REPORT ON THE Goals and Objectives for Arctic Research 2017–2018

FOR THE US ARCTIC RESEARCH PROGRAM PLAN

UNITED STATES ARCTIC RESEARCH COMMISSION

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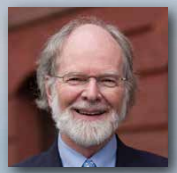

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FRONT COVER. Ikayuaq crew participates in spring whaling off of Utqiagvik, Alaska.
Photo credit: Steven Kazlowski

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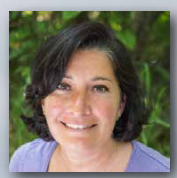

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We dedicate this report to Mayor Edward Saggan Itta, a whaler, friend, and Arctic expert. Edward was on the US Arctic Research Commission from 2012–2015, after serving as Mayor of the North Slope Borough. He provided USARC with valuable information about the region and insight into the history, culture, and everyday challenges of living in the far North. A leader with great integrity, Edward was a voice for the people of the Arctic, bridging traditional and modern life in a way few have achieved. He was an eloquent speaker who connected with audiences in a clear, compelling, and memorable way. Edward had a hearty laugh, powerful Inupiat dance moves, a strong moral compass, and true courage in the face of adversity. He always put community first and will be greatly missed. Quyanaq.

Photo credit: Lily Weed

A MESSAGE FROM USARC CHAIR FRAN ULMER

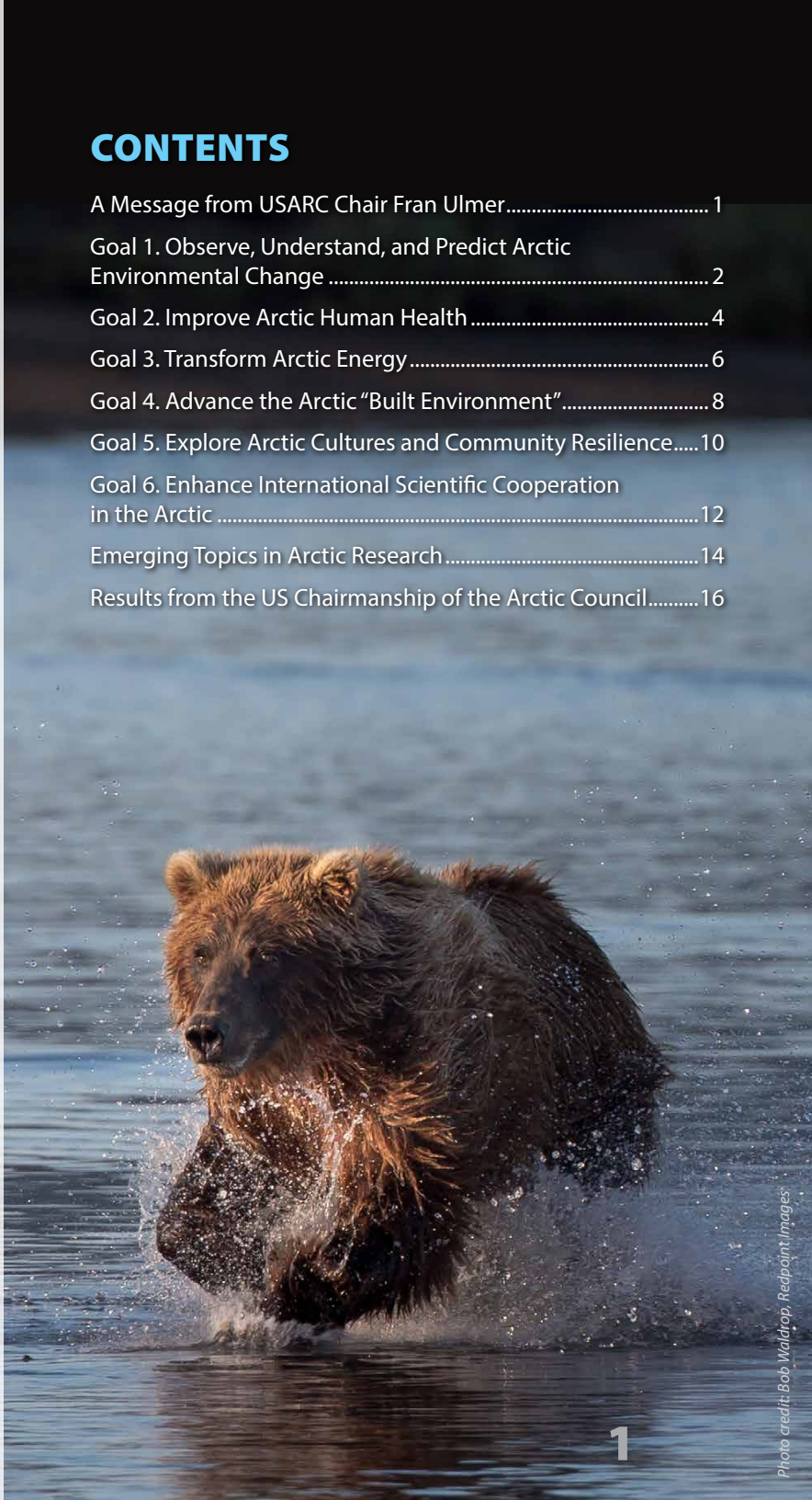
International Scientific Collaboration Must Keep Pace With Arctic Change

In September 2016, the White House hosted the first-ever Arctic Science Ministerial, convening science ministers from 25 governments to discuss research collaboration. Why did this happen?

It's because the Arctic region is rapidly and dramatically changing, redefining life for people and communities, animals and plants, ecosystem functions, and landscapes. The present doesn't look like the past, and the future will not look like the present, which makes it challenging for people to make choices about managing development and transportation, as well as land and water uses. The rapid rate of change may make it impossible for animals to adapt quickly enough to thrive or survive. Indigenous communities may be faced with food insecurity and altered social organization as a result of these changes.

Higher air temperatures, rapid retreat of land and sea ice, thawing permafrost, larger and more frequent forest fires, increasing ocean acidity, and other significant conditions demonstrate the altered state of the Arctic and have ramifications far beyond the region's borders. Examples include sea level rise, weakening of the jet stream, and much more unpredictable weather in mid-latitudes; the evidence is mounting that a warmer Arctic has significant ramifications for everyone.

Enhanced international cooperation in scientific research can improve our understanding of these changes. That understanding can help people make better decisions, empowering people and communities to take steps that will make them more resilient. Support for research generates new knowledge that can fuel economic growth and provides the talent that industry needs. The Arctic Science Ministerial (https://arctic.gov/publications/other/supporting_arctic_science.html) was an important step toward a more robust effort to share information and to cooperate across borders. The public and private sectors, academic and commercial interests, and countries in and beyond the Arctic have much to gain by continuing on this path. And so do all people, now and in the future.



CONTENTS

Photo credit: Bob Waldrop, Redpoint Images

GOAL 1. Observe, Understand, and Predict Arctic Environmental Change

MOTIVATION

Climate warming continues to influence components of the Arctic environmental system—marine and fresh waters, sea ice, glaciers, ice sheets, permafrost, snow cover, tundra and boreal forests, and attendant ecosystems. Since 1960, Alaska has warmed more than twice as rapidly as the rest of the United States, with average annual air temperatures increasing by 3°F and average winter temperatures by 6°F.[1] A similar warming pattern has been observed throughout the Arctic, and projections for Alaska could lead to an additional 2°F to 4°F increase by 2050. The duration of growing seasons has increased by nearly 50%, and will continue to lengthen. However, more favorable conditions for pests, wildfires, and water shortages may offset this advantage. Importantly, warming conditions in the Arctic will affect climate in temperate regions and sea level worldwide. Greater knowledge and understanding of the causes and impacts of Arctic climate change will help inform decisions and actions regarding these global issues.

Photo credit: US Geological Survey

RECOMMENDATIONS

- Quantify the rate and magnitude of Arctic sea ice loss and understand its impact on global climate, species distributions, marine ecosystems, offshore development, ship access, and community vulnerability to coastal erosion.
- Examine, recognize, and project trends in glacier and ice sheet extent, and snow cover loss, and their implications for freshwater budgets, ocean circulation patterns, global sea level rise, fisheries, water security, and hydropower production.
- Map the distribution and extent of permafrost warming and thawing, and document links to landscape hydrology, increasing number of wildfires, habitat alteration, release of methane and carbon dioxide, and the rising costs to maintain infrastructure.
- Investigate how changes in ocean temperature and carbon chemistry affect Arctic marine ecosystems, their composition and productivity, and the potential of Arctic fisheries.
- Bring new resources to the study of the Arctic boreal forest, one of Earth's largest biomes, to better understand the value of its ecosystem and to assess threats from increasing numbers of insects, changes in the hydrological cycle, and unusual fire regimes.
- Advance an Arctic Observing Network (AON) from a concept to an integrated, fully operational system that provides increased and timely access to data, critical information, and derived products for scientific research, as well as operational intelligence and decision support.
- Fill in key gaps in Arctic observations. A few examples include collecting data on long-term carbon fluxes from permafrost, sampling permafrost in northeastern Siberia, quantifying rates and extent of Greenland ice sheet melting (critical input for models), monitoring changes in marine biota (including fish and shellfish) in the central Arctic Ocean, and gathering meteorological data from the lowest and highest atmospheric layers over Arctic sea ice, as well as year-round oceanographic data from ice-covered regions of the Arctic Ocean.

[1] Melillo, J.M., T.C. Richmond, and G.W. Yohe, eds. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* US Global Change Research Program. Washington, DC. https://doi.org/10.7930/J0Z31WJ2.

Photo credit: Elisabeth Calvert, NOAA Hidden Ocean Expedition

Photo credit: Tim Dunton

PROGRESS

» **NASA Programs and Initiatives.** Three National Aeronautics and Space Administration (NASA) programs are making significant progress in understanding Arctic environmental change. The Arctic-Boreal Vulnerability Experiment (ABoVE) is a 10-year effort to understand the vulnerability and resilience of terrestrial ecosystems in the boreal region of North America by integrating field-based studies, modeling, and data from air- and spaceborne assets to improve our understanding of the causes and impacts of ecological change. To understand how warming ocean waters are melting Greenland's glaciers, Oceans Melting Greenland (OMG) observes water temperatures, elevation, gravity, and the water depth of Greenland's continental shelf. Operation IceBridge uses detailed airborne remote-sensing measurements to document changes in the thickness of Arctic ice sheets and the sea ice cover until satellite-based LIDAR measurements resume in 2018, with the launch of ICESat-2 (Ice, Cloud, and Land Elevation Satellite-2).

» **ONR Programs and Initiatives.** The Office of Naval Research (ONR) Arctic and Global Prediction Program supports research to enhance understanding of the physical Arctic environment and the key processes that shape it, and develops new technologies and models to improve predictions of Arctic conditions over a variety of time scales. In 2017, ONR will begin a new initiative, Arctic Mobile Observing System/Science that will focus on a mobile autonomous observational network. This follows on the heels of the three other departmental research initiatives on the Marginal Ice Zone, on the Sea State and Boundary Layer Physics of the Emerging Arctic Ocean, and on Stratified Ocean Dynamics of the Arctic.

» **NSF Programs and Initiatives.** The SEARCH (Study of Environmental Arctic Change) collaborative program, funded by the National Science Foundation (NSF), provides a foundation of Arctic change science. Other programs in NSF's Division of Polar Programs, such as the Arctic Observing Network, the Arctic Natural Sciences Program, and the Arctic System Science Program, continue to support excellent research on environmental change.

» **NPRB and Partners' Arctic Integrated Ecosystem Research Program.** The North Pacific Research Board (NPRB) and partners are investing $16M in an Arctic Integrated Ecosystem Research Program to study marine processes in the northern Bering and Chukchi Seas in 2017–2021.

» **DOE Next-Generation Ecosystem Experiments.** The goal of the Department of Energy's (DOE) Next-Generation Ecosystem Experiments is to improve climate model predictions through advanced understanding of coupled processes in Arctic terrestrial ecosystems.

» **NOAA Arctic Research Program.** The National Oceanic and Atmospheric Administration (NOAA) Arctic Research Program has a new strategic plan that supports: (a) oceanographic surveys off Alaska along eight specific transects (Distributed Biological Observatory); (b) the International Arctic Systems for Observing the Atmosphere; (c) drones, gliders, and aircraft to survey the Arctic ocean and atmosphere; (d) modeling efforts; and (e) a project office for the US Arctic Observing Network.

Background photo credit: Christopher Michel

GOAL 2. Improve Arctic Human Health

MOTIVATION

Arctic climate change is altering the presence and distribution of bacteria, viruses, and other microorganisms (pathogens) that can cause disease in people and wildlife, including species critical to subsistence. Concurrently, long-range transport of contaminants from outside the Arctic leads to their accumulation in Arctic food webs, threatening food and water security, and the health of local people.

Access to adequate amounts of clean water is strongly connected to improved health, but climate change is disrupting water and sanitation systems. The Arctic is being affected by warming and thawing permafrost, rising sea levels, increasing number and intensity of storm surges, saltwater intrusion into coastal groundwater, and northward moving animal populations that bring with them new pathogens (e.g., giardia). Additionally, climate change is drying tundra ponds and is damaging water and sanitation infrastructure.

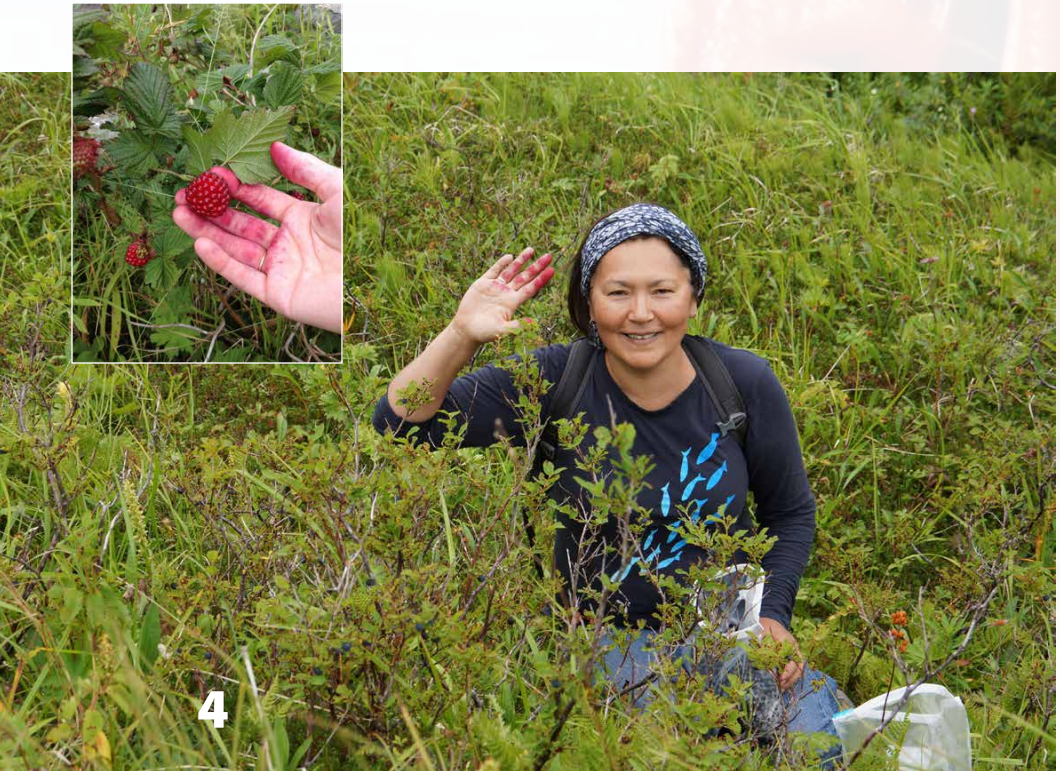


Photo credit: Yukon-Kuskokwim Health Corporation

RECOMMENDATIONS

- Promote research on innovative strategies to increase use of and access to adequate amounts of clean water and sanitation (with commensurate health improvements) in remote communities with a specific focus on climate change and its impacts on these systems and the health of Arctic residents.
- Support new approaches to health programs that recognize and strengthen the connections between people, wildlife, environment, and climate.[2]
- Analyze the possible pathways of human exposure to contaminants and diseases passed between people and wildlife in the Arctic, and how these pathways evolve with climate change.
- Investigate approaches to prepare for and manage responses to climate change that reduce negative impacts to human health and safety.
- Research climate-change-related alterations in the distribution and migratory pathways of wildlife to better inform management decisions and to protect subsistence species.

[2] "One Health" is one such initiative, as it integrates human, animal, and environmental health through the interdisciplinary work of human health experts, biologists, veterinarians, and environmental scientists.

PROGRESS

» **NSF Programs and Initiatives.** Recognizing the value and inextricable links of the food-energy-water interrelationship, NSF established an interagency initiative, Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), to examine the best ways to balance society's growing demand for food, water, and energy and still maintain necessary ecosystem services.

» **ADEC Programs and Initiatives.** The Alaska Department of Environmental Conservation (ADEC), in coordination with tribal, state, and federal agencies, is spearheading two efforts. The first is The Alaska Water and Sewer Challenge, a research and development effort to identify improved and affordable ways to deliver drinking water and sanitation services to rural Alaska. The second, the Water Innovations for Healthy Arctic Homes Conference, brought together US and international engineers, health experts, researchers, community members, policymakers, and innovators to discuss ways to make running water and sewer services safe, affordable, and sustainable in remote northern communities.

» **Healthy Alaskans 2020.** Healthy Alaskans 2020 is a state-tribal partnership that established 25 health priorities for Alaska, with targets for improvement by 2020. One priority, specific to water, is: "Increase the proportion of Alaskans with access to in-home water and wastewater services."

» **International Programs and Initiatives.** Internationally, the Arctic Monitoring Assessment Programme (AMAP) released health reports on environmental contaminants and toxic metals. Several other international research projects also focused on the impact of these hazards as well as radioactivity on human health within Arctic populations (e.g., the Northern Contaminants Programme [Canada], and Healthy Food and Lifestyle Choices [Norway, Finland, Russia]).

HEALTHY ALASKANS 2020

87%

The Healthy Alaskans 2020 metric for water is the percentage of rural community housing units with water and sewer services. It currently stands at 78%, and the target goal is 87% by 2020.

ECOSYSTEM SERVICES

Ecosystem services are the life-sustaining benefits people obtain from ecosystems. These services include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Photo credit: Gay Sheffield

Photo credit: LT Tim Smith, NOAA

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GOAL 3. Transform Arctic Energy

MOTIVATION

Communities in the Arctic seek "energy security." Replacing expensive fossil fuels with alternatives has become a priority. Improved energy efficiency and renewable technologies will help achieve socioeconomic development goals and support environmental health, as well as enhance energy security.

Photo credit: Alaska Energy Authority

Photo credit: Alaska Energy Authority

Photo credit: Dave Messier, Tanana Chiefs Conference

ENERGY SECURITY

"Energy security" is defined as access to clean, reliable, and affordable energy for cooking, home heating, lighting, communications, and other uses characterized by uninterrupted physical availability at an affordable price, while respecting environmental concerns.

RECOMMENDATIONS

- Collect and compile baseline data on Arctic energy use and rural infrastructure, including those related to fuel shipments. These data should enable research that will decrease uncertainty by identifying and mitigating investment risk, thereby increasing potential for industry involvement in renewable energy projects in remote regions.
- Develop and optimize options to increase energy efficiency and the use of renewable energy to reduce heating oil consumption.
- Promote research on battery and other storage methods for energy produced by renewable technologies, particularly under extremely cold and harsh conditions.
- Collaborate across disciplines to better understand the connections between energy, water, and food security in the Arctic (e.g., INFEWS, as per Goal 2).
- Develop methods to estimate the indirect community benefits of renewable and efficient energy use (i.e., improved air quality, energy security, and carbon footprint) that are not considered in typical renewable energy cost/benefit analyses.
- In 2016, the Alaska State Legislature defunded the Renewable Energy Fund that previously supported projects such as the design and building of small hydro projects and wind turbines in remote villages. We recommend restoring funding for this valuable program. In lieu of such support, we encourage program managers to work with state and federal collaborators, as well as international researchers and private investors, to continue progress in this area.

PROGRESS

» **USARC Arctic Renewable Energy Working Group.** USARC created and coordinates the Arctic Renewable Energy Working Group (AREWG, https://www.arctic.gov/arewg/index.html) that serves Arctic communities by identifying and addressing critical research needs in renewable energy and energy efficiency. AREWG initiated a series of workshops on residential heating research needs in remote Arctic villages and strategies for community-level capacity building. An important outcome of these workshops will be the development of research priorities for rural heating and an implementation plan to achieve them.

» **DOE Remote Alaska Communities Energy Efficiency Competition.** The Department of Energy's Remote Alaska Communities Energy Efficiency (RACEE) Competition, with $3.4M in available funding, was created to encourage Alaskan communities to develop effective tools to advance the use of reliable, affordable, and energy-efficient solutions that can be replicated throughout Alaska and the Arctic. Communities that pledged to reduce their energy consumption by at least 15% by 2020 competed for energy efficiency technical assistance. DOE announced awards to seven communities in late 2016.

» **Alaskan Success.** Several small Alaskan communities use renewable energy. Over 25 villages employ wind turbines to generate power in order to reduce their reliance on fossil fuels. Drilling in Akutan will confirm the location and size of the geothermal resource that may ultimately provide heat and power to the community, and additional geothermal projects throughout the state are in progress. Biomass resources are also being investigated as heat sources for rural district heating projects.

» **Global Progress.** On a global scale, progress is being made toward carbon-free energy. Costa Rica, Denmark, Austria, Germany, and Hawaii have made huge strides by switching to renewables, or by increasing non-polluting energy production. In the Arctic, geothermal resources helped Iceland achieve close to 100% renewable energy use.

Photo credit: Alaska Energy Authority

Background photo credit: Sacha Layos

GOAL 4. Advance the Arctic "Built Environment"


Photo credit: Patrick Murphy, San Diego State University

MOTIVATION

Damage to Arctic infrastructure, particularly in coastal and riverine communities, will continue as Earth's climate warms. Compromised infrastructure increases risks to human health, safety, and well-being and results in economic impacts on the scale of billions of dollars in Alaska alone. Rising sea level and extreme storms and their surges jeopardize infrastructure systems. The increased risk is due to near-surface permafrost warming and thawing, changing freeze-thaw cycles, reduced sea ice cover, coastal and riverine erosion, inland flooding, and forest and tundra wildfires. The reliability, capacity, and interdependency of ports, harbors, seawalls, rail lines, airports, bridges, buildings, industrial facilities, pipelines, research field stations, and military installations are increasingly susceptible to destruction and loss of life and property, resulting in large socioeconomic impacts. Support for increased Arctic shipping requires implementation and enforcement of the International Maritime Organization's Polar Code, and adequate infrastructure, such as ports, harbors, and places of refuge, aids to navigation, systems for search and rescue and for spill response, ice navigation training, navigation charts, communications systems, icebreakers, and ice centers.

BUILT ENVIRONMENT

"Built environment" is a social science term that refers to the human-made surroundings and infrastructure that provide the setting for human activity, ranging in scale from buildings to cities and including supporting systems, such as for water, sewage, energy, communications, and transportation.

RECOMMENDATIONS

- Translate current knowledge of Arctic climate and environment, and the projected changes over the next century, into a practical application to improve design criteria for engineering projects in Arctic regions. Such an application, at the intersection of science and engineering, can serve as both an educational tool for students and as a reference for engineers.
- Advance multidisciplinary research, involving engineering, socioeconomics, and climatology, among others, to quantify the potential direct and indirect economic impacts of climate change on Arctic infrastructure, thereby advancing the field beyond simple observation and risk evaluation.
- Develop a comprehensive inventory of public infrastructure that would be used as input into sophisticated models to better capture relationships between environmental stressors, infrastructure lifespan, and incremental change in the costs of capital, operation, and maintenance.
- Accelerate the pace of Arctic marine charting to increase understanding of the dynamic shape and characteristics of the Arctic seafloor. These data will not only advance planning for new offshore infrastructures, but will also improve security, safety of navigation, and fundamental understanding of the Arctic climate system.

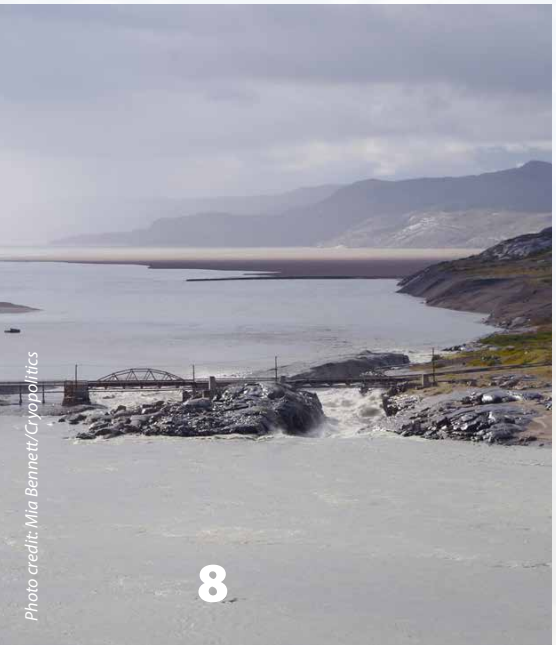
Photo credit: Mia Bennett/Cryopolitics

MAPPING ALASKA'S SHORELINES

< 5%

Less than 5% of US Arctic maritime waters (those within 200 nautical miles of Alaska shorelines in the Bering, Chukchi, and Beaufort Seas) have been mapped by modern methods.

Photo credit: Pete Souza, Official White House Photo

> "What's happening in Alaska isn't just a preview of what will happen to the rest of us if we don't take action. It's our wake-up call."
>
> – President Barack Obama
>
> *Quoted in a video: https://www.whitehouse.gov/webform/president-obama-going-alaska-heres-why*

PROGRESS

» **The Denali Commission.** The Denali Commission was recently designated as the lead coordinator for federal, state, and tribal resources to assist communities in developing and implementing solutions to address the impacts of climate change. The commission's website contains a compendium of federal resilience programs for Alaskan communities.

» **USDA Programs and Initiatives.** The US Department of Agriculture (USDA) provided $16M in grants for 17 water system projects in the Rural Alaska Villages Grant Program. The USDA also initiated cooperative agreements for rural development (housing, community facilities, wastewater systems, and broadband) with four Native nonprofit organizations in western Alaska.

» **Federal Communications Commission Programs and Initiatives.** The Federal Communications Commission intends to provide Alaska's smaller telecommunication companies with up to $1B over 10 years to encourage them to bring fast, reliable Internet access to underserved areas. Additionally, a private sector effort to complete a 1,200-mile fiber-optic cable system linking the North Slope of Alaska to existing systems is being undertaken by Quintillion Subsea Operations and funded by Cooper Investment Partners.[3]

» **Scenario Planning Efforts.** Scenario planning efforts, such as the North Slope Science Initiative's "Scenarios for North Slope Development and Related Science Needs," are becoming more common and are being used to proactively plan future management and investment.

Photo credit: Cyrus Read, US Geological Survey

ANALYSIS OF FUTURE CLIMATE CHANGE DRIVEN COSTS

The cost of infrastructure systems will increase, but by how much, and when? A recent analysis[4] quantified and monetized the risks of inaction and the benefits of local adaptation and global greenhouse gas mitigation. The study computed potential economic damages to Alaska's public infrastructure from regional climate-driven changes under future global climate scenarios. The authors concluded that the greatest damages could result from flooding (roads), followed by near-surface permafrost thaw (buildings). Cumulative estimated expenses from climate-related damage to infrastructure from 2015 to 2099 total $5.5B for a high atmospheric CO_2 scenario, and $4.2B for a lower one. When proactive adaptation efforts were projected, cumulative costs were reduced to $2.9B for high emissions and $2.3B for lower emissions. Results suggest both adaptation to a warmer climate and global action to reduce greenhouse gas emissions could significantly reduce future public infrastructure damages.

[3] K. Woolston, Quintillion, *pers. comm.*, January 25, 2017.

[4] Melvin, A.M. et al. 2016. Climate change damages to Alaska public infrastructure and the economics of proactive adaptation. *Proceedings of the National Academy of Sciences of the United States of America*. https://doi.org/10.1073/pnas.1611056113.

Background photo credit: Cyrus Read, US Geological Survey

GOAL 5. Explore Arctic Cultures and Community Resilience


Photo credit: Rudy D'Alessandro, 2011


Photo credit: Frank Matumeak

MOTIVATION

Historically, indigenous communities have demonstrated resilience and capacity to survive and thrive in an evolving and unpredictable environment. Nevertheless, many communities experienced historical trauma through interactions with Western cultures. These pressures, along with factors such as food and water insecurity, disturbances to subsistence sharing networks, and the lack of economic opportunities in remote villages, create challenges that require attention and effort at the federal, state, and especially the local level.

Given accelerating physical, biological, and social transformations in the Arctic, there is a need to monitor change, assess impacts, and mobilize responses to adequately inform adaptation policies and practice. Indigenous knowledge (IK) systems have been an essential part of successful adaptation strategies and are valuable resources for scientists. Arctic residents want IK to be considered equally with science in a mutually beneficial way. Co-production of knowledge has been recognized as a critical need, yet implementation remains uneven.

SUBSISTENCE

Subsistence is defined by Public Law 96-487 as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools or transportation; for the making and selling of handicraft articles out of nonedible by-products of fish and wildlife resources taken for personal or family consumption; and for the customary trade, barter or sharing for personal or family consumption."

RECOMMENDATIONS

- Promote research that supports Alaska-based early intervention and prevention programs, which are critically important in reducing the risk and occurrence of suicide and other adverse behaviors. To increase the likelihood of success, these programs should be community-driven or have a significant community-based component.
- Encourage research into, and use of, trauma-informed therapy that is appropriate for children, families, and communities. This includes sensitivity to the patient's background, characterized by an understanding of differences in emotional expression among cultures.
- Effectively incorporate community needs into healthy community plans, supporting cultural drivers that reinforce resilience.
- Improve communication with indigenous populations about the health factors associated with the consumption of traditional foods. These factors include dietary choice, sociocultural impacts, risk perception, and methods to balance the benefits and risks of a traditional diet.
- Investigate the impacts of climate change on sociocultural practices, especially with respect to food security. Explore the relationship between local socioeconomic conditions and risk and vulnerability to food insecurity.
- Better integrate social science and culturally sensitive and inclusive approaches into Arctic research efforts. Such approaches should be mutually beneficial, as this increases the likelihood of project success.


Photo credit: Melany Zimmerman

PROGRESS

» **USARC Arctic Mental Health Working Group.** USARC created and coordinates the Arctic Mental Health Working Group (AMHWG, https://arctic.gov/amhwg), which works collaboratively with tribes, healthcare providers, and other stakeholders to promote research on, and raise awareness of, the significant mental and behavioral health disparities that exist between Arctic and non-Arctic populations. AMHWG addresses suicide prevention in Arctic communities, with a specific emphasis on early intervention approaches for children and youth.

» **The Rising Sun Initiative.** Building upon prior efforts, the goal of the Rising Sun initiative, led and coordinated by the National Institute of Mental Health (NIMH) of the National Institutes of Health (NIH), and in partnership with other federal entities, is to reduce the incidence of suicide in indigenous groups across the circumpolar Arctic. The objective is to identify common outcomes and measures to help evaluate suicide prevention efforts and to assess their effectiveness.

» **Inuit Circumpolar Council-Alaska Programs and Initiatives.** Inuit Circumpolar Council-Alaska released its Alaskan Inuit Food Security Conceptual Framework in 2015.[5] An excellent resource on food security, it provides valuable information on the integration of IK into scientific research. In 2017, ICC-Alaska will hold three summits focused on wildlife, economics, and education.

» **Enhancing Language Proficiency.** In support of dual-language programs, the Fairbanks Native Association and the Lower Kuskokwim School District received grants of $1.6M and $1.5M, respectively, from the US Department of Education. These funds, awarded in September 2016, will enhance language proficiency for Alaska Native students in both English and native languages.

» **Understanding the Changing Arctic.** Several new efforts have been initiated to monitor and observe local change in the Arctic. The Alaska Native Tribal Health Consortium's Local Environmental Observing (LEO) Network, funded by the Environmental Protection Agency, recently expanded beyond the United States and Canada and into the Fenno-Scandinavian region to become the Circumpolar Local Environmental Observing (CLEO) Network. The Atlas of Community-based Monitoring and Indigenous Knowledge in a Changing Arctic was initiated as a task of the Sustaining Arctic Observing Networks (SAON) to help address coordination of community-based initiatives at a circumpolar level. Finally, the NSF granted $500K for a four-year "research collaboration network" on community observing called EyesNorth – A Research Coordination Network of Community-Based Observing Initiatives in the Arctic and Beyond.

[5] Inuit Circumpolar Council-Alaska. 2015. *Alaskan Inuit Food Security Conceptual Framework: How to Assess the Arctic From an Inuit Perspective*. Technical Report. Anchorage, AK.


Photo credit: Ilka Raupach


Photo credit: Melany Zimmerman

Photo credit: Pete Souza, Official White House Photo

Background photo credit: Ilka Raupach

GOAL 6. Enhance International Scientific Cooperation in the Arctic


Photo credit: Hannu Halinen

MOTIVATION

Many benefits accrue through international cooperation on Arctic research, particularly given the immense size of the region, the great magnitudes and rates of change, and the challenging environment. This was recognized and reinforced by the 25 governments that gathered at the White House in Washington, DC, on September 28, 2016, for the first-ever Arctic Science Ministerial (ASM). Such benefits include multinational sources of knowledge and expertise, shared costs and risks, greater efficiencies, and increased access to physical areas, as well as to data, information, facilities, and infrastructure. International cooperation also serves as a means for science diplomacy and confidence building, thereby diffusing tension and conflicts and encouraging trust, synergy, and integration.


Photo credit: Arctic Council Secretariat, Linnea Nordström


Photo credit: US Coast Guard Petty Officer 1st Class Sara Francis

RECOMMENDATIONS

- ASM participants should fully and faithfully follow through on their deliverables and future commitments. Obligations include participating in future gatherings of ministers, providing support for international expeditions such the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC), and creating an intergovernmental working group of Arctic research sponsors. These "Arctic Funders" would advance research by establishing a high-level forum to address issues associated with cooperation, coordination, and cosponsorship of international Arctic research.
- The eight Arctic states should enhance international Arctic scientific cooperation by becoming parties, in 2017, to the multilateral, legally binding agreement on scientific cooperation that was negotiated under the auspices of the Arctic Council. Parties should take all steps necessary to bring the agreement into force, and to exercise it accordingly, to facilitate cooperation, coordination, and scientific access.
- Given the ongoing challenges, costs, and scientific and technological demands required of a pan-Arctic observing network, there must be continued progress toward this goal. The international scientific community and research sponsors must advance the concept to an integrated, fully operational activity that provides critical information and derived products for scientific research, as well as for operational intelligence and decision support.
- To better understand the functions of an emerging seasonal open-water ecosystem in the central Arctic Ocean, and in support of international discussions concerning the prevention of unregulated commercial fishing in the high seas area of the central Arctic Ocean, the United States should increase efforts to establish a durable intergovernmental institutional structure to enhance and promote international scientific research in this region.
- The United States, through the US/Russia Intergovernmental Consultative Committee, should strengthen bilateral collaborative integrated ecosystem research efforts in the Bering and Chukchi Seas, to complement the NPRB's Arctic Integrated Ecosystem Research Program.

PROGRESS

» **Arctic Science Ministerial.** Science Ministers from 25 governments gathered at the White House in Washington, DC on September 28, 2016, to discuss four Arctic research themes and to sign a Joint Statement on developing new collaborative activities in Arctic science. The USARC published a report on the event that includes the Joint Statement signed by the Ministers, a White House Fact Sheet, meeting documents, media coverage, and a compilation of two-page descriptions, submitted by each participating government, describing the various ways in which their country supports Arctic science.

» **Arctic Council Task Force for Enhancing Scientific Cooperation.** The Arctic Council Task Force for Enhancing Scientific Cooperation completed negotiations on an agreement that will be signed at the Arctic Council Ministerial Meeting in May 2017. This agreement will become the third legally binding multilateral agreement initiated under the auspices of the Arctic Council.

» **Scientific Experts on Fish Stocks in the Central Arctic Ocean.** Over the course of four meetings of the Scientific Experts on Fish Stocks in the Central Arctic Ocean, held between 2011 and 2016, progress has been made in establishing a joint program of scientific research and monitoring for the central Arctic Ocean. Governments involved in this effort include the United States, Russia, Canada, Denmark/Greenland, Iceland, Norway, China, Japan, and Korea, as well as the European Union. A program framework has been developed that defines the baseline information requirements and methods necessary to fully assess marine ecosystem dynamics and determine the likelihood that sustainable fisheries are present. The framework also focuses on the role that fish and shellfish play in central Arctic Ocean marine ecosystems, how these ecosystems are linked with continental shelf areas, and how climate change will impact these ecosystems. An anticipated outcome is an action plan that considers estimated schedules for research, areas of operation, and costs for the proposed joint program. A preliminary field program design is being developed.

Photo credit: Sebastian Gerland, Norwegian Polar Institute

Photo credit: US Coast Guard Petty Officer 2nd Class Connie Terrell

ARCTIC COUNCIL SCIENCE AGREEMENT

The Arctic Council agreement addresses obstacles to scientific cooperation and how to overcome them. It speaks to physical access for research to land, marine, and airspace; entry and exit of persons, equipment, and materials; and access to research infrastructure and facilities. The agreement includes language on incorporating indigenous knowledge in the planning and conduct of scientific activities, and encourages communication and participation between the holders of that knowledge and the scientific participants. While the parties to the agreement will include only the eight Arctic states, scientists from non-Arctic states that partner in a project with an Arctic state will receive the same benefits.

Background photo credit: US Coast Guard Petty Officer 1st Class Sara Francis

Emerging Topics in Arctic Research

Habitat Shifts

Rapid transformation of the Arctic marine environment, such as north of the Bering Strait, may be shifting areas of high biological productivity from the seafloor up into the water column. Changes in the historical ranges of some species, such as whales and sea lions, and certain fish species have been documented. The concept of climate change "winners and losers" is not new, nor is the understanding that current winners may later become losers, or vice versa. For example, some baleen whales are now benefiting from marine conditions that increase their food supply,[6] but for how long? Species that require ice for foraging and resting, such as polar bears, walrus, and seals, are clearly losing habitat. Other concerns include the introduction of new diseases, competition for resources, and predation from species that are expanding their ranges, like killer whales, which have been attacking bowhead whales. Habitat shifts, and their manifestations, also have significant implications for subsistence, marine mammal co-management, regulatory regimes, and marine policy.

Photo credit: Kaitlin Thoresen, National Park Service

Photo credit: Michael J. Coffee, Alaska Dept. of Transportation and Public Facilities

Carbon Sequestration

Consistent with an "all of the above approach" to slow climate warming, scientists are investigating ways to remove carbon dioxide (CO_2) from the atmosphere and safely store, or sequester, it. Some researchers have tried injecting the gas deep underground in rock formations, but this has not always succeeded. Recently, an Arctic twist to this effort has been tried in Iceland.[7] Researchers claim to have identified a novel approach to trapping CO_2 by pumping it deep into subsurface volcanic rocks and adding water, which converts the CO_2 into solid carbonate minerals in less than two years, thus overcoming leakage. If this process can be scaled up and conducted at reasonable expense, it may become a valuable climate mitigation tool.

Warming and Thawing Permafrost

The global cost of thawing permafrost could be up to $43 trillion by 2100.[8] This figure factors in decreased agricultural production and higher health care costs linked to greenhouse gas release from permafrost. This cost is an underestimate, as it does not take into account damage to civil infrastructure such as roads and building foundations.[9] Thawing permafrost also releases bacteria, viruses, and other pathogens that have been contained underground for decades.[10] In 2016, abnormally warm conditions in Siberia accelerated permafrost thaw and probably released anthrax spores that killed one person and hospitalized dozens more. In addition, thousands of reindeer, an important subsistence resource, were killed during this anthrax outbreak.[11] More research into the climatic, economic, and health implications of permafrost warming and thawing will result in valuable information and undoubtedly more surprises.

Icebreakers

Icebreaking vessels are essential to conducting world-class research in the Arctic Ocean. Without that capacity, the ability to answer challenging scientific questions becomes impossible. US vessels are aging and dwindling in number; will this situation improve? The UK is building the new RRS *Sir David Attenborough*. China is considering bids to build a companion to its ice-strengthened vessel, *Xuelong*. Korea announced plans to build a second icebreaker dedicated solely to research. Sweden is planning a successor to *Oden*. Germany will replace *Polarstern*. Russia, too, has announced ambitious plans for new vessels. With the exception of the ice-strengthened R/V *Sikuliaq*, which can operate in thin, first-year ice, the US fleet of icebreakers is aging significantly. Only one heavy icebreaker, USCG *Polar Star*, commissioned 40 years ago, remains operational. USCG *Healy*, a medium icebreaker commissioned in 1999, continues to operate successfully in the Arctic, effectively supporting a broad range of scientific missions. The Executive and Congressional branches of government are taking steps to improve this situation, but resolution and a concrete plan remain elusive, and the time required to design, build, and commission a vessel can take years, if not a decade.

Photo credit: Jessica Robertson, US Geological Survey

Photo credit: Ignatius Rigor

Smart Arctic Observations

Society's need for better information in the Arctic is driving the research community to increase environmental observations and extract useful knowledge from them. Scientists are examining ways to optimize the design, distribution, and deployment of observational systems to maximize the return on investments and effort. Given the harsh Arctic environment, and the remoteness and expense of working in the region, scientists are developing novel technologies and observing platforms to document and understand this rapidly changing region. An improved observational network that provides real-time access to the data and that collects data year-round is critical to advance seasonal to decadal predictions of Arctic change. On the technological front, scientists and engineers are making progress in successfully deploying autonomous underwater vehicles (AUV) that carry a variety of sensors beneath sea ice. Significant advances are being achieved in AUV range, endurance, and sensor technologies.[12]

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Background photo credit: Rennett Stowe

Results from the US Chairmanship of the Arctic Council

The United States will successfully complete its two-year Arctic Council Chairmanship on May 11, 2017, at the Ministerial meeting in Fairbanks, Alaska. The chairmanship theme, "One Arctic: Shared Opportunities, Challenges, and Responsibilities," reflected the Council's work plan of initiatives and other efforts to promote Arctic Ocean safety, security, and stewardship; improve economic and living conditions throughout the Arctic; and address the impacts of climate change. Among the Council's accomplishments (https://www.arctic-council.org) are the following highlights, related to Arctic science and research.

Photo credit: Liv-Guri Faksnes

- Completed a legally binding agreement to enhance scientific cooperation in the Arctic.
- Conducted a One Health survey, associated with the Sustainable Development Working Group (SDWG), that considered the connections between environment, plant, animal, and human health. Published a One Health strategy for resilience.

Photo credit: Kjell Sture Johansen, Norut

- SDWG developed an online Arctic Renewable Energy Atlas of resource maps and localized supply and demand data to encourage clean energy prospecting and investment, and an Economy of the North III report, an overview of the scale and structure of the circumpolar Arctic economy.
- The Emergency Prevention, Preparedness, and Response (EPPR) Working Group advanced oil spill response preparedness via a database of Arctic response assets and by updating a field guide on oil spill response.
- A circumpolar telecommunications assessment identified the infrastructure necessary to support safe navigation, offshore development activities, search and rescue operations, and environmental and humanitarian emergencies.
- Conducted an Arctic Resilience Assessment, which considered multiple drivers of change and provided a scientific foundation for decision makers addressing climate change and other environmental stressors, in coordination with the Adaptation Actions for a Changing Arctic Part-C (via the Arctic Monitoring and Assessment Programme – AMAP) and the development of an Arctic Resilience Action Framework.
- AMAP delivered summaries for policy makers on climate change, how the Arctic cryosphere is evolving, and on chemicals of emerging concern.
- The Conservation of Arctic Flora and Fauna (CAFF) Working Group prepared an Arctic Invasive Alien Species Strategy and Action Plan to prevent and manage invasive species.
- The Arctic Council produced a synthesis report on black carbon and methane emissions.
- Produced two reports on heavy fuel oil by the Protection of the Arctic Marine Environment (PAME) Working Group.
- Conducted an external review of the accomplishments of Sustaining Arctic Observing Networks that included recommendations on organizational structure, fulfillment of SAON vision, mission, and goals, and other means to strengthen SAON.

Background photo credit: Christopher Michel

THE US ARCTIC RESEARCH COMMISSION

The US Arctic Research Commission (USARC) is an independent federal agency created by the Arctic Research and Policy Act of 1984. It is a presidentially appointed advisory body supported by staff in Washington, DC, and in Anchorage, AK. In addition to establishing the goals in this report, the Commission recommends US Arctic research policy to the President and Congress and builds cooperative links in Arctic research within the federal government, with the State of Alaska, and with international partners. The law also requires the Commission to report to Congress on the progress of the Executive Branch in reaching goals set by the Commission and on their adoption by the Interagency Arctic Research Policy Committee.

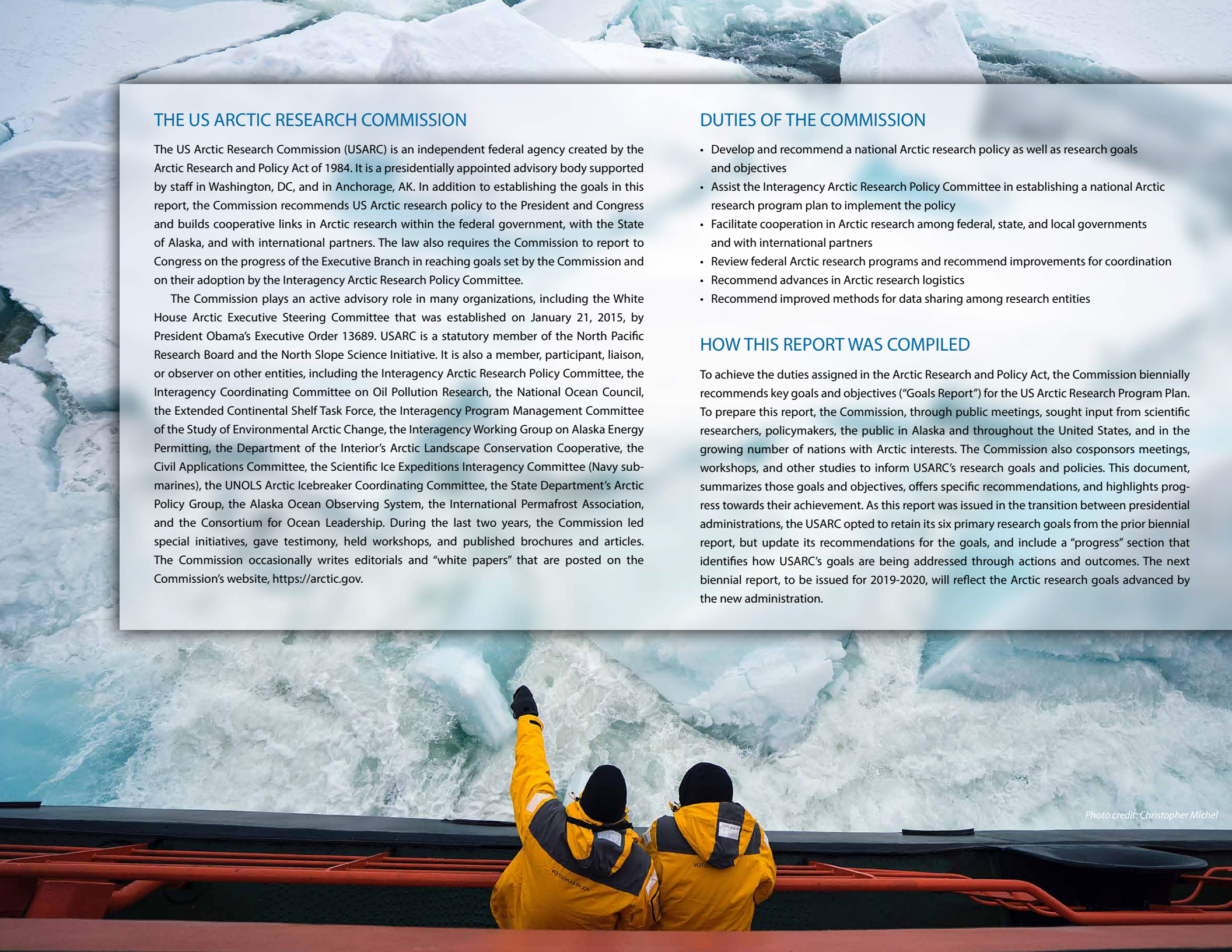
The Commission plays an active advisory role in many organizations, including the White House Arctic Executive Steering Committee that was established on January 21, 2015, by President Obama's Executive Order 13689. USARC is a statutory member of the North Pacific Research Board and the North Slope Science Initiative. It is also a member, participant, liaison, or observer on other entities, including the Interagency Arctic Research Policy Committee, the Interagency Coordinating Committee on Oil Pollution Research, the National Ocean Council, the Extended Continental Shelf Task Force, the Interagency Program Management Committee of the Study of Environmental Arctic Change, the Interagency Working Group on Alaska Energy Permitting, the Department of the Interior's Arctic Landscape Conservation Cooperative, the Civil Applications Committee, the Scientific Ice Expeditions Interagency Committee (Navy submarines), the UNOLS Arctic Icebreaker Coordinating Committee, the State Department's Arctic Policy Group, the Alaska Ocean Observing System, the International Permafrost Association, and the Consortium for Ocean Leadership. During the last two years, the Commission led special initiatives, gave testimony, held workshops, and published brochures and articles. The Commission occasionally writes editorials and "white papers" that are posted on the Commission's website, https://arctic.gov.

DUTIES OF THE COMMISSION

- Develop and recommend a national Arctic research policy as well as research goals and objectives
- Assist the Interagency Arctic Research Policy Committee in establishing a national Arctic research program plan to implement the policy
- Facilitate cooperation in Arctic research among federal, state, and local governments and with international partners
- Review federal Arctic research programs and recommend improvements for coordination
- Recommend advances in Arctic research logistics
- Recommend improved methods for data sharing among research entities

HOW THIS REPORT WAS COMPILED

To achieve the duties assigned in the Arctic Research and Policy Act, the Commission biennially recommends key goals and objectives ("Goals Report") for the US Arctic Research Program Plan. To prepare this report, the Commission, through public meetings, sought input from scientific researchers, policymakers, the public in Alaska and throughout the United States, and in the growing number of nations with Arctic interests. The Commission also cosponsors meetings, workshops, and other studies to inform USARC's research goals and policies. This document, summarizes those goals and objectives, offers specific recommendations, and highlights progress towards their achievement. As this report was issued in the transition between presidential administrations, the USARC opted to retain its six primary research goals from the prior biennial report, but update its recommendations for the goals, and include a "progress" section that identifies how USARC's goals are being addressed through actions and outcomes. The next biennial report, to be issued for 2019-2020, will reflect the Arctic research goals advanced by the new administration.



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