REPORT ON THE

Goals and Objectives for Arctic Research 2019–2020

FOR THE US ARCTIC RESEARCH PROGRAM PLAN

UNITED STATES ARCTIC RESEARCH COMMISSION

CONTENTS

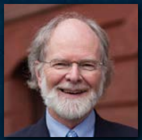
USARC Commissioners

FRAN ULMER, CHAIR
Former Chancellor
University of Alaska Anchorage
Anchorage, AK

DAVID BENTON
Former Chair
North Pacific Fisheries Management Council
Point Retreat, AK

KASAŊNAALUK MARIE N. GREENE
Former President and CEO
NANA Regional Corporation
Kotzebue, AK

LARRY A. MAYER, PhD
Director
Center for Coastal and Ocean Mapping
University of New Hampshire
Durham, NH



JAMES J. McCARTHY, PhD
Alexander Agassiz Professor of Biological Oceanography
Harvard University
Cambridge, MA

MARY C. PETE (deceased)
Director
Kuskokwim Campus
University of Alaska Fairbanks
Bethel, AK

JACQUELINE RICHTER-MENGE
Research Faculty
Institute of Northern Engineering
University of Alaska Fairbanks
Fairbanks, AK

FRANCE A. CÓRDOVA, PhD
Director
National Science Foundation
Arlington, VA

Duties of the Commission

- Develop and recommend a national Arctic research policy and Arctic 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

Principles for Conducting Research in the Arctic

The Interagency Arctic Research Policy Committee released an updated version of the principles,[1] which encourages researchers to:

- Be Accountable
- Establish Effective Communication
- Respect Indigenous Knowledge and Cultures
- Build and Sustain Relationships
- Pursue Responsible Environmental Stewardship

[1] https://www.iarpccollaborations.org/uploads/cms/documents/principles_for_conducting_research_in_the_arctic_final_2018.pdf

USARC Staff

JOHN FARRELL, PhD
Executive Director
Arlington, VA

CHERYL ROSA, DVM, PhD
Deputy Director
Anchorage, AK

KATHY FARROW
Communications Specialist
Arlington, VA

A MESSAGE FROM USARC CHAIR FRAN ULMER

Why is the world paying more attention to the Arctic?

Fran Ulmer, Tim Gallaudet, and France Córdova at the 2nd Arctic Science Ministerial.

Four reasons stand out:

- The environment of the Arctic is changing faster than in any other region on the planet.
- Changes taking place in the Arctic have global impacts.
- Diminished physical and geopolitical barriers to resource access and extraction are presenting economic and strategic possibilities.
- Arctic residents are faced with rapidly changing conditions that challenge health, safety, and cultural practices.

Many nations, beyond the eight Arctic countries, are increasing their attention to, and investment in, Arctic research and engagement to better understand and prepare for the consequences of these dramatic changes. It's critically important for the United States, a world leader in scientific research and development, to intensify its focus on this region, which for many Americans previously seemed too frozen and remote to be of serious concern. Now that warmer Arctic conditions and rapidly decreasing ice on land and sea have been linked to mid-latitude weather extremes, intensified storms, longer droughts, wildfires, floods, and rising sea levels, the North has attracted more interest and concern. Similarly, potential oil and mineral development, new shipping patterns, altered fisheries, and increased tourism all require countries, companies, and communities to focus on adjusting and preparing for these new opportunities and challenges. For economic, cultural, environmental, geopolitical, and security reasons, the commitment to science-informed and evidence-based decisions and investments is essential to the future of the entire region as well as to our nation. This report identifies important topics for Arctic research related to these changes and their consequences that can advance knowledge and enable better decisions. Informed and wise management of the valuable and vulnerable Arctic matters greatly to people in and beyond the Arctic.

Fran Ulmer

We dedicate this report to Commissioner Mary Ciuniq Pete, an enthusiastic and thoughtful administrator, researcher, mother, and friend who tirelessly championed education, health, and subsistence. Mary passed away on November 17, 2018, from ovarian cancer. In 2005, Mary became Director of the University of Alaska Fairbanks Kuskokwim Campus in Bethel, Alaska, after a decade serving as Director of the Subsistence Division for the Alaska Department of Fish and Game. In 2010, President Obama first appointed Mary to USARC, and reappointed her in 2013. Born and raised in Stebbins, Alaska, Mary, a fluent speaker of the Central Yup'ik language, was devoted to her family and to the communities, causes, and campus she served. She loved engaging in a subsistence lifestyle, carrying on traditions, helping in culturally relevant ways, and generously sharing her insights. Mary was a significant asset to the Commission, and a great friend. She is dearly missed.

Photo credit: Jimmie Lincoln

GOAL 1. Advance Arctic Infrastructure

MOTIVATION

Arctic infrastructure for transportation, buildings, communication, utilities, and energy delivery, both civilian and military, is an essential prerequisite for human activity in the North. Climate warming continues to cause damage to infrastructure, making it especially costly to maintain, repair, or replace, especially in remote Alaska. For instance, 70% of all Arctic infrastructure lies atop near-surface permafrost that will thaw in the next 30 years, and this is likely to occur even if the climate change targets of the Paris Agreement are reached.[2] Timely preventative measures, based on a well-informed understanding of environmental conditions, and their projected changes over time, can reduce infrastructure damage and costs.

RECOMMENDATIONS

- » Fund demonstration projects to address engineering design of Arctic infrastructure. Engineers and planners need decision-support tools, with regularly updated information, to plan, design, and construct infrastructure in a rapidly changing Arctic environment. Such tools will supersede outdated planning tools[3] and guidance documents,[4,5] will increase value engineering via cost reduction, and may serve as the archetype for tools designed for non-Arctic regions.
- » Transfer knowledge from engineering research projects to design guidance documents. Specifically, rewrite the out-of-date Department of Defense Unified Facilities Criteria 3-130 (Arctic and Sub-Arctic Construction).
- » Support, through federal public-private partnerships, and by working cooperatively with the State of Alaska, and with local and tribal authorities, the Arctic marine infrastructure needs identified through congressional hearings[6] and the interagency US Committee on the Marine Transportation System (CMTS).[7] Areas of emphasis include ports, navigable waterways, physical and information infrastructure, response services (e.g., search and rescue, and environmental response), and vessels.
- » Fund construction of the icebreakers identified in the US Coast Guard's polar security cutter program that are critical to meeting national needs, including research.

2 Hjort, J., et al. 2018. Degrading permafrost puts Arctic infrastructure at risk by mid-century. *Nature Communications*. https://doi.org/10.1038/s41467-018-07557-4

3 Alaska Engineering Design Information System. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.119.7647&rep=rep1&type=pdf

4 Hartman, C.W., and R.R. Johnson. 1984. *Environmental Atlas of Alaska*. University of Washington Press

5 Smith, D.W., ed. 1996. *Cold Regions Utilities Monography*. https://doi.org/10.1061/9780784401927

6 For example, the June 7, 2018, hearing of the House Subcommittee on Coast Guard and Maritime Transportation, "Maritime Transportation in the Arctic: The U.S. Role," https://republicans-transportation.house.gov/calendar/eventsingle.aspx?EventID=402555, and the December 6, 2018, hearing of the Senate Subcommittee on Oceans, Atmosphere, Fisheries and Coast Guard, "Preparing for Maritime Transportation in a Changing Arctic," https://www.commerce.senate.gov/public/index.cfm/2018/12/subcommittee-announces-hearing-to-examine-arctic-transportation-issues.

7 US Committee on the Marine Transportation System. 2018. *Revisiting Near-Term Recommendations to Prioritize Infrastructure Needs In The U.S. Arctic*. Washington, DC., 43 pp., https://www.cmts.gov/downloads/NearTermRecommendationsArctic2018.pdf

(a) Thule Air Base, Greenland. (b) Kivalina, Alaska.
(c) Canadian Forces Station Alert, Ellesmere Island.

(a) Geodesic dome at Thule Air Base, Greenland. (b) Red Dog Mine port facility, Alaska. (c) Thermosiphons, Kotzebue, Alaska.

- Consider dual-use opportunities for research when planning Arctic communication infrastructure. For example, submarine fiber optic cables traditionally used for telecommunication could also be used to collect ocean observations[8] and to detect earthquakes.[9]
- Better understand how oil and gas production and transportation infrastructure must evolve to adapt to changing Arctic environments. Examples include evaluation of gas-to-liquids transport through the Trans-Alaska Pipeline and methods to transport energy from the North Slope (as liquid natural gas and via high-voltage direct current transmission).

EXAMPLES

Adaptive Engineering. Engineers, scientists, planners, regulators, and educators need up-to-date data and projections to appropriately design the "built environment"—the human-made surroundings and infrastructure that provide the setting for human activity, ranging in scale from villages to cities, and including supporting systems for water, sewer, energy, communications, and transportation.

These data may include environmental variables, such as sea level, the frequency of extreme storms and their surges, the warming and thawing of near-surface permafrost, freeze-thaw cycles, sea ice cover, rates of coastal and riverine erosion, inland flooding, and the frequency and extent of forest and tundra wildfires.

Many guidance documents, reference materials, building codes, and criteria for designing Arctic infrastructure are outdated because the environmental conditions upon which they were based have evolved significantly over the past 30 to 40 years, in response to a changing Arctic.

Infrastructure is often expected to function for decades, yet the Arctic will continue to warm and environmental conditions will change. As such, static planning documents and guidelines, even if updated, are of limited value. Instead, an "evergreen" approach is needed to regularly assemble, validate, coordinate, and deliver quality-controlled information for planning and design.

A computer-based system of data and applications, with an easily accessible, user-friendly, and web-based interface, should be developed as a support tool for timely and effective decision making. Such a system could be used, and supported, on a subscription basis. Ideally, such a system could downscale data to regional and local scales; calculate means, trends, and other statistics; and provide projections that accurately represent current and future conditions. Scenario planning and risk assessment would be possible, as would integration of climate and environmental variables into engineering design parameters.

Consistent with the needs described above, the Department of Defense's (DoD) Environmental Security Technology Certification Program (ESTCP) released a solicitation[10] in January 2019 to support research on an environmental technology demonstration and validation effort on Arctic infrastructure titled, "DoD Infrastructure Resiliency Arctic Engineering Design Tool."

8 Ocean Networks Canada, http://www.oceannetworks.ca/ and specifically http://www.oceannetworks.ca/observatories/arctic

9 Marra, G., et al. 2018. Ultrastable laser interferometry for earthquake detection with terrestrial and submarine cables. *Science*. https://doi.org/10.1126/science.aat4458

10 https://www.serdp-estcp.org/Funding-Opportunities/ESTCP-Solicitations

Preparing for Arctic Maritime Activity. The federal government is anticipating and planning for greater and more varied vessel traffic in the US maritime Arctic. As suggested by the CMTS's interagency Arctic Marine Transportation Integrated Action Team, to make the waterways safe and secure for vessels and to minimize environmental damage, several types of infrastructure will be needed such as infrastructure associated with making waterways navigable (e.g., ports of refuge), physical infrastructure (e.g., ports, harbors, and geospatial infrastructure), and marine transportation system (MTS) information infrastructure (e.g., hydrographic surveys, shoreline mapping, aids to navigation, communications, marine weather, and sea ice forecasts; real-time oceanographic information; and Automatic Identification System). Also needed are MTS response services (e.g., for icebreaking, emergencies, environmental management, and search and rescue) and vessel-related efforts (e.g., International Maritime Organization Polar Code implementation, crew standards, and training).

Research continues to assist in several of these efforts. The Government Accountability Office[11] recently summarized federal efforts associated with offshore oil spill prevention and response, including some in the Arctic, conducted by nine agencies, involving over 100 projects per year for a total cost of about $200M from fiscal years 2011 through 2017.

In 2017, the US Coast Guard's (USCG) Research and Development Center field tested a number of technologies and systems associated with oil spills in ice-infested Arctic waters, including an oil skimmer referred to informally as the "Roomba."[12] In 2018, the USCG tested unmanned technologies, such as a communication network composed of aircraft, surface vessels, and an aerostat balloon.

The Arctic Domain Awareness Center (ADAC[13]) supports research projects on Arctic maritime activity. ADAC tested an oil-spill-mapping Long Range Autonomous Underwater Vehicle (LRAUV) that can operate under solid ice pack at 1 to 3 miles per hour for 15 days on a single battery charge and can produce 3-D maps of crude oil and petroleum products.[14] ADAC also supports the "Polar Scout" research program, which explores ways to enhance Arctic communications and domain awareness using small cube satellites successfully launched in December 2018.[15]

Arctic marine charts are suboptimal; only 4.1% of the US maritime Arctic is charted to modern international standards,[16] raising safety concerns for marine operations. The charts are based on sparse data collected long ago, and for shallow coastal regions, where typical charting vessels cannot operate, seasonal changes in bathymetry due to storm effects and ice scour compound the problem.

(a) Testing the Long Range Autonomous Underwater Vehicle. *Photo credit: ADAC, Woods Hole Oceanographic Institution, and Monterey Bay Aquarium Research Institute.* (b) University of New Hampshire's autonomous surface vessel deployed from NOAA Ship *Fairweather*. *Photo credit: Christina Belton, NOAA Office of Coast Survey*

Experts[17] recently demonstrated the feasibility and efficiency of deploying a small, 12-foot-long autonomous surface vessel (ASV) from the National Oceanographic and Atmospheric Administration (NOAA) hydrographic survey vessel *Fairweather*. The ASV was equipped with a multibeam echosounder for mapping the seafloor adjacent to Alaska's Point Hope. Future use of the ASV, possibly off Utqiagvik, and in close coordination with local authorities, is planned for 2020.

The Army's Cold Regions Research and Engineering Laboratory initiated a "Sea Ice Dynamics Experiment," sponsored by the Office of Naval Research (ONR), to understand processes governing sea ice fracture and movement.

11 https://www.gao.gov/assets/700/696318.pdf
12 Ewing, T. 2017. "Roomba" in the Arctic. *Marine Technology News*. pp. 40–45, October 2017, https://www.marinetechnologynews.com/news/roomba-arctic-554110
13 http://arcticdomainawarenesscenter.org
14 https://www.dhs.gov/science-and-technology/news/2018/12/04/snapshot-more-tests-arctic-oil-spill-mapping-robot
15 https://www.dhs.gov/science-and-technology/news/2018/12/03/news-release-uscg-st-venture-space-polar-scout-launch
16 https://nauticalcharts.noaa.gov/hsrp/recommendations/2018/HSRP-Charting-Maritime-Arctic-28feb2018.pdf
17 University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center, https://ccom.unh.edu

Anticipating Arctic Road Systems. The minimal road system in Alaska increases the cost and time for transportation to and among communities and locations rich in natural resources. Using public and private funds, Alaskans are considering two major initiatives to address this issue, the Arctic Strategic Transportation and Resource (ASTAR) Project, and the Ambler Mining District Access Project.

Scientific research and Indigenous Knowledge[18] can help inform consideration of these projects. For example, how might roads impact caribou herds, which are a valuable natural resource? What is the condition of the soils and near-surface permafrost, and how will road construction and operation impact the environment (considering hydrogeology, dust control, and spills from vehicles)? What does research suggest from independent, economic-based cost-benefit analysis of road construction?

Several State entities, including the Alaska Industrial Development and Export Authority, and the Departments of Natural Resources, Health and Social Services, Commerce, Community and Economic Development, and Transportation and Public Facilities, are conducting research associated with the projects. If they advance, both road systems would cross federal lands, and the Department of the Interior, among other agencies, would become more involved, beyond just writing mandated environmental documents.

[18] One Arctic indigenous group, the Inuit Circumpolar Council, defines Indigenous Knowledge as "a systematic way of thinking applied to phenomena across biological, physical, cultural, and spiritual systems. It includes insights based on evidence acquired through direct and long-term experience and extensive multigenerational observations, lessons, and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation."

(a) Dalton Highway, Alaska. (b) Gaswell Road, Utqiagvik, Alaska. *Photo credit: UMIAQ Design & Municipal Services, LLC*

GOAL 2. Assess Arctic Natural Resources

MOTIVATION

Research informs management of the Arctic's plentiful and rich natural resources, such as oil and gas, minerals, and wildlife, as well as those less frequently considered, such as plants, land, water, and air, and their contributions to society (i.e., "ecosystem services"). Responsible stewardship of these resources for the benefit of both present and future generations is a national value. Information gleaned from scientific research and Indigenous Knowledge is necessary to understand the Arctic's living and non-living resources, how they support life, how they evolve, and how to thoughtfully balance current use against future demand. As the Arctic becomes increasingly accessible, and as global demand for resources grows, decision-makers will need information that will allow them to make informed choices on resource use.[19]

RECOMMENDATIONS

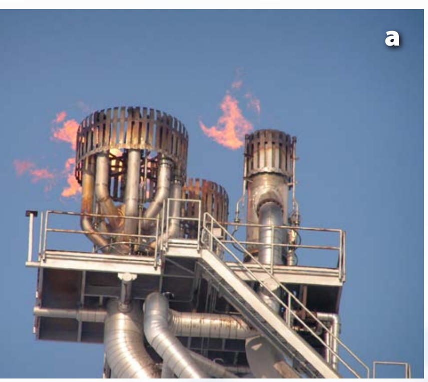
» Support US Geological Survey (USGS) efforts to better understand the oil and gas potential of Alaska's North Slope, with specific foci on petroleum systems that exist beyond the outer continental shelf area and under the continental slope, and, in cooperation with Department of Energy (DOE), identify the resource potential of gas hydrates via production testing field experiments.[20]

» Encourage DOE to fully implement its 10-year Arctic renewable energy plan,[21] follow-on initiatives to the "Remote Alaska Communities Energy Efficiency" effort,[22] and the applicable recommendations in the Renewable Energy Atlas of Alaska.[23]

» Enable the USGS to conduct detailed geologic mapping to better understand the distribution and resource potential of minerals and to develop new databases for mineral resource analysis.

» Support NOAA to conduct additional trawl surveys in the Bering Sea and north of the Bering Strait to assess fish stocks in light of shifting population localities and continue to develop camera survey techniques for untrawlable habitats.

» Encourage agencies responsible for surveying and conducting census counts of marine and terrestrial mammals to consider advanced technologies, such as unmanned aircraft systems, to improve assessments.



[19] Auad, G., et al. 2018. A dynamic management framework for socio-ecological system stewardship: A case study for the United States Bureau of Ocean Energy Management. *Journal of Environmental Management*. https://doi.org/10.1016/j.jenvman.2018.07.078

[20] https://www.netl.doe.gov/Gas-Hydrate-Test-Well-on-Alaska-North-Slope

[21] https://www.energy.gov/sites/prod/files/2015/04/f21/NSARDraftPlan_v6.pdf

[22] https://www.energy.gov/eere/remote-alaskan-communities-energy-efficiency-competition

[23] http://alaskarenewableenergy.org/index.php/focusareas/renewable-energy-atlas/

(a) Gas flare stack at Northstar Island, Alaska. (b) Trans-Alaska Pipeline. (c) Unisea fish processing plant, Unalaska, Alaska.

(a) Sampling oil to assess weathering properties. *Photo credit: SINTEF.* (b) Red Dog mine, Alaska. (c) Beaver pond and dam, Denali National Park, Alaska.

EXAMPLES

Oil Seeps. The Department of Interior's (DOI) Bureau of Ocean Energy Management is supporting a new study of natural petroleum seeps in Alaskan coastal and marine environments to identify the location and extent of these resources, to learn more about associated chemosynthetic communities, to help determine the fair market value of leased outer continental shelf blocks, and to assist in environmental analyses required by law. Future work, involving NOAA and the Bureau of Land Management, could expand this effort by chemically "fingerprinting" the natural seeps to help differentiate them from human-caused spills.

Critical Minerals. Alaska has deposits of at least 15 "critical minerals" that are essential to national security and the economy and are subject to supply chain disruption. To decrease US dependence on foreign sources of minerals such as graphite, tin, platinum, and cobalt, the DOI has listed 35 as critical nationwide, and is preparing a report to the President that includes efforts to identify new US mineral sources through improved maps. Geospatial analysis by the USGS has already identified areas in Alaska with critical mineral-resource potential to help guide future exploration activities and scientific research. The USGS is conducting a petrologic investigation of rare earth elements on the Seward Peninsula, but more work is needed. The United States could consider replicating the effort of the Canadian government, which invested about $75M (US), in a geo-mapping program to identify new energy and mineral resources.

Invasive Species and Range Expansion. Species not typically associated with the Arctic are being introduced through human activities or are moving northward because of a warming climate, impacting human health, the environment, and native species valued for food and subsistence culture.[24] New technologies and techniques can detect invasive species or ones that are expanding their range. For example, satellite imagery shows beavers moving into the tundra[25] as shrub vegetation and woody growth are on the rise. Although valued for their fur, these dam builders are reshaping the landscape and hydrological systems, and, by influencing the distribution of permafrost, further exacerbating the effects of climate change.

[24] https://www.pame.is/index.php/projects/arctic-marine-shipping/arctic-invasive-species

[25] Tape, K., et al. 2018. Tundra be dammed: Beaver colonization of the Arctic. *Global Change Biology*. https://doi.org/10.1111/gcb.14332

GOAL 3. Observe, Understand, and Forecast Arctic Environmental Change

MOTIVATION

The Arctic is warming twice as fast as the rest of the world. This dramatic, human-caused heating is impacting Arctic snow, ice, permafrost, ecosystems, and human populations. Arctic weather in 2018 was a year of extremes.[26] Above-normal air temperatures in autumn and early winter, warm water in the Bering Sea, and one of the stormiest winters of the past 70 years resulted in near-record low winter maximum ice extent across the entire Arctic. For the first time since 1850, the Bering Strait remained virtually ice-free. Similar conditions occurred in early 2019.[27] There is growing realization that rapid and extensive changes in the Arctic are redefining ecosystems, landscapes, and communities, as well as economic and geopolitical interests. Greater knowledge and understanding of the causes and consequences of Arctic environmental change are needed to inform decisions and actions.

RECOMMENDATIONS

» Better understand the production and fluxes of carbon dioxide and methane from Arctic wetlands to improve climate projections.

» Improve species management through co-production of knowledge by scientists and Indigenous Knowledge holders. Recognize the important role co-management plays in informing and supporting research goals and projects.

» Document the use and vulnerability of critical migratory bird stopover areas.

» Develop a simplified framework to assess Arctic species status, based on population size, range, behavior, and health, as a means to inform conservation and management efforts.[28]

» Support the adoption of EarthScope Transportable Array (TA) seismic stations (a network of over 200 seismic stations, with power and communication, distributed across Alaska).[29] The standard TA stations include atmospheric sensors that transmit weather observations and natural hazards information.

» Support basic research on climate geoengineering (e.g., carbon dioxide removal from the atmosphere and solar radiation management to cool the planet) and further consider ethical and governance issues, and geoengineering policies.

» Advance "attribution science"—efforts to scientifically distinguish the role of human-caused global warming from the role of natural climate fluctuations in causing individual extreme weather events, to help planners understand which extreme events are likely to increase with additional warming.

» Expand the general concept of a sustained Arctic observing network into 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.

» Collect additional data on the ecology of commercial fish species to better understand growth and movements in response to warming seas.

Photo credit: Bob Waldrop

[26] NOAA, https://arctic.noaa.gov/Report-Card/Report-Card-2018

[27] https://www.adn.com/alaska-news/2019/03/04/bering-sea-ice-is-at-an-unprecedented-low-right-now/

[28] Moore S.E., and R.R. Reeves. 2018. Tracking arctic marine mammal resilience in an era of rapid ecosystem alteration. *PLoS Biology*. https://doi.org/10.1371/journal.pbio.2006708

[29] https://www.nsf.gov/pubs/2019/nsf19048/nsf19048.jsp

EXAMPLES

When Change is Constant. The 4th National Climate Assessment, released by the White House in 2018, warns of "substantial damages" in Alaska and across the rest of the United States from increasing wildfires in the West, flooding in the East, and rising temperatures in the Midwest. Globally, the likelihood of years that are both extremely warm and dry has doubled since 1931.[30] Research attributes this change almost entirely to human activity.

- **WILDFIRES.** The recent shift in jet stream flow, possibly linked to Arctic warming and sea ice loss, has further increased temperatures across the western United States. Sluggish weather patterns allow hot, dry weather to linger, resulting in longer wildfire seasons.[31] Water loss from soil and plants has increased, and snow-melt and river levels are low, exacerbating the wildfires.
- **LICHEN DECLINE.** Lichens, which are ecologically important to the nutrient cycle and serve as a key food for animals, are slow to recover to pre-fire abundance and diversity following wildfires, which are increasing in number, temperature, and severity.[32]
- **STORM SURGE.** Climate change boosts storm surge—the temporary, weather-induced increase in sea level at a given location. Hurricane storm surge now rides higher on seas because melting polar ice sheets and a warmer, expanding ocean are causing sea level to rise. Much of the densely populated Atlantic and Gulf coasts lie less than 9 feet above mean sea level, placing half of the nation's economic productivity at risk.

CRATERS

Craters surrounded by what appears to be ejecta have been discovered in the Arctic. Researchers speculate that warming air may have caused permafrost thaw and melting of subsurface ice to form a large underground cavity. But unlike typical sinkholes, the ground above didn't collapse. Instead, pressure increased and the ground appears to have exploded up and outwards—perhaps from an accumulation of methane.

Crater on the Yamal Peninsula. *Photo credit: M. Zulinova.*

STORM SURGE

Sea level rise (in part, due to melting polar ice sheets) extended the reach of Hurricane Sandy by 27 square miles,[33] affecting 83,000 additional individuals in New Jersey and New York City, and adding over $2 billion in storm damage.

Navigating the New Arctic. The National Science Foundation's (NSF) "Navigating the New Arctic" solicitation focuses on convergent scientific challenges in a rapidly changing Arctic. It seeks to improve understanding of Arctic change; create enhanced, diverse research communities well-positioned to work at the intersections of Arctic social, natural, and built systems; produce research outcomes that inform US national security and economic development needs; and enable resilient, sustainable Arctic communities.

Carbon Dioxide, Methane, and Permafrost. On a 100-year timescale, methane is 28 times more potent than carbon dioxide as a heat-trapping gas. In terrestrial wetlands, microorganisms that digest organic matter previously frozen in permafrost produce methane. NASA's Arctic-Boreal Vulnerability Experiment (ABoVE) is documenting the release of greenhouse gases to the atmosphere from warming sediment beneath Arctic lakes. These gases cause further warming, as a positive feedback.[34,35,36]

30 Sarhadi, A., et al. 2018. Multidimensional risk in a nonstationary climate: Joint probability of increasingly severe warm and dry conditions. *Science Advances*. https://doi.org/10.1126/sciadv.aau3487
31 Mann, M., et al. 2018. Projected changes in persistent extreme summer weather events: The role of quasi-resonant amplification. *Science Advances*. https://doi.org/10.1126/sciadv.aat3272
32 Miller, J., et al. 2018. Altered fire regimes cause long-term lichen diversity losses. *Global Change Biology*. https://doi.org/10.1111/gcb.14393
33 Miller, K.G., et al. 2013. A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast. *Earth's Future*. https://doi.org/10.1002/2013EF000135
34 Schuur, E.A.G., et al. 2015. Climate change and the permafrost carbon feedback. *Nature*. https://doi.org/10.1038/nature14338
35 Anthony, K., et al. 2018. 21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes. *Nature Communications*. https://doi.org/10.1038/s41467-018-05738-9
36 Yvon-Durocher, G., et al. 2014. Methane fluxes show consistent temperature dependence across microbial to ecosystem scales. *Nature*. https://doi.org/10.1038/nature13164

Photo credit: Ed Farley, NOAA

The "Blob" Impacts Cod. The Gulf of Alaska (GOA) hosts one of the most productive fisheries in the world. Yet, in the summers of 2014–2016, the productivity of Pacific cod declined by over 80%. This was attributed to a pool of unusually warm water (the "blob") in the North Pacific that increased cod metabolism and reduced availability of prey in the GOA, which diminished body condition and increased mortality. Though water temperatures in the GOA have returned to normal, those in the Bering Sea have not—with some areas up to 9°F above normal. Recent field studies found unusually warm bottom waters in the Bering Sea, an absence of sea ice, and a marked increase in the number of "age zero" arctic cod within the Chukchi Sea compared to pre-blob years. Laboratory research documented faster growth of larval arctic cod in warmer water, but growth was negatively impacted when fish reached the age of one.

JELLYFISH SURGE

While jellyfish are a natural part of the Bering Sea ecosystem, their numbers have recently soared. Scientists are studying the phenomenon, and its potential causes and impacts, as there are not many species that eat jellyfish in the region and the jellyfish themselves consume biomass important to fish, seabirds, and marine mammals.

Photo credit: NOAA Auke Bay Labs

When an ice-dependent ecosystem loses ice…

Polar Bear Populations: Short- and Long-Term Trends. Conservation of wildlife species requires an understanding of how climate change and hunting impact demographics. Forecasts suggest that the Arctic Ocean will be ice-free in summertime by 2040, and overall declines in polar bear populations are expected to continue, regardless of greenhouse gas emission scenarios. However, there is much variability among the 19 subpopulations of polar bears. For example, despite reduced sea ice conditions, the Chukchi Sea population is thriving, probably because of abundant prey. Yet, in the long term, researchers expect that all subpopulations will be negatively affected by the loss of sea ice, which serves as a platform for hunting, traveling, and resting.[37]

[37] Regher, E. 2017. Harvesting wildlife affected by climate change: A modelling and management approach for polar bears. *Journal of Applied Ecology*. https://doi.org/10.1111/1365-2664.12864

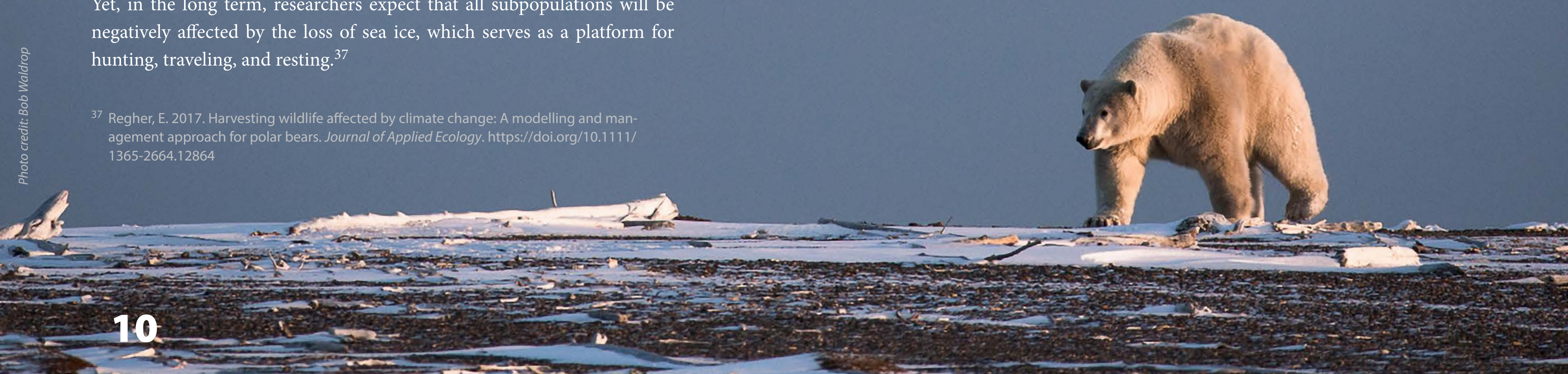


Photo credit: Bob Waldrop

The world population of spectacled eiders (*Somateria fischeri*) in their winter assemblage in the Bering Strait region.

Photo credit: USFWS

…research and Indigenous Knowledge are needed to understand the impact on the environment, plants, fish, and wildlife and the consequences to subsistence lifestyles.

A "Global Nosedive" in Migratory Bird Numbers. The impact of climate change on seabirds and shorebirds, both in the Arctic and on their overwintering grounds outside the Arctic, is twice that of mammals.[38] Populations are declining so rapidly that biologists project a near-term planet-wide wave of extinctions of migratory birds.[39] There are many climate-related factors contributing to these population declines, such as the availability of forage species, warming oceans and changing circulation patterns,[40] temperature impacts on breeding seasons, incubation and prey timing (phenology mismatch), and destruction of migratory stop-over habitat (critical for resting and feeding).

SHOREBIRD DECLINE

North American shorebirds populations have halved since the 1970s. The spoon-billed sandpiper, one of the world's rarest birds, has been reduced to a couple hundred breeding pairs.

Photo credit: G. Vyn, Cornell University

[38] Spooner, F.E., et al. 2018. Rapid warming is associated with population decline among terrestrial birds and mammals globally. *Global Change Biology*. https://doi.org/10.1111/gcb.14361

[39] Munro, M. 2017. What's killing the world's shorebirds? *Nature*. https://doi.org/10.1038/541016a

[40] Goyert, H., et al. 2018. Effects of climate change and environmental variability on the carrying capacity of Alaskan seabird populations. *The Auk*. https://doi.org/10.1642/AUK-18-37.1

Photo credit: Ryan Askren

GOAL 4. Improve Community Health and Well-Being

MOTIVATION

What is meant by "community health and well-being"? To a scientist, it may mean positive physical and mental health outcomes across all age groups. An Indigenous person may, holistically, emphasize local language, culture, subsistence, and other issues not typically considered by health agencies. At all stages of a project, research should include both perspectives. Arctic health research is often driven by disparities, defined as differences in health and health care between populations. Researchers examine disparities in respiratory and other infectious diseases, suicide rates, cancer incidence, dental disease, infant mortality, and life expectancy, among others. To improve the quality of life for all people living in the Arctic, more work is needed to identify, remedy, and mitigate disparities.

RECOMMENDATIONS

- As appropriate, scientists should engage with local residents to co-design research projects and to co-produce knowledge by gathering and incorporating community-based observations and insights.
- Collect data on the status of Alaska Native languages and conduct research that assesses the effectiveness of programs that teach Alaska Native languages. Provide support for the Community Online Database that monitors the status of Alaska Native languages.
- Develop an Alaska Suicide Surveillance Model that helps identify and provide early intervention approaches for use in rural communities. A better understanding of the full range of risk and protective factors is needed to decrease the rates of suicidal behavior among Indigenous youth.
- Improve mental and behavioral health workforce capacity in Alaska and establish Alaska-specific estimates for the number and types of mental health care providers needed.
- Create research-informed alternative approaches to providing mental health care in remote areas, including telemedicine.
- Better understand, predict, and provide surveillance for emerging pathogens and processes that may be appearing or expanding in response to climate change.
- Investigate the cascade of impacts experienced by those without adequate access to in-home water for drinking and hygiene, including their direct and indirect economic effects.


Photo credit: USFWS National Digital Library


Photo credit: Jimmie Lincoln

“Language is healing.”

– Participant, Alaska Native Collaborative Hub for Research on Resilience Partners Meeting, April 2018


Photo credit: Jimmie Lincoln


Photo credit: Billy Adams

EXAMPLES

Co-producing Arctic Knowledge. Although it may sometimes be difficult to reconcile science that emphasizes formal, systematic inquiry with Indigenous Knowledge (IK) that often relies on oral tradition, spirituality, and experience over time, co-production of knowledge can help bridge the gap. The Indigenous perspective reinforces the importance of understanding relationships among components of the environment, while science can provide data, hypotheses, and models that help to explain and understand the natural world. Governmental funding opportunities to produce Arctic knowledge sometimes require co-production, and IK holders are increasingly shaping the topics to be explored and the methodologies used. Co-production will be improved through effective application that involves co-design of projects and mutually respectful consideration of culturally appropriate approaches.

Indigenous Contributions to Subsistence Resource Management. IK holders have developed innovative approaches to monitor and assess wildlife populations. In Canada, Yukon First Nations groups are observing caribou with camera traps, GPS tracking collars, and IK, and the results are informing wildlife management decisions and plans for the Southern Lakes caribou. In the United States, Alaska's North Slope Borough collaborated with social scientists and local hunters to produce “Polar Bear TEK: A Pilot Study to Inform Polar Bear Management Models,” which provides Northern communities with information about wildlife that is relevant to subsistence resource management.

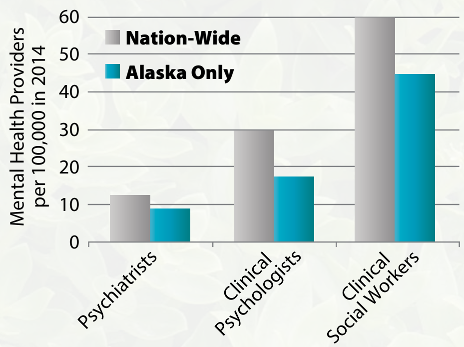
Native Languages. All 20 of Alaska's officially recognized Native languages are “threatened,” and the majority are deemed critically endangered.[41] In 2018, the Alaska Native Language Preservation and Advisory Council noted a lack of: (1) data on the status of languages, (2) programs to learn languages, and (3) effectiveness of such programs to teach languages. To consolidate information on language-learning opportunities and broadly disseminate it to Alaska Natives, the Council established a Community Online Database with the names of traditional languages, their status, and language-learning opportunities.

[41] Moseley, C. 2018. *The UNESCO Atlas of the World's Languages in Danger*. UNESCO Publishing

Shortage of Mental Health Workers in Alaska. During 2012–2017, Alaska's suicide rate was either the first or second highest in the nation,[42] with the prevalence among the Alaska Native population, particularly in remote areas, surpassing that of the general Alaska population.[43] It was estimated that ~146K adult Alaskans—**roughly 20% of the state's population—**need mental and behavioral health services.[44] Despite these numbers, the ratio of mental health care providers to population is lower in Alaska than nationally, with even lower ratios in the state's remote areas. The Arctic Mental Health Working Group[45] has made several recommendations to address this critical shortage of providers, including establishing Alaska-specific estimates for the number and types of mental health care providers needed, creating research-informed approaches to providing mental health care in remote areas, and investigating job satisfaction and retention to better understand how to grow and strengthen Alaska's mental health workforce.

ALASKA: GREATER NEED, FEWER CLINICIANS

The ratio of mental health providers per 100,000 adult population in 2014 in the United States versus Alaska. US data from World Health Organization, Global Health Observatory Data Repository. Alaska-only data are from the Alaska Department of Labor and Workforce Development and 2010 US Census data.



THE STATE OF ALASKA'S SUICIDE TOXICOLOGY PROJECT

Analysis of substances identified in suicide decedents by year, from 2015–2017, indicates a 19% decline in alcohol use, but a 64% increase in opioid use. Routine forensic toxicology testing for all suicides allows collection of demographic variation data to help identify priorities for the public health care system and medical interventions to address disparities.[46]

Health Risks Associated with Arctic Climate Change. Climate change disrupts more than the environment—it poses a threat to the physical and mental health of Arctic residents. Climate change impacts how people travel on the land, store food, practice subsistence, and transfer IK. Risks of botulism increase as food preservation becomes more challenging in extended seasons with warmer temperatures. Safe travel on frozen rivers and lakes in winter can no longer be assumed. "Solastalgia"—distress felt when the environment around you changes[49]—has been documented after forest fires and hurricanes, and the impacts can range from immediate to gradual. Quantifying the extent of these effects in Arctic communities is key to understanding their cumulative impacts with other stressors.[50]

RESEARCH-INFORMED APPROACHES HELP PROVIDE MENTAL HEALTH CARE IN REMOTE AREAS

Telemedicine and other remote e-health applications offer significant technical and clinical benefits when applied within broader-based systems serving isolated populations.[47,48] Evaluation of telemedicine, and of community and behavioral health aides as frontline mental health care providers, should be undertaken to assess their utility to both patient and provider.

[42] Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System. https://www.cdc.gov/injury/wisqars/nvdrs.html

[43] *Suicide Prevention in Alaska*. 2016. HHS Publication No. SMA16-4970. Substance Abuse and Mental Health Services Administration, Rockville, MD

[44] *Alaska Behavioral Health Systems Assessment Final Report*. 2016. Agnew::Beck Consulting LLC and Hornby Zeller Associates Inc.

[45] https://arctic.gov/amhwg/

[46] Hull-Jilly, D. 2019. Alaska Suicide Toxicology Project Summary, 2015–2017. *State of Alaska Epidemiology Bulletin*. http://www.epi.alaska.gov/bulletins/docs/rr2019_01.pdf

[47] Lin, P. 2017. *Improving Access to Mental Health Services for Rural and Northern Communities*. Canadian Mountain Network

[48] Fortney, J.C., et al. 2013. Practice-based versus telemedicine-based collaborative care for depression in rural federally qualified health centers: A pragmatic randomized comparative effectiveness trial. *American Journal of Psychiatry*. https://doi.org/10.1176/appi.ajp.2012.12050696

[49] Yoder, S. 2018. Assessment of the Potential Health Impacts of Climate Change in Alaska 7. *State of Alaska Epidemiology Bulletin*

[50] Lowe, S.R., et al. 2013. Posttraumatic stress and posttraumatic growth among low-income mothers who survived Hurricane Katrina. *Journal of Consulting and Clinical Psychology*. https://doi.org/10.1037/a0033252

Veterinary Significance of Emerging Infectious Diseases. Most (60%–80%) emerging diseases are zoonotic.[51] Any alterations in pathogen, host, or environment can alter the risk of disease, and the emergence of new pathogens can be devastating if they are highly transmissible. Many pathogens have well-defined ranges, some of which are limited by climate. A change in climate may change the range. Expansion of "vector-borne" diseases is of specific interest in the Arctic. Ticks are now encountered more often in Alaska. Their emerging presence highlights the need for disease awareness and predictive modeling to identify new threats.

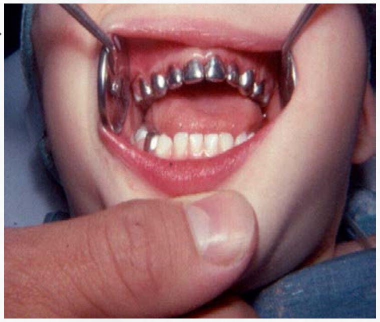
Water and Sanitation: Indirect Effects of Suboptimal Water Service. Significant health disparities in Alaska, particularly in rural villages, are attributed to the absence of in-home water and sewer services. Evidence strongly links these services to better health. The Alaska Rural Water and Sanitation Working Group[52] is gathering information from rural community members on how their lives changed after they were provided with adequate amounts of affordable clean water, that is, when a piped or haul system was installed in their community. This information helps place a value on the true cost of inadequate water provision, using both direct and indirect impacts in the analysis. This also helps inform economic analyses of rural water and sanitation deficiencies, and will provide policymakers with a better estimate of the true benefits conferred by modern water systems, as well as the costs associated with delaying installation or deferring maintenance on existing systems.

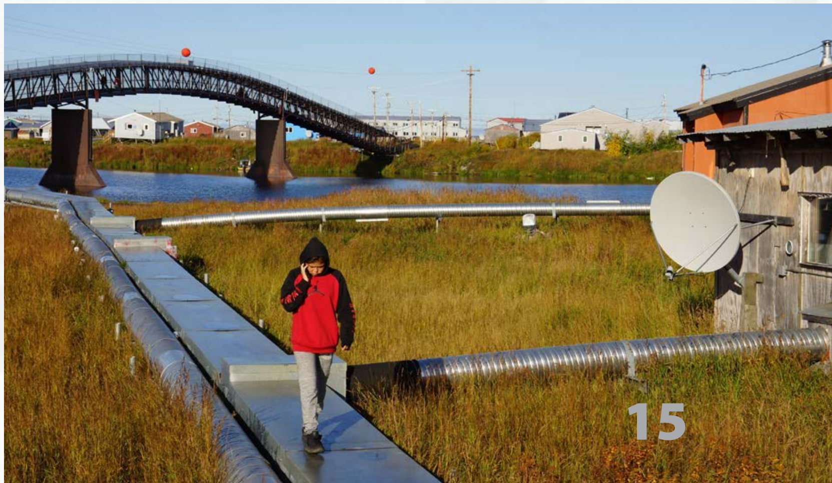
WHAT IS ONE HEALTH?

"One Health" is an approach to design and implement programs, policies, legislation, and research in which multiple sectors communicate and work together to achieve optimal health outcomes that recognize the interconnection among people, animals, plants, and their shared environment. A One Health approach is valuable because six out of every 10 infectious diseases in humans are spread by animals.[54]

New Research in Water and Sanitation: Ripple Effects Mapping (REM). REM is a participatory evaluation technique that reveals intended and unintended outcomes of an action or program. USARC and the Centers for Disease Control supported REM efforts in Arctic communities that have recently been provided piped water. REM provides data on the indirect benefits (as well as possible drawbacks) of the water provided by investigating the changes that occurred after a piped water system was installed in a village. Potential positive changes include increased school attendance and higher graduation rates, improved dental health (due to decreased sweetened beverage intake because potable water was readily available), and positive economic impacts from fewer work sick days. These results provide researchers and communities with insight to improve plans for future water systems.

Between 2011 and 2015, 73% of the children in the Yukon-Kuskokwim Delta area received full-mouth dental rehabilitation by the time they were six years old.[53]





[51] Can be transmitted between animals and humans
[52] USARC Alaska Rural Water and Sanitation Website: https://arctic.gov/water-san/
[53] Day, G., et al. 2017. Establishing an oral health surveillance system in western Alaska using the electronic dental record. Poster presentation, 5th Alaska Native Health Research Conference, Oct 16–18, 2017, Anchorage, AK
[54] Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), https://www.cdc.gov/onehealth/index.html

GOAL 5. Enhance International Scientific Cooperation in the Arctic

MOTIVATION

Data generation, reliable access to scientific information, and synthesis of results are central to understanding the Arctic region, to sustainable development, and to fostering healthy communities. Increasing demands for information and interdisciplinary research results create a challenge for Arctic states and stakeholders. Enhanced international cooperation among Arctic states and non-Arctic states can build synergies between national programs and create efficiencies for the best use of limited resources to address Arctic scientific challenges that often extend beyond the jurisdiction of any one nation.

RECOMMENDATIONS

- **Implement the Central Arctic Ocean Fisheries Agreement.** The United States should implement the "Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean" and work with the Parties[55] to establish a durable marine science organization to promote Arctic-focused ecosystem science and to realize the Agreement's joint program of scientific research.
- **Implement the Arctic science Cooperation Agreement.** The United States should implement the "Agreement on Enhancing International Arctic Scientific Cooperation" to improve cross-border access of scientists, equipment, and data. The United States should work with other Parties to develop procedures for consultation and dispute resolution. To promote coordination and consultation among US interests and stakeholders, the United States should develop internal processes and procedures, and these may assist with international implementation of the agreement.
- **Strengthen Bilateral and Multilateral Research Cooperation.** The United States should pursue opportunities to strengthen bilateral research cooperation along our borders with the Russian Federation and Canada, including ecosystem-level marine research and long-term monitoring.

[55] Parties include: United States, Canada, Denmark, on behalf of Greenland and the Faroe Islands, Norway, Russia, China, Republic of Korea, Japan, Iceland, and the European Union

(a) 2nd Arctic Science Ministerial. *Copyright BMBF/ Hans-Joachim Rickel*. (b) Signatories of the Arctic fisheries agreement in Ilulissat, Greenland, October 2018.

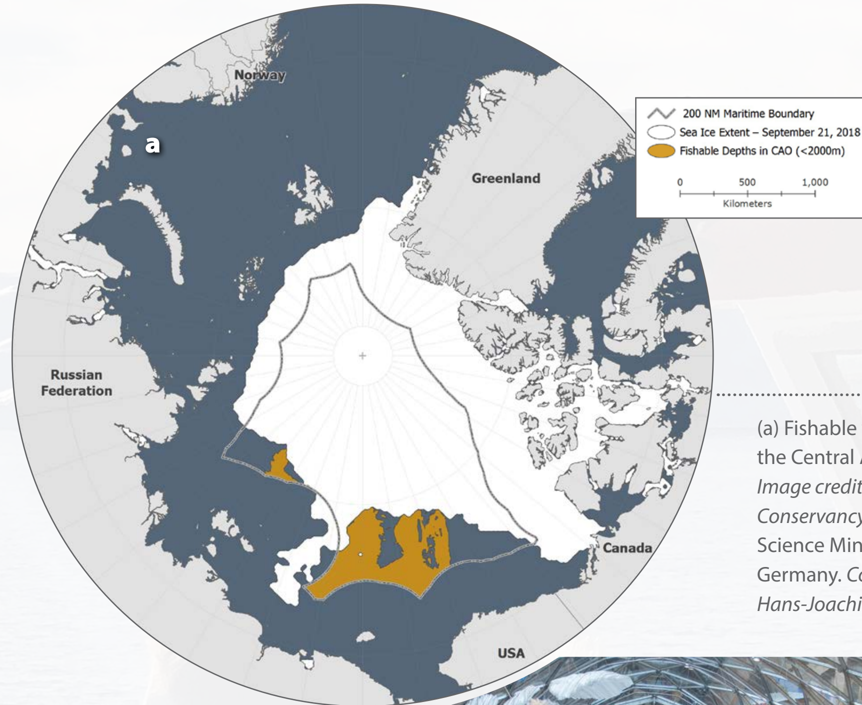
EXAMPLES

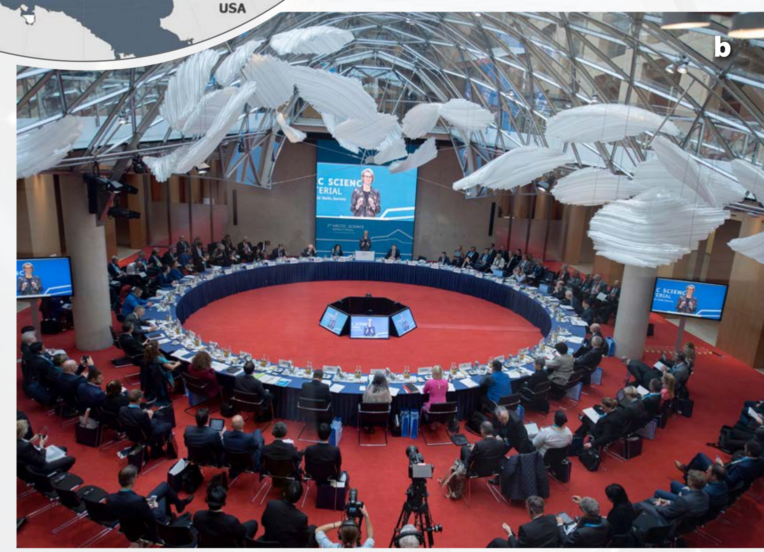
Joint Program of Scientific Research (JPSR) in the Central Arctic Ocean (CAO). The CAO fisheries agreement calls upon the Parties to establish a JPSR to increase knowledge of the CAO ecosystem and its living marine resources. This collaborative effort will help determine whether harvestable fish stocks exist in the CAO, or may, in the future, and what impacts fishing might have on its ecosystem. The Parties have an opportunity to establish a durable, pan-Arctic institutional structure that could be a stand-alone, research-focused entity modeled after the Atlantic-centered ICES (the International Council for the Exploration of the Sea), or the Pacific-centered PICES (the Pacific ICES). This structure, with explicit commitments by the Parties, would forge new partnerships between Arctic and non-Arctic states, and would improve cooperation and research planning, streamline and maximize logistical coordination, and reinforce efforts to standardize data collection and management protocols.

Arctic Science Ministerial. The second Arctic Science Ministerial,[56] held in Berlin in October 2018, was a successful follow-on to the inaugural event held at the White House in 2016.[57] In 2020, the third ministerial will be held in Japan and co-hosted by Iceland.

Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC). In September 2019, more than 600 scientists from 17 countries will begin a yearlong expedition across the Arctic Ocean aboard the drifting German Research Icebreaker *Polarstern*, frozen into the ice pack. Additional icebreakers and several polar research aircraft will support the ~$140M effort to examine the causes and consequences of recent and predicted physical, chemical, and biological changes observed in Arctic sea ice, snow, the overlying atmosphere, and the marine ecosystem. NSF is the primary US sponsor, and additional projects are being supported by DOE, NASA, and NOAA.

Belmont Forum. An international partnership of funding entities committed to advancing transdisciplinary research in environmental change released a second Arctic-focused funding solicitation in February 2019 called “Resilience in a Rapidly Changing Arctic.”[58]

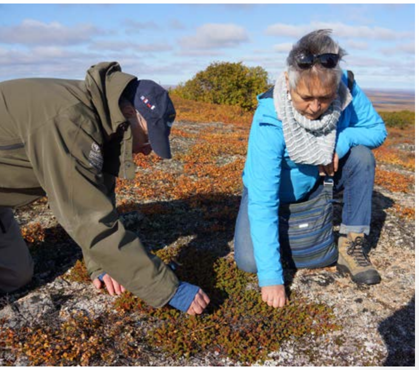




(a) Fishable waters of the Central Arctic Ocean. *Image credit: Ocean Conservancy.* (b) 2nd Arctic Science Ministerial, Berlin, Germany. *Copyright BMBF/ Hans-Joachim Rickel.*

[56] https://www.arcticscienceministerial.org/en/conclusions-1740.html
[57] https://www.arctic.gov/publications/other/supporting_arctic_science.html
[58] https://bfgo.org

Emerging Topics in Arctic Research



Co-Production of Knowledge. A holistic understanding of the evolving Arctic may be pursued by bringing together science and Indigenous Knowledge.[59] Co-production of knowledge involves scientists and Arctic Indigenous Peoples engaging in a mutually respectful, ethical, and accountable manner. Research is needed to determine how to effectively consider these perspectives. For instance, what are the essential elements of substantive engagement and preferred mechanisms for it? What is the basis to develop best practices? Did engagement work, successfully, as expected, or not, and if not, why? Have successes and failures been scrutinized and reported? Research sponsors are being encouraged[60] to review their investments in substantive community and stakeholder engagement to establish evidence-based guidance, which is essential to further improve the process.

Arctic Cod in Warming and Acidifying Waters. Climate change is warming and acidifying the Arctic Ocean, creating a one-two punch that is affecting the survival and suitability of Arctic cod's spawning habitat. Cod spawn only in cold water. Eggs emerge in the winter and spring when water temperatures typically vary between 29.5 °F and 31.6 °F, depending on freshwater influence.[61] Based on laboratory experiments during their first year of life, maximum growth was achieved at temperatures of 42.8°–44.6 °F.[62] This temperature dependency makes the species vulnerable to warming waters. Ocean acidification further challenges these fish by degrading spawning habitat, which reduces egg survival. Continued warming of Arctic waters may render unsuitable large areas presently used for spawning and recruitment of Arctic cod, which will likely impact Arctic food webs and associated ecosystem services.[63]

Arctic Drones. Technological advances in unmanned aircraft systems, or drones, and regulatory efforts to safely incorporate them into the nation's airspace are quickly improving Arctic research. The Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) advances the use of drones to survey plants and animals, to assist with oil spill response, to inspect pipelines and other infrastructure, and to map sea ice and topography. The Department of Transportation selected ACUASI to participate in a program to help governments work with drone operators and manufacturers to speed up safe entry of drones into the nation's airspace. In Russia, Kalashnikov's latest Zala Arctic Drone conducts reconnaissance missions in sub-zero temperatures for up to 250 minutes where they observe sea ice conditions and, with an onboard Automatic Identification System, distinguish vessels up to 60 miles away.

Griffon Aerospace SeaHunter.
Photo credit: Jordan W. Murdock and Robert J. Edison

[59] Behe, C., and R. Daniel. 2018. Indigenous knowledge and the coproduction of knowledge process: Creating a holistic understanding of Arctic change. Pp. S160–S161 in *State of the Climate in 2017. Bulletin of the American Meteorological Society*. https://doi.org/10.1175/2018BAMSStateoftheClimate.1

[60] Lavery, J.V. 2018. Building an evidence base for stakeholder engagement. *Science*. https://doi.org/10.1126/science.aat8429

[61] Bouchard, C., and L. Fortier. 2011. Circum-arctic comparison of the hatching season of polar cod *Boreogadus saida*: A test of the freshwater winter refuge hypothesis. *Progress in Oceanography*. https://doi.org/10.1016/j.pocean.2011.02.008

[62] Laurel, B.J., et al. 2017. Temperature-dependent growth as a function of size and age in juvenile Arctic cod (*Boreogadus saida*). *ICES Journal of Marine Science*. https://doi.org/10.1093/icesjms/fsx028

[63] Dahlke, F.T., et al. 2018. Northern cod species face spawning habitat losses if global warming exceeds 1.5°C. *Science Advances*. https://doi.org/10.1126/sciadv.aas8821

Working with the Interagency Arctic Research Policy Committee

The Arctic Research and Policy Act[64] that created USARC also established the Interagency Arctic Research Policy Committee (IARPC) that works with USARC to advance Arctic research. IARPC is a White House interagency working group of the National Science and Technology Council's Committee on Environment. IARPC is led by senior officials from 16 entities across the federal government, and is chaired by the Director of the NSF, who also serves as an *ex officio* member of USARC. The duties assigned by law to IARPC are conducted through consultation with the State of Alaska, local and Indigenous organizations, the academic community, and the broader public. Two duties are to consult and work with the Commission to develop and establish an integrated national Arctic research policy to guide federal agencies, and to develop a five-year Arctic research program plan to implement the national policy. The current plan,[65] ending in fiscal year 2021, focuses on policy-driven research activities that are substantially enhanced by multi-agency collaboration. The plan, implemented by federal and non-federal stakeholders, has nine goals (topics are health and well-being, atmosphere, sea ice, marine ecosystems, glaciers and sea level, permafrost, terrestrial and freshwater ecosystems, coastal resilience, and environmental intelligence) that have been informed by USARC's recommendations. Progress toward each goal's research objectives and performance elements is documented through an online system and through annual and biennial reports. IARPC participants engage through meetings, webinars, and via an interactive website[66] that enhances interinstitutional and interdisciplinary conversations organized around teams that collaborate on specific research topics.

IARPC has made significant progress over the last decade,[67] and has thoughtfully considered and implemented recommendations from USARC. IARPC has also addressed the extent to which the five-year plan advances the Administration's FY19 research and development (R&D) priority areas and practices, with specific links to "Military Superiority," "Security and Prosperity," "Energy Dominance," and "Health and Well-Being."

USARC greatly appreciates the strong and enduring collaboration with IARPC. Moving forward, we encourage IARPC to work with USARC to review and update national Arctic research policy[68] and to consider expanding the scope of the next five-year plan to address Arctic research beyond that limited only to multi-agency collaboration. Important Arctic research is being conducted by individual agencies, and this work should also be integrated into IARPC, and reviewed, to ensure that critical areas of research are not overlooked.

[64] https://www.arctic.gov/legislation.html
[65] https://www.iarpccollaborations.org/plan/index.html
[66] https://www.iarpccollaborations.org/index.html
[67] IARPC biennial report 2016–2017. https://www.iarpccollaborations.org/uploads/cms/documents/iarpc-biennial-report-2016-2017.pdf
[68] The policy was adopted by IARPC on February 3, 1986, as reported on page 2 of the National Science Foundation journal "Arctic Research of the United States," IARPC. Volume 1. 1987. https://storage.googleapis.com/arcticgov-static/publications/related/arotus/AROTUS 1.1987-Fall.pdf

Addressing Federal and State Priorities

This report's recommendations are broadly consistent with overarching guidance[69,70] from the White House, and with the priorities and interests expressed by Alaska and other states. For example, relevant to the Administration's FY20 emphasis on "Security of the American People," USARC's Goal 1 supports "R&D to improve the security and resilience of…critical (Arctic) infrastructure from natural hazards and physical threats" and encourages "geospatial decision support tools." USARC's leadership of the Arctic Renewable Energy Working Group, which emphasizes collaboration among governments, academia, and industry, is directly relevant to "American Energy Dominance." "American Medical Innovation" is advanced by USARC's call for greater emphasis on "basic medical research, particularly for personalized medicine, areas underserved by industry, disease prevention, and health promotion." The Commission's leadership of the Arctic Mental Health Working Group is directly in line with prioritizing R&D to improve healthcare for veterans, with a focus on mental health and suicide prevention. This work is particularly relevant to Alaska, which has the nation's highest percentage (nearly 14%) of veterans in the adult population.

The National Security Strategy (NSS) of the United States[71] also provides guidance that touches upon Arctic research. USARC's recommendations are consistent with this strategy's directive to "preserve our lead in research and technology" and to "promote American prosperity" by leading "in research, technology, invention, and innovation." The ONR initiative on an "Arctic Mobile Observing System" addresses this challenge, as does the High-frequency Active Auroral Research Program, the most powerful and flexible HF transmitter in the world, which supports DoD interests in global communications and surveillance (in the photo below). The Arctic is specifically mentioned in the NSS context of achieving better outcomes in multilateral forums. USARC addresses this in its fifth goal.

Historically, Alaska has been the only state government to identify specific Arctic research priorities. Pacific Northwest and New England states are showing greater interest in the Arctic and are pursuing investment and research opportunities.[72] USARC has considered these priorities in developing this report. Alaska's priorities for the Arctic are identified in a variety of documents, such as those[73] released by the Alaska State Committee for Research, by the State Legislature's Alaska Arctic Policy Commission,[74] and by Governors Palin and Walker.[75] All recognize the challenges and costs of a rapidly changing Arctic climate, the need to create and use the best available science and Indigenous Knowledge, and the importance of considering economic impacts and risk in developing adaptation strategies. Priorities include filling knowledge gaps to better pursue new and evolving economic opportunities to improve human and ecosystem health, and to strengthen communities.

69 https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/m-17-30.pdf
70 https://www.whitehouse.gov/wp-content/uploads/2018/07/M-18-22.pdf
71 https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf
72 https://bangordailynews.com/2019/01/07/opinion/contributors/maine-must-stay-the-course-in-arctic-connections/ and https://mypages.unh.edu/ne-arctic-convergence/home
73 Alaska Science and Technology Plan – To Build a Fire, 2016. https://www.alaska.edu/files/epscor/pdfs/ST-Plan-2016.pdf
74 Alaska Arctic Policy, http://www.akarctic.com
75 The work of Governor Palin's Climate Change Sub-Cabinet, http://climatechange.alaska.gov, and Governor Walker's acceptance of the Alaska Climate Change Action Plan and Policy Recommendations, https://www.juneauempire.com/news/gov-accepts-climate-change-plan/ and http://www.akclimateaction.org/2018/12/wondering-where-to-find-climate-change.html

Photo credit: Jessica Matthews

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, Alaska. In addition to establishing the goals in this report, the Commission develops and recommends an integrated national Arctic research policy 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 (IARPC). USARC plays a significant role in planning and implementing international Arctic Science Ministerial meetings. On behalf of the United States, USARC was designated the "competent national authority" to implement the legally binding "Agreement on Enhancing International Arctic Scientific Cooperation" signed by all eight Arctic nations (see https://www.arctic.gov/science-agrmt.html).

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 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 Study of Environmental Arctic Change (SEARCH), 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 Arctic Icebreaker Coordinating Committee of the University National Oceanographic Laboratory System, the Alaska Ocean Observing System, the State Department's Arctic Policy Group, the Arctic Research Consortium of the United States, the International Permafrost Association, and the Consortium for Ocean Leadership.

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 sought input from scientists and other researchers, holders of Indigenous Knowledge, policymakers, and the general 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 and initiatives to inform USARC's perspective and to share information. This document summarizes those goals and objectives, offers specific recommendations, and highlights progress towards their achievement.

WORKING GROUPS

USARC coordinates three working groups of federal, state, tribal, academic, nongovernmental, and other stakeholders to develop short- and long-term research objectives critical to Arctic residents. More information on these groups can be found at https://www.arctic.gov.

- **The Arctic Mental Health Working Group (AMHWG)** promotes research on the mental and behavioral health of Arctic populations. The group's mission is to strengthen systems of care to prevent suicide and improve mental health in the circumpolar North via the promotion of Indigenous Knowledge, research, and evidence-based early intervention and primary prevention efforts.
- **The Arctic Renewable Energy Working Group (AREWG)** supports research on renewable and efficient energy systems in remote Arctic communities. Recent focus has been on renewable energy/energy efficiency strategies aimed at reducing dependence on costly diesel fuel to heat homes in Arctic villages.
- **The Alaska Rural Water and Sanitation Working Group (ARWSWG)** focuses on maximizing the health benefits of in-home water and sanitation services in rural Alaska by promoting R&D on innovative approaches to water and wastewater services, increasing human capacity in villages, developing strategies to allocate capital funds through community-level engagement, and supporting research on the connections among climate, water, and human/environmental health.

COPYRIGHT INFORMATION

Photo credit: San Nguyen

www.arctic.gov

Virginia (Washington, DC) Office

4350 N. Fairfax Drive, Suite 510
Arlington, Virginia 22203
T-703.525.0111
F-703.525.0114
E-mail: info@arctic.gov

Alaska Office

420 L Street, Suite 315
Anchorage, Alaska 99501
T-907.271.4575
F-907.271.4578
E-mail: info@arctic.gov

Printed in the United States of America
April 2019