

ARCTIC RESEARCH PLAN

2022-2026



Product of the Interagency Arctic Research Policy Committee
of the National Science and Technology Council

DECEMBER 2021

About the Cover Graphic

The Arctic Research Plan 2022-2026 prioritizes four areas: Community Resilience and Health, Arctic Systems Interactions, Sustainable Economies and Livelihoods, and Risk Management and Hazard Mitigation. These priority areas address the relationships between people and the environment and the urgently needed research to better understand and respond to the most rapidly changing region on Earth.

The plan's cover graphic brings together many of the natural and cultural elements of the Arctic, including the importance of participatory research, Indigenous leadership in research, and co-production of knowledge between academic science and Indigenous Knowledge. The center art was produced by Molly Trainor (mollytrainor.com), an artist, designer, and copywriter from Nome, Alaska. Molly's Iñupiaq heritage influences her work, which is aimed at cultural heritage preservation by combining traditional technology and science subjects, storytelling, and pop culture. Design of the complete cover graphic was produced by Eric Cline of TerraGraphica.



ARCTIC RESEARCH PLAN 2022-2026

A report by the
Interagency Arctic Research Policy Committee
of the
National Science and Technology Council

December 2021



EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20502

December 15, 2021

Members of Congress:

I am pleased to transmit the new five-year Arctic Research Plan produced by the Interagency Arctic Research Policy Committee (IARPC). Covering the period 2022-2026, the plan is one of IARPC's responsibilities described in the Arctic Research Policy Act of 1984 (15 U.S.C. §4108).

Arctic communities are feeling the effects of multiple challenges. Climate change has led to unprecedented warming, with impacts including thawing permafrost wreaking havoc on buildings and roads, and loss of ice leading to eroding shorelines and even dwellings collapsing into adjacent waters. Those who practice subsistence ways of life are experiencing changes in the distribution and abundance of fish and other wildlife that affect their ability to feed their families. COVID-19 is taking a particularly hard toll in rural areas where health-care systems are overwhelmed or nonexistent.

These challenges and many others require integrated, knowledge-based action. Science and Indigenous Knowledge will be key to effectively addressing these complex issues. Collaboration across agencies, knowledge systems, and disciplines are needed now more than ever before.

The Biden/Harris Administration is strongly committed to tackling the climate crisis. In addition to advancing coordination on Arctic research through IARPC, the White House Office of Science and Technology Policy has re-established the Arctic Executive Steering Committee and the Northern Bering Sea Climate Resilience Area to enhance cross-governmental leadership on Arctic issues. The Arctic Research Plan will play a key role in advancing the understanding of climate change, its drivers, and consequences to the environment and to communities.

This Arctic Research Plan reflects the significant advances that IARPC agencies have made under the Arctic Research Plan 2017-2021 and provides a bold new vision for research over the next five years, with a focus on interagency collaboration opportunities.

I appreciate your support as this Administration works to ensure that the Nation's research efforts in the Arctic are broadly coordinated across the full spectrum of Federal agencies and interests.

A handwritten signature in black ink, appearing to read "Eric S. Lander". The signature is fluid and cursive, with a long horizontal stroke at the end.

Eric S. Lander

Assistant to the President for Science and Technology
Director, Office of Science and Technology Policy



National Science Foundation
Office of the Director

Members of Congress:

I am pleased to forward the Interagency Arctic Research Policy Committee's (IARPC) Arctic Research Plan 2022-2026. The Arctic Research Policy Act of 1984 (15 U.S.C. § 4108) requires that every 5 years, IARPC "prepare and execute an Arctic Research Plan in coordination with the U.S. Arctic Research Commission, the Governor of the State of Alaska, residents of the Arctic, the private sector, and public interest groups." This builds from the successes of previous plans as well as the strengths of each contributing agency. It outlines a holistic and bold new vision for Arctic research.

The Arctic continues to change rapidly, creating complex, dynamic, and multidisciplinary research questions. The changes in the Arctic have global consequences and profoundly impact Arctic communities who are an integral part of the Arctic environment. This plan recognizes that addressing the impacts of Arctic change is best accomplished through interagency collaboration and by working closely with state, local, and Tribal authorities, research institutions, and nonprofit, private sector, and international organizations.

In preparing the Arctic Research Plan 2022-2026, IARPC conducted outreach to include many voices, including individuals and organizations at the state, local and Tribal level. This plan recognizes that Indigenous Knowledge, Participatory Research and Indigenous leadership in research are foundational to Arctic research.

The plan identifies four priority areas for research to improve community resilience and health, advance scientific understanding of Arctic systems interactions, create more sustainable economies and livelihoods, and improve risk management and hazard mitigation. These four areas are intended to be responsive to priorities identified by Arctic communities, Federal agencies with a presence in Alaska or a responsibility to understand the Arctic region, the state of Alaska, and other non-Federal entities. The plan is also designed to accommodate challenges that may emerge in the next five years, and to include the full range of research supported by federal agencies, from basic to use-inspired and applied.

This plan is built on overarching principles of sustained engagement, inclusion and equity, and transparency and accessibility. IARPC will continue to operate under these principles through implementation. As chair of IARPC, I appreciate your support as we work together to address some of the most pressing and challenging Arctic research questions of our time.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Sethuraman Panchanathan', written over a white background.

Sethuraman Panchanathan
Director

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at www.whitehouse.gov/ostp/nstc.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at www.whitehouse.gov/ostp.

About the Interagency Arctic Research Policy Committee

The Arctic Research and Policy Act of 1984 (ARPA), Public Law 98-373, July 31, 1984, as amended, provides for a comprehensive national policy dealing with national research needs and objectives in the Arctic. ARPA establishes an Arctic Research Commission (USARC) and an Interagency Arctic Research Policy Committee (IARPC) to help implement the act. Since its inception, IARPC activities have been coordinated by the National Science Foundation (NSF), with the Director of the NSF as chair. A Presidential Memorandum issued on July 22, 2010, made the NSTC responsible for IARPC, with the Director of the NSF remaining as chair of the committee.

About This Document

This report was developed by IARPC, which is a working group of the National Science and Technology Council. This report is published by OSTP.

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Richard Spinrad, Department of Commerce

Peter Thomas, Marine Mammal Commission

Luis Tupas, U.S. Department of Agriculture

Candace Vahlsing, Office of Management and Budget

Suzanne van Drunick, Environmental Protection Agency

Acknowledgements

Plan Drafting Team: Kaja Brix (DOC), Sara Bowden (IARPC), Nikoosh Carlo (IARPC), Dorothy Castille (DHHS), Ashley Chappell (DOC), Cathy Coon (DOI), Jessica Cross (DOC), Xujing Davis (DOE), Roberto Delgado (NSF), Michael Falkowski (NASA), Stacey Fritz (DOE), Ann Gibbs (DOI), Josh Glasser (DOS), Heather Sauyaq Jean Gordon (DHHS), Colene Haffke (NSF), Erica Hill (NSF), Larry Hinzman (OSTP), Amy Holman (DOC), Elizabeth Hoy (NASA), Janet Intrieri (DOC), Renu Joseph (DOE), Yekaterina (Katia) Kontar (NSF and USGCRP), Peter Larson (DOE), Meredith LaValley (IARPC), Crystal Ciisquq Leonetti (DOI), Sally McFarlane (DOE), Jennifer Mercer (NSF), Candace Nachman (DOC), John Pearce (DOI), Ben Petro (DOD), Allen Pope (NSF), Elizabeth Powers (DOI), Kurt Preston (DOD), Cheryl Rosa (USARC), Zachary Schulman (DHS), Colleen Strawhacker (NSF), Bob Vallario (DOE), Jason Weale (DOD), and Brandon White (DOT).

Editorial Team: Sara Bowden (IARPC), Nikoosh Carlo (IARPC), Renee Crain (NSF), Larry Hinzman (OSTP), Sorina Stalla (IARPC), and Simon Stephenson (NSF, retired).

Plan Champions: Aimee Devaris (DOI), Timothy Gallaudet (DOC, retired), Gerald Geernaert (DOE), CJ Loria (DOI), and Peter Schmeissner (DHHS).

Plan Development Steering Group: Kaja Brix (DOC), Nikoosh Carlo (IARPC), Roberto Delgado (NSF), Michael Falkowski (NASA), Larry Hinzman (OSTP), Douglas Howard (DOD), Renu Joseph (DOE), Maija Katak Lukin (DOI), Elizabeth Powers (DOI), John Pearce (DOI), Candace Nachman (DOC), Jackie Richter Menge (USARC), Cheryl Rosa (USARC), and Simon Stephenson (NSF, retired) (Chair).

IARPC Secretariat: Sara Bowden, Meredith LaValley, Hazel Shapiro, Danielle Stickman, and Liz Weinberg, as well as Knauss Fellows Andrew Villeneuve and Ann-Christine Zinkann.

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Table of Contents

Acronyms Used in this Plan	vi
Glossary of Plan Structural Terms	viii
Executive Summary	ix
Introduction	1
Priority Area 1: Community Resilience and Health	9
Priority Area 2: Arctic Systems Interactions	13
Priority Area 3: Sustainable Economies and Livelihoods.....	17
Priority Area 4: Risk Management and Hazard Mitigation	21
Foundational Activities	25
Data Management	25
Education, Training, and Capacity Building.....	26
Monitoring, Observing, Modeling, and Prediction	27
Participatory Research and Indigenous Leadership in Research	29
Technology Innovation and Application	30
Implementation and Metrics for Measuring Success.....	33
References	37
Appendices.....	47

Acronyms Used in this Plan

AI	Artificial intelligence
AFN	Alaska Federation of Natives
AMAP	Arctic Monitoring and Assessment Programme
ANCSA	Alaska Native Claims Settlement Act
ARPA	Arctic Research and Policy Act of 1984
CARE	Collective benefit, authority to control, responsibility, ethics
CMTS	U.S. Committee on the Marine Transportation System
COTS	Commercial off-the-shelf
DHSEM	Department of Homeland Security and Emergency Management
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOS	Department of State
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAIR	Findability, accessibility, interoperability, and reusability
FPIC	Free, prior, and informed consent
HSPD	Homeland Security Presidential Directive
HUD	Department of Housing and Urban Development
IARPC	Interagency Arctic Research Policy Committee
ICAMS	Interagency Council for Advancing Meteorological Services
ICC	Inuit Circumpolar Council
IPCC	Intergovernmental Panel on Climate Change
LiDAR	Light detection and ranging
MMC	Marine Mammal Commission
MOMP	Monitoring, observing, modeling, and prediction
NASA	National Aeronautics and Space Administration

NASEM	National Academies of Sciences, Engineering, and Medicine
NSAR	National Strategy for the Arctic Region
NSF	National Science Foundation
NSPD	National Security Presidential Directives
NSTC	National Science and Technology Council
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
R&D	Research and development
RNWG	Research Needs Work Group
SDWG	Sustainable Development Working Group
SI	Smithsonian Institution
STEM	Science, technology, engineering, and mathematics
U.S.	United States
USACE	United States Army Corps of Engineers
US AON	United States Arctic Observing Network
USARC	United States Arctic Research Commission
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USGCRP	United States Global Change Research Program

Glossary of Plan Structural Terms

Biennial Implementation Plan: Document developed every two years that will outline specific objectives and deliverables that will be completed in the subsequent two years.

Convergence Research: Investigations driven by a specific and compelling problem that requires deep integration across disciplines.

Deliverable: Tangible, measurable, and easily communicated research product that demonstrates progress made toward satisfying the objectives and goals and is made available to relevant decision-makers and partners. Deliverables could also include achievements resulting from the establishment of new relationships.

Foundational Activity: Activity that relates to, supports, and informs the priority areas. Foundational activities are critical to improving research and better addressing each of the priority areas.

Goal: Intended convergent research outcome(s) that is realized from Federal investment and non-Federal partner efforts.

Lead Agency: The Federal agency responsible for co-leading priority areas.

Objective: Specific research action that advances the goals.

Policy Driver: Underlying U.S. Arctic and research policy that guides the development of the plan.

Priority Area: Broad cross-cutting theme that needs additional research, supports one or more policy drivers, meets the mission and interests of more than one Federal agency, and engages multiple existing collaboration teams and non-Federal partners.



Gates of the Arctic National Park & Preserve. Photo: Sean Tevebaugh/DOI

Executive Summary

The rapid changes occurring in the Arctic are complex, dynamic, and interconnected. Climate change and other environmental changes are profoundly impacting Arctic communities and have global consequences. As a result, emerging research questions are multidisciplinary and are best addressed by multiple Federal agencies working closely with non-Federal partners. Through a targeted approach to cross-cutting priority areas, the Interagency Arctic Research Policy Committee’s (IARPC) Arctic Research Plan 2022-2026 addresses the most pressing Arctic research needs that require a collaborative approach and can advance understanding of the Arctic and climate change, inform policy and planning decisions, and promote the well-being of Arctic and global communities. The plan’s priority areas respond to challenges identified by Arctic communities, Federal agencies with a presence in Alaska or a responsibility to understand the Arctic region, Federal agencies with Arctic investments, the state of Alaska, Tribal and Indigenous organizations, and other non-Federal entities.

IARPC was established by the Arctic Research and Policy Act of 1984 (ARPA) to facilitate coordination and cooperation in Arctic research. Now a subcommittee of the National Science and Technology Council (NSTC), IARPC plays a critical role in enhancing scientific monitoring and advancing Arctic research through the coordination of Federal agencies as well as domestic and international collaborators. Every five years, IARPC is required by law (ARPA) “to prepare and execute an Arctic Research Plan in coordination with the U.S. Arctic Research Commission, the Governor of the State of Alaska, residents of the Arctic, the private sector, and public interest groups.” The Arctic Research Plan 2022-2026 is the third plan since IARPC became a subcommittee of the NSTC and builds from the successes and communities of practice established by previous plans. It seeks to integrate these communities and create cross-cutting foci which require a focused research effort.

As with the Arctic Research Plan 2017-2021, this plan adheres to four critical policy drivers in U.S. Arctic research policy that reflect long-standing U.S. interests in the Arctic and the collective priorities of IARPC Federal agencies. Policy drivers include Well-Being, Stewardship, Security, and Arctic-Global Systems.

This plan includes four priority areas with thematic goals that (1) represent broad, cross-cutting themes that need additional research, (2) support one or more policy drivers, (3) meet the mission and interests

of more than one Federal agency, and (4) engage multiple existing collaboration teams and non-Federal partners. Priority areas and goals include:

- 1. Community Resilience and Health:** Improve community resilience and well-being by strengthening research and developing tools to increase understanding of interdependent social, natural, and built systems in the Arctic.
- 2. Arctic Systems Interactions:** Enhance our ability to observe, understand, predict, and project the Arctic's dynamic interconnected systems and their links to the Earth system.
- 3. Sustainable Economies and Livelihoods:** Observe and understand the Arctic's natural, social, and built systems to promote sustainable economies and livelihoods.
- 4. Risk Management and Hazard Mitigation:** Secure and improve quality of life through research that promotes an understanding of disaster risk exposure, sensitivity to hazard, and adaptive capacity.

In addition to identifying four priority areas, this plan builds upon five foundational activities. These activities are critical to achieving the priority area goals and will remain foundational to Arctic research beyond the five-year duration of this plan. Foundational activities include: Data Management; Education, Training, and Capacity Building; Monitoring, Observing, Modeling, and Prediction; Participatory Research and Indigenous Leadership in Research; and Technology Innovation and Application.

In contrast to previous IARPC Arctic research plans, this plan presents a high-level strategy without explicit direction on implementation. In order for IARPC to respond more swiftly to emerging or immediate needs, including those caused by climate change, while continuing to support U.S. Arctic policy, this plan will be implemented through biennial implementation plans. These implementation plans will identify specific objectives and deliverables. Four new priority area collaboration teams will be established to direct and coordinate activities to reach goals and ensure collaboration.



A researcher samples tundra plants. Photo: Karen Temple Beamish (PolarTREC 2016), courtesy of ARCUS

Introduction

The Arctic continues to be the most rapidly changing region on Earth, with surface warming at more than twice the global average (IPCC, 2021). Climate change is the primary driver of environmental change and has additional impacts on socioeconomic systems (AMAP, 2021). The rapidly emerging challenges of the Arctic are complex and dynamic with global implications and profound impacts on Arctic communities.¹ As an Arctic nation, by virtue of the state of Alaska, the United States is committed to advancing scientific understanding of the Arctic and the impacts of climate change. This includes understanding of the local to global consequences of Arctic change, defined as rapid climate, environmental, cultural, socioeconomic, and geopolitical changes. The interconnected processes that define the Arctic create important research questions, many of which are best addressed by multiple Federal agencies working together and in collaboration with state, local, and Tribal authorities, research institutions, and nonprofit, private sector, and international organizations.² Analyses of complex challenges are based upon integration and application of basic and applied research, which are essential to understand the social, environmental, and ecological systems of the Arctic. The strong interconnections among natural, social, and built systems must be considered. For example, the changing climate in the Arctic impacts energy, water, and food security (Markon et al., 2018) while also implicating community health and resilience, natural resource development, infrastructure, commercial activities, and ecosystem services, and creating hazards for both Arctic and global communities. Through this bold new five-year Arctic Research Plan, IARPC is addressing emerging research questions that require a timely and robust federal interagency response.

¹ Indigenous, local, and/or other Arctic residents comprising a social unit with shared attributes including but not limited to customs, (cultural) identity, values, and a sense of place situated in a given geographical area. Communities may comprise a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in specific geographical locations or settings (Green and Mercer, 2001).

² This list of entities is from the National Strategy for the Arctic Region, 2013. Throughout this document use of non-Federal partners refers to this list.

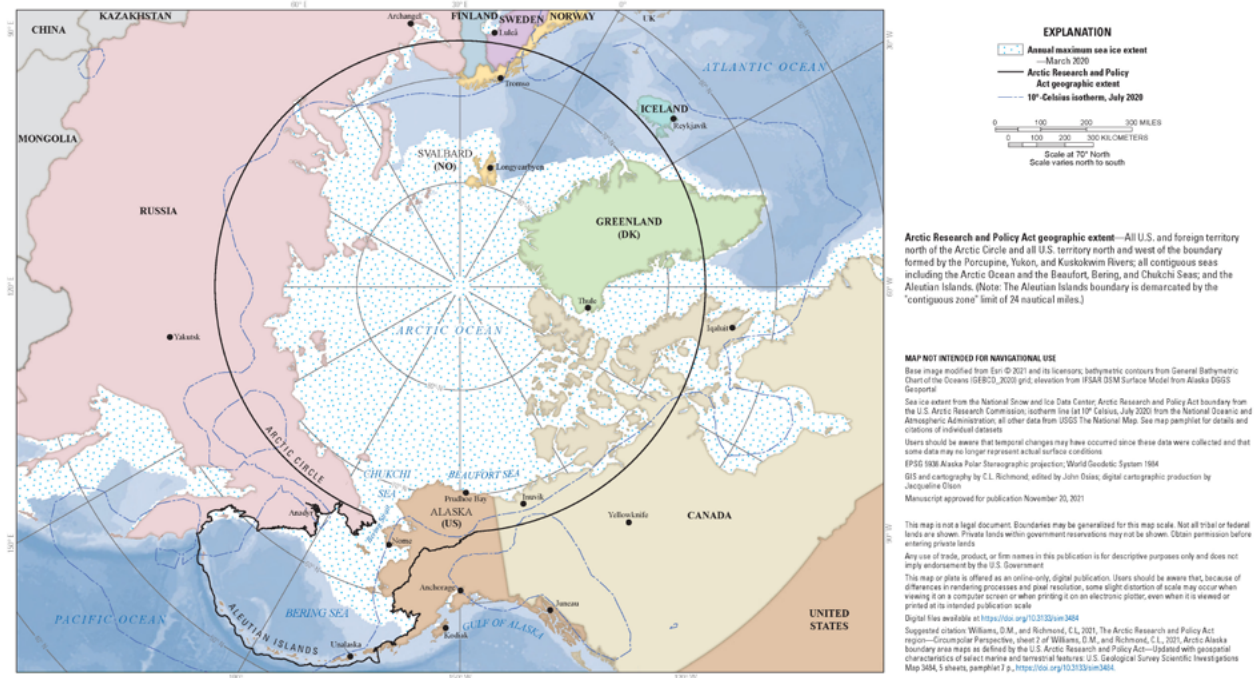


Figure 1: The Arctic Research Policy Act of 1984 (15 U.S.C. § 4108) defines the Arctic as all United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain. Image: Williams, D.M., and Richmond, C.L., 2021, The Arctic Research and Policy Act region—Circumpolar Perspective, sheet 2 of Williams, D.M., and Richmond, C.L., 2021, Arctic Alaska boundary area maps as defined by the U.S. Arctic Research and Policy Act—Updated with geospatial characteristics of select marine and terrestrial features: U.S. Geological Survey Scientific Investigations Map 3484, 5 sheets, pamphlet 7p., <https://doi.org/10.3133/sim3484>

IARPC was established by the Arctic Research Policy Act of 1984 (ARPA) to “facilitate cooperation between the Federal Government and State and local governments in Arctic research” and “recommend the undertaking of neglected areas of research.”³ Now a subcommittee of the National Science and Technology Council (NSTC), IARPC enhances scientific monitoring and research on individual components of the Arctic, as well as how the system operates as a whole, through the coordination of Federal agencies and domestic and international collaborators. It consists of representatives from 14 Federal agencies, the White House Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB).⁴

Every five years, IARPC is required by law (ARPA) to prepare and execute an Arctic research plan in “consultation with the [US Arctic Research] Commission, the Governor of the State of Alaska, the residents of the Arctic, the private sector, and public interest groups.”⁵ Through a targeted approach to priority areas set forth in this plan, IARPC will address the most pressing Arctic research needs that can advance understanding of the Arctic, inform policy and planning decisions, and promote the well-

³ Arctic Research and Policy Act Section 104: www.iarpcollaborations.org/uploads/cms/documents/arpa_amended.pdf

⁴ For more information, see the IARPC About Page: www.iarpcollaborations.org/about.html and IARPC Overview Document: www.iarpcollaborations.org/uploads/cms/documents/iarpc_overview.pdf

⁵ Arctic Research and Policy Act Section 109: www.iarpcollaborations.org/uploads/cms/documents/arpa_amended.pdf

being⁶ of Arctic and global communities. Priority areas are designed to respond to challenges identified by Arctic communities, Federal agencies with a presence in Alaska or a responsibility to understand the Arctic region, the state of Alaska, and other non-Federal entities. They are structured to be responsive to challenges that may emerge in the next five years. IARPC aligns its work with the U.S. Arctic Research Commission (USARC) and the plan's priority areas complement the targets laid out in the USARC Report on the Goals and Objectives for Arctic Research (2019-2020).⁷ This plan also responds to Biden Administration priorities on tackling climate change⁸ and promoting racial equity⁹. Each of the priority areas identified in this plan defines a broad goal for implementation by IARPC Federal agencies and, where appropriate, in collaboration with non-Federal partners. The role of non-Federal entities are critical to Arctic research now and in the future.

The Arctic Research Plan 2022-2026 is relevant to the needs of all people who live in the U.S. Arctic as well as the larger national and global community who are also impacted by changes to the Arctic climate and environment. The absence of specific acknowledgment or reference to any non-Federal entity is not an omission but to avoid pre-decisional preference or bias that a reference might appear to provide. This plan considers input from as many voices as possible, drawing from documents and reports developed by the state of Alaska and local, regional, national, and international organizations. It recognizes the importance of international collaboration in advancing understanding of transboundary research challenges. It also reflects the considerable interest and input received from Indigenous Peoples and organizations, who are significantly impacted by Arctic change and are also often first to experience these impacts. The rapidity of emerging research questions in the Arctic requires quick and decisive action to better observe, predict, and understand those shifts. IARPC responds to this need by aiming to deliver science and knowledge to decision-makers in the Arctic and beyond.

Through this plan, IARPC seeks to build and sustain a stronger relationship between the Federally funded research enterprise, the state of Alaska, and Arctic communities. In Alaska, a significant number of Arctic communities and those closest to the impacts of Arctic change are Indigenous. Indigenous Peoples have inhabited the region since time immemorial. Indigenous Knowledge encompasses both cultural and ecological systems and is critical to understanding the Arctic (ICC Alaska, 2015). The history of colonization in the U.S. Arctic involved subjugation of Indigenous Peoples and included such issues as diseases, boarding schools, removal policies, and slavery, which have negatively impacted the health and well-being of Arctic communities, resulting in lasting and ongoing trauma (Jantarasami et al., 2018).¹⁰ This plan acknowledges the history and resulting trauma of colonization. IARPC recognizes that to achieve priority area goals, there is the need for participatory research (David-Chavez and

⁶ Well-being includes mental, physical, spiritual, emotional, cultural, and social health which fulfill needs of identity, purpose, and belonging (Tagalik, 2010). It is a concern for the individual, the collective community, and culture as well (Tagalik, 2015). Individual, tribal, and community wellbeing are inseparable in the Native worldview (Tagalik, 2010; 2015).

⁷ Appendix A: Alignment of Arctic Research Plan 2022-2026 with the United States Arctic Research Commission Report on the Goals and Objectives for Arctic Research 2019-2020

⁸ Executive Order on Tackling the Climate Crisis at Home and Abroad: www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

⁹ Executive Order On Advancing Racial Equity and Support for Underserved Communities Through the Federal Government: www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

¹⁰ Emotional and psychological trauma from a history of colonization, assimilation, and political subjugation that is passed down generationally (Brave Heart et al., 2011).

U.S. Arctic Research Commission. Arctic Mental Health Working Group (AMHWG). 2017. www.arctic.gov/uploads/assets/amhwg_flyer_8-29-17.pdf

Substance Abuse and Mental Health Services Administration. Understanding Historical Trauma when Responding to an Event in Indian Country. 2014. store.samhsa.gov/sites/default/files/d7/priv/sma14-4866.pdf

Gavin, 2018), co-production of knowledge, and participation, meaningful involvement, and leadership by Indigenous Peoples in research. Communication by Federal agencies with Indigenous Peoples, communities, and Tribal Nations, as well as with the state of Alaska, Federal resource managers, and other state and local officials has improved over the past decade, but there is room for IARPC to strengthen effective two-way communications and relationships. Recognizing that financial and human resources are limited, both within Federal agencies and in Arctic communities, this plan encourages IARPC to increase this capacity and enhance engagement and participation of those most directly impacted by Arctic change. This plan also aims to elevate principles of justice, equity, diversity, and inclusion.

In 2018, IARPC updated the Federal *Principles for Conducting Research in the Arctic*. These fundamental principles guide research at all stages and encourage engagement with Indigenous communities throughout the research process.¹¹ This plan emphasizes the responsibility that IARPC and the Federal research community have to be inclusive of Indigenous Knowledge and cultures and recognizes and respects Tribal sovereignty¹² and the importance of self-determination¹³. IARPC acknowledges that the U.S. government operates under Executive Order 13175,¹⁴ which directs Federal agencies to “establish regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications [and] to strengthen the United States government-to-government relationships with Indian tribes.” Congressional Public Law 108-199 also mandates government-to-corporation consultation with “Alaska Native corporations on the same basis as Indian tribes under Executive Order No. 13175.”¹⁵ IARPC recognizes that many Federal agencies have specific obligations and approaches for Tribal consultation that acknowledge Tribal governments’ unique legal relationship with the U.S. Federal government. Nothing in this plan supersedes the consultative obligations of individual Federal agencies.

Overarching Principles

Throughout the development of the plan,¹⁶ IARPC has been guided by the following overarching principles:

1. Sustained Engagement: Advance respectful, responsive, and continuous engagement with Indigenous and Tribal organizations, Arctic communities, Federal agencies, the state of Alaska, and non-Federal partners.
2. Inclusion and Equity: Encourage diversity and ensure that everyone is treated fairly and respectfully and promote access to the tools needed to succeed.
3. Transparency and Accessibility: Commit to activities and decisions that are transparent and communicated clearly and in an accessible format.

¹¹Principles for Conducting Research in the Arctic: www.iarpcollaborations.org/principles.html

¹²Executive Order 13647. Establishing the White House Council on Native American Affairs. 2013. obamawhitehouse.archives.gov/the-press-office/2013/06/26/executive-order-establishing-white-house-council-native-american-affairs

¹³United Nations Declaration on the Rights of Indigenous Peoples. 2007. www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

¹⁴Presidential Memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships. Reaffirmed in January 2021. www.govinfo.gov/content/pkg/FR-2021-01-29/pdf/2021-02075.pdf

¹⁵108th Congress Public Law 199 [DOCID: f:publ199.108] [Page 118 STAT. 452], 2004. www.govinfo.gov/content/pkg/PLAW-108publ199/pdf/PLAW-108publ199.pdf

¹⁶Appendix B: Arctic Research Plan 2022-2026 Engagement Overview

IARPC Arctic Research Plan 2022-2026 Structure

The Arctic Research Plan 2022-2026 is the third plan developed to coordinate Federal Arctic research since IARPC became a subcommittee of the NSTC in 2010. IARPC, through a five-year planning cycle, seeks to address critical areas for which an interagency approach can accelerate progress. It does not attempt to address all Federally funded research in the Arctic nor does it seek to address all research questions or individual agency priorities in the Arctic. Implementation of previous plans has created strong communities of practice around disciplinary and multidisciplinary research areas. Building on previous efforts and engaging those communities of practice, this plan identifies the most urgent and cross-cutting research needs, resulting in interdisciplinary priority areas. Consideration of the budgets needed to achieve the priority area goals, objectives, and deliverables will take place among participating Federal agencies.

This plan presents a research framework with thematic goals. Specific objectives and deliverables will be described in biennial implementation plans. These implementation plans, the first of which will be released in mid-2022, will also identify how the plan’s foundational activities will support these priority area goals. This transition to biennial implementation plans will help IARPC respond more swiftly to emerging or immediate needs while it continues to support U.S. Arctic policy.



Figure 2: Framework for the Arctic Research Plan 2022-2026

Policy Drivers

As with the Arctic Research Plan 2017-2021, this plan adheres to four critical policy drivers¹⁷ that reflect critical areas where the U.S. Arctic research enterprise supports U.S. policy from community to global scales. They illustrate the collective priorities of IARPC Federal agencies. These policy drivers are derived from the major U.S. policy documents of the past 50 years, including the 2009 Arctic Policy Directive¹⁸ and the 2013 National Strategy for Arctic Region¹⁹, and are still relevant today.

Policy drivers include:

1. Well-Being: Enhance the wellness of Arctic residents with an emphasis on the themes of cultural vibrancy, food security, economic development, and mental and physiological health.
2. Stewardship: Advance responsible and sustainable management of the Arctic environment with an emphasis on maintaining healthy ecosystems and addressing globally driven changes.
3. Security: Strengthen regional, national, and international safety, as well as enhance risk management and emergency preparedness.
4. Arctic-Global Systems: Improve understanding of the Arctic as a component of planet Earth.

Priority Areas

This plan identifies four priority areas which represent areas of broad, crosscutting research focus. They support one or more policy drivers, meet the mission and interests of more than one Federal agency, and engage multiple existing collaboration teams²⁰ and non-Federal partners. The priority areas of this plan exemplify complex socio-environmental interactions. Recognizing this, each of the priority areas identifies a broad goal which expresses the intended outcomes that will be realized from convergent research investments. Convergence research is investigation driven by a specific and compelling research problem that requires deep integration across disciplines. In this plan, it focuses on complex and interconnected challenges that are rooted in societal needs. Convergence research grows from fundamental research questions; brings together knowledge, methods, and expertise from different disciplines and world views; and advances new frameworks to produce usable outcomes and advance understanding.²¹ The priority areas and goals include:

1. Community Resilience and Health

Goal: Improve community resilience and well-being by strengthening research and developing tools to increase understanding of interdependent social, natural, and built systems in the Arctic.

2. Arctic Systems Interactions

Goal: Enhance our ability to observe, understand, predict, and project the Arctic's dynamic interconnected systems and their links to the Earth system.

¹⁷Appendix C: Arctic Research Priorities: Analysis of National Policy Drivers

¹⁸National Security Presidential Directive 66: Arctic Region Policy 2009: www.iarpcollaborations.org/uploads/cms/documents/nps37-011209-06.pdf

¹⁹National Strategy for the Arctic Region 2013: www.iarpcollaborations.org/uploads/cms/documents/national-strategy-for-the-arctic-region-executive-office-of-the-president-2013.pdf

²⁰IARPC Collaboration Teams: www.iarpcollaborations.org/teams/index.html

²¹National Science Foundation Definition of Convergence: www.nsf.gov/od/oia/convergence/index.jsp

3. Sustainable Economies and Livelihoods

Goal: Observe and understand the Arctic’s natural, social, and built systems to promote sustainable economies and livelihoods.

4. Risk Management and Hazard Mitigation

Goal: Secure and improve quality of life through research that promotes an understanding of disaster risk exposure, sensitivity to hazard, and adaptive capacity.

Priority Area 2 reflects where Federal research agency efforts have previously been centered. Research generated from Priority Area 2 will inform priority areas 1, 3, and 4.

Continuing to strengthen relationships among Federal agencies, as well as with Indigenous organizations and Indigenous Knowledge holders, Tribal governments, Alaska Native corporations, academia and non-Federal researchers, the state of Alaska, nonprofits, the private sector, and international entities and programs will be key to IARPC’s success in advancing the priority areas identified in this plan. Sustained engagement with partners is essential in ensuring that research is usable for resource management and decision making. Success will also require recognizing and addressing barriers to diversity, equity, inclusion, and justice in Arctic research.

Foundational Activities

In addition to identifying four priority areas, this plan builds upon five foundational activities. While many of the foundational activities are already supported by existing IARPC collaboration teams, they will now be formalized in the plan framework to better identify and link these activities to supporting, informing, and advancing each of the priority areas. They are critical to achieving the priority area goals identified in this plan and will remain foundational to Arctic research beyond the five-year duration of this plan.

Foundational activities include:

1. Data Management
2. Education, Training, and Capacity Building
3. Monitoring, Observing, Modeling, and Prediction
4. Participatory Research and Indigenous Leadership in Research
5. Technology Innovation and Application

Implementation

This plan is developed to guide Federal research investments and collaboration but recognizes the importance of working with non-Federal entities across all sectors in achieving the plan’s goals. This plan will be implemented through biennial implementation plans which will aim to align Federal resources and build collaborations with state, local, and Tribal authorities, research institutions, and nonprofit, private sector, and international organizations. The plan provides high-level implementation guidance to IARPC and measures of success. As with its predecessor, this plan will be implemented by collaboration teams that are open to anyone wishing to advance knowledge about the Arctic. Teams currently include members from Federal, state, academic, nonprofit, private sector, Indigenous, and international organizations. In addition to existing collaboration teams, four new priority area

collaboration teams will be established with identified lead agencies.²² The priority area teams will direct and coordinate activities to reach the plan goals and ensure coordination and collaboration across agencies and engage non-Federal partners.

²²Lead agencies are responsible for (1) identifying and defining objectives and helping develop the priority area chapter within the biennial implementation plans, (2) leading priority area teams during the implementation period and reporting on progress towards objectives and deliverables, (3) facilitating coordination between the priority area team and the relevant collaboration teams, (4) facilitating coordination and collaboration across agencies to meet goals and objectives, and (5) recommending updates to the biennial implementation plan as needed to address new or emerging concerns.



Researchers with USGS and collaborators from Nome and Russia walk toward walrus on northern Bering Sea ice to track the movements of walrus and how the loss of sea ice affects their foraging patterns. Photo: DOI

Priority Area 1: Community Resilience and Health

Improve community resilience and well-being by strengthening research and developing tools to increase understanding of interdependent social, natural, and built systems in the Arctic.

Justification

The Community Resilience and Health Priority Area reflects an integrated approach to Federal research directly related to the Well-Being Policy Driver, with implications for the Stewardship and Security drivers. For this plan, “resilience” is the ability of a system to bounce back and thrive during and after disturbances and shocks (SDWG, 2019). For a community to be resilient, there are many interacting elements including the community’s outlook, governance and leadership structures, interpersonal networks, preparedness, preventive and curative health services, food security, place-based knowledge, and access to resources such as clean air and water, energy, shelter, technology, and transportation (Patel et al., 2017). Arctic communities have been resilient in the face of change since time immemorial. Yet, the last half-century has brought changes of unprecedented pace and scale with implications for economies, cultures, the environment, and health (Arctic Council, 2016).

Rapid warming due to climate change has cascading impacts of human health and wildlife health. Related changes in weather, increased risks from infectious diseases (Yoder, 2018), and toxic algal blooms (Anderson et al., 2018) are all growing threats to social, natural, and built systems. Coupled with these changes are increasing health disparities between Indigenous and non-Indigenous populations (Gamble et al., 2016). Mega-events, such as the public health emergency created by the COVID-19 pandemic, can impose additional shocks that may result in lasting social and economic changes. While Alaska-based leaders are making progress in identifying urgent health needs, it remains the state with the greatest health security challenges (National Health Security Preparedness Index, 2019). Taken individually, these various stressors pose formidable challenges for community resilience, health, and well-being. Taken together, combinations of stressors can greatly complicate resilience-building efforts and create difficult decisions about what and how to prioritize (Hueffer et al., 2019).

Thanks to advances in technology and innovations in research methodologies including participatory research and Indigenous approaches such as co-production of knowledge, the circumpolar knowledge base related to community resilience and health will continue to grow over the next five years. These advances will lead to research outcomes that inform agency and management decisions. Facilitated by developments in data management, modeling, observations (both satellite and in situ), and innovations in technology (including advanced computing and machine learning), and other foundational activities, notable improvements are expected in the predictive understanding of stressors, their characteristics, co-occurrence, and expected changes over time, from local to circumpolar scales. Recent research has also demonstrated the contributions to community sustainability and well-being that come with programs advancing cultural heritage, language preservation, and the use of museum and archival collections that promote health and help connect generations in a rapidly changing world (e.g., Hillerdal et al., 2019; Crowell, 2020; Margaris & Ahtuangerauk, 2020).

Advances and new knowledge will lead to an improved understanding of the physical and social impacts of stressors as well as the implications for different community-based solutions. For example, through environmental observations and health surveillance networks, the design and implementation of computational models²³ will strengthen methods for measuring multidimensional threats to community resilience and well-being (e.g., environmental and social changes that impact Arctic communities; energy, food security, and water quality; thawing permafrost and coastal erosion; concerns regarding built systems; and health disparities). Similarly, models can provide critical information to understand the interdependence of human and environmental systems, leading to improved health outcomes and enhanced resilience via a comprehensive methodology, such as the One Health approach, applied to the Arctic (e.g., Hueffer et al., 2019). Research will examine the ways that complex global stressors, such as the COVID-19 pandemic and climate change, interface with Arctic community resilience and health. Furthermore, the equitable inclusion of Indigenous Knowledge holders will strengthen methods for measuring multidimensional threats to community resilience and health, including but not limited to the impacts of sea level rise, coastal erosion, permafrost thaw, and other environmental changes on societies and culture, food security and water quality, and built systems. Improvements in meaningful engagement with Indigenous and local organizations through participatory research includes mutually beneficial research involving co-production throughout the research cycle (such as identifying research questions, conducting research, developing wellness indicators, producing results, and disseminating findings together) will lead to more relevant and timely community-based knowledge that can be used by decision-makers like health services providers and community and civic leaders. Over the next five years, increased connectivity with other Arctic nations will facilitate stronger information sharing and foster collaborative international research projects that advance understanding of transboundary resilience and health challenges. These expected research developments illustrate the broad scope of progress and its potential to both inform fundamental understanding of these highly complex landscapes and meet the needs of Arctic communities to develop novel solutions in the face of emerging challenges.

Alignment of Federal Departments and Agencies and IARPC Collaboration Teams With This Priority Area

Lead Agencies:

- Department of Interior (DOI)
- Environmental Protection Agency (EPA)

²³Computational models are scenarios simulated using computation to study complex systems. For example, a computational model can be used to study and predict an outbreak of an infectious disease. The parameters of the model are adjusted using computer simulation to study different possible outcomes.

Federal departments and agencies whose missions align well with the Community Resilience and Health Priority Area include:

- Department of Agriculture (USDA)
- Department of Commerce (DOC)
- Department of Defense (DOD)
- Department of Energy (DOE)
- Department of Health and Human Services (DHHS)
- Department of Homeland Security (DHS)
- Department of Housing and Urban Development (HUD)
- Department of State (DOS)
- Department of Transportation (DOT)
- Marine Mammal Commission (MMC)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)
- Smithsonian Institution (SI)
- U.S. Arctic Research Commission (USARC)

IARPC collaboration teams that align well with the Community Resilience and Health Priority Area include: Atmosphere, Coastal Resilience, Diversity and Inclusion Working Group, and Health and Well-Being.

Collaboration across scales is important to achieve the Community Resilience and Health Priority Area goal. Within Alaska, close collaboration with non-Federal partners will be critical, since many aspects of health and resilience are handled by state, local, Alaska Native regional nonprofits and Tribal authorities, and nongovernmental organizations. There are also opportunities to collaborate with non-Federal entities outside of Alaska to adapt tools for Arctic applications. Finally, since threats to community resilience and health span national boundaries, so too must the partnerships be built to address them—particularly through venues such as the Arctic Council.



U.S. Army Corps of Engineers researchers Jackie Richter-Menge and Bruce Elder install an ice mass balance buoy in the Beaufort Sea. Photo: Art Howard, via DOD

Priority Area 2: Arctic Systems Interactions

Enhance our ability to observe, understand, predict, and project the Arctic's dynamic interconnected systems and their links to the Earth system.

Justification

The Arctic Systems Interactions Priority Area is directly related to the Stewardship and Arctic-Global Systems policy drivers, with implications for the Well-Being and Security policy drivers. The Arctic is the fastest changing region on Earth, with changes observed in physical, biological, and socioeconomic systems. Over the past several decades, Arctic air, ocean, and land temperatures have increased at a rate more than twice the global average (IPCC, 2018; Jansen et al., 2020), a phenomenon known as Arctic amplification. Arctic sea ice extent has decreased dramatically, with summer melting occurring earlier and both the summer and winter sea ice extent shrinking faster (Markus et al., 2009; Parkinson, 2014; Bliss et al., 2017). Boreal and Arctic permafrost (perennially frozen ground) thaw increases carbon emissions that further exacerbate global temperature increase (Schuur et al., 2015; Turetsky et al., 2019). Additionally, the Greenland Ice Sheet, the largest ice mass in the Northern Hemisphere, is retreating, and the associated melt contributes to increased sea level rise (Aschwanden et al., 2019; Bevis et al., 2019). These changes will affect the environment and associated natural resources in the Arctic, and will ultimately have a large economic impact.

These changes do not happen in isolation, but involve feedbacks that impact multiple components of the Arctic's natural and human systems, as well as the larger Earth systems. Understanding these interactions, including impacts to the environment as a result of human behavior, is becoming increasingly important, and is also useful for predicting²⁴ future Arctic and global changes. For instance, changes in atmospheric constituents, clouds, and circulation affect the surface energy budget in the Arctic, thereby affecting sea ice extent. Decreasing sea ice extent, in turn, alters the air-sea interaction

²⁴Predictions are based on knowledge of the Earth system including past and current conditions, while projections integrate assumptions of possible future forcing scenarios (e.g., greenhouse gases, aerosols) to determine the potential future climate and associated impacts.

impacting the energy balance of the atmosphere and ocean. Similarly, sea ice and marine ecosystem changes are affected through changes in ocean circulation and heat and freshwater budgets. Changes in the Arctic affect global atmospheric circulation by altering the jet stream and the polar vortex, which in turn influences midlatitude weather in the United States (Cohen et al., 2020).

Changes within individual components of the Arctic system can have cascading impacts on the integrated system. For instance, sea ice change, thawing permafrost, changing storm strength, and increased sea level due to glacial melt all have an interconnected effect on Arctic coastlines, such as increased flooding, leading to erosion (Thoman et al., 2020; Radosavljevic et al., 2016; Barnhart et al., 2014; Overduin et al., 2014), which can have large economic impacts (Larsen et al., 2008; Melvin et al., 2017). Interactions between human and natural systems also have broad implications to Arctic Indigenous communities (Krupnik and Crowell, 2020) and are more broadly described within priority areas 1, 3, and 4.

In recent years, ocean primary productivity in nearly all regions of the pan-Arctic was higher than in the past, which can be linked to lower sea ice cover and increased nutrient availability (Frey et al., 2019; Thoman et al., 2020). In addition, with changes in sea ice and water temperature, some species are responding with spatial or temporal changes in their distributions. For example, in 2017, commercially important Pacific cod and pollock in the Bering Sea expanded north approximately 500-1,000 km in less than 12 months (Stevenson and Lauth, 2019). The Western Arctic bowhead whale—an important species for Indigenous ways of life—provides another example. Although the population has shown a steady increase since commercial whaling ended, the autumn migrations in 2019 and 2020 exhibited new extremes of opposite degrees in whale densities near Barrow Canyon, with very low densities and a far offshore distribution in 2019 (Citta et al., 2021; Clarke et al., 2020; Stimmelmayer et al., 2020; Ferguson et al., 2021) and record high densities and nearshore distribution in 2020 (Brower et al., in prep).

The impacts on the terrestrial ecosystem are also significant. Plant species in the Arctic are exhibiting changes with extended growth season, earlier snow-melt, and altered precipitation patterns (Schuur et al., 2018). Wildfire frequency and intensity are impacted by air temperature and weather patterns while soils, permafrost, hydrology, the terrestrial ecosystem, and human health are impacted when an area burns (Thoman et al., 2020). For example, enhanced fire activity, permafrost thaw, and changes to local and regional hydrologic cycles are also expected to enhance the release and deposition of mercury trapped in Arctic soils and tundra (Stern et al., 2012). This in turn can have negative impacts on human health (e.g., Perryman et al., 2020).

Computational models that quantify the drivers of past and current Arctic change, as well as the interactions and feedbacks of these changes with Earth's natural and human systems, are needed to understand the interconnected Arctic system. Models help represent the state of understanding of systems and are the principal mechanism through which current understanding can be projected into the future. Models of both the individual components of the Arctic as well as the comprehensive Earth system are needed. Different kinds of observations are also needed, including intensive short-term observational campaigns, long-term satellite and in situ observations, and observations that detail the Arctic climate and environment on the geologic time scale, as well as observations that include generations of Indigenous Knowledge. Modeling and observational capabilities across agencies, along with research on Arctic and Earth system processes, enhance our understanding of Arctic system interactions.

By addressing this priority area over the next five years, the U.S. Arctic research community will have a better understanding of the Arctic system and its connection to the Earth system as a whole. This will include reduced uncertainties in predictions and an increased ability to inform strategies that minimize the negative impacts and take advantage of the opportunities of a changing Arctic.

Alignment of Federal Departments and Agencies and IARPC Collaboration Teams With This Priority Area

Lead Agencies:

- Department of Commerce (DOC)
- Department of Defense (DOD)
- Department of Energy (DOE)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)

Federal departments and agencies whose missions align well with the Arctic Systems Interactions Priority Area include:

- Department of Health and Human Services (DHHS)
- Department of Homeland Security (DHS)
- Department of Interior (DOI)
- Environmental Protection Agency (EPA)
- Marine Mammal Commission (MMC)
- Smithsonian Institution (SI)
- U.S. Arctic Research Commission (USARC)

IARPC collaboration teams that align well with the Arctic Systems Interactions Priority Area include: Atmosphere, Terrestrial Ecosystems, Glaciers and Sea Level, Sea Ice, Marine Ecosystems, Permafrost, Coastal Resilience, Health and Well-Being, Arctic Data Sub-Team, Modeling Sub-Team, Arctic Observing Systems Sub-Team, the Physical Oceanography Self-Formed Team, and the Diversity and Inclusion Working Group.

Understanding the Arctic's dynamic complex natural, social, and built systems and how they influence the Earth system as a whole is critical to the mission of many IARPC Federal agencies, as well as domestic and international collaborators. The interdisciplinary nature of Arctic System Interactions inherently benefits from fundamental research supported by these Federal agencies and associated collaborators. Interagency collaboration and interconnection with multiple collaboration teams will help meet the goal of enhancing our ability to observe, understand, predict, and project the Arctic's dynamic interconnected systems, biodiversity, and habitats, and their connection to the Earth system as a whole. Furthermore, enhanced two-way communication, coordination, and collaboration among the state of Alaska, decision-makers, practitioners, non-Federal researchers, international organizations, and Indigenous communities will be key in advancing understanding of Arctic systems interactions. Building better cross-linkages among the existing collaboration teams will expand upon these partnerships. This will result in shared perspectives and questions regarding the Arctic's dynamic interconnected systems, with a focus on ways to optimize monitoring, observing, analysis, and modeling capabilities to inform decision-making.



Wind turbines provide power at the airport facility on St. Paul Island. Photo: Tanadgusix Corporation, via DOE

Priority Area 3: Sustainable Economies and Livelihoods

Observe and understand the Arctic’s natural, social, and built systems to promote sustainable economies and livelihoods.

Justification

The Well-Being and Security policy drivers are advanced by Federal investment in sustainable²⁵ economies and livelihoods throughout the region. Arctic communities and ecosystems are experiencing change at an unprecedented rate—from loss of permafrost and coastal erosion (USACE, 2019) to shifting demographics and economic uncertainty (Berman and Schmidt, 2019). Such rapid changes present challenges for built systems, natural resource management, food security, and Indigenous ways of life, all critical to the well-being and security of the Arctic, its residents, and our nation as a whole. Sustainable economies and livelihoods require both fundamental and actionable research to support informed decision-making building upon an enhanced understanding of the Arctic’s natural, social, and built systems.

Arctic marine, freshwater, and terrestrial ecosystems provide critical natural resources from subsistence foods²⁶ to fisheries of global economic importance. Changes in sea surface temperatures, contaminant levels, and migration patterns affect fish, marine mammal, and seabird populations, as well as Arctic residents who depend on these species. Changes to Arctic ecosystems also impact state, national, and global economies by affecting global shipping, access to natural resources, and fish and seafood stocks. Maintenance of healthy and productive ecosystems requires

²⁵Defined in the National Environmental Policy Act (1969) as “to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations” (42 U.S. Code § 4331). www.energy.gov/nepa/downloads/national-environmental-policy-act-1969
See also Sustainability and the U.S. EPA. 2011. www.nap.edu/read/13152/chapter/1#ii

²⁶Subsistence in Alaska: A Year 2017 Update, Division of Subsistence, Alaska Department of Fish & Game, Anchorage; www.adfg.alaska.gov/static-f/home/subsistence/pdfs/subsistence_update_2017.pdf

research to establish baseline data, understand the sources and impacts of observed change, understand the critical role of subsistence in sustainable economies and livelihoods, and inform management decisions so Arctic residents may enjoy food, energy, and livelihood security.

Community well-being and security also depend on reliable infrastructure, including roads, airstrips, bridges, and harbor and port facilities; energy, water, and telecommunication systems; and housing, education, healthcare, and local and national security facilities. However, building and maintaining Arctic infrastructure is expensive and logistically complex. These built systems require monitoring and maintenance to meet current demand, and research to inform adaptation to future environmental, demographic, and geopolitical shifts (Chinowsky et al., 2009; CMTS, 2016).²⁷ Current areas of concern include poorly constructed and maintained roads, airstrips, and waste sites and systems; inadequate housing; lack of access to clean water; and maintenance backlogs at educational and healthcare facilities. To respond effectively, Federal and state agencies and other decision-makers need research to provide accurate, up-to-date data on existing facilities, assessments of future needs, and decision-support tools to design and construct systems capable of supporting local and regional economies and mitigating the impacts of future climate change on critical infrastructure (USARC, 2019). Research to support the development of renewable, low-cost energy technologies, for example, is needed to offset the unreliable and high-cost systems currently in place in many communities and to address climate and health issues associated with current dependence on petroleum products.

Over the next five years, coordinated Federal action will facilitate effective observation and understanding of Arctic natural, social, and built systems and the challenges these systems face within the context of rapid climate change. Basic and applied research informed by community priorities, such as food²⁸ and energy security, healthy fisheries and marine mammal populations, and inclusion in Federal marine transportation policy planning (AFN, 2017; Fisher et al., 2020) can address critical challenges to livelihoods and infrastructure. Such research can also inform planning and management decision-making on critical resources such as petroleum, economic minerals, and commercial fisheries.

Alignment of Federal Departments and Agencies and IARPC Collaboration Teams With This Priority Area

Lead Agencies:

- Department of Energy (DOE)
- Additional lead agencies will be identified as objectives are developed during implementation

Federal departments and agencies whose missions align well with the Sustainable Economies and Livelihoods Priority Area include:

- Denali Commission
- Department of Agriculture (USDA)
- Department of Commerce (DOC)
- Department of Energy (DOE)

²⁷For example, the 2021 National Defense Authorization Act charged the DOD with evaluation of sites for a strategic deep-water Arctic port. Subtitle G: www.congress.gov/116/crpt/srpt236/CRPT-116srpt236.pdf

²⁸Food Sovereignty and Self Governance: Inuit Role in Managing Arctic Marine Resources: iccalaska.org/wp-icc/wp-content/uploads/2020/09/FSSG-Report_-LR.pdf

- Department of Health and Human Services (DHHS)
- Department of Homeland Security (DHS)
- Department of Housing and Urban Development (HUD)
- Department of Interior (DOI)
- Department of State (DOS)
- Department of Transportation (DOT)
- Environmental Protection Agency (EPA)
- Marine Mammal Commission (MMC)
- National Science Foundation (NSF)
- Smithsonian Institution (SI)
- U.S. Arctic Research Commission (USARC)

IARPC collaboration teams that align well with the Sustainable Economies and Livelihoods Priority Area include: Coastal Resilience, Marine Ecosystems, Terrestrial Ecosystems, Permafrost, and the Diversity and Inclusion Working Group. IARPC does not currently host a collaboration team focused on research related to Arctic infrastructure.²⁹ Development of such a team to coordinate research used for Federal efforts to monitor, assess, and develop land-based and maritime infrastructure would amplify Federal investment and prevent duplication of efforts.

Achieving sustainable economies and ecosystems requires collaboration with non-Federal entities. State of Alaska departments and agencies are critical collaborators. Tribal governments, village and regional Alaska Native Claims Settlement Act (ANCSA)³⁰ corporations, and regional nonprofit corporations are essential partners in observing and understanding the Arctic's natural, social, and built systems. International advisory and working groups, such as marine mammal and other co-management, species-focused organizations,³¹ also play key roles in sustainable Arctic livelihoods.

²⁹See the recent GAO Maritime Infrastructure Report (2020) that explicitly recommended development of an “interagency mechanism responsible for leading Federal efforts” to address gaps in infrastructure: www.gao.gov/assets/710/706502.pdf

³⁰Alaska Native Claims Settlement Act of 1971.

³¹E.g., Alaska Eskimo Whaling Commission, Eskimo Walrus Commission, Western Arctic Caribou Herd Working Group.



The edge of the village of Utqiagvik looks over eroding Arctic tundra bluffs and sea ice on the Chukchi Sea. Photo: Lisa Hupp/DOI

Priority Area 4: Risk Management and Hazard Mitigation

Secure and improve quality of life through research that promotes an understanding of disaster risk exposure, sensitivity to hazard, and adaptive capacity.

Justification

The principal policy drivers for the Risk Management and Hazard Mitigation Priority Area are Security and Well-Being. Priority Area 4 focuses on strengthening national and regional safety and security, and community resilience to natural hazards and climate change impacts with an emphasis on risk management and emergency preparedness, aided by policies which acknowledge and support the importance of personal and community well-being.

Research on risk exposure, sensitivity to hazards, and adaptive capacity are critical for ensuring safety and security in the Arctic. There is an immediate need for an Arctic research portfolio that builds community resilience and security with the fundamental purpose to provide for the well-being of all Arctic communities. It is imperative that the research portfolio is actionable and helps inform management and operational decisions.

Risk management and hazard mitigation in the Arctic require a balanced research portfolio that provides actionable insights, services, and technology tools that protect communities at the local, state, and national level. Individual research disciplines will need to work in a multi-disciplinary fashion. Progress will be the result of fundamental and applied research, enhanced monitoring, sustained observations, and predictive modeling. Along with research, there must also be technology development and application. Development requires needs-driven efforts that look for scientific solutions to address foreseeable risk management and hazard mitigation in the near- and mid-term. Arctic communities and leaders responsible for infrastructure (e.g., villages, towns, cities, cultural resources, military installations, ports, air transportation, and pipelines) communicate the need for technologies and services based on their safety and security requirements. The below themes repeat across Federal government reports, state of Alaska-led climate change reports and implementation plans, community strategic management planning processes, the Alaska Legislature-led Alaska Arctic Policy Commission

report (AAPC, 2015), and the development of programs such as the Alaska Native Tribal Health Consortium Center for Environmentally Threatened Communities, and others.

Arctic risk management and hazard mitigation challenges are diverse (RNWG, 2009; DHSEM, 2019; USCG, 2019; DOD, 2019). These include, but are not limited to, advancing knowledge related to chronic hazards (e.g., climate change and its impacts, ocean acidification, sea level rise, environmental degradation, and coastal erosion), acute and episodic events (e.g., earthquakes, tsunamis, volcanic eruptions, landslides, wildfires, unusual mortality events, harmful algal blooms, shipwrecks, oil spills, and epidemics), and threats to holistic national security and all-domain awareness (e.g., communications fragility, cyber security, and response capability). The cross-cutting themes of resilience, hazard mitigation, threat reduction, and disaster response management are fundamental in reducing risk. To be successful, the combined research efforts across Federal agencies must address the entire spectrum of concerns from local environmental security to national security.

Hazards and risks cannot be effectively addressed by one entity alone. Resilience, hazard mitigation, and disaster management expertise are found across many Federal agencies and at many levels. This priority area seeks to manage and reduce risk by bringing researchers together with Arctic community members, planners, and leaders, Indigenous organizations, the state of Alaska, and emergency managers and service providers (operators and planners). By addressing this priority area over the next five years, the U.S. Arctic research community will have a better understanding of disaster risk exposure, hazard sensitivity, and adaptive capacity in the Arctic region to enhance existing and develop needed decision support products and services.

Alignment of Federal Departments and Agencies and IARPC Collaboration Teams With This Priority Area

Lead Agencies:

- Department of Defense (DOD)
- Department of Interior (DOI)
- Department of Homeland Security (DHS)

Federal departments and agencies whose missions align well with the Risk Management and Hazard Mitigation Priority Area include:

- Denali Commission
- Department of Commerce (DOC)
- Department of Energy (DOE)
- Department of Health and Human Services (DHHS)
- Department of Housing and Urban Development (HUD)
- Department of Transportation (DOT)
- Environmental Protection Agency (EPA)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)

- Smithsonian Institution (SI)
- U.S. Arctic Research Commission (USARC)

IARPC collaboration teams that align well with the Risk Management and Hazard Mitigation Priority Area include: Coastal Resilience, Diversity and Inclusion Working Group, Health and Well-Being, Sea Ice, Terrestrial Ecosystems, Glaciers & Sea Level, Data Sub-Team, and Arctic Observing Systems Sub-Team.

Partnerships that will be critical to achieving this goal include engineers, emergency managers, and community planners from the Federal government and the state of Alaska, boroughs, and local and Tribal governments, as well as the private sector. The private sector plays a crucial role in protecting assets, workforce, and supply and distribution chains to help society keep functioning in times of and after disasters. It is through collaborative research activities that advancements in prevention, protection, mitigation, response, and recovery can be achieved. Developing a common understanding of security and well-being must be a collaborative process that includes Arctic communities.



Greater white-fronted geese fly near Utqiagvik. Photo: Peter Pearsall/DOI

Foundational Activities

Introduction

Foundational activities are critical in supporting the priority areas in this plan as well as a robust research program in the Arctic. In many cases, these activities draw from strong communities of practice that have provided the momentum for previous IARPC initiatives and efforts. In the text below, each activity is described in terms of why it is foundational and how IARPC can provide support for the success of these activities. The foundational activities are expected to continue beyond this plan and be adaptive to the priorities of Arctic residents, policy-making, and new and emerging research topics.

Data Management

Arctic data, including physical and biological samples and Indigenous Knowledge data, are irreplaceable. Often stemming from difficult and remote conditions, Arctic data are valuable in a time of rapid environmental change driven primarily by climate change. Data management is critical to basic research, monitoring, and applied research in the Arctic. It follows a cycle of data discovery, collection, and sharing; ideally, each step in the data lifecycle contributes to maximizing return on investment in data management (Rüegg et al., 2014). There is great care, review, and often standardization or harmonization in preparing, producing, and publishing data products which allow for their reuse. Nevertheless, customization of global or national tools is often necessary for Arctic applications. As data volumes increase, computational infrastructure and software management are both inextricably part of data management (e.g., Snowden et al., 2019).

A National Academies study (NASEM, 2018) outlines best practices related to open, searchable, and rapidly accessible data; there is a need for centralized discovery and access to Arctic data across institutions and agencies. IARPC encourages the adoption of open data collections, development of intelligent data management tools and practices, and use of existing data and metadata platforms to achieve interdisciplinary and interagency coordination. In order to reflect the complexity of Arctic data and knowledge systems, data management for Arctic research must be responsive to a range of partners.

Arctic research, participatory research, and data management now operate in an environment of FAIR (findable, accessible, interoperable, and reusable) data management principles (Wilkinson et al., 2016) and CARE (collective benefit, authority to control, responsibility, ethics) Principles of Indigenous Data Governance (Carroll et al., 2020). While working toward open and accessible data, it is important to recognize these nuanced approaches that protect private and sensitive data, and to respect Indigenous data sovereignty and governance (Carroll et al., 2019).

Continued international joint cooperation, innovation, and learning in all aspects of data management are integral to facilitating Arctic research. Working with international partners to implement harmonized standards and practices will make Arctic data more readily available and will improve U.S. Arctic research. Innovations in data collection, curation, discoverability, and use, such as new advances in artificial intelligence (AI), machine learning, and cloud computing, will be essential to fully use Arctic data.

IARPC, including the IARPC Data Collaboration Sub-Team, will share best practices, innovative ideas, lessons learned, and networking opportunities as it works towards discoverability, understanding, and interoperability of Arctic data and tools. IARPC will help strengthen data management literacy and expertise by proactively connecting Federal agencies, local partners, early career scientists, established researchers, Indigenous Knowledge holders, and others. IARPC is in a position to develop a culture around thoughtful data management (i.e., FAIR and CARE) and encourage the development of skills and knowledge related to advancing data management in the Arctic. IARPC is able to facilitate access to Arctic data by being a forward-looking space that can stimulate dialogue between diverse sectors to embrace actionable science (Beier et al., 2016).

As agencies work towards sharing data across the government and with the public, IARPC will be a strong partner and bridge towards achieving their Arctic research goals. Data management is rooted in Federal policy and mandated for Federal research agencies (Data Quality Act, 2001; Holdren, 2013; Foundations for Evidence-Based Policymaking Act of 2018; Geospatial Data Act of 2018). Data sovereignty and CARE principles need to be considered in the context of Federal data policies. Clear guidance, aligned with FAIR and CARE, on how to manage data compliant with these broad Federal mandates can benefit those who enable Arctic insights and can support data users, providers, and managers in achieving their aims. Federal agencies should aim to make data more discoverable, connected, and useful, emphasizing meaningful new Arctic insights. Therefore, this plan pursues responsive, responsible, and well-resourced application of best practices in Arctic data management.

Education, Training, and Capacity Building

Successful Arctic research depends on knowledge acquisition and dissemination, and on a well-trained current and future workforce. In particular, education and outreach, training, and capacity building in and of the Arctic are fundamental to Arctic research, policy development, and community resilience. Research itself also provides opportunities to educate and train students and others, and thus build capacity where the research is taking place. Arctic education and training span preschool, K-12, post-secondary to post-doctoral, community culture-based instruction and learning, and intergenerational education, and is ongoing within the practicing research community. Education and training comprise varied knowledge systems, including scientific disciplines, place-based and Indigenous Knowledge, and skill acquisition such as grant writing, cultural practices, and technological expertise. Research informs education while at the same time education is foundational to research. Outreach is also vital in creating awareness of and knowledge about the Arctic to those within and beyond the region.

The IARPC Arctic STEM (science, technology, engineering, and mathematics) Education Working Group

will promote education and training across all priority areas. Given the wide range of agency research missions and the education and outreach programs supported by IARPC member federal agencies and non-federal partners, IARPC provides a unique service as a forum for connection and promotion of coordinated efforts. IARPC is also positioned to advance the inclusion of place-based and Indigenous Knowledge and learning in education and outreach, generating inclusive practices that enhance existing resource capacity. IARPC will elevate the profile of STEM education to bring a greater focus to the value and content of Arctic-specific education and training as well as ensure integration of uniquely Arctic efforts with national Federal interagency STEM education strategic planning (NSTC, 2018; NSF, 2020). Via such integration, Arctic research can strengthen STEM education more broadly within the United States and promote pan-Arctic and global connections and awareness. As an interagency body, IARPC can lead innovation of new education delivery models informed by and serving research and communities.

As research advances, education content and delivery mechanisms also evolve (OMB M-20-29). To adequately support current and future research, Arctic STEM education must be forward-thinking and innovative, comprehensive of different knowledge systems, and relevant to the constant change of this environment. The student who emerges from such a system will be better prepared to serve future research, policy, and community needs.

The aims of Arctic education efforts are to (1) strengthen and support existing scientific disciplinary expertise, (2) increase engagement of rural and Indigenous students in STEM education and community relevant training programs, (3) generate capacity building academic-workforce development opportunities (e.g., internship programs, mentoring opportunities), (4) enhance coordination among varied Federal and non-Federal partners, (5) expand education and outreach about the Arctic to the public and to decision-makers, and (6) create new, expanded delivery paradigms and content, such as research and learning experiences that explicitly address the pedagogical and experiential approach to complex systems and bringing together knowledge systems that are critical for advancing Arctic research.

The future workforce will continue to need the deep disciplinary expertise necessary to meet the missions of IARPC agencies. This workforce will also need to be effective in teams—not only holding disciplinary expertise but effectively connecting across different disciplines, and also across knowledge systems. These teams must also be composed of those with diverse demographic backgrounds. Federal agencies must sustain and expand their own education and outreach programs to meet mission-specific research priorities and the growing need to support community-driven education and research. Building connections is also increasingly vital. Education programs will seek new opportunities for rural and Indigenous students that expand beyond traditional academic pathways. Arctic-relevant delivery models and outreach efforts will benefit from interweaving disciplinary academics and Indigenous Knowledge, humanities and arts, and explicit connections between knowledge systems and policy development and execution. Such frameworks can build capacity and connection in Arctic communities, support Arctic residents' quality of life, and increase community viability and sustainability.

Monitoring, Observing, Modeling, and Prediction

A robust research plan requires strong capabilities in monitoring, observing, modeling, and prediction (MOMP). Monitoring is a subset of observing and generally refers to observing specific variables over time to detect change. Similarly, prediction is a subset of modeling and refers to using numerical models to estimate how the Arctic or a subsystem of it may change in the future. MOMP is critical for increasing understanding of the natural and human components of the Arctic system as well as the degree and direction of past and future changes. MOMP is also essential for providing actionable data, forecasts, and new research directions.

Sustained observations and widespread monitoring support research activities by providing information on the variability of the Arctic system. This information provides a necessary baseline for future studies and data for evaluating models and making both short-term predictions and longer-scale projections. Focused short-term observational efforts are important for improving fundamental understanding of Arctic processes, regions, and extreme events. A foundational Arctic observational capability requires a sustained, coordinated, and integrated network of satellites, other remote sensing, and in situ observing systems suitable for Arctic conditions; collection of physical and biological samples; resources to train instrument operators, support data quality, and analyze observations; and continued development of new technologies, such as low-cost and autonomous sensors, to fill observational gaps. Many critical Arctic observational and monitoring efforts are conducted by non-Federal partners. IARPC will improve coordination and integration of observations conducted or supported by Federal agencies with those conducted or enabled by non-Federal partners including the state of Alaska, Indigenous and Tribal organizations, Arctic communities, research institutions, and private sector. Future development of Arctic observing capabilities should consider sustainability in field research, good practices to limit potential environmental impacts, coordination with other observational efforts, and meaningful engagement with Indigenous Peoples, including incorporation of Indigenous Knowledge through Indigenous leadership, participatory research, and co-production in the design and implementation of local, regional, and circumpolar observing systems (Krupnik and Jolly, 2002).

Computational models combine findings from theory, observations, and process studies, providing a framework for understanding interactions among components of the Arctic and between the Arctic and the global system across a range of scales and complexity. Short-term predictions and longer-term projections of the Arctic system are essential for providing information to users and decision-makers to inform the design of climate adaptation and resilience plans and to support hazard mitigation actions. A foundational modeling capability for the Arctic requires a set of models of different complexities, integration of observing and modeling capabilities, and strong interactions with partners to understand their needs, communicate uncertainties, and provide information for decision-making.

The need to advance understanding of Arctic processes and system interactions drives the effort to improve synthesis of monitoring, observing, and modeling. Numerical models require observations for initialization, evaluation, and assimilation. Integrating observational and modeling output enables creation of value-added products and can help fill spatial and temporal gaps in analysis. Models can provide critical information to inform the design and optimization of observing networks. Advances in related fields such as AI and machine learning should be explored to improve analysis and integration of large volumes of observational and model data. Such integration will accelerate the advancement of knowledge of the dynamic Arctic system and lead to improved predictive capabilities. Through the existing Arctic Observing Systems and Modeling collaboration teams, IARPC will seek to identify current gaps in observational or modeling capabilities that hamper predictive skill of the Arctic system, barriers that hold back progress in filling these gaps, and key activities most critical to improving predictability, including the need to maintain critical existing MOMP capabilities. In coordination with the Education, Training, and Capacity Building Foundational Activity, training the next generation in MOMP activities will be incorporated. IARPC will also promote international coordination and cooperation in Arctic system MOMP efforts. For example, through the U.S. Arctic Observing Network (US AON) Board, IARPC will support Federal agencies' efforts to improve the performance of Arctic-wide observing and data management activities. Lastly, IARPC will increase coordination and engagement with other Federal efforts (including public-private partnerships) focused on improved observations, modeling, and predictability of the Earth system. This will include working with the U.S. Global Change Research Program (USGCRP) and the Interagency Council on Advancing Meteorological Services (ICAMS), and identifying and prioritizing actions to implement the Earth System Predictability Research and

Development Strategic Framework and Roadmap (NSTC, 2020).

Participatory Research and Indigenous Leadership in Research

Indigenous Peoples have been part of the Arctic region for millennia and their histories, cultures, and knowledge are critical to understanding Arctic systems. Federally funded research efforts, however, have had varying levels of success (or failure) in regularly, sufficiently, and ethically including Arctic peoples. Indigenous Peoples deserve respect from researchers entering their communities, lands, and societies and should have the opportunity to benefit from the research as well as engage in meaningful consultation. IARPC is committed to cultivating participatory research³² with Arctic communities and populations and Indigenous leadership in research as a foundational activity across all four priority areas. While there are multiple types of leadership in research, this plan specifically calls Indigenous leadership to the forefront to address the ongoing ethically problematic lack of inclusion of Indigenous Peoples in research. Participatory research ensures important research ideals are followed, such as free, prior, and informed consent (FPIC),³³ and that rights of Indigenous communities to self-determination,³⁴ sovereignty,³⁵ and data sovereignty are observed. Participatory research also supports asset-based research³⁶ and co-production of knowledge³⁷ with the inclusion of Indigenous Knowledge³⁸ or non-Indigenous place-based knowledge to the amount the community wants to participate. Indigenous leadership means leadership in research by Indigenous Peoples, entities, groups, and communities, and needs to be developed by Indigenous Peoples in this role.

Participatory research and Indigenous leadership in research is for all types of research, not solely for social science research or for research with Indigenous Peoples. IARPC recognizes that different forms of participation and Indigenous leadership in research may occur based on what a community desires, from full co-production which involves developing the research questions with the community and working through all stages of the research process with them, to more limited participation, such as

³²Research that respects Indigenous sovereignty and self-determination and is participatory to the amount the community desires. Participatory research should be mutually beneficial to the Indigenous community and researcher and should build community capacity (David-Chavez and Gavin, 2018; Gordon, 2017).

³³A right outlined in United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) that people should be free from intimidation or coercion to participate in research, be offered to consent prior to the project beginning, be informed throughout the project so they can disagree if they wish, and have the right to consent or withdraw consent at any time (UN General Assembly, 2007).

³⁴The right to freely determine political status and pursue economic, social, and cultural development (UN General Assembly, 2007, Article 3).

³⁵Tribal sovereignty is self-rule by Tribes and an inherent right of Tribes that is “recognized and protected by the U.S. Constitution, legal precedent, and treaties, as well as applicable principles of human rights” (Kalt and Singer, 2004).

³⁶Asset-based research focuses on self-determination, well-being, Indigenous Knowledge, and culture (Hyett, Gabel, Marjerrison, and Schwartz, 2019; Tuck, 2009).

³⁷There are multiple definitions of co-production of knowledge. When working specifically with Indigenous Peoples, co-production includes recognition and respect of sovereignty and self-determination. This plan recognizes a form of co-production that brings together knowledge systems of Indigenous Peoples, Arctic residents, and researchers in an equitable way to define problems and identify questions and leads to advancement of knowledge, improved decision making, and greater social equity (Behe, Daniel, and Raymond-Yakoubian, 2020).

³⁸A 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 experiences and extensive and 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 (Inuit Circumpolar Council, 2020).

a researcher discussing mutually beneficial research goals with community representatives before applying for a grant or initiating a project.

Thus, IARPC acknowledges that defining and supporting participatory and Indigenous leadership in research in the Arctic is a process that will evolve based on continued feedback from and in partnership with those living in the Arctic. Participatory research may look different with each project and in each Arctic region or community. IARPC will therefore support collaborations to implement participatory and Indigenous leadership in research and focus on the following objectives to inform Federal policy, co-management actions, community priorities, and decision-making through more equitable frameworks:

- **Increasing Capacity for Participatory and Indigenous Leadership in Research:** IARPC will host discussions about ongoing Federal research projects and funding opportunities to build capacity for meaningful participatory research and Indigenous leadership in research. Similarly, IARPC will promote actions to identify ways that Federal administrative structures can be adapted or changed to support this objective. IARPC will seek opportunities to support the development or expansion of community-driven programs, liaison offices, and existing resources for researchers on how to engage with community and Indigenous organizations already in place.³⁹
- **Enabling Communication and Coordination:** IARPC will continue to support communication and coordination, including existing local and regional venues, between Federal agencies and Indigenous and rural Arctic communities to ensure active participation and long-term engagement, and so that plans and outcomes of Federal research programs are communicated appropriately. IARPC will work with and make researchers aware of existing Indigenous organizations, advisory committees, and co-management councils that focus on food security, community infrastructure, health and well-being, Indigenous practices, and species and ecosystems management. IARPC will also advance new venues where research activities can be informed by Indigenous Knowledge and the needs of Indigenous communities.
- **Sustaining Engagement and Building Trust:** Successful partnerships rely on respect, trust, early and ongoing collaboration, sustained engagement, communication and coordination, and multigenerational participation. IARPC will continue to invest in activities that build trust among Federal agencies, researchers, Arctic residents, Indigenous Peoples, and Tribal Nations to achieve sustainable outcomes.
- **Putting the IARPC Principles for Conducting Research in the Arctic into Practice:** IARPC remains committed to the Principles for Conducting Research in the Arctic (IARPC, 2018), which provides a framework for building trust, effective communication, and respecting Indigenous Peoples, cultures, and residents of the Arctic. IARPC will continue to promote the use of these principles and continue discussions on how Arctic residents and researchers can implement or revise them to enable participatory research.

Technology Innovation and Application

At a broad scale, technology and technological solutions will enable, accelerate, and deliver accurate information and products to Arctic residents and the Arctic research and development (R&D) community as they strive to address challenges posed by the priority areas identified in this plan. In working with Arctic residents and researchers to deploy new and existing technologies, it is likely that unknown challenges will emerge. IARPC will employ its existing Polar Technology Community Forum to support

³⁹Conducting Research with Northern Communities: www.arcus.org/resources/northern-communities

this activity as it encourages the broad R&D community across the priority areas to adopt the most relevant, efficient, and sustainable technologies of today. It will also define future technology research, development, and innovation required to support the priority area research needs of tomorrow.

Calls for cutting-edge technology R&D emphasize four common themes that support science, security, and stewardship of the Arctic region: (1) modernized fundamental infrastructure (e.g., energy efficiency, generation, storage, and distribution; water and wastewater; telecommunications; transportation solutions; search and rescue); (2) improvements in accuracy (e.g., high-resolution sensing application and development; data diversity; model and forecast improvements); (3) increased autonomy & autonomous data collection (e.g., to expand domain awareness and data collection, and to improve the safety of data collection in hazardous areas/situations/seasons such as wildland firefighting, flooding, unstable sea ice and permafrost, and winter hazards); and (4) accelerated information delivery (e.g., real-time or near-real time observations; consistent and reliable communication for Arctic residents and among Arctic partners).

Technology and innovation required to support the priority areas are not limited to hardware, but also include software (e.g., AI, database development, and supercomputing), modeling, mapping, forecasting, and better exploitation of environmental satellite observations. Improved models of the entire Arctic domain, from human systems to the edge of the atmosphere and the depths of the ocean, will provide better virtual testbeds for technology, infrastructure, and sensor development, and lead to a better understanding of the interplay of the atmosphere, land, ice, and water.

Where IARPC focuses on coordinating agency activities across the Arctic region, it is critical to emphasize the unique role of public-private partnerships in technology development. Public interests and academic partners excel at setting standards and identifying needs. Private companies, alongside government, can provide the rapid influx of human and financial resources necessary to drive accelerated development and commercialized solutions. IARPC will facilitate these collaborations with the aim to accelerate delivery of technological solutions across the priority areas.

IARPC is well-positioned to identify the existing commercial off-the-shelf (COTS) technologies. For example, challenges related to infrastructure are broad and overarching across the Arctic domain. Insufficient infrastructure technology continues to impact the effectiveness of R&D activities. Technological solutions that address similar large-scale challenges will provide substantial return on investment. IARPC will help identify cross-cutting technological solutions with rapid impact that can accelerate progress, enhance domain awareness, and increase fundamental knowledge for priority area R&D. For example, this could include light detection and ranging (LiDAR) or novel underwater sensing and their derived products, expanded use of AI, and increased access and use of supercomputing resources.

Implementing cutting-edge technology will accelerate the achievement of priority area goals. Technology development is a multi-agency effort, and IARPC will convene agencies to employ the best technology of today, define cyberinfrastructure gaps, determine common technology needs, and design solutions that impact the broader R&D community while also providing improved technology services as identified by Arctic communities.



A biologist working in the northwestern Arctic holds a long-billed dowitcher and measures the length from the back of its head to the tip of its bill. Photo: Lisa Hupp/DOI

Implementation and Metrics for Measuring Success

Implementation of this plan will focus upon achieving the goals identified in each of this plan's priority areas and facilitating continued investment, execution, and integration of the essential contributions of the foundational activities. This plan presents a shift from previous Arctic research plans, where the focus was primarily upon environmental processes, to also address societal issues that require a more complex, multidisciplinary approach. The existing IARPC teams^{40,41} and the communities of practice that they have fostered will greatly contribute to achieving the goals of these priority areas; however, additional multidisciplinary coordination is required to facilitate contributions and synthesize input from relevant sources. To accomplish this, four new priority area collaboration teams will be established to direct and coordinate activities to reach the goals and to ensure coordination and collaboration of resources to address pressing needs. These multi-disciplinary teams will be co-chaired by at least two Federal program managers and one non-Federal partner and will draw on Federal agency and collaboration team expertise to achieve their goals.

⁴⁰Current collaboration teams and sub-teams: Arctic Data, Arctic Observing Systems, Atmosphere, Coastal Resilience, Environmental Intelligence, Glaciers & Sea Level, Health & Well-being, Marine Ecosystems, Modeling, Permafrost, Sea Ice, Terrestrial Ecosystems; Self-forming Teams: Arctic Domain Awareness Center Network, Arctic STEM Education Working Group, Cold/High Anaerobic Digestion, Diversity & Inclusion Working Group, Early Career Forum, International Cooperative Engagement Program for Polar Research (ICE-PPR), Physical Oceanography, Polar Technology, Science Communication Forum, U.S. Forum for the International Arctic Science Committee.

⁴¹The Environmental Intelligence Collaboration Team will dissolve and its sub-teams will function as individual collaboration teams. Other collaboration and self-forming teams may seek to dissolve, while new teams may be established.

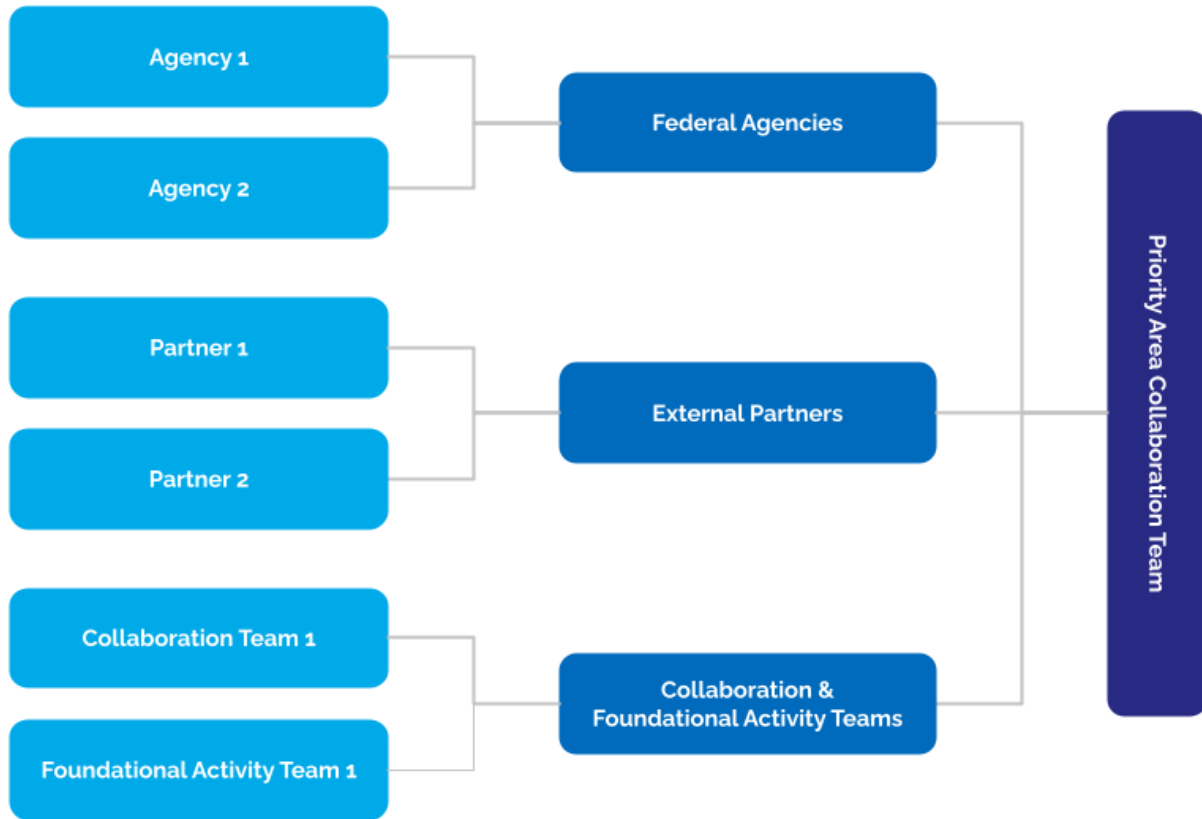


Figure 3: Schematic of the organizational structure supporting priority areas.

The current IARPC teams are vital communities of practice in their fields and remain critical to the implementation of the Arctic Research Plan 2022-2026. IARPC teams will continue to engage via IARPC Collaborations⁴² to advance disciplinary Arctic research in addition to contributing to the priority area goals. Current IARPC teams will coordinate with the new priority area collaboration teams to define what can be accomplished to advance the priority area goals and objectives. The formation of new collaboration teams in areas where there has been little IARPC engagement may be necessary. The involvement of collaborators outside the Federal sphere in all of the IARPC teams will enable greater progress by leveraging external resources and expertise.

This plan acknowledges that engaging with IARPC collaboration teams can be challenging to those without institutional support or facing barriers such as lack of internet and financial constraints. IARPC will continue to strive for inclusive team meetings. Consistent with the overarching principles of this plan, IARPC agencies will support a variety of initiatives to improve communication and engagement such as the creation of an Indigenous Fellowship Program to support Indigenous co-leadership of collaboration teams and priority area collaboration teams, inviting and compensating Indigenous and other underrepresented speakers to share their expertise in webinars and at meetings, and establishing an Indigenous Engagement and Communication Specialist position that will report to the IARPC Executive Director. Drawing on the Participatory Research and Indigenous Leadership in Research Foundational Activity, IARPC will build capacity, sustain engagement, and explore mechanisms for participation in the implementation of this plan with Indigenous Peoples.

⁴²IARPC Collaborations consists of the entire enterprise of the member collaboration teams, the support from the Secretariat, the oversight of the Staff Group and Principals, and the communication enabled through the website.

Biennial Implementation Plan: The Arctic Research Plan 2022-2026 is a high-level research strategy providing a set of priority research areas and foundational activities that will be undertaken and supported by Federal agencies over the next five years. Implementation of the plan will be outlined in biennial implementation plans, the first of which will be released in fall 2022. The biennial implementation plans will include objectives (specific research actions that advance the goals) and deliverables (tangible, measurable, and easily communicated research products that demonstrate progress made toward satisfying the objectives and goals and are made available to relevant decision-makers and partners. Deliverables could also include achievements resulting from the establishment of new relationships).⁴³ Biennial implementation plans will also describe the role of foundational activities in support of the objectives. Consideration of the resources needed to achieve the priority area goals, objectives, and deliverables will take place among participating Federal agencies.⁴⁴

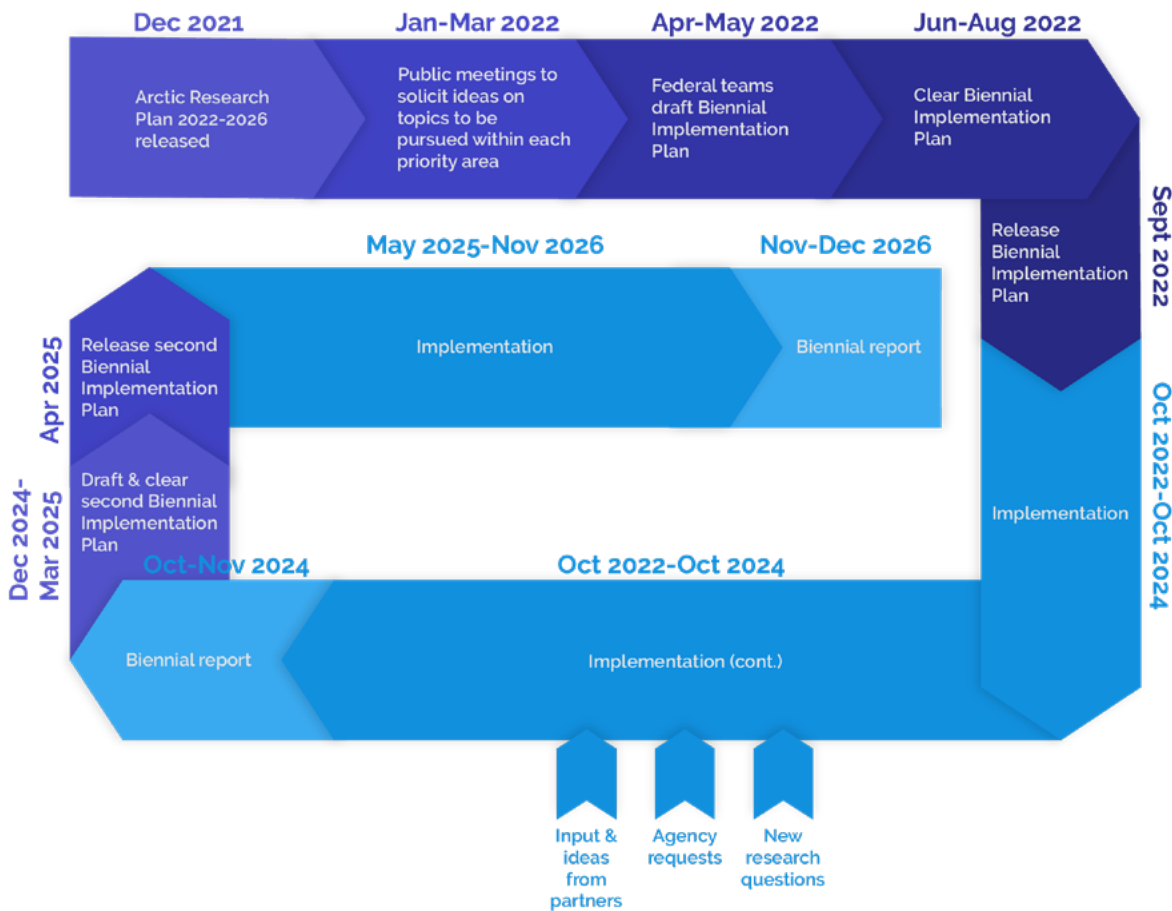


Figure 4: Schematic of the process by which the biennial implementation plans will be developed, implemented, evaluated, and updated.

Planning Process: From January to March 2022, following the release of the Arctic Research Plan 2022-2026, IARPC will hold public meetings to build connections with non-federal subject matter experts and hear from interested individuals and organizations. These meetings will

⁴³Examples of deliverables may include but are not limited to tools, reports, articles, workshops, outreach or education events, webinars, and products tailored to decision-makers or other end users.

⁴⁴As part of the annual process to develop the President’s budget.

solicit ideas on topics to be pursued within each priority area. Ideas generated during this time will inform the Federal development of the first biennial implementation plan which will be released in fall 2022. The 2022 biennial implementation plan will be updated in 2025 with consideration of previous achievements and current assessment of the most effective approach to achieve the long-term goals. Biennial implementation plans will be approved by IARPC agencies.

Reporting: In the fall of 2024, priority area collaboration team leads will produce a report detailing progress on deliverables with an emphasis on highlighting products that advance our understanding of Arctic processes and are relevant to Arctic communities and decision-makers, including how deliverables were made readily accessible. Reports will describe how the priority area objectives and deliverables advanced the missions of more than one Federal agency, resulted in an efficient use of government resources, and met the needs of decision-makers in the Arctic, in Alaska, and throughout the nation; how foundational activities enhanced and supported progress towards priority area goals; and how IARPC engaged with and communicated outcomes to non-Federal partners. These biennial reports will help the public and research and policy communities understand the progress, obstacles, and pathways toward achievement of goals in this plan and detail responsiveness to USARC's Biennial Goals Report. At the end of 2026, a final report will evaluate the outcomes and impacts of the plan and will communicate scientific advancements.

Program Management: IARPC Collaborations is the primary management coordinating structure to implement the Arctic Research Plan 2022-2026. Participation in IARPC Collaborations is open to anyone who can contribute to implementing the plan. A critical element of IARPC Collaborations is the IARPC Collaborations website, which serves as a platform for coordinating Federal government program managers and scientists, the non-Federal research community, and other collaborators to accelerate the pace of Arctic research and achieve priority area goals. The website is both a content-driven dialogue system and a project management and tracking system. Through posting events, documents, and recordings of meetings and webinars, the website helps organize team meetings and deliver information to team members. Progress on implementing the plan will be tracked through an online tracking tool where those participating in implementation can post achievements towards the goals outlined in this plan and the objectives and deliverables described in the biennial implementation plans.

Measuring Success: The IARPC Principals and Staff Group will provide oversight on the appropriateness of the plan's priority area goals in advancing the policy drivers and supporting the mission priorities of Federal agencies.⁴⁵ They will use the following metrics of success:

- How have the priority area goals enhanced and advanced the policy drivers?
- How have the foundational activities enhanced and supported the priority areas?
- How have IARPC teams engaged with collaborators to advance priority area goals and meet the needs of decision-makers in the Arctic, in Alaska, and throughout the nation?

Outcomes: Over the course of the next five years, IARPC and its member agencies will promote research aimed at improving community resilience and well-being, advancing scientific understanding of the evolution of the Arctic system, creating more sustainable economies and livelihoods, and improving risk management and hazard mitigation. Results of these concerted efforts will yield greater predictive capabilities and improved capacity for Arctic communities; state, local, and Tribal authorities, research institutions, nonprofits, private sector, and international organizations; and Federal agencies to adapt to pressing environmental changes while also enabling more informed decisions.

⁴⁵IARPC About Page: www.iarpccollaborations.org/about.html

IARPC Overview Document: www.iarpccollaborations.org/uploads/cms/documents/iarpc_overview.pdf



The R/V *Sikuliaq* travels through sea ice during an NSF-funded research cruise to study how a changing climate is affecting life in the Arctic. Photo: Kim Kenny, via NSF

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Researchers Kristin Laidre (left, University of Washington) and Malene Simon (right, Greenland Climate Research Center) check a camera along the Greenland coast. Photo: Twila Moon/NSIDC

Appendices

Appendix A: Alignment of Arctic Research Plan 2022-2026 with the U.S. Arctic Research Commission Report on the Goals and Objectives for Arctic Research 2019-2020	48
Appendix B: Arctic Research Plan 2022-2026 Engagement Overview	50
Appendix C: Arctic Research Priorities: Analysis of National Policy Drivers	53
Appendix D: Principles for Conducting Research in the Arctic (2018)	62
Appendix E: Equity and Inclusion in the Next Five-Year Arctic Research Plan	65

Appendix A: Alignment of Arctic Research Plan 2022-2026 with the United States Arctic Research Commission Report on the Goals and Objectives for Arctic Research 2019-2020

The Arctic Research and Policy Act of 1984 (amended 1990) directs the Interagency Arctic Research Policy Committee (IARPC) to develop a national Arctic research policy and a five-year plan to implement that policy. It further directs IARPC to cooperate with the United States Arctic Research Commission (USARC) to establish “...a national Arctic research program plan to implement the Arctic research policy.”¹ One duty of USARC is to, every two years, produce a statement of goals and objectives with respect to Arctic research to help guide IARPC in the performance of its duties. The United States and international scientific communities have long benefited from the insightful analyses and guidance provided in USARC Report on the Goals and Objectives for Arctic Research. As laid out below, The Arctic Research Plan 2022-2026 (hereinafter referred to as “the plan”) is closely aligned with the five goals laid out in the USARC’s Goals Report 2019-2020. Close cooperation with USARC ensures federal research activities address concerns of greatest urgency and future research investments target U.S. national interests. The next USARC Goals and Objectives report is expected in early 2022.

Arctic Research Plan Priority Area 1: Priority Area 1: Community Resilience and Health has the goal to “Improve community resilience and well-being by strengthening research and developing tools to increase understanding of interdependent social, natural, and built systems in the Arctic”. This priority area and goal are well aligned with USARC Goal 4: Improve Community Health and Well-Being. Both goals recognize that health and well-being extend beyond physical health and disease and include culture and language, food security, and more. They also both recognize the increasing health disparities between Indigenous and non-Indigenous populations and the need to address them. USARC Goal 4 is also well-aligned with the plan’s Well-Being Policy Driver to enhance the wellness of Arctic residents with an emphasis on the themes of cultural vibrancy, food security, economic development, and mental and physiological health.

Arctic Research Plan Priority Area 2: Priority Area 2: Arctic Systems Interactions goal to “enhance our ability to observe, understand, predict, and project the Arctic’s dynamic interconnected systems and their links to the Earth system” is strongly linked to both USARC Goal 3: Observe, Understand, and Forecast Arctic Environmental Change and USARC Goal 1: Advance Arctic Infrastructure. Both goals and the priority area recognize the need for augmenting environmental Arctic change knowledge, observation and predictive capabilities. They also illustrate that the impacts of these changes are not limited to the Arctic and therefore are critical to informing decisions and actions worldwide. The importance of fundamental research in understanding Arctic environmental change is also specifically highlighted in Priority Area 2, as well as in the introduction to the plan.

Arctic Research Plan Priority Area 3: Priority Area 3: Sustainable Economies and Livelihoods goal is to “observe and understand the Arctic’s natural, social, and built systems to promote sustainable economies and livelihoods”. This priority area recognizes the impacts that changes such as thawing permafrost and coastal erosion have on Arctic infrastructure and calls for actionable research to better understand the Arctic’s built systems. USARC Goal 1: Advance Arctic Infrastructure states that advancing Arctic infrastructure and reducing infrastructure damage and costs require “timely preventative measures, based on a well-informed understanding of environmental conditions, and their projected changes over time”. Both USARC Goal 1 and Priority Area 3 recognize how critical reliable infrastructure is to community well-being and human activity in the Arctic. Priority Area 3 seeks to observe and understand the Arctic’s built systems to inform the adaptation of infrastructure to future environmental shifts. This

¹U.S. Arctic Research Policy. February 3, 1986. www.iarpcollaborations.org/uploads/cms/documents/arctic_research_policy_1986.docx

is essential to USARC's goal of advancing Arctic infrastructure. Finally, Priority Area 3 specifically calls for the formation of a new collaboration team to focus on research related to infrastructure.

USARC Goal 2: Assess Arctic Natural Resources is also aligned with Priority Area 3. USARC highlights the need for research that "informs management of the Arctic's plentiful and rich natural resources, such as oil and gas, minerals, and wildlife". Recognizing how changes to the Arctic ecosystems impact "state, national, and global economies by affecting global shipping, access to natural resources, and fish and seafood stocks," Priority Area 3 supports research to inform management decisions that maintain the healthy ecosystems that provide critical natural resources.

Arctic Research Plan Priority Area 4: Priority Area 4: Risk Management and Hazard mitigation is connected to USARC Goal 1: Advance Arctic Infrastructure and USARC Goal 4: Improve Community Health and Well-Being. The goal of Priority Area 4 is to, "secure and improve quality of life through research that promotes an understanding of disaster risk exposure, sensitivity to hazard, and adaptive capacity". Achieving this goal requires advancing infrastructure (USARC Goal 1) to mitigate risk and hazards to built systems. Securing and improving quality of life is also directly tied to improving community health and well-being (USARC Goal 4).

Arctic Research Plan Foundational Activities: The USARC Report on the Goals and Objectives for Arctic Research directs attention to emerging topics in Arctic research including co-production of knowledge and use of advanced technology in Arctic research applications. The Arctic Research Plan 2022-2026 identifies participatory research (which includes co-production of knowledge) as a foundational activity and calls for co-production of knowledge in the introduction and again in priority areas 1 and 3. Technology Innovation and Application as a foundational activity of the plan promotes the importance of advanced technology in all aspects of the plan.

International Cooperation: The Arctic Research Plan 2022-2026 recognizes the importance of enhancing international scientific cooperation in the Arctic (USARC Goal 5). The introduction of the plan highlights international collaboration and relationship strengthening which are essential to understanding the interconnected processes that define the Arctic and advancing transboundary research challenges. The importance of enhancing international scientific cooperation is also specifically mentioned in priority areas 1, 2, and 3, the Data Management and Monitoring, Observing, Modeling, and Prediction foundational activities, and in the implementation chapter of the plan.

Appendix B: Arctic Research Plan 2022–2026 Engagement Overview

The Interagency Arctic Research Policy Committee (IARPC) is a committee of the U.S. National Science and Technology Council (NSTC). It aims to enhance scientific monitoring and research on local, regional, and global environmental issues in the Arctic through the coordination of federal agencies and domestic and international collaborators. By law (the Arctic Research and Policy Act of 1984), IARPC develops and implements an Arctic Research Plan every five years. The plan is developed in consultation with the U.S. Arctic Research Commission, the governor of Alaska, Arctic residents, the private sector, and public interest groups and aims to improve the collective impacts of federal agencies in Arctic research. The development of the Arctic Research Plan 2022-2026 included two public engagement periods. One engagement period was held prior to the drafting of the plan (October 2019–September 2020), and a second one was held to collect input on an initial draft of the plan (March–June 2021).

Throughout the engagement process, IARPC operated under three key overarching principles:

1. **Sustained Engagement:** Advance respectful, responsive, and continuous engagement with Indigenous and Tribal organizations, Arctic communities, federal agencies, the state of Alaska, and non-federal partners.
2. **Inclusion and Equity:** Encourage diversity and ensure that everyone is treated fairly and respectfully and promote access to the tools needed to succeed.
3. **Transparency and Accessibility:** Commit to activities and decisions that are transparent and communicated clearly and in an accessible format.

First Public Engagement Period (Oct. 2019–Sept. 2020)

From October 2019 to September 2020, IARPC collected public input to inform the development of the plan. IARPC offered multiple and varied ways for the public to provide input and continues to issue a monthly newsletter update on plan progress. During this time, IARPC worked to engage with:

- Federal agencies via direct agency input to IARPC Staff Group.
- Indigenous Peoples via targeted outreach to Indigenous community members, regional Indigenous entities, and Indigenous organizations.
- Academia via listening sessions and three external workshops coordinated by academic partners.
- The state of Alaska via direct outreach and conversations with contacts in relevant departments.
- Private sector organizations and nonprofits via personal outreach and directed invites to public webinars.
- International organizations via listening sessions and outreach to relevant international bodies.
- Early career researchers via an information session and outreach to support and encourage early career involvement.

Additional engagement activities included a radio interview on [Talk of Alaska](#) to answer questions about the plan and discuss how Alaskans can get involved. The Plan Development Director also conducted three interviews with journalists that resulted in one published article in the science journal *Frontiers in Ecology and the Environment*. In total, IARPC participated in 29 externally facing events, including conferences, meetings, listening sessions, and webinars. An additional three events were hosted by

academic partners.

A variety of mechanisms were used to collect input and comments throughout the first public engagement phase. Mechanisms included:

- A Federal Request for Information Notice (April - August 2020).
- A form on the IARPC website.
- Two IARPC-wide informational webinars.
- Collaboration team listening sessions.
- Regular reserved time during Coastal Resilience Collaboration Team meetings.
- A session specific to plan development at the 2020 Collaboration Team Leaders' Workshop.
- Verbal comments at workshops, conferences, and webinars.
- Direct federal agency input to IARPC Staff Group.

In addition to receiving input from 11 federal agencies, IARPC [received](#) 120 comments.

To inform plan development, aid workshop participants, and communicate to the public the input received during the public engagement phase, [six synthesis documents](#) were created. These included: (1) an overview of research needs and priorities identified in recent, public facing strategic documents from the state of Alaska, international organizations, northern communities, and federal departments and agencies; (2) a synthesis of comments submitted by federal agencies¹ to IARPC Staff Group; and (3) a synthesis of comments submitted specific to the public engagement phase. The synthesis of comments included input received via the engagement mechanisms listed above. The syntheses of federal and public input were used to create an initial list of priority areas that was considered and further prioritized by workshop participants.

IARPC Plan Development Workshop

To conclude the first public engagement phase, a virtual IARPC Plan Development Workshop took place from September 14-17, 2020. The purpose was to identify potential priority areas as the focus of the next Arctic Research Plan.

Participants included over 100 representatives from academic institutions (22%), Indigenous organizations, private sectors, and nonprofits (21%), federal agencies (38%), the state of Alaska (5%), and from IARPC collaboration team co-leads (14%). Participants worked collaboratively in a series of facilitated breakout groups and plenary sessions to identify four foundational activities and five priority areas, which were forwarded to the IARPC Staff Group for further consideration. A [full workshop report](#) is available on the IARPC Collaborations website.

¹Department of Defense; Department of Energy; Department of Interior; Department of Transportation; Department of Health and Human Services; National Aeronautics and Space Administration; Department of Commerce; National Science Foundation; Smithsonian; US Arctic Observing Network Board; and U.S. Coast Guard.

Second Public Engagement Period (March–June 2021)

IARPC released a draft plan and invited public comment during a four month period March to June 2021. This second engagement period invited input on the priority area goals, justifications, and potential partners; the foundational activities; and implementation and metrics for measuring success. IARPC accepted comments through the Federal Register Notice, email, hardcopy, and voicemail.

During the second engagement period, IARPC offered five webinars about the draft plan. Each information session provided an overview of IARPC, the timeline for developing the Arctic Research Plan 2022-2026, the contents of the draft plan, and how to submit comments on the draft. In addition to this information, each webinar included a deeper dive into one of the plan priority areas or the foundational activities.

Webinars included:

- [Foundational Activities](#)
- [Priority Areas 1 & 3 \(Community Resilience and Health; Sustainable Economies and Livelihoods\)](#)
- [Priority Area 2 \(Arctic Systems Interactions\)](#)
- [Priority Area 4 \(Risk Management and Hazard Mitigation\)](#)
- [Implementing the plan](#)

A total of 174 public comments were received in addition to input from six federal agencies.

Additional engagement activities included a teleconference session for those with low internet bandwidth, a radio interview on [Talk of Alaska](#) that discussed the draft plan and how to comment, and a continuation of the monthly newsletter. Members of the IARPC community held a community meeting at the 2021 Arctic Science Summit Week conference, and the IARPC Collaborations Diversity & Inclusion Working Group held a listening session about the draft plan. In addition, the Marine Ecosystems Collaboration Team and Coastal Resilience Collaboration Team held information sessions. IARPC also provided a [media kit](#) that included sample text and images that could be shared broadly in newsletters and on social media channels.

IARPC also conducted targeted engagement to Indigenous communities through an Indigenous Engagement Coordinator, a short-term contract specific to this engagement period for the draft Arctic Research Plan. Outreach included email updates sent to federally recognized Tribes and EPA Indian Environmental General Assistance Program coordinators and flyers with information about the draft plan sent to subsistence regional advisory councils and to the Northern Latitudes Partnership. IARPC plan drafters presented to the Alaska Eskimo Whaling Commission and the Yukon River Panel, at the Western Alaska Interdisciplinary Conference & Forum, and as part of the Strait Science Series. Indigenous communities could also request hard copies of the draft plan and other materials.

Appendix C: Arctic Research Priorities: Analysis of National Policy Drivers

This paper was prepared by Yekaterina Kontar in August 2020 on behalf of the IARPC Plan Development Steering Group.

Introduction and Background

The United States, by virtue of Alaska, is an Arctic nation and has substantial political, socio-economic, and environmental interests in the region. National policy drivers reflect long-standing U.S. interests in the Arctic, and consequently serve as a foundation for the Interagency Arctic Research Policy Committee (IARPC) five-year Arctic Research Plan – a comprehensive plan for the overall interagency federal effort in Arctic research.

The following four overarching policy drivers guided the inclusion of goals and the implementation of the current plan (2017-2021) and will help to guide the discussion of scope of the next plan FY 2022-2026:

1. Enhance the well-being of Arctic residents (*Well-Being*);
2. Advance stewardship of the Arctic environment (*Stewardship*);
3. Strengthen national and regional security (*Security*); and
4. Improve understanding of the Arctic as a component of planet Earth (*Arctic-Global Systems*).

The policy drivers reflect the collective priorities of the IARPC federal agencies. These priorities are derived from the major U.S. policy documents of the past 50 years, including the following:

- Richard Nixon’s 1971 National Security Decision Memorandum (NSDM-144);
- Ronald Reagan’s 1983 National Security Decision Directive (NSDD-90);
- Bill Clinton’s 1994 Presidential Decision Directive (PDD/NSC-26);
- The 1984 Arctic Research and Policy Act (ARPA);
- George Bush’s 2009 Arctic Policy Directive (NSPD 66/HSPD 25);
- Barack Obama’s 2013 National Strategy for Arctic Region (NSAR) and the 2014 NSAR Implementation Plan;
- Policy documents developed in 2015 and 2016 by the White House Arctic Executive Steering Committee;
- Donald Trump’s 2018 National Ocean Policy (from Executive Order 13840);
- The 2019 Presidential Memorandum on Ocean Mapping of the U.S. Exclusive Economic Zone and the Shoreline and Nearshore of Alaska;
- The 2020 Presidential Memorandum on Safeguarding U.S. National Interests in the Arctic and Antarctic Regions;
- Biennial Arctic Science Ministerial joint statements (2016, 2018); and
- Annual presidential memoranda on White House Research and Budgetary Priorities.

Analysis

The goal of the analysis is to determine whether the four policy drivers, first used to guide the development and implementation of the current Arctic Research Plan FY2017-2021, maintain their alignment with the current national Arctic priorities. The analysis encompasses a review of the major U.S. policy documents relating to the Arctic between December 2016 (the release date of the current plan) and August 2020. Documents include presidential memoranda and executive orders, special committees' reports, and other federal policy directives. The selection of documents is based on overall relevance to the Arctic region or national science and technology priorities and is limited to U.S. federal policies.

A total of 12 documents with dates of release from August 2017 to June 2020 were analyzed (Figure 1). Each document was searched for keywords relevant to the four policy drivers (Figure 2).

Enhance the Well-Being of Arctic Residents

The *Well-Being* policy driver is addressed in 10 of the policy documents with an emphasis on the themes of cultural vibrancy, economic development and growth, and health. The theme of domestic and foreign economic development is addressed in eight policy documents, with emphasis on U.S. national, as well as foreign, interests in the Arctic region. Economic growth is mentioned in the context of ocean mapping and the nation's overall research and development priorities.

“American leadership in science and technology is critical to achieving this Administration’s highest priorities: national security, economic growth, and job creation.” (*FY 2019 Administration Research and Development Budget Priorities*)

“The Arctic region has strategic and economic importance.” (*Science & Technology Highlights in the Second Year of the Trump Administration*)

Advance Stewardship of the Arctic Environment

The *Stewardship* policy driver is addressed in six documents relevant to the U.S. national and foreign interests in the Arctic, with an emphasis on the marine environment and globally driven changes themes. The marine environment theme is addressed in the U.S. ocean priorities. The globally driven changes theme is also addressed in the oceans context, as well as in the national overall science and technology priorities and U.S. foreign policy priorities in the region.

“To improve our Nation’s understanding of our vast ocean resources and to advance the economic, security, and environmental interests of the United States, it is the policy of the United States to support the conservation, management, and balanced use of America’s oceans by exploring, mapping, and characterizing the U.S. EEZ, including mapping the Arctic and Sub-Arctic shoreline and nearshore of Alaska.” (*Memorandum on Ocean Mapping of the US EEZ & the Shoreline & Nearshore of Alaska*)

“The rapidly changing conditions in the Arctic have national security, commerce, and transportation implications...Departments and agencies should prioritize research investments that enhance our ability to observe, understand, and predict the physical, biological, and socio-economic processes of the Arctic to protect and advance American interests.” (*2022 Administration Research and Development Budget Priorities and Cross-cutting Actions*)

Strengthen National and Regional Security

The *Security* policy driver is addressed in 11 documents relevant to the U.S. national and foreign interests in the Arctic, with an emphasis on the national and regional security, as well as risk management and emergency preparedness themes. The national and regional security policy themes are addressed in eight documents with relevance to the nation’s overall research, technology, and development interests, as well national security and American oceans mapping and research.

“To help protect our national interests in the Arctic and Antarctic regions, and to retain a strong Arctic security presence alongside our allies and partners, the United States requires a ready, capable, and available fleet of polar security icebreakers that is operationally tested and fully deployable by Fiscal Year 2029.” (*Memorandum on Safeguarding National Interests in the Arctic & Antarctic Regions*)

The risk management and emergency preparedness policy themes are addressed in the context of ocean research and U.S. foreign research collaboration in the Arctic region.

“The changing conditions of the Arctic...impact homeland and national security operations such as search and rescue, oil spill preparedness and response...Accurate operational forecasts of the environment...will be critical to safe and efficient operations (defense and commercial) in the Arctic.” (*Science & Technology for America’s Oceans: A Decadal Vision*)

Improve Understanding of the Arctic as a Component of Planet Earth

The *Arctic Global Systems* policy driver is addressed in five documents relevant to the U.S. national and foreign interests in the Arctic, with an emphasis on how physical changes in the Arctic impact the lower latitudes (e.g., sea level and meteorological conditions). Existing and potential impact of the changes in the Arctic region on the lower latitudes are addressed in the nation’s overall science, technology, and development priorities, as well as in the context of the American oceans mapping and research and U.S. international science priorities in the region.

“Arctic dynamics influence global geophysical and biochemical systems, including freshwater storage and export, ocean-ice-atmospheric interactions, weather and climate dynamics, primary production, and the ocean’s response to acidification, while also shaping human activities in the region.” (*Science & Technology for America’s Oceans: A Decadal Vision*)

“Changes in the Arctic are driven by environmental, climatic, social and economic factors that are local, regional and global. Feedback from the Arctic climatic system, in turn, has global repercussions affecting the environment, people and economies worldwide...The complexity of regional and global impacts of a warming Arctic and of associated ecosystem changes regarding land, freshwater and oceans have not yet been fully assessed and quantified. Understanding and responding to this challenge requires joint efforts by the global community.” (*2nd Arctic Science Ministerial – Joint Statement*)

Conclusions

The analysis has revealed that the policy drivers—(1) enhance the well-being of Arctic residents, (2) advance stewardship of the Arctic environment, (3) strengthen national and regional security, and (4) improve understanding of the Arctic as a component of planet Earth—remain robust and are consistent with the prevalent federal considerations regarding the Arctic region. The strongest emphases fall on the economy and security policy themes. Current national priorities have emphasized the need to

advance ocean mapping and research in the Arctic to help foster regional as well as national economic and homeland security.

As of August 2020, the current Administration has not released any updated or new Arctic Policy Directives or National Strategy for the Arctic Region. Still, the U.S. national and foreign policy continues to have a strong emphasis on the Arctic region, which is evident from the array of national documents reviewed above. Moreover, the Arctic has been highlighted as one of the Administration's budgetary research and development priorities for the FY 2022. The White House has also taken an active role in shaping the course of Arctic research by signing a Joint Statement at the 2nd Arctic Science Ministerial in October 2018 and committing "to strengthening, integrating, and sustaining Arctic observations, facilitating access to Arctic data, and sharing Arctic research infrastructure; understanding the regional and global dynamics of Arctic change; and assessing the vulnerability and building resilience of Arctic environments and societies" (2nd Arctic Science Ministerial-Joint Statement).

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- Executive Order 13840 – Regarding the Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States, June 2018. www.whitehouse.gov/presidential-actions/executive-order-regarding-ocean-policy-advance-economic-security-environmental-interests-united-states/
- Joint Statement of Ministers - On the occasion of the Second Arctic Science Ministerial. In: 2nd Arctic Science Ministerial, 25-26 October 2018, Berlin, Germany. www.arcticsscienceministerial.org/files/ASM2_Joint_Statement.pdf
- Interagency Arctic Research Policy Committee Biennial Report 2016-2017. www.whitehouse.gov/wp-content/uploads/2018/03/IARPC-Biennial-Report-2016-2017.pdf
- Memorandum for the Heads of Executive Departments and Agencies: FY 2019 Administration Research and Development Budget Priorities. www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/m-17-30.pdf
- Memorandum for the Heads of the Executive Departments and Agencies: FY 2020 Administration Research and Development Budget Priorities. www.whitehouse.gov/wp-content/uploads/2018/07/M-18-22.pdf
- Memorandum for the Heads of Executive Departments and Agencies: Fiscal Year 2021 Administration Research and Development Budget Priorities. www.whitehouse.gov/wp-content/uploads/2019/08/FY-21-RD-Budget-Priorities.pdf
- Memorandum for the Heads of Executive Departments and Agencies: Fiscal Year 2022 Administration Research and Development Budget Priorities and Cross-cutting Actions. www.whitehouse.gov/wp-

[content/uploads/2020/08/M-20-29.pdf](#)

Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska, November 2019. www.whitehouse.gov/presidential-actions/memorandum-ocean-mapping-united-states-exclusive-economic-zone-shoreline-nearshore-alaska/

Memorandum on Safeguarding U.S. National Interests in the Arctic and Antarctic Regions, June 2020. www.whitehouse.gov/presidential-actions/memorandum-safeguarding-u-s-national-interests-arctic-antarctic-regions/

National Science Foundation, FY 2021 Budget Request to Congress, February 10, 2020. www.nsf.gov/about/budget/fy2021/pdf/fy2021budget.pdf

National Security Decision Directive 90 - United States Arctic Policy. www.reaganlibrary.gov/sites/default/files/archives/reference/scanned-nsdds/nsdd90.pdf

National Security Decision Memorandum 144 - United States Arctic Policy and Arctic Policy Group. www.hsdl.org/?view&did=750480

National Security Strategy of the United States of America, December 2017. www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

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Ocean Science and Technology Highlights: Selected Projects from our Federal Agencies, June 2018. www.whitehouse.gov/wp-content/uploads/2018/06/Ocean-Science-and-Technology-Highlights-Selected-Projects-From-Our-Federal-Agencies.pdf

President's Council of Advisors on Science and Technology (PCAST) June 2020 Report: Recommendations for Strengthening American Leadership in Industries of the Future. www.science.osti.gov/-/media/ /pdf/about/pcast/202006/PCAST_June_2020_Report.pdf

Presidential Decision Directive/NSC 26 - United States Policy on the Arctic and Antarctic Regions. www.fas.org/irp/offdocs/pdd/pdd-26.pdf

Science and Technology for America's Oceans: A Decadal Vision, November 2018. www.whitehouse.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf

Science & Technology Highlights in the First Year of the Trump Administration. www.whitehouse.gov/wp-content/uploads/2018/03/Administration-2017-ST-Highlights.pdf

Science & Technology Highlights in the Second Year of the Trump Administration. www.whitehouse.gov/wp-content/uploads/2019/02/Administration-2018-ST-Highlights.pdf

Table 1. List of analyzed documents.

Policy Document	Date of Public Release	Retrieved From
FY 2019 Administration Research and Development Budget Priorities	August 17, 2017	www.whitehouse.gov/sites/whitehouse.gov/files/ostp/fy2019-administration-research-development-budget-priorities.pdf
National Security Strategy of the United States of America	December 2017	www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf
IARPC Biennial Report 2016-2017	March 2018	www.iarpccollaborations.org/uploads/cms/documents/iarpc-biennial-report-2016-2017.pdf
Ocean Science and Technology Highlights: selected Projects from Our Federal Agencies	June 2018	www.whitehouse.gov/wp-content/uploads/2018/06/Ocean-Science-and-Technology-Highlights-Selected-Projects-From-Our-Federal-Agencies.pdf
FY 2020 Administration Research and Development Budget Priorities	July 31, 2018	www.whitehouse.gov/wp-content/uploads/2018/07/M-18-22.pdf
Arctic Science Ministerial II – Joint Statement of Ministers	October 26, 2018	www.arcticsscienceministerial.org/files/ASM2_Joint_Statement.pdf
Science and Technology for America’s Oceans: A Decadal Vision	November 2018	www.whitehouse.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf
Science & Technology Highlights in the Second Year of the Trump Administration	March 1, 2019	www.whitehouse.gov/wp-content/uploads/2019/02/Administration-2018-ST-Highlights.pdf
Fiscal Year 2021 Administration Research and Development Budget Priorities	August 30, 2019	www.whitehouse.gov/wp-content/uploads/2019/08/FY-21-RD-Budget-Priorities.pdf
Presidential Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska	November 19, 2019	www.whitehouse.gov/presidential-actions/memorandum-ocean-mapping-united-states-exclusive-economic-zone-shoreline-nearshore-alaska/
Presidential Memorandum on Safeguarding U.S. National Interests in the Arctic and Antarctic Regions	June 9, 2020	www.whitehouse.gov/presidential-actions/memorandum-safeguarding-u-s-national-interests-arctic-antarctic-regions/
FY 2022 Administration Research and Development Budget Priorities and Cross-cutting Actions	August 14, 2020	www.whitehouse.gov/wp-content/uploads/2020/08/M-20-29.pdf

Table 2. References of the policy drivers outlined in the current Arctic Research Plan in the U.S. policy documents from 2017- 2020.

Policy Driver	Key Words	Related Key Words	Policy Documents, 2017-2020
Well-Being	Well-Being		IARPC Biennial Report 2016-2017 FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions
	Health	Wellness	FY 2020 Administration R&D Budget Priorities FY 2021 Administration R&D Budget Priorities IARPC Biennial Report 2016-2017 Memorandum on Ocean Mapping of the US EEZ & the Shoreline & Nearshore of Alaska
	Economy	Resources	2nd Arctic Science Ministerial – Joint Statement FY 2019 Administration R&D Budget Priorities FY 2021 Administration R&D Budget Priorities FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions IARPC Biennial Report 2016-2017 Memorandum on Ocean mapping of the US EEZ & the Shoreline & Nearshore of Alaska Memorandum on Safeguarding U.S. National Interests in the Arctic & Antarctic Regions S&T for America’s Oceans: A Decadal Vision, November 2018 S&T Highlights in the Second Year of the Trump Administration
	Development	Growth, Natural Resources, Energy	IARPC Biennial Report 2016-2017 FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions
	Culture	Society, Lifestyle, Heritage	2nd Arctic Science Ministerial – Joint Statement
	Prosperity	Vitality	IARPC Biennial Report 2016-2017 FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions National Security Strategy of the United States of America, December 2017
Stewardship	Stewardship	Leadership, Management	Memorandum on Ocean Mapping of the US EEZ & the Shoreline & Nearshore of Alaska FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions
	Environment	Habitat, Nature. Ecosystem, Biosphere	IARPC Biennial Report 2016-2017 FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions S&T for America’s Oceans: A Decadal Vision, November 2018

ARCTIC RESEARCH PLAN 2022-2026

Policy Driver	Key Words	Related Key Words	Policy Documents, 2017-2020
Stewardship	Change	Adaptation	2nd Arctic Science Ministerial – Joint Statement FY 2021 Administration R&D Budget Priorities FY 2022 Administration R&D Budget Priorities and Cross-cutting Actions IARPC Biennial Report 2016-2017 S&T Highlights in the Second Year of the Trump Administration
	Local Action	Community	
Security	Security	National Security, Regional Security, Safety Defense, Protection	FY 2019 Administration R&D Budget Priorities FY 2020 Administration R&D Budget Priorities FY 2021 Administration R&D Budget Priorities FY2022 Administration R&D Budget Priorities and Cross-cutting Actions IARPC Biennial Report 2016-2017 Memorandum on Ocean Mapping of the US EEZ & the Shoreline & Nearshore of Alaska National Interests in the Arctic & Antarctic Regions National Security Strategy of the United States of America, December 2017 S&T for America’s Oceans: A Decadal Vision, November 2018
	Emergency	Emergency Preparedness, Emergency Response, Crisis, Disaster	2nd Arctic Science Ministerial – Joint Statement Ocean S&T Highlights, June 2018
	Risk	Risk Management, Risk Reduction, Uncertainty, Vulnerability	Ocean S&T Highlights, June 2018
	Prediction	Forecasting	IARPC Biennial Report 2016-2017 FY2022 Administration R&D Budget Priorities and Cross-cutting Actions 2nd Arctic Science Ministerial – Joint Statement

ARCTIC RESEARCH PLAN 2022-2026

Policy Driver	Key Words	Related Key Words	Policy Documents, 2017-2020
Arctic Global System	Global System	Planet, Earth	2nd Arctic Science Ministerial – Joint Statement FY 2021 Administration R&D Budget Priorities IARPC Biennial Report 2016-2017 S&T for America’s Oceans: A Decadal Vision, November 2018 S&T Highlights in the Second Year of the Trump Administration
	Weather	Meteorological Conditions, Climate, Temperature, Weather Systems	IARPC Biennial Report 2016-2017
	Sea Level		
	Cryosphere		IARPC Biennial Report 2016-2017

Appendix D: Principles for Conducting Research in the Arctic (2018)

U.S. Interagency Arctic Research Policy Committee (IARPC)¹

Introduction

The 2018 *Principles for Conducting Research in the Arctic* (hereafter the Principles) revise the *Principles for the Conduct of Research in the Arctic* (1990)²; they align with U.S. Arctic policy³ and apply to research across all disciplines. To guide research activities throughout the Arctic, the U.S. Interagency Arctic Research Policy Committee (IARPC) prepared the following Principles:

- Be **Accountable**
- Establish Effective **Communication**
- **Respect** Indigenous Knowledge and Cultures
- Build and Sustain **Relationships**
- Pursue Responsible **Environmental Stewardship**⁴

These Principles are directed at academic and federal researchers funded by IARPC agencies but are equally relevant to other individuals and organizations pursuing or funding research in the Arctic. They are guidelines for conducting responsible and ethical research and they encourage respect for all individuals, cultures, and the environment. The Principles are not intended to supplant existing regulations and guidelines; researchers should follow federal, state, and local regulations, policies and guidelines. Research involving human subjects must adhere to specific requirements.⁵ Projects on Indigenous homelands or involving Indigenous Peoples should be coordinated with Indigenous leadership and should follow all applicable regulations and local research guidelines.

The Principles

1. Be Accountable

¹The Arctic Research and Policy Act of 1984 (ARPA), Public Law 98-373, July 31, 1984, as amended by Public Law 101-609, November 16, 1990, provides for a comprehensive national policy dealing with national research needs and objectives in the Arctic. The ARPA establishes an Arctic Research Commission (ARC) and an Interagency Arctic Research Policy Committee (IARPC) to help implement the Act. Since its inception, IARPC activities have been coordinated by the National Science Foundation (NSF), with the Director of the NSF as chair. A Presidential Memorandum issued on July 22, 2010, made the NSTC responsible for IARPC, with the Director of the NSF remaining as chair of the committee.

²The original *Principles for the Conduct of Research in the Arctic*, (available at: <https://www.nsf.gov/geo/opp/arctic/conduct.jsp>) were prepared by the Interagency Social Science Task Force at the direction of the Interagency Arctic Research Policy Committee (IARPC). The Principles will be reviewed by IARPC every five years for inclusion in the Arctic Research Plan.

³The Arctic Research and Policy Act of 1984 (ARPA), Public Law 98-373, July 31, 1984, as amended by Public Law 101-609, November 16, 1990; National Security Presidential Directive/NSPD 66, Homeland Security Presidential Directive/HSPD 25: Arctic Region Policy, The White House, Washington DC, 2009; National Strategy for the Arctic Region, The White House, Washington DC, 2013.

⁴The U.S. National Strategy for the Arctic Region (2013) describes “responsible stewardship of the Arctic environment” as “active conservation of resources, balanced management, and the application of scientific and traditional knowledge of physical and living environments.”

⁵The US Federal Policy for protection of persons involved in Human Subjects Research is codified in the Department of Health and Human Services regulations [45 CFR part 46](#). This has been adopted in the regulations of 15 Federal departments and agencies that conduct or support human subjects research. Reference: <https://www.hhs.gov/ohrp/regulations-and-policy/regulations/common-rule/index.html>

1.1 Promote a work environment that is safe, harassment-free, and inclusive. Principal investigators and co-investigators are responsible for all decisions and actions made on their project.

1.2 Act with integrity, and honor verbal and written commitments. Participation in research must be voluntary and cause no harm. When required, participants' informed consent must be obtained. Research methodology, sponsors, and how the information or images will be used and published should be disclosed and understandable to all involved. Provide reasonable opportunities to individuals, who share information or images, to review and agree, or withdraw their contributions prior to publication.

1.3 Consider the physical and socio-economic well-being of all Arctic residents—Indigenous and non-Indigenous. Credit all research collaborators' contributions, including Indigenous Knowledge holders', in publications and presentations of research with their consent. Discuss expectations for compensation with all collaborators and individuals providing information or services for the project.

1.4 Maintain data confidentiality in accordance with existing standards and requirements when handling personal or culturally sensitive information or personally or community identifiable information.

2. Establish Effective Communication

2.1 Communicate expectations, objectives, and potential outcomes at all stages of the project. Provide reasonable opportunities to local collaborators and Tribes to participate in planning, data collection, analysis, interpretation of results, and development of conclusions. Researchers should identify all sponsors and collaborators, sources of financial support, and receive guidance from the community about the most effective and preferred methods of communication.

2.2 Tribes and communities often conduct their own research. Where possible, inquire about ongoing Tribal and community research and priorities, and collaborate appropriately. Be aware and respectful of Indigenous Peoples' practices and protocols for accountability.

2.3 Coordinate visits or fieldwork to avoid disrupting peak subsistence periods, traditional activities, religious events, and health services. Coordinate activities such as research vessel tracks or aircraft flights to avoid impact to residents.

2.4 Identify potentially sensitive data and observations with individuals and/or the community and establish measures to reduce the likelihood of any harm to individuals or the community. Researchers should share research results, preferably in person, with communities prior to broader release, especially in cases where the project's results could be of concern. Following publication, research results should be made accessible to local communities and repositories.

3. Respect Indigenous Knowledge and Culture

3.1 Respect is enhanced by mutual understanding. Researchers are encouraged to learn about the regions in which they will conduct research. Understand the region's history, cultures, languages, community perceptions of past and current research conducted in the region, and organizational structures, practices, values, and institutions.

3.2 Respect all hunting, fishing, harvesting, and gathering practices and use areas. Avoid disturbing cultural resources such as sacred sites, archaeological sites, cultural materials and markers, and cultural property. Adhere to local and Indigenous traditions, customs, and locally-adopted

research guidelines. Many Indigenous Peoples have permitting requirements and research guidelines that provide specific protocols.

3.3 Be open to new viewpoints and be aware of and acknowledge differences and biases when discussing analysis and interpretation of data and observations with residents. Arctic Indigenous Peoples hold unique knowledge and understanding of their homelands and can offer valuable collaborative partnerships with scientists. Inclusion of Indigenous Knowledge in research is encouraged.

4. Build and Sustain Relationships

4.1 Build meaningful relationships based on good faith and partnership with communities and their representatives. When working in or near communities, develop a community engagement plan in collaboration and cooperation with Arctic Indigenous Peoples and other residents.

4.2 As research concepts develop, researchers and interested communities should determine their level of collaboration. Not all research will be of direct interest to Arctic residents, nor may all communities have the capacity to participate. Do not assume community interest or capacity prior to discussions with Tribal and community leaders.

4.3 For projects involving Arctic Indigenous residents and others as research collaborators or study participants, determine in advance who collects, owns, manages, evaluates, and disseminates the data to allow projects to proceed with a shared understanding of data governance and ownership. Work closely with community leaders or representatives to resolve conflicts if they arise.

4.4 Researchers and Arctic residents may perceive benefits and risks differently, thus potential outcomes of a research project for the community and the environment should be addressed and discussed. Researchers are encouraged to work with local liaisons and research assistants, and to engage residents in research design, planning, data collection, storage, analysis, interpretation, and reporting.

5. Pursue Responsible Environmental Stewardship

5.1 Scientific research and local and Indigenous Knowledge contribute to stewardship of the Arctic environment. Researchers should limit the impact of their research on the environment and obtain appropriate permits.

5.2 Avoid disturbing flora and fauna that are not the subject of the research and minimize disturbance to flora and fauna that are the subject of the research. In the case of fauna, researchers need to be aware of federal, state, and local regulations and coordinate with applicable land managers and experts to avoid causing unnecessary stress on individuals, herds, or populations of animals that may respond to human presence.

5.3 Avoid and minimize impacts to terrestrial, aquatic and marine habitats, including but not limited to: noise, vegetation trampling, and other environmental impacts.

Implementation

The Principles reflect the expectations of the IARPC agencies. They are based on input received from federal agencies and the public. Federal agencies will determine the most appropriate way to apply the Principles when supporting research in the Arctic.

Appendix E: Equity and Inclusion in the Next Five-Year Arctic Research Plan

This paper was prepared by Liz Weinberg with support from Nikoosh Carlo in August 2020 on behalf of the IARPC Plan Development Steering Group.

Discussions and planning around Arctic science¹ provide an opportunity to improve equity and inclusion. In particular, the 2022-2026 Arctic Research Plan may be a space in which to establish clear goals and metrics for supporting equity and inclusion in Arctic research. This paper seeks to provide definitions and examples of equity and inclusion in the context of the Arctic Research Plan. It synthesizes and strives to reflect a series of reports, articles, and other documents written by and in collaboration with Indigenous communities and Black, Indigenous, and people of color (BIPOC) scientists to analyze and explain a path toward increased equity and inclusion in Arctic science.

Drawing from these sources, this paper describes some of the historical and ongoing roadblocks to equity and inclusion. To build on existing efforts to improve equity and inclusion, it recommends actions in three key areas: centering Indigenous and BIPOC voices, knowledge, and research needs; establishing and deepening relationships; and increasing staffing and federal agency capacity.

What is the history of equity and inclusion in Arctic science?

Western science has historically been one aspect of colonization: Western science is driven by “discovery,” and information gathered by (typically white) academically-trained scientists has frequently been considered the most accurate, reliable, and important information. Science in the Arctic is no exception. However, Indigenous Peoples in the Arctic have occupied this region since time immemorial and are closely linked to Arctic lands, animals, and ecosystems; they continue to hold sovereignty over their well-being and that of the ecosystems they are a part of. For hundreds of generations they have closely observed their environment, conducted their own inquiries, and produced long-term understandings of patterns and processes in Arctic ecosystems.

Colonization disrupted the process and transmission of Indigenous Knowledge, and colonizing researchers conducted both ethical misconduct and extractive research.^{2,3,4} This history has resulted in trauma within Indigenous communities and mistrust of institutions such as the federal government, state government, and academia. BIPOC communities and individuals continue to be excluded from Arctic science communities due to the legacy of colonization, a lack of capacity building and compensation,

¹ Note: throughout this paper, the terms “science” and “research” are used interchangeably.

² Carlo, Nikoosh. 2020. Arctic Observing: Indigenous Peoples’ History, Perspectives, and Approaches for Partnership. Fairbanks: Center for Arctic Policy Studies.

³ Smith, Linda T. 1999. Decolonizing Methodologies: Research and Indigenous Peoples. London: Zed Books.

⁴ David-Chavez, Dominique M., and Michael C. Gavin. 2018. “A global assessment of Indigenous community engagement in climate research.” *Environmental Research Letters* 13, no. 12.

and the fact that these spaces typically prioritize white and Western paradigms over Indigenous and other nonwhite cultures and worldviews.^{5,6,7,8,9} In recent decades, many individuals and institutions—both Indigenous and non-Indigenous—within Arctic science have actively worked to engage Indigenous Peoples in Alaska through funding, conference invitations, and other efforts.^{10,11,12} Current Arctic science efforts present an opportunity to improve inclusion.

In the past several years, IARPC has implemented or initiated some steps to attempt to address these historical and ongoing issues, including through the formation of a Diversity & Inclusion Working Group and an Indigenous Engagement Working Group (in progress). However, IARPC and IARPC Collaborations still have far to go. There continues to be limited engagement by Indigenous people, Black people, and people of color within collaboration teams, owing to imbalances felt in those spaces, a centuries-long history of exclusion and overlooked input, and the fact that accessing collaboration teams requires internet bandwidth, which can be limited in Arctic Indigenous communities. To more effectively address some of these historical and ongoing issues and to support sustained engagement with Indigenous Peoples, Black people, and communities of color, the next Arctic Research Plan should consider *equity* and *inclusion* as foundational themes, with an emphasis on establishing clear goals and metrics.

What do equity and inclusion mean in the context of the Arctic?

Equity gives everyone the tools they need to succeed. It is often compared with *equality*, in which everyone is given the same resources or time, regardless of their starting point. In contrast, equity meets individuals and communities where they are, seeking to remove barriers and/or make up for past injustices. Equity in Arctic science means, for example, financially supporting efforts by Indigenous communities to improve internet access, working with communities to ensure that public comment periods and research projects do not overlap with important lifecycle events such as subsistence harvest times, providing mentorship and funding explicitly for scientists of color, collaborating with Indigenous communities to build capacity, training scientists and federal agency staff to effectively listen to and incorporate BIPOC comments and address their needs, and supporting community self-determination of where funding should go and how it should be used.

Inclusion means that not only are people invited into a space, but that they are given respect and fully incorporated into the group. Their comments are carefully and thoughtfully considered, they are treated fairly and respectfully, and they are welcomed. Inclusion means not prioritizing one worldview or

⁵ Association of Village Council Presidents, Kawerak Inc., Bering Sea Elders Group, and Aleut Community of St. Paul. 2020. Navigating the New Arctic Program Comment Letter.

⁶ Carlo 2020.

⁷ Inuit Circumpolar Council-Alaska. 2015. Alaskan Inuit Food Security Conceptual Framework: How to Assess the Arctic from an Inuit Perspective: Summary Report and Recommendations Report. Anchorage, AK.

⁸ Howley, Korena Di Roma. 2020. Deep Biases Prevent Diverse Talent from Advancing. Eos, <https://doi.org/10.1029/2020EO145065>

⁹ Kawerak Inc, Association of Village Council Presidents, Aleut Community of St. Paul Island, Bering Sea Elders Group, and Alaska Native Tribal Health Consortium. 2020. Letter to NOAA Fisheries, North Pacific Research Board, Alaska Ocean Observing System, and the U.S. Arctic Research Commission regarding the need for co-productive approaches to research planning in the Bering Sea, August 2, 2020.

¹⁰ “Caleb Pungowiyi.” Caleb Scholars Program. <https://www.calebscholars.org/about-caleb/>. See also the efforts and work of Orville Huntington, Richard Glenn, Vera Metcalf, Patricia Cochran, and others

¹¹ IASC. 2019. Indigenous, Early Career, & Russian Science Travel Funding Available. International Arctic Science Committee.

¹² ARCUS. Conducting Research with Northern Communities: Documented Practices and Resources for Productive, Respectful Relationships Between Researchers and Community Members.

culture over another. In Arctic science, inclusion means, for example, ensuring that BIPOC individuals have opportunities and support to speak, present, ask questions, and lead; and restructuring introductions, presentations, and discussions to incorporate multiple cultural protocols. Inclusion in Arctic science could also look like institutions ensuring that non-BIPOC researchers are trained in cultural competency and have opportunities to reflect on their personal roles in making Arctic science more inclusive.

Why center equity and inclusion in the next Arctic Research Plan?

Equity and inclusion are keys to sustained engagement with Indigenous communities and BIPOC scientists. These concepts could be applied to many other groups, including but not limited to women scientists, LGBTQ+ scientists, and scientists with disabilities, all of whom are underrepresented in Arctic science. Indeed, IARPC has made strides toward greater inclusion of women in science in particular.

However, this paper focuses on Indigenous communities and BIPOC scientists in recognition that these groups are most heavily impacted by the legacy of colonization in science, and that research has happened historically to, without communication with, and on the bodies of Indigenous and Black people. While they face many different issues and challenges, the legacy of colonization means there are significant overlaps in how equity and inclusion can be implemented. Moreover, there are overlaps in these two groups, as the “I” in BIPOC represents Indigenous individuals, including those from the Arctic.

How can we approach equity and inclusion in the Arctic Research Plan?

Creating an environment that is equitable and inclusive of historically underrepresented groups begins with understanding barriers from their perspectives. Through a survey of [community-driven articles and reports](#) by Indigenous organizations and BIPOC scientists, we identified several barriers:

Including and building equity for Indigenous Peoples into the Arctic Research Plan would first and foremost require recognizing that knowledge transfer is a two-way street; the validity of Indigenous Knowledge is often ignored. Indigenous Knowledge is a form of systematic, interconnected observation and knowledge based on thousands of years of cultural tradition and relationships with the land and ecological systems.¹³ Indigenous Peoples are experts in their landscapes, ecosystems, and cultures.^{14,15,16,17,18} Moreover, Indigenous Peoples have sovereignty over their lands and data and often have well-established information and action priorities for their communities. The value of Indigenous communities’ participation in Arctic science for those communities needs to be clear. Often these

¹³Daniel, Raychelle. 2019. Understanding our environment requires an indigenous worldview, *Eos*, 100, <https://doi.org/10.1029/2019EO137482>.

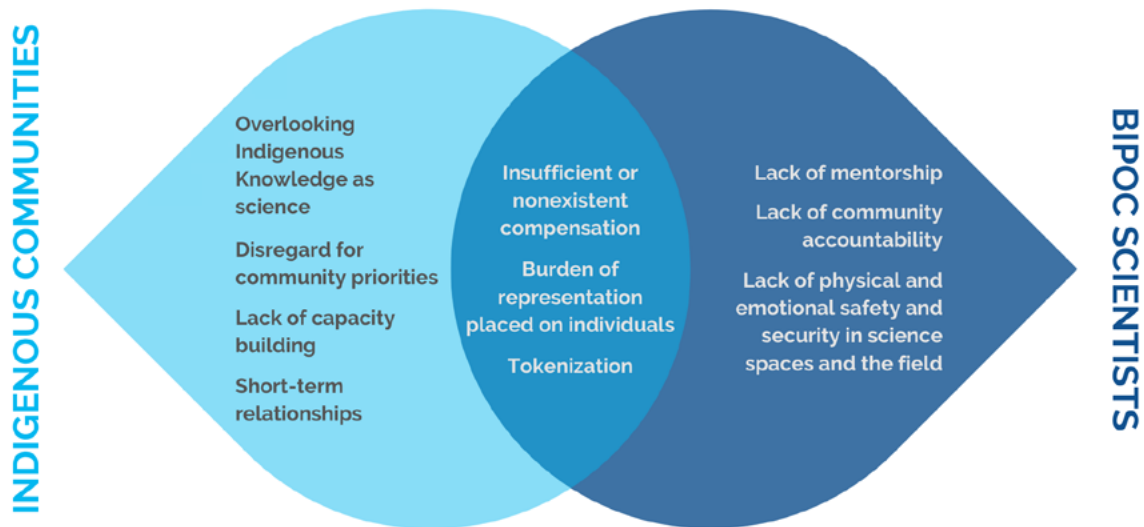
¹⁴Inuit Circumpolar Council-Alaska, 2015.

¹⁵Chang, Michael, Jasmine Ramgotra, Melissa Watkinson, Dana Wu, Ava Holliday, and Sara Breslow. 2020. 2019 Salish Sea Equity & Justice Symposium Report: Diversity, equity, inclusion, and justice in the marine and environmental fields in the Salish Sea region.

¹⁶Fienup-Riordan, Ann and Eddy Carmack. 2011. “The ocean is always changing”: Nearshore and farshore perspectives on Arctic coastal seas. *Oceanography* 24(3):266–279, <http://dx.doi.org/10.5670/oceanog.2011.78>.

¹⁷Barnhardt, Ray and Angayuqaq Oscar Kawagley. 2005. Indigenous Knowledge Systems and Alaska Native Ways of Knowing. *Anthropology and Education Quarterly*, 36(1), pp. 8-23.

¹⁸Kawerak et al. 2020.



Indigenous communities and BIPOC scientists face numerous barriers to equity and inclusion in Arctic science spaces. While each of these communities experiences its own unique barriers, some barriers, including lack of compensation and the prevalence of tokenization, are held in common. The Arctic Research Plan is an opportunity to address some of these barriers within the context of the IARPC scope of work.

communities are asked to share their data, priorities, and input without getting anything in return or seeing any significant change; in some cases their input is used to impinge upon their food sovereignty or other aspects of their communities.^{19,20,21,22}

The next Arctic Research Plan could develop teams or priorities that address inclusive and equitable research methods in which researchers gain permission from Tribal councils, build and maintain long-term relationships with communities, and support community efforts to build capacity, particularly

¹⁹Alaska Native Knowledge Network. 2000. Guidelines for Respecting Cultural Knowledge. Anchorage: AK.

²⁰University of Alaska. 2013. Improving Local Participation in Research in Northwest Alaska: Final Workshop Summary and Workgroup Recommendations.

²¹Johnson, Noor, Carolina Behe, Finn Danielsen, Eva-Maria Krümmel, Scot Nickels, and Peter L. Pulsifer. 2016. Community-Based Monitoring and Indigenous Knowledge in a Changing Arctic: A Review for the Sustaining Arctic Observing Networks. Final report to Sustaining Arctic Observing Networks. Ottawa, ON: Inuit Circumpolar Council.

²²Alaska Eskimo Whaling Commission. Our History. <http://www.aewc-alaska.org/about-us.html>.

with youth.^{23,24,25,26,27,28,29,30} To build equity and inclusion, the plan and IARPC in general could consistently create spaces and opportunities throughout the research process for Indigenous communities to be actively involved in Arctic research, particularly recognizing that lack of compensation, internet connection, and other factors are barriers that need to be overcome, and that research priorities and timing need to be set with subsistence harvesting seasons in mind. The plan could also recognize and support the need for Indigenous communities to set their own priorities and make decisions about where funding is directed.

To include and build equity for BIPOC researchers, safety and security are paramount: it is not enough to invite BIPOC researchers into Arctic science spaces without ensuring that they will be emotionally and physically safe and able to thrive when they arrive.^{31,32} An opportunity exists for the next Arctic Research Plan to emphasize the importance of safety in fieldwork situations, particularly for BIPOC women and LGBTQ+ individuals. It could encourage support for BIPOC role models and mentorship—which means encouraging hiring BIPOC scientists and compensating them for the mentorship they give other scientists.^{33,34} It is important that the onus of identifying or fixing systemic racism is not placed on BIPOC scientists, and that individual BIPOC scientists are not expected to speak on behalf of their entire race or community.³⁵ Accountability is also key: space must be made for discussions of race, racism, and the ongoing impacts of colonization, and all scientists must be held accountable for racist comments and actions.^{36,37}

For both Arctic Indigenous communities and BIPOC scientists, certain themes arise consistently. First, addressing the lack of compensation given to Indigenous communities and BIPOC scientists could help the Arctic Research Plan support equity and inclusion. BIPOC individuals continue to earn less than their white counterparts and may bear the ongoing trauma of colonization, and Indigenous communities have survived a long and continued history of land dispossession and economic marginalization.³⁸

²³Johnson et al. 2016.

²⁴Inuit Circumpolar Council. 2016. Coastal Monitoring Indigenous Knowledge Holders Meeting Report. Ottawa, ON: Inuit Circumpolar Council.

²⁵Gwich'in Tribal Council. 2011. Conducting Traditional Knowledge Research in the Gwich'in Settlement Area: A Guide for Researchers.

²⁶Interagency Arctic Research Policy Committee. 2018. Principles for Conducting Research in the Arctic.

²⁷University of Alaska 2013.

²⁸IASC. 2020. Report from the IASC Action Group on Indigenous Involvement.

²⁹Inuit Regional Corporation. Guidelines for Research in the Inuvialuit Settlement Region.

³⁰Kawerak et al. 2020

³¹Black Ecologists. 2020. Black Ecologists Statement, Ecological Society of America.

³²Langin, Katie. 2020. "I Can't Even Enjoy This." #BlackBirdersWeek Organizer Shares Her Struggles as a Black Scientist. Science, doi:10.1126/science.caredit.abd1901.

³³Black Ecologists 2020.

³⁴Howley 2020.

³⁵Nature Editors. 2020. Systemic Racism: Science Must Listen, Learn and Change. Nature 582, 147, doi: 10.1038/d41586-020-01678-x.

³⁶Dutt, Kuheli. 2020. Race and Racism in the Geosciences. Nature Geoscience 13, 2–3, <https://doi.org/10.1038/s41561-019-0519-z>.

³⁷Langin 2020.

³⁸Patten, Eileen. 2016. Racial, gender wage gaps persist in U.S. despite some progress. Pew FactTank.

Moreover, while scientists are often salaried, Indigenous community members often are not and yet are frequently asked to provide input or information.³⁹ Second, it is important to recognize and seek to address that the burden of representation often falls on a few, typically overtaxed, individuals. Third, BIPOC individuals are often brought into science spaces as “tokens” to point to a general support of diversity and inclusion, without receiving significant community support.⁴⁰

What are the stages of creating an environment that is actively equitable and inclusive?

Individual and group support for equity and inclusion can be seen along a spectrum, from roadblock to passive ally to active ally to accomplice. Effectively fostering equity and inclusion requires active allyship and accompliceship.^{41,42}

Roadblock: A roadblock dismisses the importance of equity and inclusion. They may make assumptions about Indigenous communities, BIPOC scientists, and other minoritized groups, and shut down or avoid conversations about race and racism.

Passive ally: A passive, or performative, ally recognizes the importance of equity and inclusion but in a vague and oversimplified way. They may overlook their own personal responsibility and speak over or on behalf of minoritized individuals or communities. A passive ally often expects rewards or praise for their allyship.

Active ally: An active ally recognizes the importance of equity and inclusion and strives to center it in their work. They provide funding for Indigenous communities and BIPOC scientists, call out injustice, actively work to educate themselves, and/or seek to transfer the benefits of their privilege to those without it. An active ally recognizes that their actions may not be, and do not need to be, recognized or celebrated.

Accomplice: An accomplice includes the traits of an active ally, and consistently applies themselves to challenge institutionalized racism, colonization, and white supremacy. They create long-term, meaningful relationships with the communities they are attempting to support and stand with them in support of those communities’ goals.

What are the next steps for centering equity and inclusion in the Arctic Research Plan and in IARPC?

Centering equity and inclusion will require a long-term, multi-pronged approach. In addition to the recommendations above, the Arctic Research Plan and IARPC can begin to improve equity and inclusion by:

Centering Indigenous and BIPOC Voices, Knowledge, and Research Needs

- Ensure adequate time, opportunities, and mechanisms for the public to weigh in on the draft plan, including making sure that public comment periods do not fall within subsistence harvest periods, are of adequate length, and are communicated to Indigenous entities before and during the public comment period.

³⁹IASC 2020.

⁴⁰Gewin, Virginia. 2020. What Black scientists want from colleagues and their institutions. *Nature* 583. 319-322. doi: 10.1038/d41586-020-01883-8

⁴¹Swiftwolfe, Dakota. 2019. Indigenous Ally Toolkit. Montreal Urban Aboriginal Community Strategy Network.

⁴²Phillips, Holiday. 2020. Performative Allyship Is Deadly (Here’s What to Do Instead). Forge.

- Include agreed-upon methods for Indigenous engagement and inclusion of Indigenous Knowledge throughout the plan and its implementation; emphasize the role of Co-Production of Knowledge and Tribal sovereignty.
- Collaborate with Indigenous communities to link basic research objectives to information needs identified by Indigenous Peoples and entities.
- Create a plan structure that allows participants with limited or variable availability to be involved throughout implementation.
- Support Indigenous Peoples and BIPOC peoples in leading collaboration teams and in attending presentations and meetings. This includes offering administrative support and financial compensation for their time.

Establishing and Deepening Relationships

- Encourage IARPC leadership, collaboration team leads, and others to visit communities (at times that are convenient for community members) outside of the five-year planning process to share information, receive feedback, and adjust implementation and focused efforts as requested and necessary.
- Work with local and regional entities on outreach to communities and compensate those entities for their time.
- Co-create meaningful opportunities for Indigenous leadership within the new plan structure and consider means for adequate compensation.
- Establish meaningful relationships with organizations that represent BIPOC scientists and ensure they have the means to comment on the plan draft.
- Create agreed-upon mechanisms for making knowledge generated through plan implementation useful, usable, and consistently shared.
- Use collaboration teams and self-forming teams to support a workshop to foster dialogue on historical and ongoing barriers toward equity and inclusion and paths forward.

Increasing Staffing and Federal Agency Capacity

- Hire an Indigenous engagement coordinator hosted by the IARPC Secretariat who works with and across the other federal agencies and with existing Tribal liaison networks.
- Collect best practices from federal agencies who work well with Indigenous communities.
- Offer training and programming about the history of Arctic Indigenous Peoples, colonialism in research and the Arctic, and decolonization; foster spaces for self-reflection.

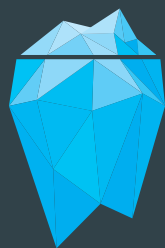
This list was generated from a variety of sources over the span of plan development to date, including those cited, the March 2019 comment letter on the National Science Foundation’s Navigating the New Arctic Program submitted by the Association of Village Council Presidents, Kawerak Inc., Bering Sea Elders Group, and Aleut Community of St. Paul,⁴³ and the August 2020 letter on co-productive approaches

⁴³Association of Village Council Presidents et al., 2020.

to research planning in the Bering Sea sent by Kawerak Inc., the Association of Village Council Presidents, the Aleut Community of St. Paul Island, the Bering Sea Elders Group, and the Alaska Native Tribal Health Consortium.⁴⁴ It is not intended to be prescriptive or exhaustive, and aims to give workshop participants and plan developers ideas to consider as they determine the content and structure of the next plan.

Through efforts like the Principles for Conducting Research in the Arctic, IARPC member agencies and IARPC Collaborations members have taken a step toward making Arctic research more equitable and inclusive. The drafting of the next Arctic Research Plan is an opportunity to deepen and strengthen these efforts, and to weave equity and inclusion throughout all our Arctic research endeavors.

⁴⁴Kawerak et al., 2020.



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