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U.S. Geological Survey Science Strategy for Arctic Alaska, Fiscal Years 2022–24

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U.S. Geological Survey scientists collect cryosphere field data at Gulkana Glacier in the eastern Alaska Range. Photograph by Louis Sass, U.S. Geological Survey.

“Given the pace of transformation in northern latitudes, a business-as-usual approach[...] is not sufficient.”

Cover. Glacier in Alaska. Photograph by Dee Williams, U.S. Geological Survey.

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U.S. Geological Survey, Reston, Virginia: 2022

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Suggested citation:
Williams, D.M., and Devaris, Aimee, 2022, U.S. Geological Survey science strategy for Arctic Alaska, fiscal years 2022–24: U.S. Geological Survey Circular 1499, 14 p., https://doi.org/10.3133/cir1499.

ISSN 2330-5703 (online)

Contents

Figures

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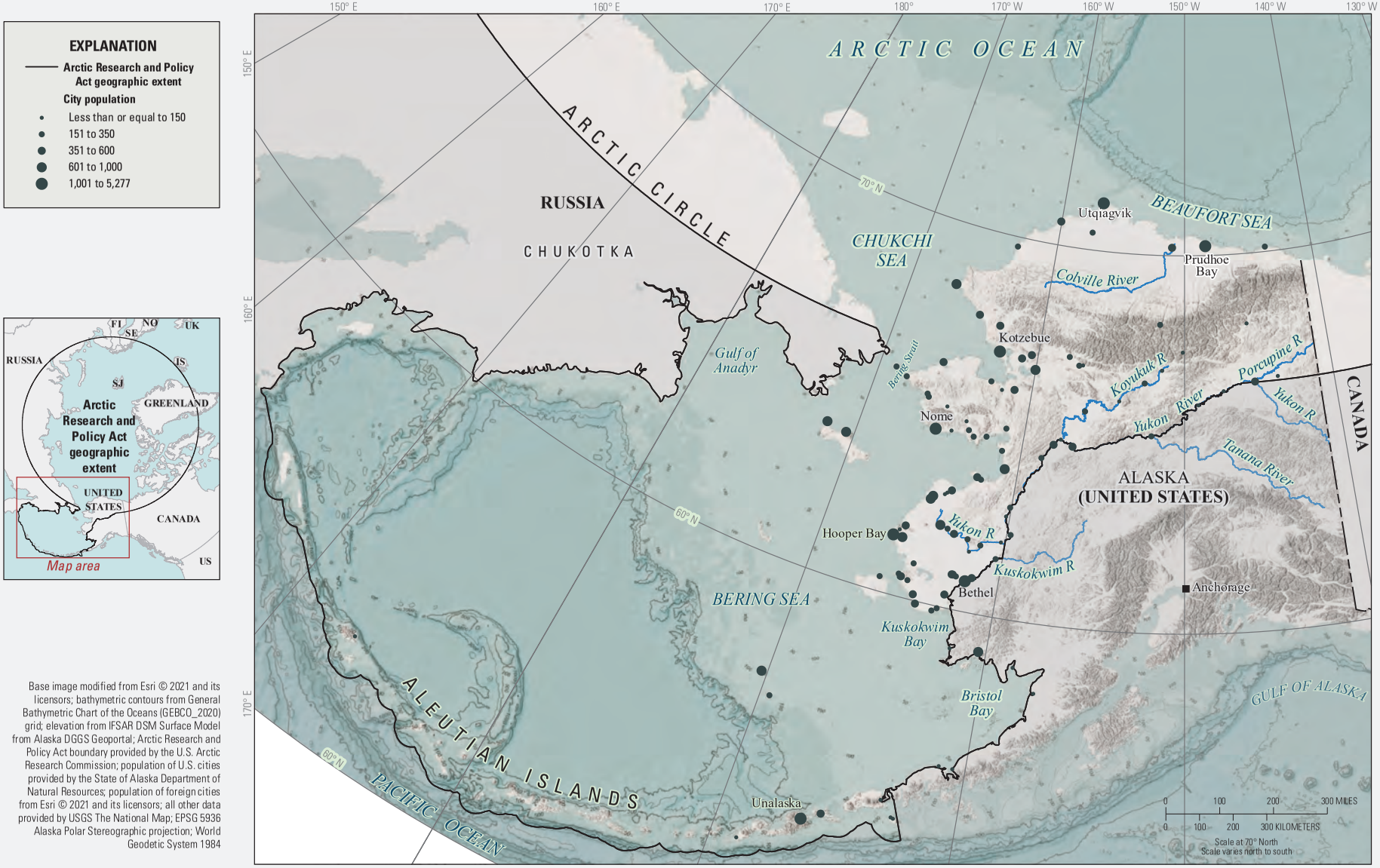
Introduction

The United States is an Arctic nation because of Alaska and thus maintains tremendous interests and stewardship responsibilities in the region, especially as the region undergoes substantial environmental transformation. This Arctic Science Strategy is intended to support those interests and responsibilities by expressing the core values, mission, vision, and the broad research goals and priority objectives of the U.S. Geological Survey (USGS) for science coordination in Arctic Alaska. It synthesizes strategic planning activities across the USGS in the Arctic over the next 3-year planning horizon, identifies some major networks of collaboration, and aligns with current research priorities of the Department of the Interior (DOI) Climate Action Plan, released October 7, 2021 (U.S. Department of the Interior, 2021). Also, in recognition of the rapid pace of Arctic environmental changes and the corresponding need to move with urgency beyond routine patterns of operation, this strategy extends an implementation challenge to staff and colleagues in hopes of reaching for breakthrough results in some target areas of performance.

Background

With a total area of territorial land and waters exceeding 1 million square miles, the U.S. Arctic is more expansive than people may realize. The Arctic Research and Policy Act of 1984 defines the Arctic for U.S. operational and science administration purposes as "...all United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers [in Alaska]; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain" (Arctic Research and Policy Act of 1984, Section 112). This definition notably includes certain parts of Alaska south of the Arctic Circle, including the Aleutian Islands and portions of central and western mainland Alaska, such as the Seward Peninsula and the Yukon Delta. To support a common understanding and to provide useful context about the basic geography, scope, and scale of Arctic matters, the USGS recently completed a series of updated general reference maps that provide geospatial information about relevant features of the U.S. Arctic (fig. 1). The maps offer value as stand-alone products but are intended to be used in conjunction with an interactive website https:// www.usgs.gov/tools/arctic-alaska-mapper sourced by annual data updates, allowing users to access the various map layers in a dynamic up-to-date environment. This map series and website concept constitute a foundational feature of the USGS Arctic Science Strategy. In a corresponding manner, this updated strategy will also place more emphasis on integrating knowledge across individual projects and landscapes and on expediting the potential transfer of knowledge into subject areas and spatio-temporal scales where decision-makers need more insight.



Base image modified from Esri © 2021 and its licensors; bathymetric contours from General Bathymetric Chart of the Oceans (GEBCO_2020) grid; elevation from IFSAR DSM Surface Model from Alaska DGGS Geoportal; Arctic Research and Policy Act boundary provided by the U.S. Arctic Research Commission; population of U.S. cities provided by the State of Alaska Department of Natural Resources; population of foreign cities from Esri © 2021 and its licensors; all other data provided by USGS The National Map; EPSG 5936 Alaska Polar Stereographic projection; World Geodetic System 1984

Figure 1. Arctic Research and Policy Act of 1984 (15 U.S.C. § 4108) geographic area extent across the Bering Sea. [Modified from Williams and Richmond (2021, sheet 1).]

U.S. Geological Survey personnel drilling to take water chemistry samples for permafrost study in the Yukon River Basin. Photograph by Ryan Toohey, U.S. Geological Survey Alaska Climate Science Center.

In 2021, DOI identified the following thematic priorities that intersect most closely with USGS research activities in Alaska (U.S. Department of the Interior, 2022; www.doi.gov/ourpriorities):

- Investing in Climate Research
- Incentivizing Clean Energy
- Protecting Public Health and Safety
- Sustaining Economic Vitality
- Conserving Public Lands and Waters
- Protecting Biodiversity
- Centering Equity and Environmental Justice
- Strengthening Tribal Relations
- Promoting Diversity, Equity, Inclusion and Accessibility

Drivers for Arctic Science Strategy

The most fundamental driver for developing an updated Arctic Science Strategy is the increasing rate of environmental change in the region and the corresponding urgency for relevant information needed by residents of Alaska and the many state and local agencies and Native organizations that represent them. Another primary driver is the increasing relevance of Arctic issues to national and global affairs. These primary drivers require more scientific collaboration and co-production of knowledge to help decision-makers better understand, monitor, and mitigate pressing concerns across the circumpolar North. Although warming and cooling cycles have occurred over millennium of geologic time, the current warming trend is unprecedented and affects the Arctic at a much faster rate than other places on Earth (Thoman and others, 2020; Arctic Monitoring and Assessment Programme, 2021). Over the past 4 decades, rapidly warming temperatures have caused cascading consequences that already include record reduction of sea-ice cover, loss of land ice from glaciers and the Greenland Ice Sheet, reduction in snow cover, widespread permafrost thaw, and proliferating wildfires. These ongoing physical changes have implications in the Arctic and beyond for altering weather patterns and storm events, raising sea level, restructuring marine and terrestrial ecosystems, expanding marine transport, accessing mineral and biological resources, increasing greenhouse gas emissions, increasing the severity of some natural hazard processes such as landslides and floods, threatening human health, well-being, and infrastructure, and disrupting national security (Taylor and others 2017; Overland and others, 2019; Richter-Menge and others, 2019; Previdi and others, 2021).

Such dynamic circumstances motivate close attention to all Arctic governance planning and operations, especially within DOI, which is responsible for the stewardship of more than 60 percent of the U.S. Arctic land base and more than 95 percent of the U.S. Arctic marine waters. Notable DOI-managed Arctic landholdings include the National Petroleum Reserve-Alaska, Arctic National Wildlife Refuge, Gates of the Arctic National Park and Preserve, Yukon Delta National Wildlife Refuge, the Alaska Maritime National Wildlife Refuge, and all the offshore submerged lands that constitute the Alaska Region Outer Continental Shelf beginning 3 miles from shore and extending to the 200-mile limit of the Exclusive Economic Zone. The DOI thus plays a central role in how the United States stewards its public lands, manages environmental protections, pursues environmental justice, and honors nation-to-nation relationships with Tribes.

The USGS Arctic Science Strategy closely aligns with policy directives set forward in the following documents: Executive Order 13990 of January 20, 2021 (Protecting Public Health and the Environment; The White House, 2021c), Executive Order 14008 of January 27, 2021 (Tackling the Climate Crisis at Home and Abroad), Executive Order 14017 of February 24, 2021 (America's Supply Chains), Executive Order 13953 of September 30, 2020 (Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries), and the 2019 Presidential Memorandum on Ocean Mapping, (including Alaska mapping) and its subsequent National Ocean Mapping, Exploration, and Characterization Strategy and Implementation Plan (National Ocean Mapping, Exploration, and Characterization Council, 2020, Ocean Science and Technology Subcommittee, 2020). This Strategy also builds upon the DOI Climate Action Plan (U.S. Department of the Interior, 2021) released October 7, 2021, and the USGS 21st Century Science Strategy (U.S. Geological Survey, 2021, https://doi.org/10.3133/cir1476) first posted January 19, 2021.

Interagency Context

As DOI's lead science agency, the USGS plays an important role in facilitating partnerships and contributing to the alignment of Arctic research capacities across local, state, federal, and global institutions to improve effective use of limited financial resources and to address urgent information priorities. To serve its role, the USGS is creating an Arctic Science Strategy that provides a clear reference point to inform current and near-term agency priorities in the Arctic. The year 2021 marked a substantial planning horizon as numerous institutions simultaneously began to update their Arctic research goals.

In December 2021, the Interagency Arctic Research Policy Committee released its updated U.S. Arctic Research Plan, 2022–26 (NSTC, 2022), and soon thereafter began defining a Biennial Implementation Plan (with support from USGS funding). Internationally, the Arctic Council administers numerous working groups such as the Circumpolar Biodiversity Monitoring Program and the Arctic Monitoring and Assessment Program, which are also developing new 5-year plans to advance next steps for Arctic biodiversity conservation strategies. In September 2021, the Arctic Executive Steering Committee was reestablished, and the U.S. Arctic Research Commission was rejuvenated by multiple new White House appointments. In that institutional context, this Strategy outlines the USGS mission, vision, broad strategic goals, and some priority objectives for the Arctic region over the next 3 years, though it may be further updated at any time. All implementation plans and coordination will continue to occur through annual budget planning processes conducted by existing program advisory councils and executive leadership within the USGS and DOI. Strategy implementation also remains subject to availability of funding and to the evolving circumstances imposed by ongoing COVID-19 recovery efforts.

International Context

Eight nations hold territorial claims north of the Arctic Circle, including the United States, Canada, Denmark (via Greenland), Iceland, Norway, Sweden, Finland, and Russia. These eight countries are often referred to as the Arctic States, and they are the member states of the Arctic Council (fig. 2). The Arctic Council was created in 1996 through a Ministerial Joint Declaration in Ottawa as an international forum that operates through consensus, rather than treaty, to emphasize the peaceful and cooperative nature of the Arctic region. In addition to the eight member states, six organizations representing Arctic indigenous peoples have status as Permanent Participants. Additionally, 13 non-Arctic states, 13 intergovernmental organizations, and 12 nongovernmental organizations have been approved as observers, making for a current total of 38 observer states and organizations (Arctic Council, 2021). The growing international tally of highly attentive participants in Arctic affairs further supports the rationale for development of this updated USGS Arctic Science Strategy.

Building on the Past and Present

The USGS mission is to monitor, analyze, and predict current and evolving dynamics of complex human and natural Earth-system interactions and to deliver actionable information at scales and timeframes relevant to decision-makers. Consistent with its national mission, the USGS in Alaska provides timely and objective scientific information to help address issues and inform management decisions across five inter-connected topical areas: geospatial mapping, ecosystem changes, energy and mineral resources, natural hazards, water (and cryosphere) resources.

Due to the persistent high DOI focus on Alaska, the USGS has maintained a wide variety of research programs and projects focused on the Arctic, which can only be briefly summarized here. It is also important to note that all these activities depend on strong partnerships with other Federal science agencies, the state of Alaska, and many private and academic contributors.

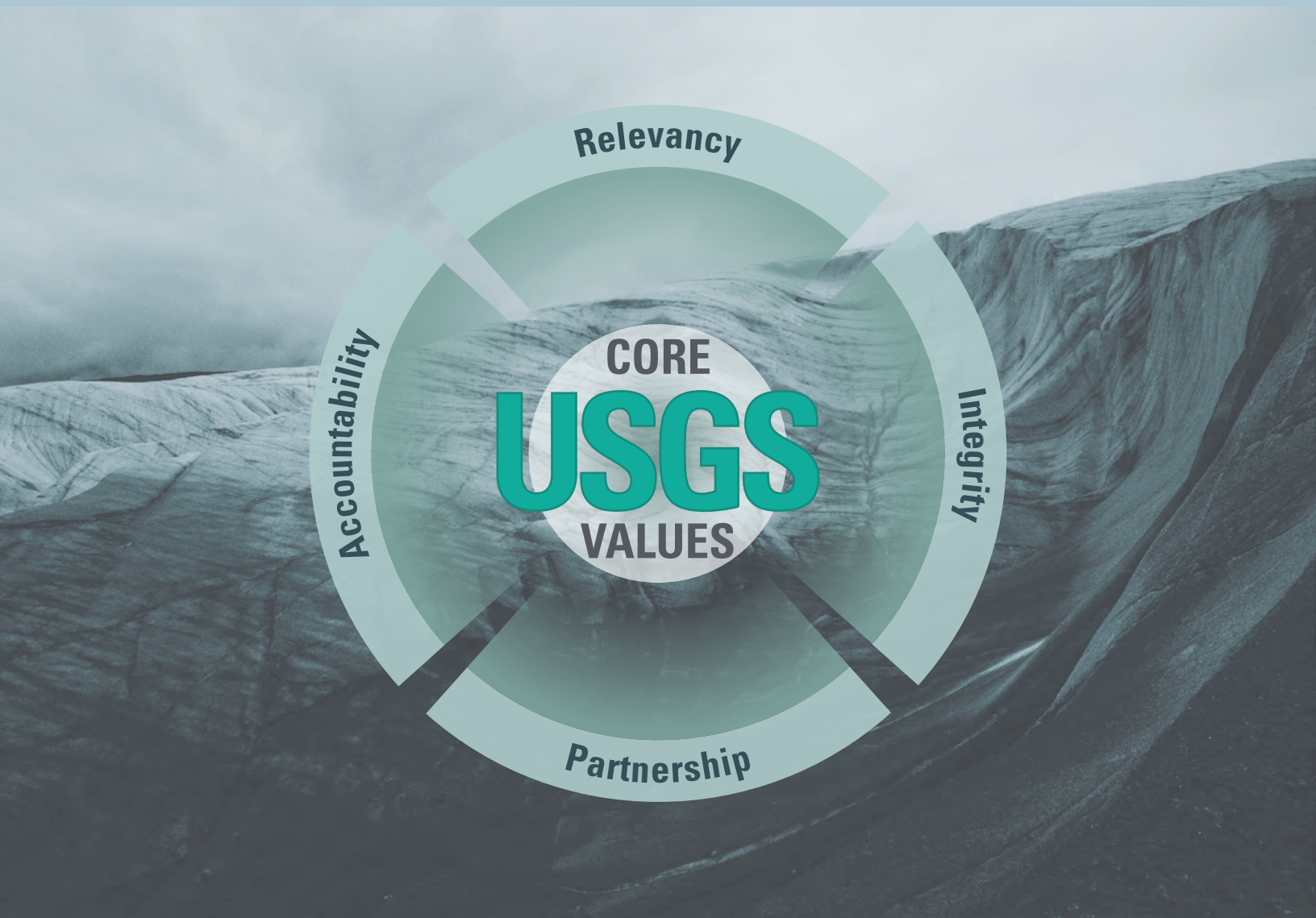


Figure 2. Boundaries of the U.S. Arctic in international context. [Modified from Williams and Richmond (2021, sheet 2).]

Hazard risk management and mitigation is a vital concern to all residents in the Arctic. The USGS addresses numerous Arctic hazards and ongoing changes to hydrologic and cryospheric systems, such as:

- Observing dynamic glacier-climate interactions at long-term benchmark monitoring sites;
- Mapping permafrost and the various implications of thaw;
- Collecting and curating paleoclimate records in sediment and ice cores to understand past precipitation, sedimentation, air and ocean temperature, and atmospheric composition variability;
- Assessing rates of shoreline erosion along the extensive coastline.
- Modeling vegetation and wildfire characteristics of tundra and boreal forests;
- Monitoring volcanic and earthquake activity, especially in the Aleutian region of the Arctic; investigating tsunami records to inform ongoing risk from local and Pacific wide tsunami sources;
- Monitoring variations in Earth's geomagnetic field to support power-grid and directional drilling operations;
- Promoting the development of online databases and tools to facilitate community resilience and adaptation planning.

The USGS also has critical statutory and non-statutory roles regarding management and analysis of floods, earthquakes, tsunamis, landslides, coastal erosion, volcanic eruptions, wildfires, and magnetic storms. These concerns will remain high priorities of research and investment in the coming years, with notable growing attention on improved coastal community resilience.

Rising to Future Challenges

Looking forward, the USGS remains committed to maintaining a leadership role in Arctic science and technology by delivering accurate study of relevant physical, geological, chemical, and biological resources or hazards, and by promoting integration of these activities through an increasingly holistic and service-oriented approach. The USGS will work to develop systemic frameworks to link observational capabilities across scales—from small plot to national monitoring networks to global satellite observations. Such investments in data collection and integration will include technological advancements in high performance computing, cloud computing, artificial intelligence, machine learning, visualization, and decision support tools. Future work will build on current activities and expertise, while also transitioning into new focal areas of emerging concern.

The USGS is also committed to ensuring inclusive and equitable workforce strategies and increasing participation in science for underrepresented groups in Alaska and the Arctic. For example, the Volcano Science Center recently established an URGE (Unlearning Racism in the Geosciences) pod that developed a 2-year Action Plan and chartered the Alaska Region Diversity, Equity, Inclusion, and Accessibility Steering Committee to see this work through to completion. The committee is currently undertaking work in removing barriers in recruitment and hiring processes, establishing an accessible mentoring program, mainstreaming inclusive habits and behaviors in the workplace, improving field and laboratory plans to include safety protocols related to anti-harassment, and promoting access to educational/awareness materials regarding racism. Also, in July 2021, the Alaska Regional Office established a new MOU between USGS and Alaska Pacific University (APU) for a period of 5 years to support APU as an Alaska Native Serving Institution. USGS continues to participate annually in the Alaska Native Science and Engineering Program (ANSEP) to support systematic change in the hiring patterns of Alaska Natives in science and engineering by placing students on a career path to leadership. Additionally, a worthy highlight is USGS participation in the Indigenous Observation Network, which is a notable long-term, community-based, water-quality monitoring program operating across Alaska and Western Canada. The program is led by the Yukon River Intertribal Watershed Council in partnership with the USGS and the University of Alaska-Fairbanks. More than 1,600 samples for surface water geochemistry analyses have been collected at 35 sites throughout the Yukon River Basin over the past 15+ years. The program involves significant co-production of knowledge with members of Indigenous communities and capacity building through training in sampling methods and data analysis. Future work is anticipated to build on such examples of participatory research.

Where opportunity allows, the USGS Alaska Regional Office, in consultation with mission area leadership and regional partners, will seek to enhance operational capacity in five strategic goals and associated objectives.

Goal 1

Improve Alaska geospatial data collection, mapping, modeling and visualization tools to help build communities of practice and predictive capabilities among scientific, Indigenous, and policy experts around shared interests and concerns.

Objectives

- Maintain a national archive of remotely sensed data and products of the Earth's land surface that informs assessments of Arctic environmental conditions and natural hazards;
- Increase capacity to access and use downscaled climate projections, develop ecosystem-based impact scenarios at relevant scales, and enable better stakeholder access to output products from both;
- Work with AMEC and other partners to improve mapping and monitoring of land and surface-water conditions across Alaska, including remapping hydrography and watershed boundaries to meet national high-resolution standards; complete the updated production of Alaska's topographic map products, and deliver an interactive web platform sourced by annual data updates that facilitate awareness of U.S. Arctic boundary conditions;
- Enhance research coordination with university faculty and graduate students through the Cooperative Research Unit at University of Alaska-Fairbanks and continue to partner with the ANSEP and other institutions to strengthen recruitment of STEM graduates (from the fields of science, technology, engineering, and mathematics) into the USGS;
- Maintain active support for external science advisory board collaborations through regional partnerships with the AMEC, Interagency Arctic Research Policy Committee, North Pacific Research Board, Alaska Ocean Observing System, Alaska Center for Climate Assessment and Policy, Alaska Sea Grant, Arctic Spatial Data Infrastructure, Alaska Conservation Foundation, National Fish and Wildlife Foundation, and Arctic Council working groups.

Goal 2

Research ecosystem structure and function to help inform decisions about natural resource management and to sustain the economic and environmental health of the Arctic.

Objectives

- Identify the abundance and map the distributions of DOI trust species of concern (polar bear [*Ursus maritumus*], walrus [*Odobenus rosmarus*], sea otter [*Enhydra lutris*], migratory birds) and other species of concern through sustained monitoring and biogeographic modeling techniques;
- Assess shifting food-web structures and changes in abundance and distribution for Arctic fish to inform land and resource management;
- Develop tools to automate processing of approved location data from satellite tags used on wildlife and develop a web-based database for serving these data;
- Use ecological and decision sciences to inform DOI strategies for achieving management, conservation, mitigation, and subsistence objectives in the face of continuing changes in land use and development, climate, and other drivers;
- Monitor diseases in wildlife and bird populations, predict the ecological and public health consequences, and provide data to inform management of wildlife disease.

USGS Vision

Lead the nation in 21st century integrated research, assessments, and prediction of natural resources and processes to meet society's needs.

Arctic Vision

To support a thriving, adaptive, equitable, and secure northern society sustained by a healthy ecosystem and enabled by collaborative scientific engagement and timely information delivery.

Goal 3

Produce information and assessments that focus on the location, quantity, and quality of mineral and energy resources, including the economic and environmental effects of resource extraction and use.

Objectives

- Conduct research to better understand the geologic framework in Alaska and identify areas that may have the potential to contain undiscovered critical mineral resources in concert with the Earth Mapping Resources Initiative (https://www.usgs.gov/special-topics/earth-mri);
- Understand and quantify the distribution of critical elements and other mineral resources in ore-forming systems of Alaska (onshore and offshore) that may reduce mineral import dependence;
- Update regional assessments of renewable energy resources from geothermal, wind and wave energy in Alaska Arctic and sub-arctic communities;
- Build upon the 2013 USGS carbon sequestration assessment (U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team, 2013; https://pubs.usgs.gov/circ/1386) on Alaska's North Slope to identify alternate forms of geologic storage and potential direct air capture deployment, locations of high carbon storage potential with low engineering risk, and related emerging economic opportunities.
- Continue researching the geology of Alaska's North Slope and adjacent offshore areas, building upon the latest delivery of undiscovered, technically recoverable hydrocarbon resource estimates and watching for coastal hazard implications as climate changes.

Goal 4

Monitor, assess, and conduct targeted research on Alaska's natural hazards to improve public safety and reduce risk and economic losses.

Objectives

- Issue timely warnings for volcanic eruption and promote risk reduction for earthquakes, landslides, and other geologic hazards;
- Modernize and expand the volcano monitoring network to increase pre-eruption warning time, improve rapid detection and characterization of volcanic activity and hazards, and enhance research related to Alaska's active volcanoes;
- Enhance capacity to assess and monitor emergent hazards resulting from melting glaciers and thawing permafrost, such as landslides, glacial lake outburst floods, glacier detachments, subsidence and thermokarst, mercury bioaccumulation;
- Complete assessment of historical shoreline change rates for the Arctic coastline of Alaska;
- Expand the USGS Coastal Storm Modeling System to forecast and assess coastal impacts of storm surge, erosion, and flooding along the north and west coasts of Alaska; improve understanding of tsunami record and vulnerability in arctic Alaska.

U.S. Geological Survey biologist identifies and counts Common murre (*Uria aalg*) carcasses on the Alaska Peninsula following a massive die-off in 2015/2016, Wide Bay, Alaska Peninsula. Photograph by Tony DeGange, U.S. Geological Survey.

Goal 5

Address novel and pressing challenges of water-resource management and related ecological impacts and emerging threats.

Objectives

- Maintain the benchmark glacier research and monitoring program to continue quantifying changes in mass balance, volume, spatial extent and connections to climate conditions, and refining knowledge of relationships to sea level change, water supply, and ecosystem linkages;
- Maintain and expand the network of streamgages to inform flood forecasting, water cycle modeling, development and permitting, and water use and availability;
- Develop and test remotely sensed methods of measuring river discharge flow, sediment re-suspension and pollution for improving flood-hazard mitigation and public health awareness;
- Expand water quality monitoring and investigations throughout the icefield-to-ocean ecosystem and river-ice transport corridors of Arctic rivers and lakes to better understand how changes in glaciers, permafrost, and landcover will affect changes in water and air quality, streamflow, nutrients, and sediments;
- Enhance rapid response and laboratory support for the investigation of algal toxins and detecting and assessing the range of certain pathogens and parasitic distributions in Alaska;

Implementation Challenge

Given the pace of transformation in northern latitudes, a business-as-usual approach that simply continues to conduct and support established patterns of research and publication is not sufficient. Federal agencies need to take additional measures to ensure that scientific research is conducted in appropriate partnership with stakeholders, relevant to pressing information needs, and made widely available to other scientists, decision-makers, stakeholder communities, and the public. An improved information network is vital to facilitate understanding, to ensure more informed and accountable decision-making, and to engage more easily with innovators and private industry who may translate scientific knowledge into useful products and services (Young and Lander, 2021).

USGS partners and external stakeholders, especially in Arctic Alaska, have come to expect a much deeper engagement with scientists and science agencies than previously exercised. “Co-production” and participatory science is the new collaborative model of research, by which we mean and endorse the concept of active engagement among multiple interested parties (scientists, Indigenous knowledge-holders, residents, policy makers) to produce new social outcomes, including advancement of knowledge, improved decision-making, and greater social equity (Miller and Wyborn, 2020; Williams and Erikson, 2021; NSTC, 2022). While not every scientific enterprise is well suited for co-production, both intellectual merit and social equity improves when the participatory science model is used with community input and undertaken through high-quality interactions. Thus, the “implementation challenge” issued by the USGS Alaska Regional Office for the coming years is to call upon all colleagues and staff working in the Arctic to accelerate actions on three fronts: (1) advancing science to meet pressing societal needs; (2) ensuring that scientific knowledge produced is understandable, usable, and responsive to the needs of key stakeholders and decision-makers; and (3) engaging more fully with the emerging model of participatory science.

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Eroding glacier and frozen lake evokes the beauty of the Arctic as well as the rapidly diminishing cryosphere actively monitored by the U.S. Geological Survey. Photograph by Dee Williams, U.S. Geological Survey.

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Back of front cover. Cracking ice. Photograph by Justin Kauffman, Unsplash.com. **ii–iii.** Matanuska Glacier in Alaska. Photograph by Sophia Simoes, Unsplash.com. **iv.** Ice on Baikal Lake, Khuzhir, Russia. Photograph by Philipp Trubchenko, Unsplash.com. **1.** Family of polar bears (*Ursus maritimus*) at play in Kaktovik, Alaska. Photograph by Glenn Gilchrist, Unsplash.com. **3.** Alaska Glacier. Photograph by Bridger Bowcutt, Unsplash.com. **4.** U.S. Geological Survey scientist drives beside eroded coastal bluffs along Barter Island on the North Slope of Alaska. Photograph by U.S. Geological Survey. **6.** Trekking across Root Glacier in Wrangell-St. Elias National Park. Photograph by McKayla Crump, Unsplash.com. **8–9.** Frost on a window pane, 2016. Photograph by Kelly Sikkema, Unsplash.com. **11.** Ice climbing on the Matanuska Glacier in Alaska. Photograph by Elise V., Unsplash.com. **12.** Meteor streaking across the sky in Jeris, Finland. Photograph by Jaanus Jagomägi, Unsplash.com. **14–15.** Matanuska Glacier with some black ice streaks. Photograph by Sophia Simoes, Unsplash.com.

Manuscript approved on September 8, 2022

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Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center:
Edited by Jeffery Suwak
Illustration by Teresa A. Lewis
Design and layout by Teresa A. Lewis and Yanis X. Castillo

ISSN 2330-5703 (online)
https://doi.org/10.3133/cir1499