

Arctic Research Crosscut Budget Report

FY 2022–2024

PRODUCT OF THE INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE
OF THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

MARCH 2024

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ABOUT THE INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

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

ABOUT THIS DOCUMENT

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AURORA BOREALIS, ARCTIC CIRCLE, ALASKA.

Photo credit: Mike Beauchamp/iStock.com

Preface

President Biden has been clear: We are an Arctic nation, and we recognize the importance of this region to our collective security. It is critical that we work together to ensure that the Arctic remains a region of cooperation rather than conflict. The United States has long acknowledged the importance of the Arctic to global security and our nation’s economic well-being, as well as the outsized influence the region exerts on the global climate system. The Arctic has been a bellwether of change over recent decades, with emerging geopolitical conflicts and rapidly increasing threats to its people, environment, and infrastructure. For these reasons and more, the Biden-Harris Administration, the U.S. Congress, our military, and our citizenry are concerned with the rapid changes occurring in the High North.

The rapidly changing climate is heavily impacting the Arctic ecosystems and societies, particularly Indigenous communities. The Arctic is warming two to four times faster than other regions of the world, depending upon the time frame and specific region studied. This rapid warming is directly impacting glacier and ice sheet melting, permafrost thaw, summer and winter sea ice extent and thickness, migration and population dynamics of marine and terrestrial animal and plant species, wildfire frequency and severity, natural emissions of carbon dioxide (CO₂) and methane, and atmospheric and oceanic circulation and heat transport. Several of these processes propagate outside the Arctic, affecting weather and extreme events in more temperate regions. A significant number of communities in Alaska are facing profound choices of either adapting to these environmental changes or relocating. Situational awareness of the current natural, climatic, and political environment is critical for community planning, managing natural resources, ensuring homeland security, and maintaining military readiness in the Arctic. The research conducted by U.S. government agencies is providing insight into Arctic change, enhancing our national security, and informing efforts of individuals and communities to prepare and adapt.

By assembling budgetary information collected across the National Science & Technology Council (NSTC)’s Interagency Arctic Research Policy Committee (IARPC) agencies and departments, this report is intended to advance efforts to ensure that federally funded Arctic research is complementary, cost-efficient, and effective, and that a coordinated approach across the federal agencies is applied to address U.S. research goals and objectives in the Arctic. The report, a first in a series to be published annually, highlights U.S. research investments in the Arctic in light of our national priorities, as reflected in the 2022 National Strategy for the Arctic Region.

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ACRONYMS USED IN THIS PLAN

AIP.....	Arctic Investigations Program	LTER.....	Long-Term Ecological Research
ARM.....	Atmospheric Radiation Measurement	NASA.....	National Aeronautics and Space Administration
ARS.....	Agricultural Research Service	NEON.....	National Ecological Observatory Network
ASC.....	Smithsonian Institution Arctic Studies Center	NESDIS.....	National Environmental Satellite, Data, and Information Service
BER.....	Biological Environmental Research	NGEE Arctic.....	Next Generation Ecosystem Experiment – Arctic
CAFI.....	Cooperative Alaska Forest Inventory	NIFA.....	National Institute of Food and Agriculture
CDC.....	Centers for Disease Control and Prevention	NIH.....	National Institutes of Health
CRREL.....	Cold Regions Research and Engineering Lab	NISAR.....	NASA-ISRO Synthetic Aperture Radar
DBO.....	Distributed Biological Observatory	NOAA.....	National Oceanic and Atmospheric Administration
DHS.....	Department of Homeland Security	NOS.....	National Ocean Service
DOC.....	Department of Commerce	NSF.....	National Science Foundation
DoD.....	Department of Defense	OAR.....	Oceanic and Atmospheric Research Office
DOE.....	Department of Energy	OMAO.....	Office of Marine and Aviation Operations
DOI.....	Department of the Interior	OMB.....	Office of Management and Budget
EcoFOCI.....	Arctic Research Program, Ecosystems and Fisheries – Oceanography Coordinated Investigations	ONR.....	Office of Naval Research
EESDD.....	Earth and Environmental Systems Sciences Division	OPP.....	Office of Polar Programs
FDA.....	Food and Drug Administration	OSTP.....	Office of Science and Technology Policy
HHS.....	Department of Health and Human Services	R&A.....	Earth Science Research and Analysis
HiLAT.....	High-Latitude Application and Testing of Earth System Models	STPI.....	Science and Technology Policy Institute
HUD.....	Department of Housing and Urban Development	USARC.....	U.S. Arctic Research Commission
IARPC.....	Interagency Arctic Research Policy Committee	USCG.....	U.S. Coast Guard
IDA.....	Institute for Defense Analyses	USDA.....	U.S. Department of Agriculture
InterFACE.....	Interdisciplinary Research for Arctic Coastal Environments	USFS.....	U.S. Forest Service
LTAR.....	Long-Term Agroecosystem Research	USFWS.....	U.S. Fish and Wildlife Service
		USGS.....	U.S. Geological Survey



Introduction

Previous and ongoing studies demonstrate the critical importance and influence the Arctic region exerts on global climate dynamics and the consequences that reverberate through political, economic, social, and environmental realms. It is now more important than ever to have robust information about U.S. activities in the Arctic region along with the costs, benefits, and justifications of those activities. The United States is an Arctic nation with a rich history of research, including collaboration and co-production with Indigenous Peoples in the region. Over the past 50 years, our national policy relating to the Arctic has been well defined yet evolving to address the changing geopolitical and environmental conditions. The general themes of current U.S. Arctic policies are captured in the four pillars of the [2022 National Strategy for the Arctic Region \(NSAR\)](#):

- Security: Develop Capabilities for Expanded Arctic
- Climate Change and Environmental Protection: Build Resilience and Advance Adaptation, while Mitigating Emissions
- Sustainable Economic Development: Improve Livelihoods and Expand Economic Opportunity
- International Cooperation and Governance: Sustain Arctic Institutions and Uphold International Law

The impacts and consequences of a rapidly changing climate, which are particularly acute in the Arctic region, have become increasingly important in national policies and plans, including those in the United States. Many of the efforts described in the research summaries herein will improve our understanding of these changes and inform future investments in Arctic research. The research conducted by the federal government yields a qualitative and quantitative characterization of the system dynamics. The purpose of this work is to help individuals and communities adapt through improved infrastructure design and construction, more accurate projections of climate change and environmental impacts, and enhanced resilience to the harsh Arctic climate.

Arctic research informs a number of different sectors. National and environmental security remain among the top priorities for Arctic research investments. Research from several agencies, including the Department of Defense and Department of Homeland Security, provide greater insights on Arctic domain awareness and projections on how the environment will continue to change in coming decades to centuries. Food security, understanding the effects of climate change on local ecosystems, and co-management of natural resources, including fisheries, wildlife, mining, and energy development, are among research programs supported by the Department of the Interior, Department of Agriculture, Department of Energy, and National Aeronautics and Space Administration. Community health and resilience, economics, risk management, and hazard mitigation are among the critically important research efforts of the Department of Health and Human Services, the Department of Housing and Urban Development, and the Department of Commerce. The vast remoteness of communities and harsh weather also present unique research challenges among social structures, including the high costs of food and energy, limited broadband connectivity, infrastructure fallibility and short lifespans, education, and capacity building. Basic research supported by the National Science Foundation provides much of the essential understanding to develop these operational capabilities.

SPRING WHALING. Ikayuaq crew participates in spring whaling off of Utqiagvik, Alaska. *Photo credit: Steven Kazlowski*



The Arctic is an international region that covers parts of eight countries (United States, Canada, Russia, Iceland, Finland, Norway, Sweden, and Denmark/Greenland). Non-Arctic countries also have interests in the region, including research. Many of the important research challenges addressed by federal agencies are not constrained to the U.S. borders but instead include spatial domains of the pan-Arctic, including the Arctic Ocean and marginal seas. These include studies related to atmospheric dynamics, oceanic circulation, or other environmental processes that have global- or continental-scale implications. U.S. federal agencies have developed international partnerships to advance understanding of the Arctic and to develop reliable projections of environmental and societal dynamics. Such collaborations result in greater accomplishments and are achieved more efficiently. They are essential for making informed decisions and sound investments.

The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (P.L. 117-263) requires the White House Office of Science and Technology Policy (OSTP), in coordination with the Office of Management and Budget (OMB), to collect annual budget data for all existing federal programs relating to Arctic research and research-related activities. This crosscut budget¹ analysis is the first effort to compile federal agency Arctic research budget data into one comprehensive report. This crosscut represents unclassified Arctic research budget data and associated qualitative information from [member agencies and departments of the Interagency Arctic Research Policy Committee²](#) (IARPC). Beginning with fiscal year 2025 and annually thereafter, until fiscal year 2034, OSTP will submit an annual report to Congress summarizing each agency’s budget request related to Arctic research activities. Such reporting of research budget data is consistent with ARPA “Section 110. Coordination and Review of Budget Requests,” which further requires the U.S. Arctic Research Commission to review the request and report to Congress on the budget’s adherence to IARPC’s five-year Arctic Research Plan, also defined in ARPA. This report provides that crosscut analysis of unclassified Arctic research budget data and associated qualitative information from federal departments and agencies of the U.S. government. It will be used to ensure that the federal government develops a coordinated budgetary approach to pursuing our nation’s research goals and objectives in the Arctic.

¹ “At its most basic level, a crosscut budget is often used to present budget information from two or more agencies whose activities are targeted at a common policy goal or related policy goals. Crosscut budgets can assist in making data from multiple agencies more understandable, and...may also be used to track program accomplishments, measure progress towards achieving program goals, or compare activities conducted by various agencies aimed at the same goal.” [Description from [Congressional Research Service RL34239](#)]

² Defined in the [Arctic Research and Policy Act of 1984 \(ARPA\)](#), P.L. 98-373, July 31, 1984, as amended by P.L. 101-609, November 16, 1990.

Arctic Research Crosscut Budget by Agency

The federal government spent over \$550 million on Arctic research in fiscal year (FY) 2023 ([Table 1](#)). The National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Department of Defense (DoD)—agencies with the three largest Arctic budgets—account for over 80% of the FY 2023 total. Based on agency summaries, NSF invests primarily in basic research, DoD invests primarily in applied research, and NASA invests primarily in research infrastructure ([Figure 1](#)).

TABLE 1. ARCTIC RESEARCH CROSSCUT BY AGENCY. Funding amounts are shown in millions of dollars. Agencies reported estimated program funding to the nearest \$100,000 and excluded programs, projects, or activities that receive less than \$100,000 annually. Agency submissions include estimated labor costs and exclude development activities.

AGENCY	FY 2022 ACTUAL	FY 2022 WITH SUPPLEMENTAL	FY 2023 ENACTED	FY 2023 WITH SUPPLEMENTAL	FY 2024 PRESIDENT'S BUDGET ³
Arctic Research Commission	1.7	1.7	1.7	1.7	1.8
Denali Commission	0.3	0.3	0.3	0.3	0.5
Department of Agriculture	1.3	1.3	0.3	0.3	1.8
Department of Commerce	20.7	21.0	14.7	16.2	19.7
Department of Defense	70.1	71.4	120.9	125.9	28.5
Department of Energy	34.2	34.2	27.9	27.9	30.0
Department of Health and Human Services	30.9	30.9	32.7	33.2	33.4
Department of Homeland Security	21.0	21.0	8.0	8.0	0.0
Department of Housing and Urban Development	0.0	0.0	0.6	0.6	0.0
Department of the Interior	24.3	24.3	25.3	25.3	22.7
National Aeronautics and Space Administration	154.7	154.7	177.2	177.2	181.0
National Science Foundation	151.2	151.2	142.4	154.1	124.3
Smithsonian Institution	2.3	2.3	2.2	2.2	2.3
Total	512.5	514.2	554.2	573.0	446.0

³ These amounts represent the President's annual budget request to Congress. Actual spending for FY 2024 will likely be different.

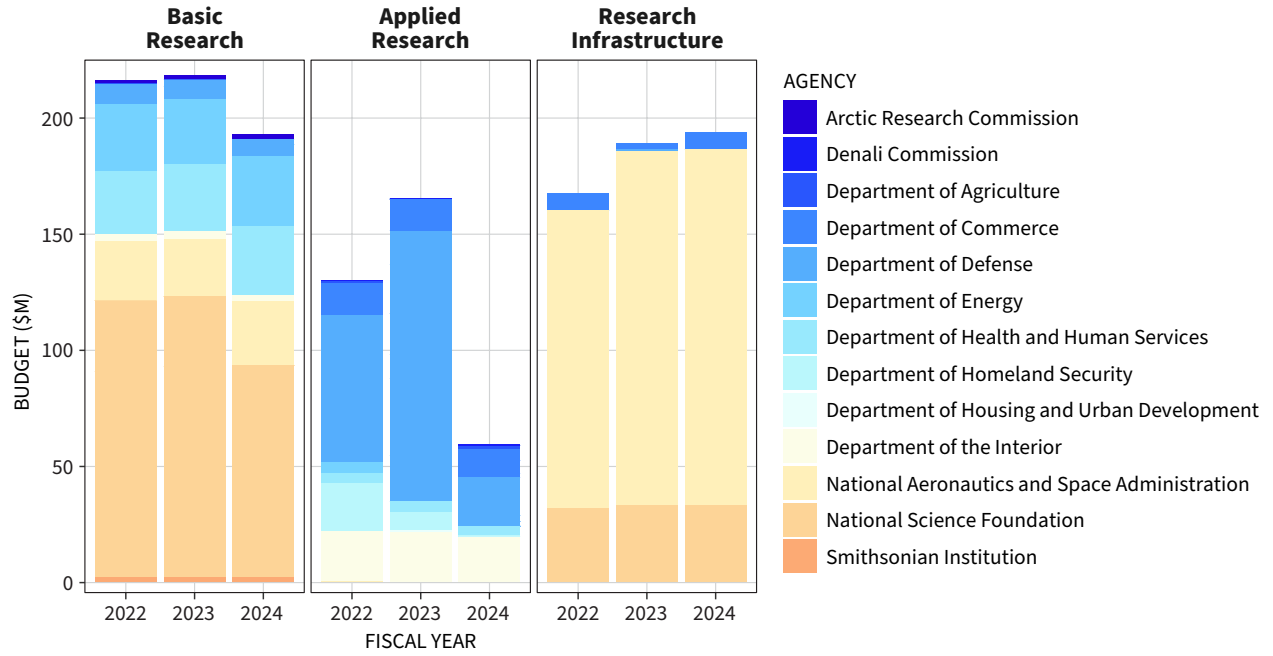


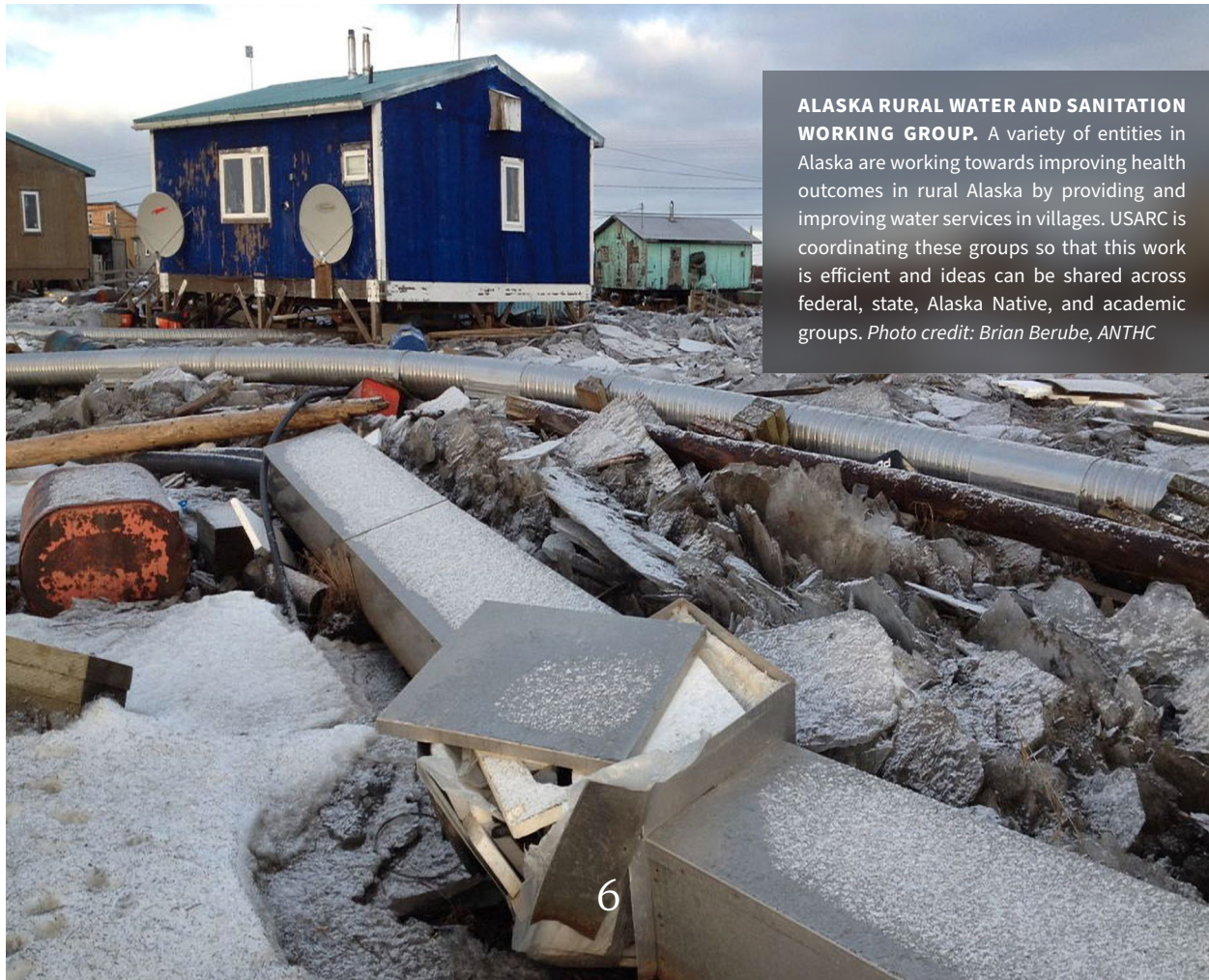
FIGURE 1. ARCTIC RESEARCH BUDGETS BY RESEARCH CATEGORY. In self-reported budgets provided to OMB, agencies categorized Arctic research investments as *basic research*, *applied research*, or *research infrastructure* per OMB Circular No. A-11 definitions. Of the three top funders of Arctic research, the National Science Foundation primarily funds *basic research*, while the Department of Defense primarily conducts *applied research*, and the National Aeronautics and Space Administration primarily funds *research infrastructure*. Budget data are reported in millions of dollars (\$M) and include supplemental funding for FY 2022 and FY 2023.

Overview of Federal Programs

A concise overview of federal investments by agency is presented here. A more complete discussion of the agencies' specific programs is presented in Appendix B. In the following summaries of the overarching agency missions and investments, efforts related to, for example, satellite observations, mapping, or domain awareness may initially appear to be redundant or duplicative. However, it is essential to delve into the specific programs to understand their distinct purposes and recognize the important complementarity among these research programs. Through cooperation and collaboration, these federal entities have achieved far more than would have been possible had they worked in isolation.

ARCTIC RESEARCH COMMISSION (USARC)

USARC expects to spend \$1.72M in FY 2023 on Arctic research and related activities. This represents all of USARC's budget. USARC contributions include developing and recommending a national Arctic research policy and Arctic research goals and objectives, assisting IARPC in establishing a national Arctic research program plan to implement the policy, and facilitating cooperation in Arctic research among federal, state, and local governments and with international partners.



ALASKA RURAL WATER AND SANITATION WORKING GROUP. A variety of entities in Alaska are working towards improving health outcomes in rural Alaska by providing and improving water services in villages. USARC is coordinating these groups so that this work is efficient and ideas can be shared across federal, state, Alaska Native, and academic groups. *Photo credit: Brian Berube, ANTHC*

VIRTUAL FENCES PROJECT. University of Alaska researchers place a GPS collar on a reindeer to aid producers in managing reindeer reintroduction on remote ranges on the Seward Peninsula. Photo credit: Gregory Finstad, University of Alaska



DENALI COMMISSION

The Denali Commission expects to spend \$0.5M on Arctic research to “develop critical utilities, infrastructure, and economic support throughout Alaska.”⁴ The Denali Commission contributes to Arctic research through the Statewide Threat Assessment, an ongoing effort to document erosion, flooding, and thawing permafrost in Alaska. The 2024 Statewide Threat Assessment will bring together stakeholders, scientists, policymakers, Indigenous Knowledge holders, and federal, state, and Tribal representatives to update methodology using data collected over the last five years.

DEPARTMENT OF AGRICULTURE (USDA)

USDA expects to spend \$0.3M in FY 2023 on Arctic research to advance agriculture-related sciences. Arctic research at USDA takes place through National Institute of Food and Agriculture (NIFA) grants and U.S. Forest Service (USFS) wildfire and climate research programs. In addition, USDA requested an increase of \$1.5M in FY 2024 to support the Agricultural Research Service’s (ARS) Regional Climate Hubs and Long-Term Agroecosystem Research (LTAR) network.⁵ Examples of program activities funded through NIFA grant awards include GPS radio collars to help reindeer producers monitor the location and movement of their animals via an online mapping program, long-term data collection through the University of Alaska’s Cooperative Alaska Forest Inventory (CAFI) to monitor boreal forests, and global climate model simulations at Rutgers University to examine the effects of projected climate change on the Arctic terrestrial system. USFS-funded research activities include conducting ecological research to understand the effects of ongoing climatic changes in the Arctic and implications for resource management, and investigating sustainable fuel treatments to reduce wildfire risk in the Arctic.

⁴ The Denali Commission can accept gifts or donations from non-federal entities, as well as transfers of funds from other federal agencies.

⁵ USDA program summary only described NIFA programs. Descriptions of ARS and USFS activities were submitted in the budget report to OMB.

RESEARCH ON THE ICE. Scientists in an endless vista of ice, sea, and meltwater as seen from the icebreaker USCGC Healy. Photo credit: Jeremy Potter NOAA/OAR/OER



DEPARTMENT OF COMMERCE (DOC)

DOC expects to spend \$16.2M in FY 2023 on Arctic research. Arctic research takes place primarily through the National Oceanic and Atmospheric Administration (NOAA), with additional support through North Pacific Research Board grants. Grants have not yet been awarded for FY 2024, so funding for Arctic research through the North Pacific Research Board in FY 2024 is unknown and reported as zero. NOAA works towards “better understanding and predicting Arctic change and its global implications, and delivering sound science that supports healthy, productive, and resilient communities and ecosystems.” Arctic research is conducted across multiple NOAA centers and offices, including: the National Ocean Service (NOS)’s Center for Operational Oceanographic Products and Services, Integrated Ocean Observing System, and National Centers for Coastal and Ocean Science; the National Environmental Satellite, Data, and Information Service (NESDIS); NOAA Fisheries’ Alaska Fisheries Science Center Groundfish Assessment Program, Northern Bering Sea Surface Trawl and Ecosystem Survey, and Climate Ecosystem and Fisheries Initiative; the Oceanic and Atmospheric Research Office (OAR)’s Arctic Research Program, Ecosystems and Fisheries – Oceanography Coordinated Investigations (EcoFOCI), Distributed Biological Observatory (DBO), Barrow Observatory, and International Arctic Buoy Programme; and the Office of Marine and Aviation Operations (OMAO). Research activities are extensive, including: evaluating, developing, and installing observing technologies (e.g., a shipboard Imaging FlowCytobot instrument to assess the potential risk of harmful algal blooms); providing Arctic Ocean and sea ice products, services, and frameworks; conducting research cruises that support stock assessments; surveying species important to Native Alaskan communities to support ecosystem management; studying ocean-ice-atmospheric processes and marine ecosystems to characterize climate variability in the Arctic; improving data access to Alaskan communities; and contributing funds, aircraft, and personnel support to support research efforts conducted in the Arctic.

DEPARTMENT OF DEFENSE (DoD)

DoD expects to spend \$125.9M in FY 2023 to “enhance situational awareness, logistics, navigation, and operations” of defense activities and “increase the resiliency of Arctic facilities and communities.” Arctic research at DoD occurs across multiple offices, including the U.S. Army Corps of Engineers Cold Regions Research and Engineering Lab (CRREL), the Office of Naval Research (ONR), the Space Force, the Air Force Research Laboratory, the Defense Advanced Research Projects Agency, the Ted Stevens Center for Arctic Security Studies, and the Office of the Under Secretary of Defense for Research and Engineering (through funding awards). Examples of program activities include sea, air, land, and space-based sensing, mapping, and modeling to support Arctic cold-weather operations; climate science and policy studies for defense and security planners, Arctic health, and the security of Indigenous Peoples; and technology innovation for Arctic region-adapted materials and engineering.

DEPARTMENT OF ENERGY (DOE)

DOE expects to spend \$27.9M on Arctic research in FY 2023. Arctic research activities take place in DOE’s Biological Environmental Research (BER) Earth and Environmental Systems Sciences Division (EESSD). Larger DOE national laboratory-led Arctic research efforts within EESSD include the High-Latitude Application and Testing of Earth System Models (HiLAT) project,⁶ the Interdisciplinary Research for Arctic Coastal Environments (InteRFACE) project, Atmospheric Radiation Measurement (ARM) user facility,⁷ and the Next Generation Ecosystem Experiment – Arctic (NGEE Arctic) project. DOE also reported FY 2022 funding for a Methane Hydrates research project in the Office of Fossil Energy and Carbon Management.⁸ Examples of program activities include operating an atmospheric observatory in Alaska to provide data on aerosol, cloud, and radiative processes at high latitudes; applying DOE’s high-resolution global and regional models to better understand high-latitude Earth system interactions; studying impacts of land processes, sea ice, ocean dynamics, coastal change, river and marine biogeochemistry, atmospheric processes, and human systems on Arctic coastal change through developing models to improve landfast ice, wave-sea ice interactions, turbulence, biogeochemistry, and permafrost hydrology; and studying permafrost-dominated Arctic ecosystems and their representation in Earth system models.

⁶ HiLAT addresses both Arctic and Antarctic climate questions.

⁷ The North Slope of Alaska (NSA) atmospheric observatory is operated by the ARM user facility, along with two other permanent non-Arctic sites and three other mobile non-Arctic sites for short-term deployment.

⁸ The Methane Hydrates research project was not funded beyond FY 2022.

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS)

HHS expects to spend \$28.7M in FY 2023 to improve “health and well-being of Alaska’s residents through research programs and grants.” Within HHS, the National Institutes of Health (NIH) awards funds for “several projects in the region,” and the Centers for Disease Control and Prevention (CDC)’s Arctic Investigations Program (AIP) supports infectious disease surveillance, assessment of health disparities, vaccine evaluations, and research conducted by public health and clinical partners. In addition to NIH and CDC activities, the Food and Drug Administration (FDA) “supports an extramural project that engages American Indian and Alaska Native communities, partners, and researchers to explore the knowledge and attitudes about clinical trials from tribal and Native American communities.” Examples of program activities across NIH and CDC include researching culturally informed advance care planning, supporting biomedical research and research training programs for undergraduates, and surveilling respiratory pathogens and climate-sensitive zoonotic pathogens.

DEPARTMENT OF HOMELAND SECURITY (DHS)

DHS expects to spend \$8M in FY 2023 on Arctic research. The U.S. Coast Guard (USCG) conducts research “to improve situational awareness for in the Arctic, including providing support for maritime domain awareness, communications, and search and rescue missions.” Examples of program activities include exploring technological solutions to enhance capabilities and operate effectively in the Arctic and working with state and local communities in Alaska on emergency management and resiliency challenges. While the reported Arctic research activities are scheduled to be completed in FY 2023, the DHS Science and Technology Directorate recently announced a \$45M funding opportunity for up to 10 years to support a new Center of Excellence for Homeland Security in the Arctic.

R/V SIKULIAQ. This research vessel, owned by NSF and operated by the University of Alaska, enables scientists to collect seafloor samples, use remotely operated vehicles, and conduct surveys throughout the water column with an array of instrumentation in open pack ice of Alaska and polar regions. Here, *Sikuliaq* is conducting an ice station in the Chukchi Sea, May 2021. *Photo credit: Ethan Roth*



INTERNATIONAL COLLABORATIONS. U.S., Canadian, and European representatives from the public and private sectors discuss socio-ecological topics that require international attention. This week-long engagement in Svalbard in June 2018 resulted in new international collaborations. *Photo credit: Jørn Berger-Nyvoll, UiT*



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

HUD conducts research through the Office of Policy Development and Research (PD&R). Currently PD&R does not have dedicated funding for Arctic research, however, the office accepts unsolicited research requests from the field. Recently, through this process, a PD&R grant was awarded to Nome, Alaska. The award will develop and support research of 3D concrete printing. This research supports a developing material science industry, the Port of Nome infrastructure, and may lend itself to Arctic resilience strategies. HUD expects to spend \$0.6M in FY 2023 on a project studying the use of 3D printing technology to construct affordable, energy-efficient, and sustainable housing in a sub-arctic environment.

DEPARTMENT OF THE INTERIOR (DOI)

DOI expects to spend \$25.3M in FY 2023 on monitoring, modeling, and research responsibilities in the Arctic. Arctic research activities take place across multiple bureaus, namely: the Bureau of Land Management, the Bureau of Ocean Energy Management, the Bureau of Safety and Environmental Enforcement, the National Park Service, the U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS). DOI is responsible for maintaining 62% (by area) of all U.S. Arctic lands, and the funding estimates in this report include land management efforts as well as administrative support costs for applied research. Examples of program activities include managing energy development, wildlife refuges, and mineral resources; administering the Beringia National Heritage Program to preserve the heritage of the Indigenous Peoples along the Bering Strait; providing land imaging, geologic, topographic, biogeographic, and hydrographic mapping services necessary to model and understand Earth systems and processes; studying ecosystem issues such as land and species conservation, climate change, and health risks from environmental contaminants and pathogens; researching and monitoring glacier changes; and maintaining stream gages. DOI did not include USFWS inventory and monitoring activities in the Arctic National Wildlife Refuge in this budget summary.

MARINE MAMMAL COMMISSION

The Marine Mammal Commission has a longstanding commitment to support the assessment of marine mammal stocks and the management of risks to marine mammals and subsistence communities in a changing Arctic. The Commission’s small grants program supports projects aimed at meeting the conservation and protection goals of the Marine Mammal Protection Act (MMPA). Alaska or Arctic-focused research proposals are often funded in response to broader requests for proposals and support may exceed \$100K in a given year. The research program awards grants based on proposals submitted in response to an annual call for proposals, which may include specific research topics identified by the Commission. In 2019, the request for proposals focused on the impacts of a changing ocean on marine mammals of importance to Alaska Natives. Since the Commission was established in 1972, it has supported more than 1,000 projects.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA funding of Arctic research is an estimated \$177 million in FY 2023. Arctic research efforts at NASA aim to “advance scientific understanding of the Earth system and its response to natural and human-induced changes and to improve our ability to predict climate, weather, and natural hazards.”⁹ NASA satellite and aircraft remote-sensing capabilities are critical tools for characterizing and understanding the changes occurring in the Arctic, which hosts some of the most inaccessible and inhospitable zones on Earth. NASA Arctic research, observation, and monitoring is supported by the Earth Science Flight Program and the Earth Science Research and Analysis (R&A) and Flight Programs, which contain several “focus areas” that include Arctic research. Activities within the Earth Science Flight Program and Earth Science R&A Program broadly support research, modeling, monitoring, and observation efforts. Examples include NASA satellite and aircraft remote-sensing capabilities that support research on climate change; carbon cycle, hydrology, and ecosystems research; a global survey of Earth’s major lakes, rivers, wetlands, and oceans; and observations that monitor sea ice, ice sheets, and glaciers.

⁹ Quoted text in this chapter, such as in this section describing NASA programs, refers to program summaries submitted by agencies in Appendix B.



HARVESTING FOR SUBSISTENCE. Emma White of Quinhagak cuts salmon to hang up for drying at her fishcamp on a tributary of the Kanektok River in 2005. Harvesting salmon for subsistence is widely practiced throughout Alaska. Photo credit: © Wayde Carroll, Source: Smithsonian Arctic Studies Center in Alaska



NATIONAL SCIENCE FOUNDATION (NSF)

NSF expects to spend \$154M in FY 2023 to “better understand the Arctic’s biological, geophysical, chemical, and sociocultural processes and systems and to learn from multiple knowledge systems.” NSF Arctic research is supported by the Office of Polar Programs (OPP) and other disciplinary programs within NSF. Program activities include maintaining research infrastructure as well as funding basic research: NSF maintains three Arctic-focused Long-Term Ecological Research (LTER) sites in Alaska, multiple ecological study sites in Alaska that are in the National Ecological Observatory Network (NEON), Summit Station in Greenland, and the research vessel *Sikuliaq*. NSF also publishes data products from NSF-supported Arctic research through the NSF Arctic Data Center and NSF’s Public Access Repository. Examples of program activities include providing logistical and field support capabilities for Arctic research; bringing together Indigenous Knowledge holders, scientists, government representatives, nongovernmental organizations, and others to exchange knowledge and strengthen modeling and community support; and funding research on the impact of pollutants from warming Arctic soils on human health.

SMITHSONIAN INSTITUTION ARCTIC STUDIES CENTER (ASC)

The Smithsonian Institution expects to spend \$2.2M in FY 2023 on Arctic research. Arctic research takes place primarily through ASC at the National Museum of Natural History, with additional contributions from the National Zoo and Smithsonian Conservation Biology Institute. ASC “conducts archaeological, ethnographic, and heritage studies of peoples and cultures throughout the circumpolar regions, publishes scholarly materials, mounts exhibits, and prepares educational materials from offices in Washington, D.C., and in Anchorage, Alaska,” and is “the only U.S. agency devoted exclusively to anthropological and cultural studies of Arctic peoples.” Examples of program activities at ASC include research on the impacts of Arctic environmental change on human and animal populations, publications on North American Native cultures that include populations in the Arctic and subarctic, and the National Museum of Natural History exhibitions dealing with Arctic species and ecosystems. Funding reported for ASC represents both what was allocated internally within the National Museum of Natural History’s budget for the program as well as portions of collections support.¹⁰

¹⁰ The Smithsonian Institution did not report what portion of the funds are from collections support.

Conclusions

This synthesis of investments by the federal government reflects a broad range of programs and projects relating to Arctic research, including observation, modeling, monitoring, and prediction, as well as research infrastructure. This analysis was based upon the self-reporting of federal agencies on their activities related to Arctic research. In other words, the agencies themselves determined what they considered as Arctic research and which activities and budget items were relevant.

While the research efforts supported by U.S. federal departments, bureaus, offices, and commissions are anchored in their individual missions and differ greatly depending upon their purpose, they are nevertheless complementary, enabling agencies to achieve more by leveraging the efforts and accomplishments of other federal entities. For example, research analyses completed by NASA enable more quantitative analyses on environmental assessments by those agencies responsible for land, water, or natural resource management.

This report presents the first in a series of annual crosscut analyses of federal agency investments in Arctic research that will be continued until FY 2034. The U.S. government has made significant progress in providing information and evolving our understanding of the Arctic, which is essential to advancing our national interests in the region. This budget crosscut exercise is an important step to ensure that federally funded Arctic research is complementary, cost-efficient, and effective across government, and that a coordinated, multi-entity approach is developed to address the research goals and objectives in the Arctic. Further, it will enable reporting to Congress on the adherence of federal research efforts to national objectives.

Appendix A

The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (P.L. 117–263)

SEC. 5912. REPORTS ON ARCTIC RESEARCH, BUDGET, AND SPENDING.

(a) Crosscut Report on Arctic Research Programs.--

- (1) In general.--Not later than 180 days after the date of the enactment of this Act, the Director of the Office of Science and Technology Policy, in coordination with the Director of the Office of Management and Budget, shall submit a detailed report to Congress regarding all existing Federal programs relating to Arctic research and research-related activities, including observation, modeling, monitoring, and prediction, and research infrastructure. The report shall include--
 - (A) the goals of each such program;
 - (B) the funding levels for each such program for each of the 5 immediately preceding fiscal years;
 - (C) the anticipated funding levels for each such program for each of the 5 following fiscal years; and
 - (D) the total funding appropriated for the current fiscal year for such programs.
- (2) Distribution.--Not later than 30 days after submitting the report to Congress pursuant to subsection (a), the Director of the Office of Science and Technology Policy shall make a report available on a public website.

(b) Annual Agency Budget and Spending Report.--

- (1) Annual agency budgets.--Each agency represented on the Interagency Arctic Research Policy Committee shall each include in their agency's annual budget request to Congress a description of their agency's projected Arctic research activities and associated budget for the fiscal year covered by the budget request.
- (2) Report to congress.--Beginning with fiscal year 2025 and thereafter until fiscal year 2034, not later than 60 days after the President's budget request for such fiscal year is submitted to Congress, the Office of Science and Technology Policy shall submit an annual report to Congress summarizing each agency's budget request related to Arctic research activities per the information submitted in accordance with paragraph (1).

Appendix B

Agency Program Summaries

The following are agency-provided summaries of their research activities in the Arctic, as submitted to OMB.

ARCTIC RESEARCH COMMISSION

The Arctic Research Commission (USARC) is an independent federal agency created by the Arctic Research and Policy Act of 1984 and assigned specific duties therein, as listed below. The Commission is a presidentially appointed advisory body supported by staff in offices in Arlington, Virginia, and in Anchorage, Alaska.

USARC’s primary contribution to establishing U.S. Arctic research policy is a biennial “Report on the Goals and Objectives for Arctic Research for the U.S. Arctic Research Program Plan” to the President and Congress. In addition to the report, the Commission develops and recommends an integrated national Arctic research policy and builds cooperative links in Arctic research within the federal government, with the State of Alaska, with Tribes and Alaska Native Organizations, and with international partners. The law also requires the Commission to review the Arctic research budget “crosscut” in the President’s annual budget request and report to Congress on how the crosscut adheres to the five-year Arctic Research Plan produced by the Interagency Arctic Research Policy Committee (IARPC).

USARC plays a significant role in planning and implementing international Arctic Science Ministerial meetings and other international Arctic science initiatives and has been involved in the Arctic Council since its inception. USARC serves as the “competent national authority” in implementing the legally binding “Agreement on Enhancing International Arctic Scientific Cooperation.”

USARC is a statutory member of the North Pacific Research Board and the North Slope Science Initiative. USARC is also a member, participant, liaison, or observer on the Interagency Arctic Research Policy Committee, the Interagency Coordinating Committee on Oil Pollution Research, the National Ocean Council, the Extended Continental Shelf Task Force, the Study of Environmental Arctic Change (SEARCH), the Civil Applications Committee, the Scientific Ice Expeditions Interagency Committee (Navy submarines), the Arctic Icebreaker Coordinating Committee of the University National Oceanographic Laboratory System, the Alaska Ocean Observing System, the Department of State’s Arctic Policy Group, the Arctic Research Consortium of the United States, the International Permafrost Association, and the Ted Stevens Center for Arctic Security Studies.

Duties of the Commission:

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

CENTERS FOR DISEASE CONTROL AND PREVENTION

The Centers for Disease Control and Prevention's (CDC's) Arctic Investigations Program (AIP), located in Anchorage, Alaska, focuses on the prevention and control of infectious diseases in peoples of the Arctic and subarctic. During 2022 and 2023, activities have focused on continued infectious disease surveillance, assessment of health disparities related to infectious diseases, evaluations of the effectiveness of an array of vaccines against infectious diseases, research support for projects utilizing the Alaska Area Specimen Bank, and support of CDC-funded research that is primarily being conducted by collaborating public health and clinical partners.

Along with the State of Alaska, AIP conducts statewide surveillance of five invasive bacterial diseases that cause significant morbidity and mortality. The surveillance is used to monitor long-term trends in these pathogens as well as evaluate the impact of various interventions within Alaska. Additionally, AIP provides leadership to, and participates in, an International Circumpolar Surveillance for the same five pathogens. This collaboration monitors invasive bacterial infections and administers prevention activities. AIP also conducts, or is involved in, surveillance for respiratory pathogens and climate-sensitive zoonotic pathogens within the state of Alaska, in both rural and urban settings.

One primary focus of the AIP is evaluation of the effectiveness of vaccines in preventing infectious disease morbidity and mortality. AIP, along with collaborators, is involved in the evaluation of the long-term effectiveness of vaccines for the hepatitis A and hepatitis B viruses, as well as the human papillomavirus. Studies are also being conducted to look at the shorter-term effectiveness of a vaccine for *Haemophilus influenzae* and mRNA vaccines to prevent COVID-19 infection. In a tribal-federal partnership, AIP also co-maintains the Alaska Area Specimen Bank, which provides a quality resource for research in accordance with the health priorities of the Alaska Native people.

DENALI COMMISSION

The Statewide Threat Assessment is an ongoing effort to document three major threats to Alaskan communities: erosion, flooding, and thawing permafrost. It builds on several past efforts, including the Baseline Erosion Assessment (BEA) and other erosion assessments, U.S. General Accounting Office reports, and the 2019 Statewide Threat Assessment.

For each study and report, teams of federal, state, Tribal, and local stakeholders coordinate to identify problems, develop criteria for assessing those problems, and disseminate the compiled information. Comprehensive lists of Alaska communities that have or are perceived to have erosion, flooding, or permafrost issues have been created and the seriousness of the problems ranked. These lists help to inform, illustrate need, and assess the potential for climate-change-related damages as well as to understand ways to mitigate and plan for such events.

Since the 2019 Statewide Threat Assessment, the climate has continued to change. Increases in air and water temperatures, as well as other factors, have contributed to the acceleration of permafrost thawing and erosion, and increased flooding. In some cases, the actual amount of land loss and destruction have exceeded forecasts. This trend is likely to continue.

The 2024 Statewide Threat Assessment will again bring together stakeholders, scientists, policymakers, Indigenous Knowledge holders, and federal, state, and Tribal representatives. The main tasks will include assembling the team and updating the methodology of past assessments and reports. It will incorporate data that have been collected over the last five years and build a holistic perspective of the threats to Alaskan communities. Advances in technology, monitoring, and modeling will permit this Statewide Threat Assessment to present a robust and informed data set that will contribute to the dialogue and assist community members and policymakers in the decision-making process.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) provides leadership and funding for programs that advance agriculture-related sciences. It invests in and supports initiatives that ensure the long-term viability of agriculture and rural communities. For FY 2022, USDA NIFA reported spending \$960K on Arctic research through the research and development reporting submitted to the Office of Management and Budget. Individual projects were funded through Hatch Research and McIntire-Stennis capacity funding programs.

One USDA NIFA-supported project at the University of Alaska used GPS radio collars to help reindeer producers monitor the location and movement of their animals via an online mapping program. Virtual boundaries are set on maps, and producers receive an email and text notification when reindeer are approaching designated boundaries so they can intervene if necessary. This successful research has provided Alaskan reindeer producers with a tool to assist with the reintroduction of reindeer to remote grazing allotments.

Initiated in 1994, the University of Alaska's Cooperative Alaska Forest Inventory (CAFI) monitors boreal forests through long-term data collection made possible by strong partnerships. Data are collected annually. The long-term data set is used in many ways, including in forest growth models and in climate change analyses.

Rutgers University is using global climate model simulations to examine the effects of projected climate change on the Arctic terrestrial system. To date, their analysis projects an overall increase in precipitation under future climate conditions; however, this precipitation increase is associated with a decrease in the ratio of snow to total precipitation due to warmer season temperatures. This project is ongoing and is currently making projections on freshwater availability.

DEPARTMENT OF DEFENSE

The Department of Defense (DoD) recognizes the strategic importance of the Arctic region and its evolving geopolitical and environmental challenges. With the aims of enhancing situational awareness, logistics, navigation, and operations, as well as increasing the resiliency of Arctic facilities and communities, DoD has invested in a wide-ranging research portfolio. This summary provides an overview of DoD's Arctic research efforts and its commitment to maintaining a strong presence in the region.

SEA, AIR, LAND, AND SPACE-BASED SENSING, MAPPING, AND MODELING TO SUPPORT ARCTIC COLD-WEATHER OPERATIONS

Given the Arctic's extreme weather and changing physical hazards, sea, land, and coastal operations in the region require high-resolution, near-real-time information. The Cold Regions Research and Engineering Laboratory funds several programs, including the U.S. Army Corps of Engineers National Coastal Mapping Program, and is assessing features on land such as snow depth, ice thickness, and freeze-thaw depth through its Arctic Terrain Sensing with Drone Platforms program element. The Office of Naval Research (ONR) supports a suite of programs covering Arctic acoustics, sea ice dynamics, marine meteorology, autonomous observing platforms, and uncrewed airborne systems. Both the CRREL and ONR support mathematical modeling and prediction of Arctic weather systems and extreme weather events. The Space Force supports research on high-latitude ionospheric observing techniques and regional modeling to provide near-real-time forecasting to enable rapid response to natural and adversarial threats to the electromagnetic spectrum.

CLIMATE CHANGE AND ENVIRONMENTAL ADAPTATION

The Ted Stevens Center for Arctic and Security Studies performs research and analysis to advance awareness and understanding of the Arctic region and its domain-specific risks. Areas of interest include Arctic change and environmental security, climate science and policy studies for defense and security planners, Arctic health security, and Indigenous Peoples security within a pan-Arctic construct.

ARCTIC REGION-ADAPTED MATERIALS AND ENGINEERING

The stresses that cold environments and extreme weather bring to bear on equipment and infrastructure require innovative technologies. The Air Force Research Laboratory materials programs study enzymatic, protein-based, and other biotechnological approaches to protect assets from freezing and thawing under Arctic conditions. The Defense Advanced Research Projects Agency supports innovative research that includes the engineering of microbes and other biological or bio-inspired components to produce novel materials that can be used in extreme environments. Because operations in the Arctic are frequently isolated from resupply for long periods, DoD supports the Austere Field Repair program, which will develop Forward Operating Base on-site manufacturing capabilities via mobile mini factories.

DEPARTMENT OF ENERGY

The Department of Energy's (DOE's) Biological Environmental Research (BER) and Earth Environmental Systems Sciences Division (EESSD) supports DOE's mission goals for transformative science for energy and national security by enabling major scientific developments in climate, environmental, and Earth system research. The goal of new science is to develop and enhance a predictive, systems-level understanding of the fundamental processes associated with extreme phenomena.

In 2018, EESSD issued a five-year strategic plan that included five scientific grand challenges, one of which is entitled, "High Latitude Scientific Grand Challenge." While the Arctic is a critical environmental system, EESSD is organized around key science topics (e.g., modeling, atmospheric sciences, and environmental system science) that represent important areas of uncertainty in the energy/environment relationship. Some of the larger DOE national laboratory-led efforts that include a focus on the Arctic are described below.

The goal of the High-Latitude Application and Testing of Earth System Models (HiLAT) project is to reduce the uncertainties and enhance the predictive understanding of high-latitude environmental change and its global consequences by furthering our knowledge of high-latitude Earth system interactions and their connection to lower latitudes through the targeted application of DOE's high-resolution global and regional models at seasonal to decadal timescales. Over the past eight years, this activity has produced the first coupled regionally refined global Earth system model for the Arctic in collaboration with DOE's Energy Exascale Earth System Model (E3SM).

The Interdisciplinary Research For Arctic Coastal Environments (InterFACE) project focuses on how the coupled, multiscale feedbacks among land processes, sea ice, ocean dynamics, coastal change, river and marine biogeochemistry, atmospheric processes, and human systems will control the trajectory and rate of change across the Arctic coastal interface. Over four years, the project has developed models that have improved representation of landfast ice, wave-sea ice interactions, turbulence, biogeochemistry, and permafrost hydrology. Most of the work is currently focused along the North Slope of Alaska's coast; the next phase will become more pan-Arctic.

The Atmospheric Radiation Measurement (ARM) user facility operates one of its atmospheric observatories in Utqiavik, Alaska, to provide comprehensive data about aerosol, cloud, and radiative processes at high latitudes to the scientific community in order to improve the representation of high-latitude cloud and radiation processes in Earth system models. This site supports 60 active instruments, many of which were built specifically for high latitudes. ARM transmits all data gathered at this site to the ARM Data Center, where they are made freely available via Data Discovery.

The Next Generation Ecosystem Experiment – Arctic (NGEE Arctic) project seeks to improve understanding of the evolution of permafrost-dominated Arctic ecosystems and their representation in Earth system models. During the past three phases of the project, NGEE Arctic observations, synthesis products, and model scaling have informed the conceptualization and parameterization of several modeling components that will improve DOE's E3SM. In the upcoming phase, NGEE Arctic will deliver quantified improvements in prediction of climate-ecosystem feedbacks at the pan-Arctic scale.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

The Department of Health and Human Services (HHS) is invested in improving health and well-being of Alaska's residents through research programs and grants.

For example, because Arctic Indigenous populations face significantly lower life expectancy, higher infant mortality, and other disparities compared with the general population of Alaska, the HHS National Institutes of Health (NIH) funds several projects in the region. Some current projects include:

- Sponsored Programs Administration Development (SPAD) for Alaska Pacific University, Anchorage, Alaska
- Jumpstarting Culturally Informed Advance Care Planning with ANAI People in Primary Care, Southcentral Foundation, Anchorage, Alaska
- University of Alaska Anchorage
 - U-RISE at University of Alaska Anchorage (“Biomed U-RISE”)
 - Convergence of multiple exposures during pregnancy: Effect of wildfires and maternal stressors on birth outcomes among Alaskan women
- University of Alaska Fairbanks
 - Vitamin D and Healthy Aging: Establishing the Sled Dog Sentinel for the Circumpolar North
 - Modernizing a Shared-Use Large Animal Facility Supporting Translational Hibernation Research at UAF
 - Biomedical Learning and Student Training (BLaST) Program (three awards)

Another example of HHS division engagement in research in Alaska is through the Food and Drug Administration (FDA), which supports an extramural project that engages American Indian and Alaska Native communities, partners, and researchers to explore the knowledge and attitudes about clinical trials from Tribal and Native American communities.

Anchorage, Alaska, host the Centers for Disease Control and Prevention's (CDC) Arctic Investigations Program (AIP), which focuses on the prevention and control of infectious diseases in Arctic and subarctic people. During 2022 and 2023, activities have focused on infectious disease surveillance, assessment of health disparities related to infectious diseases, evaluations an array of vaccines against infectious diseases, research support for projects using the Alaska Area Specimen Bank, and support of CDC-funded collaborative research that is primarily being conducted by public health and clinical partners.

Additionally, AIP provides leadership to, and participates in an International Circumpolar Surveillance for the same five pathogens. This international collaboration is designed for monitoring of invasive bacterial infections as well as prevention activities. AIP also conducts, or is involved in, surveillance for respiratory pathogens and climate-sensitive zoonotic pathogens in various settings within the state of Alaska, in both rural and urban locations.

In 2022, the AIP published results from a 35-year study evaluating the long-term effectiveness of a vaccination to prevent hepatitis B. The study demonstrated that protection continued for 35 years of 86% of the people who participated or they responded to a booster dose of vaccine.

In 2021 HUD joined the Interagency Arctic Research Policy Committee and in 2022 became a member of the Arctic Executive Steering Committee. Through these positions the department will become more familiar with the Arctic, identify investment opportunities in the region, and development elements of work that can be integrated into the [“HUD Climate Action Plan”](#).

DEPARTMENT OF HOMELAND SECURITY

The Department of Homeland Security (DHS) continues to focus on research and development to improve situational awareness for in the Arctic, including providing support for maritime domain awareness, communications, and search and rescue missions. First, through the U.S. Coast Guard and in collaboration with interagency partners, DHS is exploring technological solutions that would enhance its capabilities to operate effectively in the dynamic Arctic domain. Second, DHS is working with state and local communities in Alaska to better understand their unique emergency management and resiliency challenges. Finally, the DHS Science and Technology Directorate recently announced a \$45M funding opportunity for a new Center of Excellence for Homeland Security in the Arctic. The process for identifying and selecting the new Center is underway, and DHS will announce its decision in FY2024.

DEPARTMENT OF THE INTERIOR

The Department of the Interior (DOI) manages U.S. public lands, ensuring they are available for recreation, job growth and creation, conservation of natural and cultural resources, and responsible energy development. DOI has extensive scientific and stewardship expertise in the Arctic, as DOI manages 62% (by area) of all U.S. Arctic lands. DOI is the parent agency of 10 federal bureaus, many of which have substantial monitoring, modeling, and/or research responsibilities in the Arctic.

The Bureau of Land Management manages 23.1 million acres of public lands north of the Brooks Range, which includes the National Petroleum Reserve-Alaska, the largest contiguous block of federal land managed by a single agency. This area provides important habitat for migratory birds and caribou, access for subsistence hunting and fishing for rural residents, and oil and gas exploration and development activities.

The Bureau of Ocean Energy Management manages the development of energy and mineral resources of the 485 million acres of Alaska's outer continental shelf and conducts research to support management decisions.

The Bureau of Safety and Environmental Enforcement works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.

The National Park Service manages several protected areas in the Arctic, including the Gates of the Arctic, and administers the Beringia National Heritage Program, which seeks to preserve the heritage of the Indigenous Peoples along the Bering Strait.

The U.S. Fish and Wildlife Service (USFWS) manages 16 national wildlife refuges in Alaska, including the Arctic National Wildlife Refuge. USFWS engages in inventory and monitoring in the Arctic National Wildlife Refuge, but those investments are not included in this budget summary.

The U.S. Geological Survey (USGS) is a non-regulatory science agency that engages in extensive research in the Arctic. As the civilian mapping agency, the USGS delivers land imaging, geologic, topographic, biogeographic, and hydrographic mapping, and data that provide the foundational information and analytics necessary to model and understand Earth systems and processes. The USGS also tackles ongoing and emerging ecosystem issues identified as priorities, including land and species conservation, sustainable energy, drought, wildland fire, coastal change, and community resilience. Additional priorities include scientific understanding of the sources, transport, fate, and exposure pathways of health risks posed to fish, wildlife, and humans by environmental contaminants and pathogens; advancing understanding of processes and climate extremes that influence terrestrial and aquatic ecosystems; providing data and analyses that document patterns of change; and developing models to project change under multiple scenarios. USGS hazards science supports the safety and security of the nation against a wide range of natural hazards, including floods, earthquakes, volcanic eruptions, landslides, coastal change hazards, geomagnetic storms, and wildfires. The USGS maintains a vital network of stream gages to inform flood forecasting, water cycle modeling, development and permitting, and water use and availability. It also maintains the benchmark glacier research and monitoring program to quantify changes in mass balance, volume, spatial extent, and connections to climate conditions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Arctic research is vital to the mission of the National Aeronautics and Space Administration (NASA), as environmental changes in this polar region can profoundly affect the whole planet. NASA's satellite and aircraft remote-sensing capabilities are critical tools for characterizing and understanding the changes occurring in the Arctic, which includes some of the most inaccessible and inhospitable zones on Earth. NASA also sponsors several Arctic research endeavors via its Earth Science Research and Analysis (R&A) Program. The Earth Science Flight Program builds and operates the satellite missions. Both programs conduct airborne campaigns that deliver critical measurements and data for the Arctic and globally. The R&A Program consists of a portfolio of projects designed to advance scientific understanding of the Earth system and its response to natural and human-induced changes and to improve our ability to predict climate, weather, and natural hazards. Within the R&A Program, there are several focus areas that include projects and objectives emphasizing Arctic observations and analyses.

RESEARCH AND MODELING EFFORTS

The Climate Variability and Change Focus Area studies global climate and sea level to understand their changes on seasonal to decadal timescales. Arctic research questions are addressed through several programs. The Cryospheric Sciences program supports studies based on satellite and aircraft remote-sensing observations to understand the factors controlling changes in Earth's ice and its interaction with other Earth systems. The Physical Oceanography program investigates the ocean's role in climate variability at different timescales. The Modeling, Analysis, and Prediction program supports advanced modeling capabilities to improve understanding of the physical processes that control the Earth system and enable prediction.

The Carbon Cycle and Ecosystems Focus Area seeks to detect and predict changes in Earth's ecosystems and biogeochemical cycles. Arctic research questions are addressed through (1) the Ocean Biology and Biogeochemistry (OBB) program suite of projects that address aspects of carbon cycle, hydrology, and ecosystem research from space, and (2) the Terrestrial Ecology program's Arctic-Boreal Vulnerability Experiment (ABOVE) field campaign conducted in Alaska and western Canada that is focused on understanding environmental change and associated impacts on social-ecological systems. In addition, the Atmospheric Composition focus area funds research and field campaigns such as the upcoming Arctic Radiation-Cloud-Aerosol-Surface-Interaction Experiment, and the Water and Energy Cycle focus area is investing in new capabilities to measure snow water equivalent and snow albedo. The Earth Surface and Interior focus area continues to develop new remote-sensing methods to observe permafrost and the active layer, especially in anticipation of the upcoming 2024 launch of the NASA-ISRO Synthetic Aperture Radar (NISAR).

MONITORING AND OBSERVATION EFFORTS

NASA Earth science satellites provide information about the physical, chemical, and biological state of Earth's surface and the overlying atmosphere. Four satellite missions whose products are of particular interest in addressing Arctic change include: (1) the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission, which observes Earth's global gravity changes monthly and monitors water movement across the planet, including changes in ice sheets and glaciers; (2) the Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2), which gathers data that precisely track changes in Earth's terrain, including glaciers, sea ice, and forests; (3) the Surface Water and Ocean Topography (SWOT) mission, surveys Earth's major lakes, rivers, wetlands, and oceans with unprecedented resolution; and (4) the NISAR satellite, currently scheduled for launch in 2024, will enable researchers to systematically measure centimeter-level motion of the world's ice sheets and glaciers and obtain the most complete measurements of rapidly changing sea ice motion and thickness.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) goals for the Arctic include better understanding and predicting Arctic change and its global implications, and delivering sound science that supports healthy, productive, and resilient communities and ecosystems. NOAA's line offices have worked to achieve these goals through FY2022–FY2024 resourcing and have successfully created products and services that help inform decision-making in the Arctic and that benefit local communities.

The National Ocean Service's (NOS) Center for Operational Oceanographic Products and Services and Integrated Ocean Observing System evaluate and develop new observing technologies to provide the region with flexible, cost-effective options to inform coastal decision-making. In FY2023, NOS's National Centers for Coastal and Ocean Science supported the installation and maintenance of a shipboard Imaging FlowCytobot instrument, which allows scientists to assess the potential risk of harmful algal blooms and communicate those risks to Alaska Native communities in the region.

The National Environmental Satellite, Data, and Information Service (NESDIS) provides enhanced remotely sensed Arctic Ocean and sea ice products and services, with applications in modeling, operational analysis and forecasting, fisheries, navigation, and climate monitoring. NESDIS has initiated a collaboration between the Polar Program at the Center for Satellite Application and Research and the NESDIS Innovation Program to develop an Arctic-wide sea ice motion product and framework for obtaining information on sea ice change, providing analysis-ready data for use in research and operations.

NOAA Fisheries' Alaska Fisheries Science Center conducts research cruises that support stock assessments through programs like the Groundfish Assessment Program and the Northern Bering Sea Surface Trawl and Ecosystem Survey. NOAA Fisheries also conducts periodic surveys of species important to Native Alaskan communities, including Arctic ice seals, whales, and northern fur seals. These activities provide data for Stock Assessment Reports that inform ecosystem management, as well as support federal management and co-management with Indigenous partners through the Marine Mammal Protection Act. NOAA Fisheries also collects data supporting integrated ecosystem assessments and supports the development of the Climate Ecosystem and Fisheries Initiative to facilitate climate-informed and ecosystem-based management.

The Oceanic and Atmospheric Research Office's (OAR) Arctic Research Program aims to improve the understanding of ocean-ice-atmospheric processes and marine ecosystems in the Arctic to characterize the region's response to climate variability. A general focus is supporting coordination, collaboration, and development of projects to make data accessible to Alaskan communities, improve sea ice models for hunting and transportation, improve co-creation of knowledge with Indigenous communities, and collaborate to predict and evaluate climate impacts on marine fisheries. OAR supports programs like Ecosystems and Fisheries–Oceanography Coordinated Investigations (EcoFOCI), the Distributed Biological Observatory (DBO), the Barrow Observatory, and the International Arctic Buoy Programme.

The Office of Marine and Aviation Operations (OMAO) makes much of the line offices' work possible with their funds supporting Days at Sea for agency research efforts, primarily on NOAA Ship *Oscar Dyson*. OMAO also provides the aircraft and personnel necessary for marine mammal surveys conducted in the Arctic.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation’s (NSF’s) Arctic Research Program seeks to better understand the Arctic’s biological, geophysical, chemical, and sociocultural processes and systems and to learn from multiple knowledge systems. NSF supports Arctic research in coordination with federal and international partners. NSF maintains Arctic research infrastructure, including three Arctic-focused Long-Term Ecological Research (LTER) sites in Alaska; multiple Alaska sites of the National Ecological Observatory Network (NEON), some co-located with LTER sites; Summit Station in Greenland; R/V *Sikuliaq*; and logistical and field support capabilities that enable Arctic research. Data products from NSF-supported Arctic research are publicly available from the NSF Arctic Data Center and NSF’s Public Access Repository. Below are selected highlights of NSF-supported basic research and research infrastructure.

- Two NSF-funded projects are looking to the past to understand the threat to coastal cities as the Greenland Ice Sheet melts. GreenDrill, an international collaboration led by researchers from Columbia University, uses rapid-access drilling to sample ice and bedrock in Northwest Greenland spanning hundreds of thousands of years of Earth history. University of Vermont researchers use samples collected in the 1960s to understand the response of Northwest Greenland’s ice sheet to strong warming approximately 400,000 years ago. Both team’s results show that the ice sheet shrank significantly during warm periods, potentially raising sea level by at least 5 feet.
- Harmful algal blooms (HABs) arise when colonies of algae grow rapidly in the ocean and in lakes, producing toxins that can threaten human health, especially in communities that depend on foods that can concentrate the toxins. In late summer 2022, NSF-supported researchers from Woods Hole Oceanographic Institution provided real-time warning to Alaskan coastal villages of a very dense and toxic HAB threatening the region. In one notable case, the warning may have saved families from eating shellfish with toxin levels five times the limit for human consumption.
- Thousands of sites in the Arctic are contaminated by persistent pollutants that can enter the food chain as Arctic soils warm. Researchers from the University of Nevada-Reno, the Qawalangin Tribe of Unalaska, and the City of Unalaska are studying the risk of human exposure to such contaminants on Unalaska Island. This co-produced project supports culturally important subsistence lifestyles, trains residents for research and management techniques, fosters proactive and sustainable public health risk management, and informs management and remediation efforts.
- Navigating the New Arctic (NNA), one of NSF’s “Big Ideas,” addressed convergent scientific, engineering, and educational challenges in, and related to, the rapidly changing Arctic. The solutions to these challenges are needed to understand and forecast environmental change; advance economic prosperity; promote human and ecological health; and preserve security for the United States, the circumpolar Arctic region, and the globe. NNA encouraged projects that leverage partnerships to address fundamental science issues of societal importance.
- NEON partners broadly to further the impact of the infrastructure investments, advance scientific frontiers, enhance workforce development, and grow diverse communities of users. NEON partnered (1) with the American Geophysical Union and the University of Alaska to create methods to monitor berries, a critical natural food source, at NEON sites, and (2) with the Alaska Native Science and Engineering Program and the U.S. Forest Service to recruit candidates for opportunities in Alaska at the post-graduate, graduate, and postdoctoral levels.

SMITHSONIAN ARCTIC STUDIES CENTER

The Arctic Studies Center (ASC) of the Smithsonian Institution conducts archaeological, ethnographic, and heritage studies of peoples and cultures throughout the circumpolar regions; publishes scholarly materials; mounts exhibits; and prepares educational materials from offices in Washington, D.C., and in Anchorage, Alaska. The ASC is the only U.S. agency devoted exclusively to anthropological and cultural studies of Arctic peoples. One of its major functions is to curate the nation’s anthropological Arctic collections.

Over the past several years, the Smithsonian has conducted research on Arctic change as reported in the book: *Arctic Crashes: People and Animals in the Changing North*. The project explored how historical and modern Arctic environmental change have resulted in changing patterns of marine and terrestrial animal behavior and distributions, and how past and present human populations have responded to shifts in their resource base. Lessons learned have been incorporated into educational programs that have been made available to northern communities through scholarly reports, popular media, and exhibitions, with special attention given to Alaskan Indigenous communities through the activities of the ASC office in the Anchorage Museum.

Special projects have resulted in major publications. The 950-page introductory and synthesis volume to the Smithsonian’s multi-volume *Handbook of North American Indians* brought to a close the Smithsonian’s epic documentation of North American Native cultures, including volumes on the Arctic and subarctic. *Bark and Skin Boats of Northern Eurasia* is a historical atlas of the traditional watercraft of more than 50 native cultures ranging from Scandinavia to Bering Strait and Alaska. Smithsonian Press will soon publish *Laaxaayík, Near the Glacier: The Cultural Ecology and Archaeology of Yakutat Fiord, Alaska*, a work describing the effects of climate change on the past several hundred-year history of the Yakutat Tlingit. All these works have been accomplished with collaboration with local and Indigenous partners. The 2022 annual Ernest S. Burch lecture, “The Valkyries of Linen: Women’s Power and Cloth Production in the Viking North Atlantic,” was given by Michèle Hayeur-Smith. Archaeological research was conducted on sixteenth century Inuit contacts with Basque whalers in the northern Gulf of St. Lawrence.

Educational activities include the opening of a new Natural History Museum exhibition titled “Lights Out: Recovering the Night Sky,” which documents the damaging effect of light pollution on insects, birds, and other nocturnal species, and advocates for changes in the way humans have chosen to illuminate the world. Other Arctic Studies Center exhibitions dealing specifically with the Arctic include “Narwhal: Revealing an Arctic Legend” that reports the discovery that this iconic Arctic sea mammal uses its tusk as a sensory organ to monitor changes in water temperature and salinity, possibly to avoid drowning when freezing seawater begins to close its breathing holes. Another exhibition, “Knowing Nature: Stories of the Boreal Forest,” explores with central role played by the boreal forest, the larger continuous forest on Earth, as the “lungs” of the planet and the likely source of our future freshwater supply, as well as the critical habitat of many species of birds and animals we depend on for material and spiritual support. Finally, the ASC Alaska office has been instrumental in developing educational media programs using Smithsonian collections to encourage and preserve language and cultural heritage among Northern Peoples. Our 2022 Arctic Studies Newsletter reports these and many more ASC activities.

CARIBOU IN FRONT OF MOUNT DENALI.

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