DRAFT

ARCTIC RESEARCH PLAN

2022-2026

PRODUCT OF THE

Interagency Arctic Research Policy Committee

OF THE

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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Introduction

The Arctic and IARPC

The Arctic continues to be the fastest changing region on Earth (IPCC, 2019). Climate change is the primary driver of environmental change and has an additional impact on socio-economic systems (Hinzman et al., 2017). The rapidly emerging challenges of the Arctic are complex and dynamic with global implications and profound impacts for Arctic communities. As an Arctic nation, the United States is committed to advancing understanding of the local to global consequences of Arctic change, defined as the rapid climate, environmental, cultural, and socioeconomic changes occurring in the Arctic. The interconnected and complex processes facing the Arctic create research questions that are best addressed by multiple federal agencies working together. The strong interconnections among people, natural, 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. Emerging research questions require a timely and robust response, which is being met by the Interagency Arctic Research Policy Committee (IARPC) through this bold new five-year Arctic Research Plan.

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" (ARPA Section 104). 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).[1]

Through a targeted approach to priority areas set forth in this plan, IARPC will address the most pressing Arctic research needs that require a collaborative approach and can advance understanding of the Arctic, inform policy and planning decisions, and promote the well-being of Arctic and global communities. Priority areas are new to the plan framework and are designed to respond to research challenges identified by Arctic communities, federal agencies with a presence in Alaska, federal agencies with Arctic investments, the state of Alaska, and other non-federal partners. They are also structured to be responsive to challenges that may emerge in the next five years. IARPC also aligns its work with the U.S. Arctic Research Commission's (USARC) and priority areas complement the targets laid out in the USARC Report on the Goals and Objectives for Arctic Research (2019-2020).[2] Each of the priority areas identified in this plan defines a broad goal for IARPC. These goals will be advanced by

[1] See the IARPC About Page: https://www.iarpccollaborations.org/about.html and IARPC Overview Document: https://www.iarpccollaborations.org/uploads/cms/documents/iarpc_overview.pdf

[2] Appendix A

implementation plans that will be developed and updated biennially through collaboration and discussion with non-federal partners.

The Arctic Research Plan 2022-2026 considers 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 Arctic change. It 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 also reflects the considerable interest and input received from Indigenous organizations and individuals in Alaska 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 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 and Indigenous Knowledge encompasses both cultural and ecological systems and is critical to understanding the Arctic (ICC Alaska, 2015). This plan recognizes the complex interactions between human, societal, and environmental challenges and the need for co-production of knowledge, Indigenous participation in research, and Indigenous-led research. This is especially true for research related to community resilience and health, sustainable economies and livelihoods, and risk management and hazard mitigation, which have all been identified as priority areas in this plan. Communication by federal departments and agencies with Indigenous communities, 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 take steps to increase this capacity and enhance engagement and participation of those who are often most directly impacted by Arctic change.

In 2018, IARPC updated the federal *Principles for Conducting Research in the Arctic*. These fundamental principles are meant to guide research at all stages and encourage engagement with Indigenous communities throughout the research process.[3] 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 Sovereignty and the importance of self-determination. IARPC acknowledges that the U.S. government operates under Executive Order 13175,[4] 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." IARPC also recognizes that many federal

[3] See https://www.iarpccollaborations.org/principles.html

[4] Reaffirmed in January 2021 in memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships

agencies have individual Tribal Consultation Plans that acknowledge Tribal governments' unique legal relationship with the U.S. federal government (National Strategy for the Arctic Region, 2013). Nothing in this plan supersedes the consultative obligations of individual federal agencies.

IARPC Arctic Research Plan 2022-2026 Structure and Definitions

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. Previous plans have taken a disciplinary approach, which has established strong communities of practice within each scientific discipline. This plan is taking the next step in integrating these communities of practice and creating interdisciplinary foci. In the development of this plan, IARPC engaged with federal and non-federal partners to identify the most urgent and cross-cutting research needs, resulting in multidisciplinary priority areas.

In contrast to previous IARPC Arctic research plans, this plan presents a strategy with thematic goals without explicit direction on implementation. Specific objectives, deliverables, and metrics will be described in biennial implementation plans. These implementation plans, the first of which will be released in early 2022, will also identify the collaborating teams,[5] foundational activities, and other partners that will contribute information, understanding, data, or tools needed to achieve 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.

Policy Drivers

As with the Arctic Research Plan 2017-2021, this plan adheres to four critical policy drivers[6] that reflect long-standing U.S. interests in the Arctic and the collective priorities of IARPC federal agencies. These priorities are derived from the major U.S. policy documents of the past 50 years, including the 2009 Arctic Policy Directive (NSPD 66/HSPD 25) and the 2013 National Strategy for Arctic Region (NSAR), 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, economic development, and mental and physiological health.

(2) Stewardship: Advance responsible management of the Arctic environment with an emphasis on globally driven changes.

(3) Security: Strengthen national and regional safety, as well as risk management and emergency preparedness themes.

[5] Read more about IARPC collaboration teams: https://www.iarpccollaborations.org/teams/index.html
[6] Appendix B

(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 focus that need additional attention or research, support one or more policy drivers, meet the mission and interests of more than one federal agency, and engage multiple existing collaboration teams and non-federal partners. The priority areas of this plan exemplify the complex interactions between human, societal, and environmental challenges. Recognizing this, each of the priority areas identifies a broad, cross-cutting goal which expresses the intended convergent outcomes that will be realized from research investments. Convergent research focuses on addressing complex and interconnected challenges that are rooted in societal need. It brings together knowledge, methods, and expertise from different disciplines and world views and advances new frameworks to produce usable outcomes and advance understanding.[7] The priority areas and goals include:

(1) Community Resilience and Health

Goal: Improve community resilience and well-being by strengthening research and 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 linkages to the Earth system as a whole.

(3) Sustainable Economies and Livelihoods

Goal: Monitor, maintain, and proactively adapt 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 an understanding of disaster risk exposure, sensitivity to hazard, and adaptive capacity.

Making decisions on how to prioritize critical Arctic research requires partnerships across scales and sectors. Continuing to strengthen partnerships among federal agencies, as well as with Indigenous organizations and Indigenous Knowledge holders, Tribal governments and corporations, academia and non-federal researchers, the state of Alaska, nonprofits, the private sector, and international partners and programs will be key to IARPC's success in advancing the priority areas identified in this plan. Partnerships will be developed and built upon through the implementation process.

[7] National Science Foundation Definition of Convergence: https://www.nsf.gov/od/oia/convergence/index.jsp

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. These activities have been identified as essential tools to support a robust and impactful federal research program. 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) Co-Production of Knowledge and Indigenous-Led Research

(2) Data Management

(3) Education

(4) Monitoring, Observing, Modeling, and Prediction

(5) Technology Application and Innovation

Implementation

This plan will be implemented through biennial implementation plans which will aim to align federal resources and leverage partnerships with non-federal entities. The plan provides high-level implementation guidance to IARPC and measures of success by which IARPC will hold itself accountable. As with its predecessor, this plan will be implemented by collaboration teams that are open to all interested parties. 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. These teams will direct and coordinate activities to reach the plan goals and ensure coordination and collaboration of resources to address pressing needs.

Throughout the implementation of the plan, IARPC will operate under three key overarching principles:[8]

1. Sustained Engagement: Advance respectful, responsive, and continuous engagement with Indigenous and Tribal organizations, Arctic communities, federal agencies, the state of Alaska, and all partners.
2. Inclusion and Equity: Ensure that everyone is welcomed and 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.

[8] Appendix C

Priority Area 1: Community Resilience and Health

Improve community resilience and well-being by strengthening research and 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. 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, preventative and curative health services, food security, place-based knowledge, and access to resources such as clean water and energy, shelter, and transportation (Patel et al., 2017). Arctic communities have been resilient in the face of change for thousands of years. 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). Among the many changes, from weather and temperature to the nature and scope of infectious diseases (Yoder, 2018) and the human and wildlife health risks from toxic algal blooms (Anderson et al., 2018), are growing threats to social, natural, and built systems and 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 push communities past tipping points and lead to lasting social and economic changes. While Alaska-based leaders are making progress to identify urgent health needs, prior to the COVID-19 pandemic, Alaska was identified as 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 resiliency-building efforts and create difficult decisions about what and how to prioritize (Hueffer et al., 2019).

Thanks to advances in technology, innovations in research methodologies, and improved approaches to co-production of knowledge, the circumpolar knowledge base related to community resilience and health will grow stronger over the next five years. Facilitated by developments in data management, modeling, observations, and 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. Advances will lead to an improved understanding of the physical and social impacts of stressors as well as the implications for different community responses. For example, through environmental observations and health surveillance networks, the design and implementation of models 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; concerns regarding built systems, and health disparities). Similarly, models can provide critical information for understanding the interdependence of human, animal, and

environmental health, leading to improved health outcomes and enhanced resilience via a 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 throughout the cycle of identifying research questions, conducting research, developing wellness indicators, producing results, and disseminating findings will lead to more relevant and timely knowledge co-production that can be used by decision-makers. Finally, 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, human- environmental landscapes and meet the needs of Arctic communities.

Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and Non-Federal Partners

Federal departments and agencies that 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 Interior (DOI)
- Department of State (DOS)
- Environmental Protection Agency (EPA)
- 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.

Partnerships across scales are important to achieve the Community Resilience and Health Priority Area goal. Within Alaska, partnerships with non-federal actors will be critical, since many aspects of health and resilience are handled by state, local, and Tribal authorities, as well as nongovernmental organizations. Beyond Alaska, non-federal partners have demonstrated capacity to adapt tools for Arctic applications, such as the One Health Systems Mapping and Analysis Resource Toolkit™ (developed by the University of Minnesota). Finally, since threats to community resilience and health span national boundaries, so too must the partnerships built to address them—particularly through venues such as the Arctic Council.

Priority Area 2: Arctic Systems Interactions

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

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 extents shrinking faster (Markus et al., 2009; Parkinson, 2014; Bliss et al., 2017). Arctic permafrost (perennially frozen ground) thaw is resulting in increased 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, has been retreating, and the associated melt contributes to increased sea-level rise (Aschwanden et al., 2019; Bevis et al., 2019).

These changes do not happen in isolation, but produce feedbacks that impact other components of the Arctic's natural and human systems, as well as the larger Earth systems. Understanding these interactions is becoming increasingly important, especially for predicting future Arctic and global change. For instance, changes in atmospheric constituents, clouds, and circulation affect the surface energy budget in the Arctic, thereby affecting sea ice extent. Similarly, sea ice changes and marine ecosystem changes are affected through changes in ocean circulation and heat and freshwater budgets. Changes in the Arctic affect 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).

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 expanding northward and others are shifting the timing of migrations. 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), and, in 2019, the autumn migration of

bowhead whales—an important species for Indigenous ways of life—was observed further offshore than previous light ice-cover years (Clarke et al., 2020; Stimmelmayr et al., 2020; Ferguson et al., 2021).

The impacts on the terrestrial ecosystem are also significant. Plant species in the Arctic are exhibiting changes with extended growth season, earlier snow-melting, 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). The 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., Fahnestock et al., 2019; Perryman et al., 2020).

Models that quantify the drivers of Arctic change, as well as the interactions and feedbacks of these changes with Earth 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. Different kinds of observations are also needed, including intensive short-term observational campaigns, long-term satellite and ground based observations, and models of both the individual components of the Arctic as well as the comprehensive Earth system. Modeling and observational capabilities across agencies, along with process based-research, 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 minimise the negative impacts and take advantage of the opportunities of a changing Arctic.

Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and Non-Federal Partners

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

- 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 Interior (DOI)
- Marine Mammal Commission (MMC)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)
- Smithsonian Institution (SI)

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, and the Physical Oceanography Self-Formed Team.

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 of the IARPC federal agencies, as well as domestic and international collaborators. Enhanced two-way communication, coordination, and collaboration between decision-makers, practitioners, non-federal researchers, international partners, and Indigenous communities will be key in advancing understanding of Arctic systems interactions. Building better cross-linkages among the existing collaboration teams should leverage and 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 maximize monitoring, observing, analysis, and modeling capabilities to inform decision-making.

Priority Area 3: Sustainable Economies and Livelihoods

Monitor, maintain, and proactively adapt 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 sustainable economies and livelihoods throughout the region. Arctic communities and ecosystems are experiencing environmental change at an unprecedented rate—from loss of permafrost and coastal erosion (U.S Army Corps of Engineers, 2019) to shifting demographics and economic uncertainty. 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. Together, sustainable resource management, innovative infrastructure design, and the knowledge and resilience of Arctic communities contribute to strong local economies and durable built systems.

Productive terrestrial, marine, and atmospheric systems in the U.S. Arctic are critical to sustainable Arctic livelihoods, furnishing natural resources, parks, and wilderness areas and pollock and salmon fisheries of global economic importance. Maintenance of healthy and productive ecosystems requires ongoing monitoring and assessment, establishing baseline data on distribution and abundance, and understanding the sources and impacts of observed change. Ecosystem changes have cascading effects. Changes in sea surface temperatures, contaminant levels, and migration patterns affect not just fish, marine mammal, and seabird populations, but also Arctic residents who depend on these species culturally and economically. More broadly, changes to Arctic ecosystems impact national and global economies by affecting global shipping routes, access to natural resources, and fish and seafood stocks.

Community well-being and security are heavily dependent upon infrastructure, presenting significant challenges because building and maintaining infrastructure is expensive and logistically complex in Arctic environments. Existing public and private regional infrastructure includes roads, airstrips, bridges, and harbor and port facilities; energy and electricity systems; telecommunications systems; and housing, education, healthcare, and national defense facilities. These built systems require monitoring and ongoing maintenance to meet current demand, and proactive planning and adaptation to accommodate future environmental, demographic, and geopolitical shifts (Chinowsky et al., 2009; U.S. Committee on the Marine Transportation System, 2016).[9] Current areas of concern include poor construction and maintenance of roads, airstrips, landfill and waste sites; inadequate housing; lack of access to clean water; unreliable, expensive energy and commodities; and maintenance backlogs at educational and healthcare facilities. To respond effectively, federal agencies need accurate, up-to-date data on existing facilities, assessments of future needs, and decision-support tools to plan, design,

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

and construct infrastructure capable of supporting local and regional economies and mitigating the impacts of future change (U.S. Arctic Research Program, 2019).

Coordinated federal action will facilitate effective observation, monitoring, maintenance, and adaptation of Arctic ecosystems and infrastructure. Federal activities and policies must consider community resilience and the well-being and long-term security of sustainable economies. Research responsive to local needs, challenges, and solutions is essential to effectively identifying and addressing critical concerns such as community relocation, loss of housing to erosion and thawing permafrost, and emergency response planning. Successful community partnerships depend upon early and ongoing communication and collaboration with multigenerational participation to achieve sustainable outcomes.[10] Priorities identified by Arctic communities include, for example, accessible and affordable telecommunications infrastructure, healthy fisheries and marine mammal populations, and inclusion in federal marine transportation policy planning (Alaska Federation of Natives, 2017; Fischer et al, 2020).

Federal responsiveness to the concerns and priorities of Arctic communities and Indigenous organizations depends upon accurate, up-to-date data derived from both basic and applied research. Federal programs can prioritize urgent and impactful applied work that effectively links federal action to sustainable economies (Fischer et al, 2020), with careful consideration of Indigenous ways of life, living conditions, and the management of natural resources (Promoting Resilience and Adaptation in Coastal Arctic Alaska, 2017). Inclusive coordination of monitoring activities and infrastructure maintenance will ideally avoid duplication of efforts, reduce burdens on communities, and promote transparency and fiscal responsibility.

By 2026, federal agency coordination and action will strive to improve data collection, cataloging, and needs assessment of Arctic infrastructure. Such coordination will advance coastal and offshore geophysical mapping; updated topographic, vegetation, and hydrographic datasets; evaluation of soil, water, and air quality and contaminants; marine pollution and debris; and populations of key species. It will also improve natural resource assessments and the evaluation of the economic, social, and environmental effects of resource extraction and use.

Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and Non-Federal Partners

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

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

[10] *Principles for Conducting Research in the Arctic*: https://www.iarpccollaborations.org/principles.html

- Department of Defense (DOD)
- Department of Energy (DOE)
- Department of Homeland Security (DHS)
- Department of Health and Human Services (DHHS)
- 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)

IARPC collaboration teams that align well with the Sustainable Economies and Livelihoods Priority Area include: Coastal Resilience, Marine Ecosystems, Terrestrial Ecosystems, and Permafrost. IARPC does not currently host a collaboration team focused on Arctic infrastructure.[11] Development of such a team to coordinate 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 non-federal partners. State of Alaska departments and agencies are critical collaborators. Tribal governments and village and regional Alaska Native Claims Settlement Act (ANCSA)[12] corporations are essential for knowledge co-production and ensuring that federal efforts respond to community needs. International advisory and working groups, such as marine mammal and other co-management, species-focused organizations,[13] also play key roles in sustainable Arctic livelihoods.

[11] See 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: https://www.gao.gov/assets/710/706502.pdf
[12] Alaska Native Claims Settlement Act of 1971.
[13] E.g., Alaska Eskimo Whaling Commission, Eskimo Walrus Commission, Western Arctic Caribou Herd Working Group.

Priority Area 4: Risk Management and Hazard Mitigation

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

Justification

The principal policy driver for the Risk Management and Hazard Mitigation Priority Area is the Security Policy Driver focused on strengthening national and regional safety and security. This includes 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 a good life and well-being for all Arctic communities.

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. Development requires needs-driven efforts that look for scientific solutions to address foreseeable risk management and hazard mitigation needs in the near- and mid-term. Arctic communities and leaders responsible for infrastructure (e.g., villages, towns, cities, military installations, ports, 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 Health Consortium's Center for Environmentally Threatened Communities, and others.

Arctic risk management and hazard mitigation challenges are diverse (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 [RNWG, 2009], ocean acidification, sea-level rise, environmental degradation, and coastal erosion), acute and episodic events (e.g., unusual mortality events, harmful algal blooms, wildfires, shipwrecks, oil spills, and pandemics), and holistic security concerns (e.g., domain awareness, communications fragility, 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 and leaders, Indigenous organizations, emergency managers and service providers (operators and planners), and researchers. It is through collaborative research activities that advancements in prevention, protection, mitigation, response, and recovery can be achieved.

Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and Non-Federal Partners

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

- Denali Commission
- 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 Interior (DOI)
- 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, Health and Well-Being, Sea Ice, Terrestrial Ecosystems, Glaciers & Sea Level, Data Sub-Team, and the Arctic Observing Systems Sub-Team.

Partnerships that will be critical to achieving this goal include engineers, emergency managers, and community planners from 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.

Foundational Activities

Introduction

Foundational activities are critical in supporting the priority areas in this plan as well as a robust federal research program in the Arctic. In many cases, these activities draw from strong communities of practice that have supported 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 new and emerging topics.

Co-Production of Knowledge and Indigenous-Led Research

Indigenous Peoples have been part of the Arctic region for millennia and their histories, cultures, and knowledge are critical to understanding Arctic socio-ecological systems. Indigenous Knowledge has developed over many generations, providing a holistic perspective of the Arctic environment, but has yet to be sufficiently incorporated in many federal research efforts. Given the many perspectives held by Indigenous Peoples, federally-funded monitoring, research, and decision-making in the Arctic should build upon and expand opportunities for co-production of knowledge and Indigenous-led research. Activities initiated by and with Indigenous organizations and knowledge holders are more likely to effectively address local needs and their solutions. IARPC supports co-production of knowledge and Indigenous-led research as a foundational activity across all four priority areas because of the clear and inherent value of these activities.

Many collaborative and shared activities can be defined as co-production of knowledge. The Inuit Circumpolar Council (ICC Alaska, 2020, p. 32) describes co-production of knowledge as a process by which Indigenous Knowledge and science are *brought together* to understand the Arctic for adaptive and holistic decision-making. IARPC adopts this definition as it encompasses the many formal and informal processes by which Indigenous Peoples, Arctic communities, researchers, and policy makers work together to define challenges and conduct research collaboratively. This definition allows space for those directly affected by and potentially benefiting from federal activities to create a co-produced process and define needed research. Similarly, the term Indigenous-led research may incorporate different types of activities, but at its core, it is about increasing capacity and opportunity for Indigenous-led and Indigenous-driven research (Petrov et al., 2020).

IARPC does not currently host a collaboration team focused on this foundational activity but will create a forum of representatives from both federal agencies and Indigenous entities to create a co-produced list of specific and actionable recommendations to assist IARPC and federal agencies in implementing this foundational activity. Additionally, IARPC will strive to make advances to better support co-production of knowledge and Indigenous-led research by:

- **Enabling Communication and Coordination:** IARPC will continue to support communication and coordination between federal agencies and Indigenous Arctic communities to ensure

active participation and long-term engagement, and so that 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 federal 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 communication and coordination, and multigenerational participation. IARPC will continue to invest in activities that build trust among federal agencies, federally-funded researchers, and Indigenous Peoples 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 educate researchers on building trust, effective communication, and respecting Indigenous Peoples and cultures of the Arctic. IARPC will promote the use of these principles among IARPC agencies and track their effectiveness.
- **Increasing Capacity within Arctic Communities for Indigenous-Led Research:** IARPC will host discussions about federal funding opportunities to enhance research and capacity building that would enable more Indigenous entities and scholars to pursue their own observations and research. Similarly, IARPC will promote actions to identify ways that federal administrative structures can be adapted or changed for greater inclusion of Indigenous voices and to support Indigenous-led research. IARPC will seek opportunities to support the development or expansion of community-driven programs and liaison offices in coordination with community and Indigenous-led organizations already in place.

Data Management

Arctic data, which can include Indigenous Knowledge, are irreplaceable. Often stemming from difficult and remote conditions, Arctic data are valuable in a time of rapid environmental 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 the reuse of these products. 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. IARPC encourages the scientific community to adopt open data collections, develop intelligent data management tools and practices, and use 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, co-production of knowledge, 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 (Carroll et al., 2019) and autonomy.

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 more data available and will improve U.S. Arctic research. Innovations in data collection, curation, discoverability, and use, such as new advances in artificial intelligence, 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). Clear guidance, aligned with FAIR and CARE, on how to manage data compliant with these broad federal mandates can benefit federal agencies that enable the Arctic research enterprise and can support each other in achieving these aims (e.g., Arctic Spatial Data Infrastructure). Federal agencies should aim to make data 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

Education and outreach are fundamental to Arctic research, policy development, and community resilience. Arctic education spans pre-school, K-12, post-secondary to post-doctoral, and community culture-based instruction and learning, and is ongoing within the practicing research community. Education comprises varied knowledge systems, including scientific disciplines, place-based and

Indigenous Knowledge, and skill acquisition such as grant writing 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 STEM (science, technology, engineering, and mathematics) team will promote education across all priority areas. Given the wide range of agency research missions and the education and outreach programs supported by federal agencies and their 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. IARPC will elevate the profile of STEM education to bring a greater focus to the value and content of Arctic-specific education 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 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 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; (3) generate academic-workforce development opportunities (e.g., internship programs); (4) enhance coordination among varied federal and external 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 science.

The future workforce will continue to require the deep disciplinary expertise needed to meet the missions of IARPC agencies while also requiring teams capable of exercising scientific and demographic diversity and different knowledge systems. 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, improve 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). 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. It 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 remote and in situ observing systems suitable for Arctic conditions; 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. Future development of Arctic observing capabilities should consider potential environmental impacts and incorporate Indigenous Knowledge through co-production in the design and implementation of observing systems (Krupnik and Jolly, 2002).

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 plans, mitigation of hazards, and development of resilience plans. 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 artificial intelligence (AI) 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 sub-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 Foundational Activity, training of the next generation in MOMP activities should 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) and its engagement with the Sustaining Arctic Observing Networks (SAON) initiative, 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.

Technology Innovation and Application

At a broad scale, technology and technological solutions will enable, accelerate, and deliver accurate information, products, and solutions to the Arctic research and development (R&D) community as it strives to address challenges posed by the priority areas identified in this plan. In deploying new and existing technologies, it is likely that unknown technological barriers will emerge. IARPC will employ its existing Polar Technology Community Forum to support this activity as it encourages the broad R&D community across the priority areas to adopt the most relevant and efficient 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, distributed generation, storage, and distribution; 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 to Arctic partners).

Technology and innovation required to support the priority areas are not limited to hardware, but also include software (e.g., artificial intelligence, database development, and supercomputing), modeling, mapping, and forecasting. Improved models of the entire Arctic domain, from human systems to the edge of the atmosphere and the depths of the oceans, 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 can provide the rapid influx of human and financial resources necessary to drive accelerated development and commercialized solutions. IARPC will help create and support these collaborative partnerships with the aim to accelerate delivery of technological solutions across the priority areas.

The IARPC community 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. This could include integration of Light Detection and Ranging (LiDAR) and derived products, expanded use of artificial intelligence, 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 technology 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.

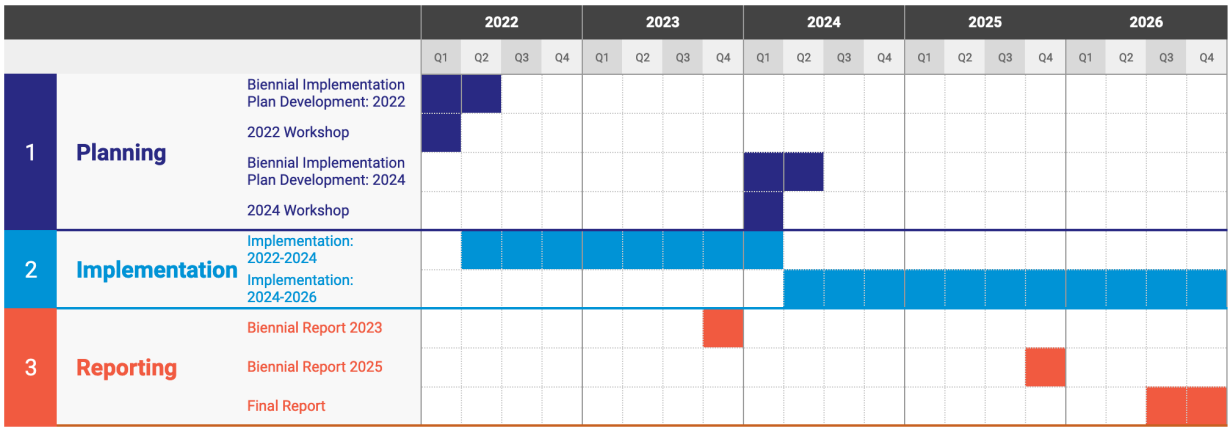
Implementation and Metrics for Measuring Success

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, multi-disciplinary approach. The existing IARPC teams[14,15] and the communities of practice that they have engendered 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. Four new priority area collaboration teams will be established to direct and coordinate activities to reach the mid-term and five-year goals and to ensure coordination and collaboration of resources to address pressing needs. These multi-disciplinary teams will be co-chaired by at least one federal program manager and one non-federal partner. Engagement of Indigenous partners in the planning and execution of research will be supported by enabling Indigenous-led research, promoting co-production of knowledge, and increasing financial support for Indigenous leadership in meetings, conferences, and research programs.

Planning: Implementation of the plan will be outlined in biennial implementation plans. The first of these plans will be completed in early 2022 and subsequently updated in the first half of 2024 (see timeline). The biennial implementation plan will outline objectives, deliverables, and metrics of success that will be completed within the first two years. Development of the first biennial implementation plan will follow a workshop that will recommend short-term goals and deliverables. The 2022 biennial implementation plan will be updated in early 2024 with consideration of previous achievements and current assessment of the most effective approach to achieve the long-term goals. During the final year (2025), team leaders will determine if an extension or revision of the implementation plan is required. Biennial implementation plans will be approved by IARPC agencies.

[14] Current 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, Diversity & Inclusion Working Group, Early Career Forum, Physical Oceanography, Science Communication Forum, U.S. Forum for the International Arctic Science Committee.

[15] The 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.



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 Collaborations[16] 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 develop the biennial implementation plans and help define what can be accomplished to advance the priority area goals and objectives. The involvement of relevant partners outside the federal sphere in all of the IARPC teams will enable greater progress by leveraging external resources and expertise.

Reporting: In the autumn of 2023 and 2025, priority area collaboration team leaders will produce a biennial 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. Reports will include evaluation based on the metrics of success (outlined below), and accomplishments related to priority area goals and foundational activities. These biennial reports, as called for in the Arctic Research Policy Act (ARPA), will help the public, research, and policy communities understand the progress, obstacles, and pathways toward achievement of goals in this plan and detail responsiveness to the U.S. Arctic Research Commission's Biennial Goals Report. At the end of 2026, a final report will evaluate the outcomes 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 website, which serves as a platform for coordinating federal government program managers and scientists, the non-federal research community, and other partners 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

[16] IARPC 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 communications enabled through the website.

those participating in implementation can post achievements towards the goals outlined in this plan and the deliverables described in the biennial implementation plans.

Measuring Success: Within the biennial implementation plans, specific metrics will be developed as appropriate to the goals and deliverables for each priority area. Deliverables may include tools, reports, articles, workshops, outreach or education events, webinars, and products tailored to decision-makers or other end users. General metrics of success should guide biennial implementation plan development for each priority area and will also be used to assess progress every two years and at the end of the five-year plan. They are as follows:

- How do achievements present convergence among activities within each priority area and ensure mid-term goals, metrics, and completed activities build toward overarching priority area goals?
- How do the outcomes and deliverables advance one or more policy drivers?
- How do the outcomes and deliverables meet the mission and interests of more than one federal agency?
- How are the outcomes and deliverables used by decision-makers in the Arctic, in Alaska, and throughout the nation?
- How do the priority area collaboration teams engage external partners (e.g., state of Alaska, Arctic communities, private sector, public interest groups, international entities, Tribes, and Indigenous entities)?
- How have foundational activities enhanced and supported Arctic research and advanced progress towards priority area goals?
- How does IARPC facilitate the research and reporting activities of each priority area?
- How do the achievements demonstrate accelerated progress, improve efficacy, and result in more efficient use of government resources?

The IARPC Staff Group and Principals will provide oversight on the success of IARPC's efforts to address priority area goals in support of the policy drivers and meet the mission priorities of federal agencies.[17] Expected outcomes and deliverables from these efforts include substantially advanced scientific understanding of the evolution of the Arctic system, the impact to Arctic societies and individuals, and the consequent global impacts. Results of these concerted efforts will yield greater predictive capabilities and improved capacity for communities and federal agencies to adapt to pressing environmental changes while also enabling more informed decisions.

[17] See IARPC About Page: https://www.iarpccollaborations.org/about.html and IARPC Overview Document: https://www.iarpccollaborations.org/uploads/cms/documents/iarpc_overview.pdf

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Appendices

A. Alignment of Priority Areas with USARC Goals Report
B. Policy Driver Background Document
C. Overview of Engagement Process
D. List of IARPC Agencies and Principals
E. Principles for the Conduct of Research in the Arctic
F. Equity and Inclusion Background Document