

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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17

Introduction

18 The Arctic and IARPC

19 The Arctic continues to be the fastest changing region on Earth (IPCC, 2019). Climate change is the
20 primary driver of environmental change and has an additional impact on socio-economic systems
21 (Hinzman et al., 2017). The rapidly emerging challenges of the Arctic are complex and dynamic with
22 global implications and profound impacts for Arctic communities. As an Arctic nation, the United States
23 is committed to advancing understanding of the local to global consequences of Arctic change, defined
24 as the rapid climate, environmental, cultural, and socioeconomic changes occurring in the Arctic. The
25 interconnected and complex processes facing the Arctic create research questions that are best
26 addressed by multiple federal agencies working together. The strong interconnections among people,
27 natural, and built systems must be considered. For example, the changing climate in the Arctic impacts
28 energy, water, and food security (Markon et al., 2018) while also implicating community health and
29 resilience, natural resource development, infrastructure, commercial activities, and ecosystem
30 services, and creating hazards for both Arctic and global communities. Emerging research questions
31 require a timely and robust response, which is being met by the Interagency Arctic Research Policy
32 Committee (IARPC) through this bold new five-year Arctic Research Plan.

33 IARPC was established by the Arctic Research Policy Act of 1984 (ARPA) to "facilitate cooperation
34 between the Federal Government and State and local governments in Arctic research" and
35 "recommend the undertaking of neglected areas of research" (ARPA Section 104). Now a subcommittee
36 of the National Science and Technology Council (NSTC), IARPC enhances scientific monitoring and
37 research on individual components of the Arctic, as well as how the system operates as a whole, through
38 the coordination of federal agencies and domestic and international collaborators. It consists of
39 representatives from 14 federal agencies, the White House Office of Science and Technology Policy
40 (OSTP), and the Office of Management and Budget (OMB).¹

41 Through a targeted approach to priority areas set forth in this plan, IARPC will address the most pressing
42 Arctic research needs that require a collaborative approach and can advance understanding of the
43 Arctic, inform policy and planning decisions, and promote the well-being of Arctic and global
44 communities. Priority areas are new to the plan framework and are designed to respond to research
45 challenges identified by Arctic communities, federal agencies with a presence in Alaska, federal
46 agencies with Arctic investments, the state of Alaska, and other non-federal partners. They are also
47 structured to be responsive to challenges that may emerge in the next five years. IARPC also aligns its
48 work with the U.S. Arctic Research Commission's (USARC) and priority areas complement the targets
49 laid out in the USARC Report on the Goals and Objectives for Arctic Research (2019-2020).² Each of the
50 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.iarpcollaborations.org/about.html> and IARPC Overview Document: https://www.iarpcollaborations.org/uploads/cms/documents/iarpc_overview.pdf

² Appendix A

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

53 The Arctic Research Plan 2022-2026 considers the needs of all people who live in the U.S. Arctic as well
54 as the larger national and global community who are also impacted by Arctic change. It considers input
55 from as many voices as possible, drawing from documents and reports developed by the state of Alaska
56 and local, regional, national, and international organizations. It also reflects the considerable interest
57 and input received from Indigenous organizations and individuals in Alaska who are significantly
58 impacted by Arctic change and are also often first to experience these impacts. The rapidity of emerging
59 research questions in the Arctic requires quick and decisive action to better observe, predict, and
60 understand those shifts. IARPC responds to this need by aiming to deliver science and knowledge to
61 decision-makers in the Arctic and beyond.

62 Through this plan, IARPC seeks to build and sustain a stronger relationship between the federally
63 funded research enterprise and Arctic communities. In Alaska, a significant number of Arctic
64 communities and those closest to the impacts of Arctic change are Indigenous. Indigenous Peoples
65 have inhabited the region since time immemorial and Indigenous Knowledge encompasses both
66 cultural and ecological systems and is critical to understanding the Arctic (ICC Alaska, 2015). This plan
67 recognizes the complex interactions between human, societal, and environmental challenges and the
68 need for co-production of knowledge, Indigenous participation in research, and Indigenous-led
69 research. This is especially true for research related to community resilience and health, sustainable
70 economies and livelihoods, and risk management and hazard mitigation, which have all been identified
71 as priority areas in this plan. Communication by federal departments and agencies with Indigenous
72 communities, as well as with the state of Alaska, federal resource managers, and other state and local
73 officials has improved over the past decade, but there is room for IARPC to strengthen effective two-
74 way communications and relationships. Recognizing that financial and human resources are limited,
75 both within federal agencies and in Arctic communities, this plan encourages IARPC to take steps to
76 increase this capacity and enhance engagement and participation of those who are often most directly
77 impacted by Arctic change.

78 In 2018, IARPC updated the federal *Principles for Conducting Research in the Arctic*. These fundamental
79 principles are meant to guide research at all stages and encourage engagement with Indigenous
80 communities throughout the research process.³ This plan emphasizes the responsibility that IARPC and
81 the federal research community have to be inclusive of Indigenous Knowledge and cultures and
82 recognizes and respects Tribal Sovereignty and the importance of self-determination. IARPC
83 acknowledges that the U.S. government operates under Executive Order 13175,⁴ which directs federal
84 agencies to “establish regular and meaningful consultation and collaboration with tribal officials in the
85 development of federal policies that have tribal implications [and] to strengthen the United States
86 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](#)

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

90 **IARPC Arctic Research Plan 2022-2026 Structure and Definitions**

91 The Arctic Research Plan 2022-2026 is the third plan developed to coordinate federal Arctic research
92 since IARPC became a subcommittee of the NSTC in 2010. IARPC, through a five-year planning cycle,
93 seeks to address critical areas for which an interagency approach can accelerate progress. It does not
94 attempt to address all federally funded research in the Arctic nor does it seek to address all research
95 questions or individual agency priorities in the Arctic. Previous plans have taken a disciplinary
96 approach, which has established strong communities of practice within each scientific discipline. This
97 plan is taking the next step in integrating these communities of practice and creating interdisciplinary
98 foci. In the development of this plan, IARPC engaged with federal and non-federal partners to identify
99 the most urgent and cross-cutting research needs, resulting in multidisciplinary priority areas.

100 In contrast to previous IARPC Arctic research plans, this plan presents a strategy with thematic goals
101 without explicit direction on implementation. Specific objectives, deliverables, and metrics will be
102 described in biennial implementation plans. These implementation plans, the first of which will be
103 released in early 2022, will also identify the collaborating teams,⁵ foundational activities, and other
104 partners that will contribute information, understanding, data, or tools needed to achieve priority area
105 goals. This transition to biennial implementation plans will help IARPC respond more swiftly to
106 emerging or immediate needs while it continues to support U.S. Arctic policy.

107 **Policy Drivers**

108 As with the Arctic Research Plan 2017-2021, this plan adheres to four critical policy drivers⁶ that reflect
109 long-standing U.S. interests in the Arctic and the collective priorities of IARPC federal agencies. These
110 priorities are derived from the major U.S. policy documents of the past 50 years, including the 2009
111 Arctic Policy Directive (NSPD 66/HSPD 25) and the 2013 National Strategy for Arctic Region (NSAR), and
112 are still relevant today.

113 Policy drivers include:

- 114 (1) Well-Being: Enhance the wellness of Arctic residents with an emphasis on the themes of cultural
115 vibrancy, economic development, and mental and physiological health.
- 116 (2) Stewardship: Advance responsible management of the Arctic environment with an emphasis
117 on globally driven changes.
- 118 (3) Security: Strengthen national and regional safety, as well as risk management and emergency
119 preparedness themes.

⁵ Read more about IARPC collaboration teams: <https://www.iarpccollaborations.org/teams/index.html>

⁶ Appendix B

120 (4) Arctic-Global Systems: Improve understanding of the Arctic as a component of planet Earth.

121 **Priority Areas**

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

132 (1) Community Resilience and Health

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

135 (2) Arctic Systems Interactions

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

138 (3) Sustainable Economies and Livelihoods

139 Goal: Monitor, maintain, and proactively adapt the Arctic's natural, social, and built systems to
140 promote sustainable economies and livelihoods.

141 (4) Risk Management and Hazard Mitigation

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

144 Making decisions on how to prioritize critical Arctic research requires partnerships across scales and
145 sectors. Continuing to strengthen partnerships among federal agencies, as well as with Indigenous
146 organizations and Indigenous Knowledge holders, Tribal governments and corporations, academia and
147 non-federal researchers, the state of Alaska, nonprofits, the private sector, and international partners
148 and programs will be key to IARPC's success in advancing the priority areas identified in this plan.
149 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>

150 Foundational Activities

151 In addition to identifying four priority areas, this plan builds upon five foundational activities. While
152 many of the foundational activities are already supported by existing IARPC collaboration teams, they
153 will now be formalized in the plan framework to better identify and link these activities to supporting,
154 informing, and advancing each of the priority areas. These activities have been identified as essential
155 tools to support a robust and impactful federal research program. They are critical to achieving the
156 priority area goals identified in this plan and will remain foundational to Arctic research beyond the five
157 year duration of this plan.

158 Foundational activities include:

- 159 (1) Co-Production of Knowledge and Indigenous-Led Research
- 160 (2) Data Management
- 161 (3) Education
- 162 (4) Monitoring, Observing, Modeling, and Prediction
- 163 (5) Technology Application and Innovation

164 Implementation

165 This plan will be implemented through biennial implementation plans which will aim to align federal
166 resources and leverage partnerships with non-federal entities. The plan provides high-level
167 implementation guidance to IARPC and measures of success by which IARPC will hold itself
168 accountable. As with its predecessor, this plan will be implemented by collaboration teams that are
169 open to all interested parties. Teams currently include members from federal, state, academic,
170 nonprofit, private sector, Indigenous, and international organizations. In addition to existing
171 collaboration teams, four new priority area collaboration teams will be established. These teams will
172 direct and coordinate activities to reach the plan goals and ensure coordination and collaboration of
173 resources to address pressing needs.

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

- 175 1. Sustained Engagement: Advance respectful, responsive, and continuous engagement with
176 Indigenous and Tribal organizations, Arctic communities, federal agencies, the state of
177 Alaska, and all partners.
- 178 2. Inclusion and Equity: Ensure that everyone is welcomed and treated fairly and respectfully
179 and promote access to the tools needed to succeed.
- 180 3. Transparency and Accessibility: Commit to activities and decisions that are transparent and
181 communicated clearly and in an accessible format.

⁸ Appendix C

182

Priority Area 1: Community Resilience and Health

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

185 Justification

186 The Community Resilience and Health Priority Area reflects an integrated approach to federal research
187 directly related to the Well-Being Policy Driver, with implications for the Stewardship and Security
188 drivers. Resilience is the ability of a system to bounce back and thrive during and after disturbances and
189 shocks (SDWG, 2019). For a community to be resilient, there are many interacting elements including
190 the community's outlook, governance and leadership structures, interpersonal networks,
191 preparedness, preventative and curative health services, food security, place-based knowledge, and
192 access to resources such as clean water and energy, shelter, and transportation (Patel et al., 2017).
193 Arctic communities have been resilient in the face of change for thousands of years. Yet, the last half
194 century has brought changes of unprecedented pace and scale with implications for economies,
195 cultures, the environment, and health (Arctic Council, 2016). Among the many changes, from weather
196 and temperature to the nature and scope of infectious diseases (Yoder, 2018) and the human and
197 wildlife health risks from toxic algal blooms (Anderson et al., 2018), are growing threats to social,
198 natural, and built systems and increasing health disparities between Indigenous and non-Indigenous
199 populations (Gamble et al., 2016). Mega-events, such as the public health emergency created by the
200 COVID-19 pandemic, can impose additional shocks that may push communities past tipping points and
201 lead to lasting social and economic changes. While Alaska-based leaders are making progress to
202 identify urgent health needs, prior to the COVID-19 pandemic, Alaska was identified as the state with
203 the greatest health security challenges (National Health Security Preparedness Index, 2019). Taken
204 individually, these various stressors pose formidable challenges for community resilience, health, and
205 well-being. Taken together, combinations of stressors can greatly complicate resiliency-building efforts
206 and create difficult decisions about what and how to prioritize (Hueffer et al., 2019).

207 Thanks to advances in technology, innovations in research methodologies, and improved approaches
208 to co-production of knowledge, the circumpolar knowledge base related to community resilience and
209 health will grow stronger over the next five years. Facilitated by developments in data management,
210 modeling, observations, and technology (including advanced computing and machine learning), and
211 other foundational activities, notable improvements are expected in the predictive understanding of
212 stressors, their characteristics, co-occurrence, and expected changes over time, from local to
213 circumpolar scales. Advances will lead to an improved understanding of the physical and social impacts
214 of stressors as well as the implications for different community responses. For example, through
215 environmental observations and health surveillance networks, the design and implementation of
216 models will strengthen methods for measuring multidimensional threats to community resilience and
217 well-being (e.g., environmental and social changes that impact Arctic communities; energy, food
218 security, and water quality; concerns regarding built systems, and health disparities). Similarly, models
219 can provide critical information for understanding the interdependence of human, animal, and

220 environmental health, leading to improved health outcomes and enhanced resilience via a One Health
221 approach applied to the Arctic (e.g., Hueffer et al., 2019). Research will examine the ways that complex
222 global stressors, such as the COVID-19 pandemic and climate change, interface with Arctic community
223 resilience and health. Furthermore, the equitable inclusion of Indigenous Knowledge holders will
224 strengthen methods for measuring multidimensional threats to community resilience and health,
225 including but not limited to the impacts of sea level rise, coastal erosion, permafrost thaw, and other
226 environmental changes on societies and culture, food security and water quality, and built systems.
227 Improvements in meaningful engagement with Indigenous and local organizations throughout the
228 cycle of identifying research questions, conducting research, developing wellness indicators, producing
229 results, and disseminating findings will lead to more relevant and timely knowledge co-production that
230 can be used by decision-makers. Finally, increased connectivity with other Arctic nations will facilitate
231 stronger information sharing and foster collaborative international research projects that advance
232 understanding of transboundary resilience and health challenges. These expected research
233 developments illustrate the broad scope of progress and its potential to both inform fundamental
234 understanding of these highly complex, human- environmental landscapes and meet the needs of
235 Arctic communities.

236 **Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and** 237 **Non-Federal Partners**

238 Federal departments and agencies that align well with the Community Resilience and Health Priority
239 Area include:

- 240 ● Department of Agriculture (USDA)
- 241 ● Department of Commerce (DOC)
- 242 ● Department of Defense (DOD)
- 243 ● Department of Energy (DOE)
- 244 ● Department of Health and Human Services (DHHS)
- 245 ● Department of Homeland Security (DHS)
- 246 ● Department of Housing and Urban Development (HUD)
- 247 ● Department of Interior (DOI)
- 248 ● Department of State (DOS)
- 249 ● Environmental Protection Agency (EPA)
- 250 ● Marine Mammal Commission (MMC)
- 251 ● National Aeronautics and Space Administration (NASA)
- 252 ● National Science Foundation (NSF)
- 253 ● Smithsonian Institution (SI)
- 254 ● U.S. Arctic Research Commission (USARC)

255

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

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

267

Priority Area 2: Arctic Systems Interactions

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

270 Justification

271 The Arctic Systems Interactions Priority Area is directly related to the Stewardship and Arctic-Global
272 Systems policy drivers, with implications for the Well-Being and Security policy drivers. The Arctic is the
273 fastest changing region on Earth, with changes observed in physical, biological, and socioeconomic
274 systems. Over the past several decades, Arctic air, ocean, and land temperatures have increased at a
275 rate more than twice the global average (IPCC, 2018; Jansen et al., 2020), a phenomenon known as
276 "Arctic Amplification." Arctic sea ice extent has decreased dramatically, with summer melting occurring
277 earlier, and both the summer and winter sea ice extents shrinking faster (Markus et al., 2009; Parkinson,
278 2014; Bliss et al., 2017). Arctic permafrost (perennially frozen ground) thaw is resulting in increased
279 carbon emissions that further exacerbate global temperature increase (Schuur et al., 2015; Turetsky et
280 al., 2019). Additionally, the Greenland Ice Sheet, the largest ice mass in the Northern Hemisphere, has
281 been retreating, and the associated melt contributes to increased sea-level rise (Aschwanden et al.,
282 2019; Bevis et al., 2019).

283 These changes do not happen in isolation, but produce feedbacks that impact other components of the
284 Arctic's natural and human systems, as well as the larger Earth systems. Understanding these
285 interactions is becoming increasingly important, especially for predicting future Arctic and global
286 change. For instance, changes in atmospheric constituents, clouds, and circulation affect the surface
287 energy budget in the Arctic, thereby affecting sea ice extent. Similarly, sea ice changes and marine
288 ecosystem changes are affected through changes in ocean circulation and heat and freshwater
289 budgets. Changes in the Arctic affect atmospheric circulation by altering the jet stream and the polar
290 vortex, which in turn influences midlatitude weather in the United States (Cohen et al., 2020).

291 Changes within individual components of the Arctic system can have cascading impacts on the
292 integrated system. For instance, sea ice change, thawing permafrost, changing storm strength, and
293 increased sea level due to glacial melt all have an interconnected effect on Arctic coastlines, such as
294 increased flooding, leading to erosion (Thoman et al., 2020; Radosavljevic et al., 2016; Barnhart et al.,
295 2014; Overduin et al., 2014), which can have large economic impacts (Larsen et al., 2008; Melvin et al.,
296 2017).

297 In recent years, ocean primary productivity in nearly all regions of the pan-Arctic was higher than in the
298 past, which can be linked to lower sea ice cover and increased nutrient availability (Frey et al., 2019;
299 Thoman et al., 2020). In addition, with changes in sea ice and water temperature, some species are
300 expanding northward and others are shifting the timing of migrations. For example, in 2017,
301 commercially important Pacific cod and pollock in the Bering Sea expanded north approximately 500-
302 1,000 km in less than 12 months (Stevenson and Lauth, 2019), and, in 2019, the autumn migration of

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

305 The impacts on the terrestrial ecosystem are also significant. Plant species in the Arctic are exhibiting
306 changes with extended growth season, earlier snow-melting, and altered precipitation patterns
307 (Schoor et al., 2018). Wildfire frequency and intensity are impacted by air temperature and weather
308 patterns while soils, permafrost, hydrology, the terrestrial ecosystem, and human health are impacted
309 when an area burns (Thoman et al., 2020). The enhanced fire activity, permafrost thaw, and changes to
310 local and regional hydrologic cycles are also expected to enhance the release and deposition of mercury
311 trapped in Arctic soils and tundra (Stern et al., 2012). This in turn can have negative impacts on human
312 health (e.g., Fahnestock et al., 2019; Perryman et al., 2020).

313 Models that quantify the drivers of Arctic change, as well as the interactions and feedbacks of these
314 changes with Earth systems, are needed to understand the interconnected Arctic system. Models help
315 represent the state of understanding of systems and are the principal mechanism through which
316 current understanding can be projected into the future. Different kinds of observations are also needed,
317 including intensive short-term observational campaigns, long-term satellite and ground based
318 observations, and models of both the individual components of the Arctic as well as the comprehensive
319 Earth system. Modeling and observational capabilities across agencies, along with process based-
320 research, enhance our understanding of Arctic system interactions.

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

325 **Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and** 326 **Non-Federal Partners**

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

- 329 ● Department of Commerce (DOC)
- 330 ● Department of Defense (DOD)
- 331 ● Department of Energy (DOE)
- 332 ● Department of Health and Human Services (DHHS)
- 333 ● Department of Homeland Security (DHS)
- 334 ● Department of Interior (DOI)
- 335 ● Marine Mammal Commission (MMC)
- 336 ● National Aeronautics and Space Administration (NASA)
- 337 ● National Science Foundation (NSF)
- 338 ● Smithsonian Institution (SI)

339

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

344 Understanding the Arctic's dynamic complex natural, social, and built systems and how they influence
345 the Earth system as a whole is critical to the mission of many of the IARPC federal agencies, as well as
346 domestic and international collaborators. Enhanced two-way communication, coordination, and
347 collaboration between decision-makers, practitioners, non-federal researchers, international partners,
348 and Indigenous communities will be key in advancing understanding of Arctic systems interactions.
349 Building better cross-linkages among the existing collaboration teams should leverage and expand
350 upon these partnerships. This will result in shared perspectives and questions regarding the Arctic's
351 dynamic interconnected systems, with a focus on ways to maximize monitoring, observing, analysis,
352 and modeling capabilities to inform decision-making.

353

Priority Area 3: Sustainable Economies and Livelihoods

354

Monitor, maintain, and proactively adapt the Arctic’s natural, social, and built systems to promote sustainable economies and livelihoods.

355

Justification

356

357 The Well-Being and Security policy drivers are advanced by federal investment in sustainable
358 economies and livelihoods throughout the region. Arctic communities and ecosystems are
359 experiencing environmental change at an unprecedented rate—from loss of permafrost and coastal
360 erosion (U.S Army Corps of Engineers, 2019) to shifting demographics and economic uncertainty. Such
361 rapid changes present challenges for built systems, natural resource management, food security, and
362 Indigenous ways of life, all critical to the well-being and security of the Arctic, its residents, and our
363 nation as a whole. Together, sustainable resource management, innovative infrastructure design, and
364 the knowledge and resilience of Arctic communities contribute to strong local economies and durable
365 built systems.

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

375 Community well-being and security are heavily dependent upon infrastructure, presenting significant
376 challenges because building and maintaining infrastructure is expensive and logistically complex in
377 Arctic environments. Existing public and private regional infrastructure includes roads, airstrips,
378 bridges, and harbor and port facilities; energy and electricity systems; telecommunications systems;
379 and housing, education, healthcare, and national defense facilities. These built systems require
380 monitoring and ongoing maintenance to meet current demand, and proactive planning and adaptation
381 to accommodate future environmental, demographic, and geopolitical shifts (Chinowsky et al., 2009;
382 U.S. Committee on the Marine Transportation System, 2016).⁹ Current areas of concern include poor
383 construction and maintenance of roads, airstrips, landfill and waste sites; inadequate housing; lack of
384 access to clean water; unreliable, expensive energy and commodities; and maintenance backlogs at
385 educational and healthcare facilities. To respond effectively, federal agencies need accurate, up-to-
386 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>

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

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

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

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

414 **Alignment with Federal Agencies and Departments, IARPC Collaboration Teams, and** 415 **Non-Federal Partners**

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

- 418 ● Denali Commission
- 419 ● Department of Agriculture (USDA)
- 420 ● Department of Commerce (DOC)

¹⁰ Principles for Conducting Research in the Arctic: <https://www.iarpcollaborations.org/principles.html>

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- 421 ● Department of Defense (DOD)
- 422 ● Department of Energy (DOE)
- 423 ● Department of Homeland Security (DHS)
- 424 ● Department of Health and Human Services (DHHS)
- 425 ● Department of Interior (DOI)
- 426 ● Department of State (DOS)
- 427 ● Department of Transportation (DOT)
- 428 ● Environmental Protection Agency (EPA)
- 429 ● Marine Mammal Commission (MMC)
- 430 ● National Science Foundation (NSF)
- 431 ● Smithsonian Institution (SI)

432

433 IARPC collaboration teams that align well with the Sustainable Economies and Livelihoods Priority Area
434 include: Coastal Resilience, Marine Ecosystems, Terrestrial Ecosystems, and Permafrost. IARPC does
435 not currently host a collaboration team focused on Arctic infrastructure.¹¹ Development of such a team
436 to coordinate federal efforts to monitor, assess, and develop land-based and maritime infrastructure
437 would amplify federal investment and prevent duplication of efforts.

438 Achieving sustainable economies and ecosystems requires non-federal partners. State of Alaska
439 departments and agencies are critical collaborators. Tribal governments and village and regional
440 Alaska Native Claims Settlement Act (ANCSA)¹² corporations are essential for knowledge co-production
441 and ensuring that federal efforts respond to community needs. International advisory and working
442 groups, such as marine mammal and other co-management, species-focused organizations,¹³ also play
443 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.

444

Priority Area 4: Risk Management and Hazard Mitigation

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

447 Justification

448 The principal policy driver for the Risk Management and Hazard Mitigation Priority Area is the Security
449 Policy Driver focused on strengthening national and regional safety and security. This includes an
450 emphasis on risk management and emergency preparedness, aided by policies which acknowledge and
451 support the importance of personal and community well-being.

452 Research on risk exposure, sensitivity to hazards, and adaptive capacity are critical for ensuring safety
453 and security in the Arctic. There is an immediate need for an Arctic research portfolio that builds
454 community resilience and security with the fundamental purpose to provide a good life and well-being
455 for all Arctic communities.

456 Risk management and hazard mitigation in the Arctic require a balanced research portfolio that
457 provides actionable insights, services, and technology tools that protect communities at the local,
458 state, and national level. Individual research disciplines will need to work in a multi-disciplinary fashion.
459 Progress will be the result of fundamental and applied research, enhanced monitoring, sustained
460 observations, and predictive modeling. Along with research, there must also be technology
461 development. Development requires needs-driven efforts that look for scientific solutions to address
462 foreseeable risk management and hazard mitigation needs in the near- and mid-term. Arctic
463 communities and leaders responsible for infrastructure (e.g., villages, towns, cities, military
464 installations, ports, and pipelines) communicate the need for technologies and services based on their
465 safety and security requirements. The below themes repeat across federal government reports, state of
466 Alaska-led climate change reports and implementation plans, community strategic management
467 planning processes, the Alaska Legislature-led Alaska Arctic Policy Commission report (AAPC, 2015),
468 and the development of programs such as the Alaska Native Health Consortium's Center for
469 Environmentally Threatened Communities, and others.

470 Arctic risk management and hazard mitigation challenges are diverse (DHSEM, 2019; USCG, 2019; DOD,
471 2019). These include, but are not limited to, advancing knowledge related to chronic hazards (e.g.,
472 climate change and its impacts [RNWG, 2009], ocean acidification, sea-level rise, environmental
473 degradation, and coastal erosion), acute and episodic events (e.g., unusual mortality events, harmful
474 algal blooms, wildfires, shipwrecks, oil spills, and pandemics), and holistic security concerns (e.g.,
475 domain awareness, communications fragility, and response capability). The cross-cutting themes of
476 resilience, hazard mitigation, threat reduction, and disaster response management are fundamental in
477 reducing risk. To be successful, the combined research efforts across federal agencies must address the
478 entire spectrum of concerns from local environmental security to national security.

479 Hazards and risks cannot be effectively addressed by one entity alone. Resilience, hazard mitigation,
480 and disaster management expertise are found across many federal agencies and at many levels. This

481 priority area seeks to manage and reduce risk by bringing researchers together with Arctic community
482 members and leaders, Indigenous organizations, emergency managers and service providers
483 (operators and planners), and researchers. It is through collaborative research activities that
484 advancements in prevention, protection, mitigation, response, and recovery can be achieved.

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

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

- 489 ● Denali Commission
- 490 ● Department of Commerce (DOC)
- 491 ● Department of Defense (DOD)
- 492 ● Department of Energy (DOE)
- 493 ● Department of Health and Human Services (DHHS)
- 494 ● Department of Homeland Security (DHS)
- 495 ● Department of Interior (DOI)
- 496 ● Department of Transportation (DOT)
- 497 ● Environmental Protection Agency (EPA)
- 498 ● National Aeronautics and Space Administration (NASA)
- 499 ● National Science Foundation (NSF)
- 500 ● Smithsonian Institution (SI)
- 501 ● U.S. Arctic Research Commission (USARC)

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

505 Partnerships that will be critical to achieving this goal include engineers, emergency managers, and
506 community planners from the state of Alaska, boroughs, and local and Tribal governments, as well as
507 the private sector. The private sector plays a crucial role in protecting assets, workforce, and supply and
508 distribution chains to help society keep functioning in times of and after disasters.

509

Foundational Activities

510 Introduction

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

517 Co-Production of Knowledge and Indigenous-Led Research

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

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

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

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

545 active participation and long-term engagement, and so that outcomes of federal research
546 programs are communicated appropriately. IARPC will work with and make researchers aware
547 of existing Indigenous organizations, advisory committees, and co-management councils that
548 focus on food security, community infrastructure, health and well-being, Indigenous practices,
549 and species and ecosystems management. IARPC will also advance new venues where federal
550 research activities can be informed by Indigenous Knowledge and the needs of Indigenous
551 communities.

552 • **Sustaining Engagement and Building Trust:** Successful partnerships rely on respect, trust,
553 early and ongoing collaboration, sustained communication and coordination, and
554 multigenerational participation. IARPC will continue to invest in activities that build trust
555 among federal agencies, federally-funded researchers, and Indigenous Peoples to achieve
556 sustainable outcomes.

557 • **Putting the IARPC Principles for Conducting Research in the Arctic into Practice:** IARPC
558 remains committed to the Principles for Conducting Research in the Arctic (IARPC, 2018), which
559 educate researchers on building trust, effective communication, and respecting Indigenous
560 Peoples and cultures of the Arctic. IARPC will promote the use of these principles among IARPC
561 agencies and track their effectiveness.

562 • **Increasing Capacity within Arctic Communities for Indigenous-Led Research:** IARPC will
563 host discussions about federal funding opportunities to enhance research and capacity
564 building that would enable more Indigenous entities and scholars to pursue their own
565 observations and research. Similarly, IARPC will promote actions to identify ways that federal
566 administrative structures can be adapted or changed for greater inclusion of Indigenous voices
567 and to support Indigenous-led research. IARPC will seek opportunities to support the
568 development or expansion of community-driven programs and liaison offices in coordination
569 with community and Indigenous-led organizations already in place.

570 **Data Management**

571 Arctic data, which can include Indigenous Knowledge, are irreplaceable. Often stemming from difficult
572 and remote conditions, Arctic data are valuable in a time of rapid environmental change. Data
573 management is critical to basic research, monitoring, and applied research in the Arctic. It follows a
574 cycle of data discovery, collection, and sharing; ideally, each step in the data lifecycle contributes to
575 maximizing return on investment in data management (Rüegg et al., 2014). There is great care, review,
576 and often standardization or harmonization in preparing, producing, and publishing data products
577 which allow for the reuse of these products. As data volumes increase, computational infrastructure
578 and software management are both inextricably part of data management (e.g., Snowden et al., 2019).

579 A National Academies study (NASEM, 2018) outlines best practices related to open, searchable, and
580 rapidly accessible data. IARPC encourages the scientific community to adopt open data collections,
581 develop intelligent data management tools and practices, and use existing data and metadata

582 platforms to achieve interdisciplinary and interagency coordination. In order to reflect the complexity
583 of Arctic data and knowledge systems, data management for Arctic research must be responsive to a
584 range of partners. Arctic research, co-production of knowledge, and data management now operate in
585 an environment of FAIR (Findable, Accessible, Interoperable, and Reusable) data management
586 principles (Wilkinson et al., 2016) and CARE (Collective Benefit, Authority to Control, Responsibility,
587 Ethics) Principles of Indigenous Data Governance (Carroll et al., 2020). While working toward open and
588 accessible data, it is important to recognize these nuanced approaches that protect private and
589 sensitive data, and to respect Indigenous data sovereignty (Carroll et al., 2019) and autonomy.

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

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

604 As agencies work towards sharing data across the government and with the public, IARPC will be a
605 strong partner and bridge towards achieving their Arctic research goals. Data management is rooted in
606 federal policy and mandated for federal research agencies (Data Quality Act, 2001; Holdren, 2013;
607 Foundations for Evidence-Based Policymaking Act of 2018; Geospatial Data Act of 2018). Clear
608 guidance, aligned with FAIR and CARE, on how to manage data compliant with these broad federal
609 mandates can benefit federal agencies that enable the Arctic research enterprise and can support each
610 other in achieving these aims (e.g., Arctic Spatial Data Infrastructure). Federal agencies should aim to
611 make data connected and useful, emphasizing meaningful new Arctic insights. Therefore, this plan
612 pursues responsive, responsible, and well-resourced application of best practices in Arctic data
613 management.

614 **Education**

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

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619 Indigenous Knowledge, and skill acquisition such as grant writing and technological expertise.
620 Research informs education while at the same time education is foundational to research. Outreach is
621 also vital in creating awareness of and knowledge about the Arctic to those within and beyond the
622 region.

623 The IARPC STEM (science, technology, engineering, and mathematics) team will promote education
624 across all priority areas. Given the wide range of agency research missions and the education and
625 outreach programs supported by federal agencies and their partners, IARPC provides a unique service
626 as a forum for connection and promotion of coordinated efforts. IARPC is also positioned to advance
627 the inclusion of place-based and Indigenous Knowledge and learning in education and outreach. IARPC
628 will elevate the profile of STEM education to bring a greater focus to the value and content of Arctic-
629 specific education as well as ensure integration of uniquely Arctic efforts with national federal
630 interagency STEM education strategic planning (NSTC 2018, NSF 2020). Via such integration, Arctic
631 research can strengthen STEM education more broadly within the United States, and promote pan-
632 Arctic and global connections and awareness. As an interagency body, IARPC can lead innovation of
633 new delivery models informed by and serving research and communities.

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

639 The aims of Arctic education efforts are to (1) strengthen and support existing scientific disciplinary
640 expertise; (2) increase engagement of rural and Indigenous students in STEM education; (3) generate
641 academic-workforce development opportunities (e.g., internship programs); (4) enhance coordination
642 among varied federal and external partners; (5) expand education and outreach about the Arctic to the
643 public and to decision-makers; and (6) create new, expanded delivery paradigms and content, such as
644 research and learning experiences that explicitly address the pedagogical and experiential approach to
645 complex systems and bringing together knowledge systems that are critical for advancing Arctic
646 science.

647 The future workforce will continue to require the deep disciplinary expertise needed to meet the
648 missions of IARPC agencies while also requiring teams capable of exercising scientific and demographic
649 diversity and different knowledge systems. Federal agencies must sustain and expand their own
650 education and outreach programs to meet mission-specific research priorities and the growing need to
651 support community-driven education and research. Building connections is also increasingly vital.
652 Education programs will seek new opportunities for rural and Indigenous students that expand beyond
653 traditional academic pathways. Arctic-relevant delivery models and outreach efforts will benefit from
654 interweaving disciplinary academics and Indigenous Knowledge, humanities and arts, and explicit
655 connections between knowledge systems and policy development and execution. Such frameworks

656 can build capacity and connection in Arctic communities, improve Arctic residents' quality of life, and
657 increase community viability and sustainability.

658 **Monitoring, Observing, Modeling, and Prediction**

659 A robust research plan requires strong capabilities in monitoring, observing, modeling, and prediction
660 (MOMP). MOMP is critical for increasing understanding of the natural and human components of the
661 Arctic system as well as the degree and direction of past and future changes. It is also essential for
662 providing actionable data, forecasts, and new research directions.

663 Sustained observations and widespread monitoring support research activities by providing
664 information on the variability of the Arctic system. This information provides a necessary baseline for
665 future studies and data for evaluating models and making both short-term predictions and longer-scale
666 projections. Focused short-term observational efforts are important for improving fundamental
667 understanding of Arctic processes, regions, and extreme events. A foundational Arctic observational
668 capability requires a sustained, coordinated, and integrated network of remote and in situ observing
669 systems suitable for Arctic conditions; resources to train instrument operators, support data quality,
670 and analyze observations; and continued development of new technologies, such as low cost and
671 autonomous sensors, to fill observational gaps. Future development of Arctic observing capabilities
672 should consider potential environmental impacts and incorporate Indigenous Knowledge through co-
673 production in the design and implementation of observing systems (Krupnik and Jolly, 2002).

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

682 The need to advance understanding of Arctic processes and system interactions drives the effort to
683 improve synthesis of monitoring, observing, and modeling. Numerical models require observations for
684 initialization, evaluation, and assimilation. Integrating observational and modeling output enables
685 creation of value-added products and can help fill spatial and temporal gaps in analysis. Models can
686 provide critical information to inform the design and optimization of observing networks. Advances in
687 related fields such as artificial intelligence (AI) should be explored to improve analysis and integration
688 of large volumes of observational and model data. Such integration will accelerate the advancement of
689 knowledge of the dynamic Arctic system and lead to improved predictive capabilities. Through the
690 existing Arctic Observing Systems and Modeling collaboration sub-teams, IARPC will seek to identify
691 current gaps in observational or modeling capabilities that hamper predictive skill of the Arctic system,
692 barriers that hold back progress in filling these gaps, and key activities most critical to improving

693 predictability, including the need to maintain critical existing MOMP capabilities. In coordination with
694 the Education Foundational Activity, training of the next generation in MOMP activities should be
695 incorporated. IARPC will also promote international coordination and cooperation in Arctic system
696 MOMP efforts. For example, through the U.S. Arctic Observing Network (US AON) and its engagement
697 with the Sustaining Arctic Observing Networks (SAON) initiative, IARPC will support federal agencies'
698 efforts to improve the performance of Arctic-wide observing and data management activities. Lastly,
699 IARPC will increase coordination and engagement with other federal efforts (including public-private
700 partnerships) focused on improved observations, modeling, and predictability of the Earth system. This
701 will include working with the U.S. Global Change Research Program (USGCRP) and the Interagency
702 Council on Advancing Meteorological Services (ICAMS), and identifying and prioritizing actions to
703 implement the Earth System Predictability Research and Development Strategic Framework and
704 Roadmap.

705 **Technology Innovation and Application**

706 At a broad scale, technology and technological solutions will enable, accelerate, and deliver accurate
707 information, products, and solutions to the Arctic research and development (R&D) community as it
708 strives to address challenges posed by the priority areas identified in this plan. In deploying new and
709 existing technologies, it is likely that unknown technological barriers will emerge. IARPC will employ its
710 existing Polar Technology Community Forum to support this activity as it encourages the broad R&D
711 community across the priority areas to adopt the most relevant and efficient technologies of today. It
712 will also define future technology research, development, and innovation required to support the
713 priority area research needs of tomorrow.

714 Calls for cutting-edge technology R&D emphasize four common themes that support science, security,
715 and stewardship of the Arctic region: (1) Modernized Fundamental Infrastructure (e.g., energy
716 efficiency, distributed generation, storage, and distribution; telecommunications; transportation
717 solutions; search and rescue); (2) Improvements in Accuracy (e.g., high-resolution sensing application
718 and development; data diversity; model and forecast improvements); (3) Increased Autonomy &
719 Autonomous Data Collection (e.g., to expand domain awareness and data collection, and to improve
720 the safety of data collection in hazardous areas/situations/seasons such as wildland firefighting,
721 flooding, unstable sea ice and permafrost, and winter hazards); and (4) Accelerated Information
722 Delivery (e.g., real-time or near-real time observations; consistent and reliable communication to Arctic
723 partners).

724 Technology and innovation required to support the priority areas are not limited to hardware, but also
725 include software (e.g., artificial intelligence, database development, and supercomputing), modeling,
726 mapping, and forecasting. Improved models of the entire Arctic domain, from human systems to the
727 edge of the atmosphere and the depths of the oceans, will provide better virtual testbeds for
728 technology, infrastructure, and sensor development, and lead to a better understanding of the
729 interplay of the atmosphere, land, ice, and water.

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

736 The IARPC community is well-positioned to identify the existing commercial off-the-shelf (COTS)
737 technologies. For example, challenges related to infrastructure are broad and overarching across the
738 Arctic domain. Insufficient infrastructure technology continues to impact the effectiveness of R&D
739 activities. Technological solutions that address similar large-scale challenges will provide substantial
740 return on investment. IARPC will help identify cross-cutting technological solutions with rapid impact
741 that can accelerate progress, enhance domain awareness, and increase fundamental knowledge for
742 priority area R&D. This could include integration of Light Detection and Ranging (LiDAR) and derived
743 products, expanded use of artificial intelligence, and increased access and use of supercomputing
744 resources.

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

750

Implementation and Metrics for Measuring Success

751 Implementation of this plan will focus upon achieving the goals identified in each of this plan's priority
752 areas and facilitating continued investment, execution, and integration of the essential contributions
753 of the foundational activities. This plan presents a shift from previous Arctic research plans, where the
754 focus was primarily upon environmental processes to also address societal issues that require a more
755 complex, multi-disciplinary approach. The existing IARPC teams^{14,15} and the communities of practice
756 that they have engendered will greatly contribute to achieving the goals of these priority areas;
757 however, additional multidisciplinary coordination is required to facilitate contributions and
758 synthesize input from relevant sources. Four new priority area collaboration teams will be established
759 to direct and coordinate activities to reach the mid-term and five-year goals and to ensure coordination
760 and collaboration of resources to address pressing needs. These multi-disciplinary teams will be co-
761 chaired by at least one federal program manager and one non-federal partner. Engagement of
762 Indigenous partners in the planning and execution of research will be supported by enabling
763 Indigenous-led research, promoting co-production of knowledge, and increasing financial support for
764 Indigenous leadership in meetings, conferences, and research programs.

765 **Planning:** Implementation of the plan will be outlined in biennial implementation plans. The first of
766 these plans will be completed in early 2022 and subsequently updated in the first half of 2024 (see
767 timeline). The biennial implementation plan will outline objectives, deliverables, and metrics of success
768 that will be completed within the first two years. Development of the first biennial implementation plan
769 will follow a workshop that will recommend short-term goals and deliverables. The 2022 biennial
770 implementation plan will be updated in early 2024 with consideration of previous achievements and
771 current assessment of the most effective approach to achieve the long-term goals. During the final year
772 (2025), team leaders will determine if an extension or revision of the implementation plan is required.
773 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.

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		2022				2023				2024				2025				2026					
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
1	Planning	Biennial Implementation Plan Development: 2022	■	■																			
		2022 Workshop	■																				
		Biennial Implementation Plan Development: 2024									■	■											
		2024 Workshop									■	■											
2	Implementation	Implementation: 2022-2024	■	■	■	■	■	■	■	■	■	■											
		Implementation: 2024-2026									■	■	■	■	■	■	■	■	■	■	■	■	■
3	Reporting	Biennial Report 2023																				■	
		Biennial Report 2025																					■
		Final Report																					■

774
 775 The current IARPC teams are vital communities of practice in their fields and remain critical to the
 776 implementation of the Arctic Research Plan 2022-2026. IARPC teams will continue to engage via IARPC
 777 Collaborations¹⁶ to advance disciplinary Arctic research in addition to contributing to the priority area
 778 goals. Current IARPC teams will coordinate with the new priority area collaboration teams to develop
 779 the biennial implementation plans and help define what can be accomplished to advance the priority
 780 area goals and objectives. The involvement of relevant partners outside the federal sphere in all of the
 781 IARPC teams will enable greater progress by leveraging external resources and expertise.

782 **Reporting:** In the autumn of 2023 and 2025, priority area collaboration team leaders will produce a
 783 biennial report detailing progress on deliverables with an emphasis on highlighting products that
 784 advance our understanding of Arctic processes and are relevant to Arctic communities and decision-
 785 makers. Reports will include evaluation based on the metrics of success (outlined below), and
 786 accomplishments related to priority area goals and foundational activities. These biennial reports, as
 787 called for in the Arctic Research Policy Act (ARPA), will help the public, research, and policy communities
 788 understand the progress, obstacles, and pathways toward achievement of goals in this plan and detail
 789 responsiveness to the U.S. Arctic Research Commission’s Biennial Goals Report. At the end of 2026, a
 790 final report will evaluate the outcomes of the plan and will communicate scientific advancements.

791 **Program Management:** IARPC Collaborations is the primary management coordinating structure to
 792 implement the Arctic Research Plan 2022-2026. Participation in IARPC Collaborations is open to anyone
 793 who can contribute to implementing the plan. A critical element of IARPC Collaborations is the IARPC
 794 website, which serves as a platform for coordinating federal government program managers and
 795 scientists, the non-federal research community, and other partners to accelerate the pace of Arctic
 796 research and achieve priority area goals. The website is both a content driven dialogue system and a
 797 project management and tracking system. Through posting events, documents, and recordings of
 798 meetings and webinars, the website helps organize team meetings and deliver information to team
 799 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.

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

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

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

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

¹⁷ See IARPC About Page: <https://www.iarpcollaborations.org/about.html> and IARPC Overview Document:
https://www.iarpcollaborations.org/uploads/cms/documents/iarpc_overview.pdf

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Appendices

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