those in the southern latitudes. “Ships will fatigue over time, so when building ships it’s for sustained operations, not for a one time operation,” stated RADM Bone. There is also an impact on communications and navigation. Arctic shipping is in its infancy stage, so routes have not been determined, but ships need safe routes and experienced mariners in order to maneuver through the sea ice. The Northwest Passage presents unique challenges; it has severe sea ice conditions, no guaranteed ice breaker support, and rapidly changing weather conditions, so ships operating there must be capable of independent operations. “To tackle some of these challenges, there is an establishment of a polar code,” RADM (ret.) Bone said. “It is a set of standards for both design and operations, which are goal based.” ABS serves as a direct advisor to the USCG; they provide technical recommendations for setting technical standards.
Coastal nations are predicted to demonstrate their sovereignty in the Arctic by increasing activities using government vessels from their respective Coast Guard and Navy. For example, Russia is building ice breakers and now has over 14 of these vessels (some of which are the largest on Earth). The USCG cannot currently compete with Russia’s growing ice breaking fleet. The U.S. needs to replace and replenish its ice breakers in order to actively participate in Arctic operations, he noted. New commercial assets, such as ice class tankers, ice breakers, drilling rigs, and production platforms are also necessary tools to engage in commercial activities in the Arctic. While ABS has been involved in the Arctic in a long time, “we see a continued effort in both supporting the government activities in the Arctic and support for safe ships and structures and safe operating environment for the people up there, as well as the commercial interest that are clearly there,” concluded RADM Bone.

**Dave Benton – Consultant for the Alaska Seafood Industry**

Mr. Dave Benton stated at the beginning of his presentation that the requests described by previous speakers are also those that the seafood industry requires to operate in a safe and effective manner in the Arctic. Before listing the wishes of his industry, Mr. Benton described what the seafood industry doesn’t require. It doesn’t need a management plan; the Fisheries Management Plan (FMP) was adopted by the Council in 2009. This FMP prohibits commercial fisheries from taking place north of the Bering Strait. As opposed to most other regulatory plans, it was not generated by the government; instead, it was put forth by the seafood industry. Through the years, a number of fisheries noticed that areas north of the Bering Strait were becoming more accessible to fishermen. So in 2005, industry leaders decided to “save themselves from themselves” and they closed off the area to fishing, Mr. Benton explained.
The central part of the Arctic Ocean (the High Seas portion of the Arctic region) was broached next by Mr. Benton. To better manage this area, the industry desires baseline research regarding what species are there, their life history characteristics, how these fit in an ecosystem, and at what level they can be sustainably harvested.

“How would you conduct a fishery in an environmentally responsible manner,” he progressed, when the researchers are still trying to figure out the basic research underlying this ecosystem. While the scientific community is trying to determine if there is an economically viable fishery in Arctic international waters, industry is thinking about moving operations into this area, but finding it difficult without the science in place. “The international component for research is the only way to get what we need. We have to have the cooperation of our Russian neighbors,” he admitted. The U.S. fisheries industry wants an expansion of collaborations with Canada and Russia, as well as other countries already conducting research in these parts of the world (e.g. China, Japan, Korea). “Having recognized the limitations of what we can do here, we need to reach out to other parts of the world that have the resources that can help us get what we need,” RADM Bone concluded. “We need to have a strong voice to educate the folks on the Hill about the needs that the U.S. has in the Arctic.”

Click here to watch the discussion portion of Science Needs for Arctic Operations
Click here to see the PowerPoint presentation for Science Needs for Arctic Operations
Panel 3: Why the Arctic Matters to the Lower 48

Mark Abbott, Ph.D. – Oregon State University
Moderator

Dr. Abbott opened the panel by describing what participants had heard in previous panels, and introduced his speaker’s theme - identifying what impacts of Arctic changes might happen beyond the Arctic boundary, in the “Lower 48” (a term used by Alaskans to identify the states outside of Alaska). Dr. Abbott introduced the Forum’s first international panel – while not international himself, Dr. Jim Overland would present his work on the impacts of Arctic temperature amplifications on mid-latitudes of the globe; Mr. Dustin Whalen, from the Canadian Geological Survey, would discuss his research about emerging issues in Arctic coastal zones and potential lower latitude impacts; Dr. Greg O’Corry-Crowe, originally from Ireland but now at Harbor Branch Oceanographic Institute, would discuss migratory species; and Dr. Steve Feldgus would provide a policy and legislative perspective on the issue.
Dr. James Overland discussed the effects of Arctic warming on the Earth’s mid-latitudes. Dr. Overland explained that changes presently taking place in the Arctic will continue to occur for another 40 years, potentially reaching a four degrees Celsius increase in temperature by 2040. Any mitigation strategies that we apply now, Dr. Overland explained, will affect the second part of the century.

He spoke of the uniqueness and importance of the loss of multiyear sea ice in the changes experienced by the Arctic. Loss of multiyear sea ice will likely completely shift the Arctic’s weather system as old sea ice previously acted as a “fly wheel” for the Arctic’s climate. “The change is locked in for the Arctic,” said Dr. Overland. “Once you’ve gotten rid of multiyear sea ice, it is virtually impossible to go back to the situation that we had a decade ago.” There are several repercussions that are tied to the loss of multiyear sea ice; reduced sea ice generates more open water, which causes the ocean to absorb more sunlight. As a result of this added heat in the Arctic, there is an impact on atmospheric circulation patterns at mid-latitudes. In fact, scientists have already started observing the impact of warming on the chaotic mid-latitude weather system. However, the real question resides in how Arctic warming will impact this already large and disordered mid-latitude weather system. In the 1980’s, El Niño was solely used to predict longer seasonal forecasts. Today, changes taking place in the Arctic also contribute to weather patterns and could be used to improve monthly seasonal atmospheric forecasts.

A warming Arctic also means a shifting polar vortex, explained Dr. Overland. In the past, the polar vortex was very stable, “what happened in the Arctic, stayed in the Arctic,” he stated. However, over the last five, years a new bulge of hot air over the Arctic has changed the wind patterns making “the edge of the polar vortex very wavy.” The destabilized polar vortex brings cold air to the continent and warm air to the Arctic. For example, over the last month, there was a low pressure system from the East Coast all the way into the Arctic. Since the winds flow around these low pressures, the cold Arctic air was therefore carried to mid-latitudes. Most disturbing, scientists do not know how much of this is forced by the Arctic versus
how much is random. “We know the Arctic changes are big, but how we affect the wavier jet stream pattern is the research program,” said Dr. Overland

Wavy polar vortex configuration

More typical, compact configuration

Figure 5. Wobbly polar vortex triggers extreme cold air outbreak. Maps show the 500-millibar geopotential height (the altitude where the air pressure is 500 millibars) on January 5, 2014 (left), and in mid-November 2013 (right). The cold air of the polar vortex is purple. (Credit: NOAA)

Dr. Overland summarized the observed change in the Arctic as a “one way trip” for the next three decades since once the Arctic system has shifted from a thick multiyear old sea ice to mostly first year sea ice it is difficult to return to an old system. It is important to remember that a small amount of carbon increase is amplified by unique feedbacks in the Arctic, which ultimately may increase extreme weather patterns in the mid-latitude over the coming decades. Furthermore, it is possible that continued Arctic warming will increase winter storm events that are regional, episodic, and extremes of existing weather patterns.
Dustin Whalen - Canadian Geological Survey

Mr. Dustin Whalen presented his research on Arctic coastal dynamics. The regional coastal areas most severely impacted by the changes in coastal dynamics are the Laptev Sea, East Siberian Sea, Bering Sea, and Beaufort Sea. Globally, coastlines are retreating by 0.5 m per year, but this change is much greater for coastal zones around these seas. These seas are retreating on average by 1.5-2 m and there can be 15 m of loss in coastline in just one storm. Mr. Whalen gave the extreme example of Papey Island, an uninhabited island off the coast of Iceland that has lost 1.5 km of its coastline since the 1950s. What is worse, Mr. Whalen explained, “is that we are currently experiencing an acceleration of coastal retreat; coastal retreat [on Papey Island] has doubled in the last 10 years.” Two factors of the changing Arctic are driving coastal erosion: the melting of permafrost, and increased wave action due to melting ice. Sea level rise is also expected to impact coastal erosion. Scientists are already observing increased mean annual temps, increased sea-state and storminess, which essentially feed into greater coastal erosion.

Coastal erosion has implications for the health and well-being, security and socioeconomics, species habitat loss, and industrial development. Mr. Whalen first investigated the impacts of increased volumes of sediment being eroded into the ocean on health and well-being. He explained that adding such volumes to the ocean system would likely increase the dissolved organic carbon, release trapped methane, and increase the flow of freshwater into the system. The entry of old carbon into the ocean has large repercussions for the marine food web and global carbon cycle.

Coastal erosion is also expected to affect the sovereignty in the north because nations require the coast for infrastructure and land based camps. Also, the “loss of way of life” is worrying as indigenous people need the land for their subsistence culture. Mr. Whalen explained that traditional knowledge needs to be included in the science and the overall picture. Mr. Whalen broached cultural impacts as well, specifically for the “history of discovery and adventure.” Coastal erosion also has implications for industrial development. Industries, such as mining and oil and gas,
need shore based infrastructures, safe harbors and ports, and rely on the transportation of goods so the continuous and unpredictable movement of the shoreline increases risk for such industries. For example, McKinley Bay used to be an important shipping port for Canada in the 1980s with boats sheltering in this bay over winter. However, McKinley Bay is no longer accessible due to heavy erosion.

Mr. Whalen concluded with a final example of a changing coast. He described the changing state of sea ice on the Gulf of St. Lawrence in Canada. In the past, the Gulf of St. Lawrence had a seasonal ice cover resulting in less severe coastal erosion in the winter. However, sea ice is not as prominent in the winter time and so the coast is more susceptible to erosion. In the Gulf of St. Lawrence, the ice is only removed partially resulting in packed ice that scours and changes the dynamics of the coastline. These changes to the Gulf of St. Lawrence have huge complications as they change the dynamics of the system. “As the climate changes, so do the coasts, whether they change in the Arctic or further down south…it is as important to communicate this at the community level as it is to communicate it at higher levels of the government,” concluded Mr. Whalen.

Greg O’Corry-Crowe, Ph.D. – Harbor Branch Oceanographic Institute, Florida Atlantic University

“I’m from Ireland, which was an Arctic country about 10,000 years ago! And we are expecting to be an Arctic country again in 10,000 years,” Dr. Greg O’Corry-Crowe teased at the beginning of his talk. Dr. O’Corry-Crowe discussed the changing Arctic’s impacts on the biosphere. In agreement with previous speakers who warned of increased rates of change in temperature, coastal erosion, and other physical factors, Dr. O’Corry-Crowe explained that unprecedented and accelerated changes were also expected in the biological realm. “In the mid-latitudes you can move north or south, you can adapt or unfortunately you may be one of the losers and you die out, but for polar species the first option isn’t an option at all and so they must either acclimate or
die,” he explained as he introduced his research on polar and migratory species adaptation to climate change.

All Arctic species are facing a contraction of their distribution range. For marine species, scientists expect to see increased connectivity of high Arctic populations, and isolation of subarctic populations. As for temperate species, they will likely experience a range expansion with increased overlap between subarctic and temperate species. For example, some fish species, such as the polar cod, are now dealing with new sources of competition as temperate species expand their range to northern latitudes. Competition is not the only change that species will experience as they come in contact with each other; more hybridization is expected among polar species and their guests. To highlight this point, he showed an image of a “grolar” or “pizzly,” a hybrid between a polar bear and a grizzly. “We need to give them time and space to try and adapt to the cards that we’ve dealt them,” he emphasized.

![Figure 6](image.png)

**Figure 6.** Northern nations are seeing more killer whales in the Arctic; these animals feed primarily on other mammals, so will they feed on seals and beluga whales? What will be the cascading effects? (Credit: Pavel Lunkin/Flickr)

Migratory species will likely play a role in the ecosystem’s trophic cascade. The movement of new predators from temperate zones into the Arctic will have cascading effects on the local fauna. Increased predation, especially on keystone species, can dramatically alter the balance of the entire ecosystems. He gave the classic example of killer whales that decimated the near shore ecosystem of the north Pacific as they preyed on sea otters (the system’s keystone species).
Northern nations are seeing more killer whales in the Arctic; these animals feed primarily on other mammals, so will they feed on seals and beluga whales? What will be the cascading effects? These are just some of the questions that still remain unanswered by scientists, like Dr. O’Corry-Crowe, who study such migratory species in the Arctic.

At the ecosystem level, productivity will change with thawing permafrost and the shift in nutrient loading in the system. Changing productivity will in turn affect migratory species that may stop migrating to seek food. Migratory species connect ecosystems, so we are predicting to see changes in these areas due to fewer migrations, Dr. O’Corry-Crowe explained. Also, reduction of summer sea ice has resulted in the loss of primary food sources for some species, but some are employing alternative strategies to survive. “We are seeing animals essentially acclimatizing to a different strategy in the time of their lifespan to try to survive,” he explained. There is also a risk of infectious diseases; migratory species could play a key role in the emergence and elimination of some of these diseases. However, pathogen dynamics is understudied and still requires significant amounts of research. Scientists are now looking at the genetics and epigenetics of survival in a changing Arctic, but this too will require more dedicated research.

In closing, Dr. O’Corry-Crowe discussed two useful new lines of research that could be applied to Arctic research. Firstly, an economic estimate to the value of ecosystem changes taking place in the Arctic, also known as ecosystem services. “It’s a human biased approach. What can the ecosystem do for me in terms of productivity and support?” Dr. O’Corry-Crowe explained before listing several examples of ecosystem services. Migratory species are major cultural and subsistence resources for indigenous peoples, so their changing migratory patterns will affect ecosystem services for these people. The emergence of commercially viable species has important consequences for commercial fisheries, and the role of disease and pathogen movement will both change ecosystem services. Secondly, scientists have begun to apply the resilience concept to Arctic systems. Resilience is the long-term capacity of a system to deal with change and continue to maintain or develop under different circumstances. To better understand how the Arctic and subarctic systems will cope with these changes, Dr. O’Corry-Crowe utilizes the resilience concept to see which keystone species will be able to handle a changing Arctic. These lines of research might potentially help fill crucial gaps for Arctic communities as ecosystem services will help draw attention to Arctic research and the resilience concept may help elucidate and predict the changes that are due to take place among polar species.
Steve Feldgus, Ph.D. – House Natural Resources Committee

“My perspective is quite different from the rest of the panel,” Dr. Steve Feldgus began. “I’m dealing with a much more personal level: how does the Arctic affect the people in the Lower 48?” The Arctic has been receiving a lot of media attention recently. In the past month alone, the Arctic National Wildlife Refuge (ANWR) was proposed, as was a five-year leasing program that proposes new lease sales between 2017-2022 in the Beaufort and Chukchi Seas. To go along with this leasing program, new drilling regulations were put forth for the Arctic.

In April, the U.S. will be taking up chairmanship of the Arctic Council, but Dr. Feldgus explained that this issue is not well understood on Capitol Hill because there are a lot of different commissions and councils, and each council has many different working groups. To complicate matters, there are several different research initiatives as well. Congressional staff could take this opportunity to move issues forward, but it is very hard to get Congress to engage due to lack of understanding.” Only three Members of Congress have a direct local interest in Alaska and without local constituents pushing matters forward for the Arctic, it is very difficult to motivate members to follow the Arctic related science, agencies, and their reports. Additionally, the Obama Administration is trying very hard to balance the tension between development and conservation. “They tell us to conserve and develop, and to do them both carefully and in harmony with each other,” said Dr. Feldgus.

Dr. Feldgus requested the help of participants in clarifying Arctic matters to congressional staff stating, “if we can get your help in explaining this clearly to congressional staff, that would be extremely helpful...if you can boil it down to a five minute discussion of what all of these initiatives are, what they are doing, why they are important, and why their boss should care, I think that will get more staff, and consequently their Members, focused on these issues and thus have more understanding of these when they come up in appropriations bills for authorization language.” If Members of Congress know how these research initiatives fit into the big picture, then it is a lot easier for them to sell an idea to the rest of Congress.
and their constituents. Exploiting and conserving the Arctic’s resources will necessitate cooperation from both the executive and legislative branches of the government.

Click here to watch the discussion portion of Why the Arctic Matters to the Lower 48
Click here to see the PowerPoint presentation for Why the Arctic Matters to the Lower 48
Dr. France Córdova

Nominated by President Barack Obama to head the $7.2-billion independent federal agency, France A. Córdova, was sworn in as the 14th director of the National Science Foundation (NSF) on March 31, 2014. Córdova leads the only government science agency charged with advancing all fields of scientific discovery, technological innovation, and science, technology, engineering and mathematics (STEM) education. NSF's programs and initiatives keep the U.S. at the forefront of science and engineering, empower future generations of scientists and engineers, and foster U.S. prosperity and global leadership. Federal interagency research planning is coordinated through the Interagency Arctic Research Policy Committee (IARPC), which is chaired by NSF. The Arctic Sciences Section in the Division of Polar Programs (POLAR) supports scientific research in the Arctic, related research, and operational support. Science programs include disciplinary, multidisciplinary, and broad, interdisciplinary investigations directed toward both the Arctic as a region of special scientific interest and a region important to global systems. NSF supports more than $100 million annually in Arctic Science.

Dr. Córdova is president emerita of Purdue University, where she served as president from 2007 to 2012. Córdova's scientific contributions have been in the areas of observational and experimental astrophysics, multi-spectral research on x-ray and gamma ray sources and space-borne instrumentation. She has published more than 150 scientific papers. In 1997, she was awarded an honorary doctorate by Loyola Marymount University, Los Angeles. She is a recipient of NASA's highest honor, the Distinguished Service Medal, and was recognized as a Kilby Laureate in 2000. Dr. Córdova was elected to the American Academy of Arts and Sciences and is a National Associate of the National Academies. She is also a fellow of the American Association for the Advancement of Science (AAAS) and the Association for Women In Science (AWIS).

Dr. Córdova is married to Christian J. Foster, a science educator, and they have two adult children.
Director John Holdren

Dr. John P. Holdren is Assistant to the President for Science and Technology, Director of the White House Office of Science and Technology Policy, and Co-Chair of the President's Council of Advisors on Science and Technology (PCAST). Prior to joining the Obama administration, Dr. Holdren was the Teresa and John Heinz Professor of Environmental Policy and Director of the Program on Science, Technology, and Public Policy at Harvard University's Kennedy School of Government. He also served as professor in Harvard's Department of Earth and Planetary Sciences and Director of the independent, nonprofit Woods Hole Research Center. Previously he was on the faculty of the University of California, Berkeley, where he co-founded in 1973 and co-led until 1996 the interdisciplinary graduate-degree program in energy and resources.

Dr. Holdren holds advanced degrees in aerospace engineering and theoretical plasma physics from MIT and Stanford. He is a member of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts and Sciences, as well as a foreign member of the Royal Society of London and former president of the American Association for the Advancement of Science. He served as a member of the MacArthur Foundation’s Board of Trustees from 1991 to 2005, as Chair of the National Academy of Sciences Committee on International Security and Arms Control from 1994 to 2005, and as Co-Chair of the independent, bipartisan National Commission on Energy Policy from 2002 to 2009. His awards include a MacArthur Foundation Prize Fellowship, the John Heinz Prize in Public Policy, the Tyler Prize for Environmental Achievement, and the Volvo Environment Prize. In December 1995, he gave the acceptance lecture for the Nobel Peace Prize on behalf of the Pugwash Conferences on Science and World Affairs, an international organization of scientists and public figures in which he held leadership positions from 1982 to 1997.
Senator Angus King (I-ME)

On January 3, 2013, Angus S. King, Jr. was sworn in as Maine’s first Independent United States Senator. He is a steadfast believer in the need for greater bipartisan dialogue and relationship building among legislators. In 2014, Senator King participated in a congressional delegation excursion with Navy officials in the Arctic. In addition to observing Navy operations, King said the trip underscored the need to develop a plan for the Arctic. A member of the Armed Services and Energy and Natural Resources Committees, Senator King has called for consideration of appointing a U.S. Ambassador to the Arctic, acceding to the United Nations Convention on the Law of the Sea, examining the need for long-lead investments in infrastructure, investigating opportunities to cooperate with Russia, and understanding the impact of changes on Arctic people.

Senator King began his career as a staff attorney for Pine Tree Legal Assistance in Skowhegan. In 1972, he served as chief counsel to U.S. Senate Subcommittee on Alcoholism and Narcotics in the office of former Maine Senator William Hathaway. In 1975, he returned to Maine to practice with Smith, Loyd and King in Brunswick. In 1983, he was appointed Vice President of Swift River/Hafslund Company, an alternative energy development company working on hydro and biomass projects in Maine and New England. Six years later, he founded Northeast Energy Management, Inc., a developer of large-scale energy conservation initiatives at commercial and industrial facilities in Maine. In 1994, Senator King was elected Maine’s 72nd Governor. During his two terms in the Blaine House, he focused on economic development and job creation, and also achieved significant reforms in education, mental health services, land conservation, environmental protection, and the delivery of state services. He was re-elected in 1998 by one of the largest margins in Maine’s history.

Senator King was born in Alexandria, VA in 1944. He graduated from Dartmouth College in 1966 and from University of Virginia Law School in 1969. Senator King is married to Mary Herman and has four sons, Angus III, Duncan, James, and Ben, one daughter, Molly, and six grandchildren. He lives in Brunswick.
**Senator Lisa Murkowski (R-AK)**

Senator Lisa Murkowski is the first Alaskan-born Senator and only the sixth U.S. Senator to serve the state. The state’s senior Senator, Lisa Murkowski is a third-generation Alaskan, born in Ketchikan and raised in towns across the state. Senator Murkowski serves as the Chairman of both the Senate Energy and Natural Resources Committee and the Senate Appropriations Subcommittee on the Interior and Environment.

Senator Murkowski is considered the leading expert among her Congressional colleagues on Arctic issues – and has worked passionately on Capitol Hill to raise awareness that Alaska is the reason that America is an Arctic Nation. During the 112th Congress, Senator Murkowski was named Co-Chair of the bipartisan Senate Oceans Caucus, which educates and informs the Senate on the importance of the oceans bordering the United States and issues the Arctic Ocean faces, as well as the opportunities it holds. Murkowski has represented the nation at international events like the Conference of Arctic Parliamentarians and Arctic Council. With the U.S. assuming position as Chair of the Arctic Council this April, Senator Murkowski wants to make sure that the United States is maximizing its presence in the north.

Prior to her appointment to the United States Senate, Senator Murkowski practiced commercial law in Anchorage and served three terms in the Alaska State House of Representatives. She was elected to a full six-year U.S. Senate term in 2004, and was re-elected in 2010 in an historic write-in campaign.

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**Jack Omelak**

Jack Omelak was born and raised in Alaska, and has backgrounds in natural science, federal Indian law, anthropology, rural development, and arctic policy development. Currently, he is the Executive Director of The Alaska Nanuuq Commission which, along with the USFWS, is charged with managing the two U.S. populations of polar bears. He also serves as the U.S. Co-Chair of the U.S. and Russia Bi-Lateral Treaty for the Conservation of Chukchi Polar Bears. Jack has been the lead author in drafting the first
international management plan for the U.S. for polar bears, and is also part of the team writing the U.S. conservation and recovery plan for polar bears under the Endangered Species Act.

He is also a founding member of the Arctic Marine Mammal Coalition which is composed of five Arctic marine mammal co-management groups. This body is proactive in shaping Arctic policy in regards to emerging Arctic shipping and the protection and safety of marine mammal users. He is also an executive steering committee member in the formation of Alaska's first waterway safety committee.

Hon. Fran Ulmer

Fran Ulmer is chair of the U.S. Arctic Research Commission, where she has served since being appointed by President Obama in March 2011. In June 2010, President Obama appointed her to the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. From 2007 to 2011, Ms. Ulmer was chancellor of Alaska's largest public university, the University of Alaska Anchorage (UAA). Before that, she was a Distinguished Visiting Professor of Public Policy and Director of the Institute of Social and Economic Research at UAA. She is a member of the Global Board of the Nature Conservancy and on the Board of the National Parks Conservation Association.

Ms. Ulmer served as an elected official for 18 years as the mayor of Juneau, a state representative, and as Lieutenant Governor of Alaska. She previously worked as legal counsel to the Alaska Legislature, legislative assistant to Governor Jay Hammond, and Director of Policy Development for the state. In addition, she was the first Chair of the Alaska Coastal Policy Council and served for more than 10 years on the North Pacific Anadromous Fish Commission. She has served on numerous local, state, and federal advisory committees and boards. Ms. Ulmer earned a J.D. cum laude from the University of Wisconsin Law School, and has been a Fellow at the Institute of Politics at the Kennedy School of Government.
Panel Speaker Biographies

Mark Abbott, Ph.D.

Dr. Mark Abbott is Dean and Professor at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University. He received his B.S. in Conservation of Natural Resources from the University of California, Berkeley, in 1974 and his Ph.D. in Ecology from the University of California, Davis, in 1978. He has been at OSU since 1988 and has been Dean of the College since 2001. He served on the National Science Board from 2006 until 2013. Dr. Abbott's research focuses on the interaction of biological and physical processes in the upper ocean and relies on both remote sensing and field observations. Dr. Abbott is a pioneer in the use of satellite ocean color data to study coupled physical/biological processes. He has also advised the Office of Naval Research and the National Science Foundation on ocean information infrastructure. He is currently president of The Oceanography Society and chairs the Committee on Earth Science and Applications from Space for the NRC.

Dave Benton

Dave Benton has over 35 years of experience in national and international oceans governance. He was appointed to the United States Arctic Research Commission by President Barak Obama in June of 2012. His past experience includes representing the State of Alaska in international negotiations including negotiations with China, Russia, Japan, Korea, Poland, Canada, and at the United Nations. He also represented the State of Alaska before Congress and in numerous national oceans policy fora. Benton was appointed by President Clinton as Alaska’s Commissioner on the U.S. Canada Pacific Salmon Commission, serving as part of the U.S. team that negotiated a 10 year resolution to the salmon management conflict between the U.S. and Canada. He helped establish the Northern Boundary Fund, a $75 million bi-national endowment that
funds fishery science and restoration projects in northern British Columbia and Alaska. He served nine years on the North Pacific Fishery Management Council, three years as Chair. Benton helped establish the North Pacific Research Board, which funds marine research in the North Pacific, Bering Sea, and Arctic Ocean. He served as the first Chair of the NPRB at its inception in 2001-2003 and again as the special fisheries representative 2004-2006. From 2004 to 2010, Benton was the Executive Director of the Marine Conservation Alliance, a coalition of harvesters, processors, and coastal communities involved in Alaska’s groundfish and crab fisheries. He currently sits on the Board representing the USARC and works as a consultant to the seafood industry and environmental organizations on a range of oceans management and conservation matters. Mr. Benton spends his spare time as President of the Alaska Lighthouse Association, and is deeply involved in restoring Point Retreat Lighthouse on Admiralty Island.

Cecilia Bitz, Ph.D.

Dr. Cecilia Bitz is a professor in the Atmospheric Sciences Department at the University of Washington, and she is part of the UW Program on Climate Change. Dr. Bitz’s research focus is on climate and climate change in the high latitudes, especially involving the cryosphere. She is currently working on Arctic sea ice predictability, the hydroclimate of Antarctica, and climate control of snow depths on sea ice. Dr. Bitz is an active volunteer and science advisor to Polar Bears International. She won the 2013 Rosenstiel award for Oceanography and Meteorology and the 2013 Ascent award for the Atmospheric Science section of the American Geophysical Union. In 2015, she became a fellow of the American Meteorological Society.
RADM Craig Bone (ret.)

Upon retirement from the U.S. Coast Guard after more than 31 years of service, Rear Admiral Craig E. Bone joined the corporate management of ABS, the leading international classification society, in the newly created position of Vice President, Corporate Programs. In February 2010, he assumed the position of Vice President of Government Operations. RADM Bone leads all government service delivery and governmental affairs from the society’s Washington, DC office located in Alexandria, Virginia.

In his many years with the Coast Guard RADM Bone has held a series of very senior positions, most recently as Commander of the Eleventh CG District on the Pacific coast. He is the former Assistant Commandant for Marine Safety, Security and Environmental Protection, directing the agency’s policy and programs for port, vessel and facility maritime safety and security management. He has led the U.S. delegation to the IMO and spearheaded implementation of the Marine Transportation Security Act and the development of international commercial vessel safety and security standards. He has served as Captain of the Port and Officer in Charge of Marine Inspection for the ports of New York/New Jersey and Savannah, Georgia as well as a breadth of ship construction and repair experience as a marine inspector serving in U.S. ports and overseas shipyards.

RADM Bone holds Master’s degrees in Information Systems Technology from the George Washington University and in National Resource Strategy from the Industrial College of the Armed Forces in addition to a Bachelor’s of Science degree in Marine Science from the U.S. Coast Guard Academy.
**Greg O’Corry-Crowe, Ph.D.**

Dr. Greg O’Corry-Crowe’s research focuses on combining molecular genetics with field ecology to study the molecular and behavioral ecology of marine apex predators. He is particularly interested in investigating the effects of ecosystem and climate change on upper tropic levels with an emphasis on polar and temperate marine mammals. Dr. O’Corry-Crowe completed his studies (B.Sc., Ph.D.) at University College Dublin, Ireland where he focused on terrestrial mammals (ungulates and carnivores), before embarking on a career in marine science. His research interests extend beyond the marine realm to: the evolution of social behavior and mating systems in mammals, the role of individual fitness in population viability and adaptation, and the application of ancient DNA (aDNA) technology to ecosystem and evolutionary questions. He is formerly a research scientist at NOAA and adjunct Professor at San Diego State University, and is currently Associate Research Professor at Florida Atlantic University.

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**Steve Feldgus, Ph.D.**

Dr. Steve Feldgus is the Senior Energy Policy Advisor for the House Natural Resources Committee Democrats. Previously, he served as Senior Advisor to the Directors of the Bureau of Safety and Environmental Enforcement and the Bureau of Land Management, both at the Department of the Interior. Prior to working at DOI, Dr. Feldgus worked for Chairman Nick J. Rahall as legislative staff on the House Natural Resources Energy and Mineral Resources Subcommittee, and as the energy and environment legislative assistant for Sen. Robert Menendez in both the House and Senate. He received his Ph.D. in Physical Chemistry from the University of Wisconsin-Madison, his B.S. in Chemistry from the University of Massachusetts at Amherst, and started working in Congress on an American Association for the Advancement of Science / American Chemical Society Congressional Fellowship in the office of then-Senator Jon S. Corzine.
Jackie Grebmeier, Ph.D.

Dr. Jacqueline Grebmeier is Research Professor and a biological oceanographer at the University of Maryland Center for Environmental Science. Dr. Grebmeier earned a Bachelor of Arts in Zoology from the University of California, Davis in 1977 and went on to receive Masters Degrees in Biology from Stanford University in 1979, and in Marine Affairs from the University of Washington in 1983, specializing in applications of Arctic science to Arctic policy. Dr. Grebmeier earned a Ph.D. in Biological Oceanography from the University of Alaska Fairbanks in 1987. She has played a leadership role in coordinating and promoting national and international arctic research. She recently completed her service as the U.S. delegate to, and a vice-president of the International Arctic Science Committee, and as a member of the U.S. Polar Research Board of the National Academies, and she also served formerly as a Commissioner of the U.S. Arctic Research Commission following appointment by President Clinton. She has contributed to other coordinated international and national science planning efforts including service on the steering committee for U.S. efforts during the International Polar Year. Over the last thirty years she has participated in over 45 oceanographic expeditions on both U.S. and foreign vessels, many as Chief Scientist, and she was the overall project lead scientist for the U.S. Western Arctic Shelf-Basin Interactions project, which was one of the largest U.S. funded global change studies undertaken in the Arctic. Her research includes studies of pelagic-benthic coupling in marine systems, benthic carbon cycling, benthic faunal population structure, and polar ecosystem health, and she has published approximately 100 peer-reviewed scientific papers and she has also served as editor of several books and journal special issues. Her research is focused on understanding how arctic marine ecosystems respond to environmental change, particularly efforts to illuminate the importance of benthic biological systems.
Randall Luthi became President of the National Ocean Industries Association (NOIA) on March 1, 2010. An attorney and rancher from Freedom, Wyoming, Luthi has had an exciting and varied career, including serving as a legislative assistant in the U.S. Senate and career service as an attorney at the Department of the Interior, and the National Oceanic and Atmospheric Administration, where he worked on natural resource damages following the Exxon Valdez accident.

Luthi most recently served as the Director of the Minerals Management Service (MMS) at the Department of the Interior (DOI) from July 2007 through January 2009. In addition to overseeing offshore lease sales and collection and distribution to the States and Federal government of mineral revenues and royalties, Luthi oversaw the expansion of a renewable energy office at MMS. Luthi also served as the Deputy Director of the Department’s Fish and Wildlife Service (FWS), and started the law firm of Luthi & Voyles, LLC, in Thayne, Wyoming. Luthi’s career in the Wyoming House of Representatives began in 1995 with his name being drawn from a cowboy hat by Governor Mike Sullivan to declare him the victor in a tie vote. As Majority Leader and Speaker of the Wyoming House, Luthi was instrumental in formulation of state budgets. Currently, Luthi also serves as Chairman of the Wyoming Stockgrowers Agricultural Land Trust Board.

Luthi is now in his fourth tour of duty in Washington, DC. He has previously served as a legislative assistant for then Senator Alan K. Simpson, was an attorney/advisor in the Solicitor’s Office at DOI, and Senior Counselor for Environmental Regulations at the National Oceanic Atmospheric Administration in the Department of Commerce.

Luthi graduated from the University of Wyoming in 1979 with a Bachelor of Science Degree in administration of justice, and earned a law degree from the University of Wyoming in 1982. Too short to be effective on a basketball court, he is more inclined to chase a racquetball around the court on occasion. He also enjoys hunting, fishing, and, of course, cheering for the University of Wyoming Cowboys and Cowgirls.
Dr. Larry Mayer is a Professor and the Director of the School of Marine Science and Ocean Engineering and The Center for Coastal and Ocean Mapping at the University of New Hampshire. He graduated magna cum laude with an Honors degree in Geology from the University of Rhode Island in 1973 and received a Ph.D. from the Scripps Institution of Oceanography in Marine Geophysics in 1979. After being selected as an astronaut candidate finalist for NASA's first class of mission specialists, Dr. Mayer went on to a Post-Doc at the School of Oceanography at the University of Rhode Island, an Assistant Professorship at Dalhousie University, and the NSERC Industrial Research Chair in Ocean Mapping at the University of New Brunswick. In 2000, Dr. Mayer became the founding director of the Center for Coastal and Ocean Mapping at the University of New Hampshire and the co-director of the NOAA/UNH Joint Hydrographic Center.

Dr. Mayer has participated in more than 90 cruises during the last 35 years, and has been chief or co-chief scientist of numerous expeditions, including two legs of the Ocean Drilling Program and five mapping expeditions in the ice covered regions of the high Arctic. He is the recipient of the Keen Medal for Marine Geology and an Honorary Doctorate from the University of Stockholm. He was a member of the President’s Panel on Ocean Exploration, National Science Foundation’s Advisory Committee for the Geosciences, and chaired a National Academy of Science Committee on national needs for coastal mapping and charting as well as the recently completed National Academies report on the impact of the Deepwater Horizon Spill on ecosystem services in the Gulf of Mexico. He was the co-chair of the NOAA’s Ocean Exploration Advisory Working Group, and is currently Vice-Chair of the Consortium for Ocean Leadership’s Board of Trustees, a member of the U.S. State Department’s Extended Continental Shelf Task Force, and the Navy’s SCICEX Advisory Committee. Dr. Mayer’s present research deals with sonar imaging and remote characterization of the seafloor as well as advanced applications of 3-D visualization to ocean mapping problems and applications of mapping to Law of the Sea issues, particularly in the Arctic.
Erik Milito

Erik Milito is the Director of Upstream and Industry Operations for the American Petroleum Institute (API), which is the national trade association representing more than 500 companies involved in all aspects of the oil and gas industry, including exploration production, refining and transportation. Milito’s work covers regulatory and legislative matters related to domestic exploration and production, including access to domestic oil and natural gas resources both onshore and offshore. Prior to his current position, Milito served as managing counsel covering a host of legal issues, including oil and gas leasing, royalty, environmental, fuels, transportation, safety, and civil justice reform.

Prior to joining API, Milito served for over four years on active duty in the U.S. Army as a judge advocate, and additional four years in the U.S. Army Reserve, resigning at the rank of Major. Milito was assigned to active duty tours in Hawaii, Korea and Aberdeen Proving Ground, Maryland, and he served as a prosecutor, defense attorney and command advisor. Milito was awarded the Meritorious Service Medal and Army Commendation Medals during his military tenure. After leaving the Army, Milito worked as a career attorney with the Solicitor’s Office of the U.S. Department of the Interior. While at Interior, Milito worked on royalty, employment law, and disability access issues.

Milito attended the University of Notre Dame on an R.O.T.C. scholarship, and received a bachelor’s degree in business administration. Milito then received his juris doctor from Marquette University Law School, where he was a member of the law review.

Milito has testified about industry efforts related to the Macondo incident before the House Committee on Natural Resources, the House Committee on Science and Technology, the Senate Subcommittee on Oceans, Atmosphere, Fisheries and Coast Guard, the National Commission on the Deepwater Horizon Oil Spill, and the National Academy of Engineering Investigation of the Spill. Milito testified before the Senate Energy and Natural Resources Committee and the House Natural Resources Committee on offshore oil and gas issues, and the House Subcommittee on Energy and Mineral Resources in hearings related to development of unconventional oil and gas resources. Milito also testified before the Senate Energy and Natural Resources Committee and the House Natural Resources Committee on the agreement between the United States and Mexico to allow development of oil
and natural gas resources along the countries maritime border in the Gulf of Mexico that has since been approved by Congress and the President. Most recently, Milito testified before the House Subcommittee on Nonproliferation, Trade and Terrorism about the importance of crude oil exports to the economy and national security. Milito has authored and co-authored several papers related to natural resources issues and routinely appears as a keynote and guest speaker on U.S. energy topics.

Milito formerly served on the Board of Trustees of the Rocky Mountain Mineral Law Foundation, and on the Board of Directors of the Alexandria, Virginia Boys and Girls Club. Milito and his wife Elizabeth have four children, William, Helen, Evelyn, and Jacob and live in Alexandria, Virginia.

Jim Overland, Ph.D.

Dr. James E. Overland is a Research Oceanographer at the NOAA Pacific Marine Environmental Laboratory in Seattle and Affiliate Professor, Department of Atmospheric Sciences, University of Washington. Dr. Overland’s interests are communicating climate change information about the Arctic and subarctic. He was a lead author for the International 5th IPCC Report and contributed to the U.S. government response to Endangered Species Act listings for polar bears and ice seals, and drilling in the Chukchi Sea. Dr. Overland has received the American Geophysical Union Ambassador’s Award, the Department of Commerce Bronze Medal and the NOAA Administrator’s Award for scientific excellence in support of national and international policy on climate change in the Arctic. His current research is on all aspects of Arctic change, including rapid loss of summer sea ice, potential linkages of Arctic change with mid-latitude weather, and ecosystem impacts in the Pacific Arctic. Overland is a past editor of Journal of Geophysical Research-Oceans and has contributed over 180 peer reviewed articles on climate and ecosystems.
Gary Rasicot

Gary Rasicot is Director, Marine Transportation Systems for the United States Coast Guard and responsible for overseeing the Arctic Implementation Plan. His directorate is responsible for a wide variety of navigation safety and security functions, including Waterways Management, Aids to Navigation, Domestic and Polar Ice Operations, Coastal and Marine Spatial Planning, and permitting for Bridges that span navigable waters.

In his previous Senior Executive Service position, Mr. Rasicot served as the Director of Global Maritime Operational Threat Response (MOTR) Coordination Center. As the nation’s primary coordinator of the MOTR process, he was responsible for facilitating the development of interagency approved U.S. Government courses of action in response to threats against the United States and its interests in the maritime domain.

A majority of Rasicot’s military career as a senior officer involved the development and implementation of National and Coast Guard Policy on National Security. He led policy development a coordination efforts of 22 federal agencies that resulted in National Security Presidential Directive 41/Homeland Security Presidential Directive 13, creating the first strategically-focused maritime security policy for the United States. Additionally, Mr. Rasicot assisted in the interagency development and implementation of the Nation's Maritime Operational Threat Response Plan. The plan made an immediate impact in developing interagency cooperation and coordination for U. S. maritime security response efforts for “real world” events. He co-authored the MOTR Forces Plan, which was signed by the President and provides the interagency structure to ensure maritime combating terrorism resource needs are met.

Rasicot is a 1984 graduate of the United States Coast Guard Academy in New London, CT, where he received a Bachelor of Science degree. He holds a Master’s Degree in Strategic Studies from the U.S. Army War College and a Master’s Degree in Public Administration from the University of Maryland.
Charles “Kolo” Rathburn

Charles “Kolo” Rathburn is currently a professional staff member on the U.S. Senate Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies. His role on the Committee involves overseeing budgets at the Department of Commerce and National Science Foundation and advising the Chairman of the CJS Subcommittee, Senator Richard Shelby of Alabama, on funding and policy issues. Before coming to the Appropriations Committee, Kolo served as a NOAA Sea Grant Legislative Fellow and then Legislative Assistant to U.S. Senator Roger Wicker of Mississippi. During that time, Kolo worked extensively on issues related to the 2010 Deepwater Horizon oil spill in the Gulf. He received a Master of Science degree from the Graduate Program in Marine Biology at the College of Charleston in 2009 and holds a Bachelor of Science degree in Biology from Chaminade University of Honolulu.

Kevin Schaefer, Ph.D.

Dr. Kevin Schaefer currently works at the National Snow and Ice data center at the University of Colorado in Boulder. After graduating from the University of Illinois in 1984, Dr. Schaefer worked for NASA as an aerospace engineer on Space Shuttle operations and ending up as a manager of science capabilities for the Space Station. In 1994, Dr. Schaefer became the manager of NASA data centers supporting the Earth observation program. Dr. Schaefer participated in several multi-agency working groups focused on climate change and supported the White House Council on Environmental Quality in the selection of sustainable development indicators. In 1997, he returned to school and in 2004 obtained a PhD in atmospheric science from Colorado State University. Dr. Schaefer spent two years as a national research council postdoctoral fellow at NOAA in Boulder using carbon dioxide concentrations from the global flask network to improve models and began studying permafrost dynamics at the National Snow and Ice Data Center in 2006. Dr. Schaefer published one of the first estimates of carbon emissions from thawing permafrost in 2011, served as lead author on a
2012 United Nations on the topic, and has published several articles on the effects of permafrost emissions on global climate.

Fiamma Straneo, Ph.D.

Dr. Fiamma Straneo is a Senior Scientist in the Physical Oceanography Department at the Woods Hole Oceanographic Institution. She studies the subpolar North Atlantic and Arctic oceans and their role in climate and climate variability on interannual to centennial timescales. Specific areas of interest are the interaction of the Greenland Ice Sheet with the ocean, freshwater export from the Arctic and from Greenland into the North Atlantic and the overturning circulation in the subpolar North Atlantic. She is chair of GRISO (an international science network focused on Greenland Ice Sheet-Ocean Interactions, formerly a US CLIVAR Working Group), chair of the Land-ice Team of SEARCH, a member of the Atlantic Meridional Overturning Circulation Science Team, and on the Science Steering Group of ASOF (Arctic SubArctic Ocean Fluxes). She has led over a dozen field expeditions to the Arctic and Greenland that have employed icebreakers, local vessels, helicopters, and snowmobiles. Her work has been featured in the New York Times, the Guardian, NPR amongst other media outlets.

Dustin Whalen

Dustin Whalen has been working in the Arctic Ocean on coastal and nearshore processes for the last 10 years. With over 30 field excursions to the area in Winter, Spring, and Summer, he has considerable hands-on knowledge of Arctic coastal erosion, coastal flooding, and nearshore sediment transport. As Physical Scientist with Natural Resources Canada since 2004, he has and continues to be involved with the Government of Canada’s priority to work with all
stakeholders to enhance the base level of coastal knowledge to better position and adapt to the changing coastline and climate. He is interested in how the ice-rich coastlines of the Arctic Ocean (in particular the Beaufort Sea) have changed in the past and will change in the future, how this will impact the communities and stakeholders in the Arctic and beyond. As an active proponent of the importance of science communication at the ground level, over the last seven years Dustin has maintained and distributed a daily community based Spring ice break-up newsletter as a means to inform all stakeholders on a real-time basis of this annual event that has the potential for huge coastal impacts. Growing up on the coast of Nova Scotia, Canada, Dustin is no stranger to the severe impacts of coastal erosion and coastal flooding; it is this mindset and passion that he brings to the Arctic coastal science world today and for many years to come. Dustin resides in Nova Scotia Canada with his wife and two young kids.

RADM Jonathan White

Rear Admiral Jonathan White was born in Panama City, Florida. His father was a World War II Army Air Corps veteran and Purple Heart recipient; his mother supported the war through her work in Oak Ridge, Tennessee. His passion for the Navy and oceanography began at age seven, thanks to the influence of a Navy diver who lived next door.

White earned a Bachelor of Science degree in Oceanographic Technology from the Florida Institute of Technology in 1981 and holds a master’s degree in Meteorology and Oceanography from the U.S. Naval Postgraduate School.

After working at sea as a civilian oceanographer on board a seismic survey vessel, he was commissioned through Navy Officer Candidate School in 1983, and assigned as a surface warfare officer to USS John L. Hall (FFG 32) in Mayport, Florida. White joined the oceanography community in 1987. Since then, he has had operational shore assignments at Jacksonville, Florida; Guam; Monterey, California; and Stuttgart, Germany, where his joint duty included Special Operations Command Europe, and strike plans officer for U.S. European Command during Operation Allied Force in Kosovo and Serbia. White commanded Naval Training Meteorology and Oceanography Facility, Pensacola, Florida, and was the 50th superintendent of the United States Naval Observatory.
White’s sea tours as a naval oceanographer include commander, Cruiser Destroyer Group 12 where he completed deployments on board USS Saratoga (CV 60) and USS Wasp (LHD 1). White was selected as a flag officer and honorary chief petty officer in 2009 and served as commander, Naval Meteorology and Oceanography Command. He was promoted to the rank of rear admiral (upper half) in August 2012 as he assumed his duties as director, Task Force Climate Change, and Navy deputy to National Oceanic and Atmospheric Administration. White wears numerous personal and unit awards, which are all a tribute to the Sailors, Marines, Airmen, Soldiers, Coast Guardsmen, and civilians he has served alongside throughout his career.

Photography and Videography: Will Ramos