WRITTEN TESTIMONY BY

RDML SHEPARD M. SMITH, NOAA
DIRECTOR, OFFICE of COAST SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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Introduction

Good afternoon Chairman Maloney, Ranking Member Gibbs, and Members of the Subcommittee. It is a pleasure to be here today with my U.S. Coast Guard and U.S. Army Corps of Engineers colleagues to discuss our work supporting safe and efficient marine transportation in the Arctic. The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) cooperates and coordinates on a regular basis with these agencies in support of the nation's economic and national security interests in the Arctic.

NOAA's Arctic responsibilities cut across every NOAA mission area, from weather and sea ice analyses, to navigation services and fisheries management. For over two hundred years, NOAA and its predecessor organizations have provided foundational data, products, and services to support safe, efficient maritime commerce across the nation. NOAA has a long history in the Arctic, including conducting research and providing weather and climate services, sea ice forecasting, nautical charting and other navigation services, natural resource management, and oil spill preparedness and response. Today, as sea ice diminishes and economic and maritime activity in the Arctic grows, NOAA remains committed to its work in the Arctic. For this testimony, I will focus on the NOAA components highlighted in the Committee on the Marine Transportation System's 2018 report on critical infrastructure investments necessary to support a safe and secure Arctic marine transportation system.

CMTS Report

In December 2018, the Committee on the Marine Transportation System (CMTS) issued an update on the near-term recommendations in its 2016 *Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic*.[1] The report's recommendations span five key categories integral to the Arctic Marine Transportation System (Arctic MTS), including: (1) navigable waterways, (2) physical infrastructure, (3) information infrastructure, (4) emergency response, and (5) vessel operations. As the report describes, even as sea ice retreat increases opportunities for navigation-related activities, the Arctic remains a challenging environment for marine transportation. There are still unpredictable ice floes, extreme weather conditions, and seasonal accessibility based on variation in ice location. NOAA's navigation products, as well as its weather, and emergency response science and services feature heavily in the physical, information infrastructure and emergency response sections of the report. The *U.S. MTS Arctic Infrastructure Table* at the end of the report is a good snapshot of current conditions and gaps in critical Arctic MTS infrastructure.

NOAA's Arctic MTS Services

Because most of the U.S. Arctic is not connected by road or rail, marine transportation is an essential means of transporting goods and people. NOAA's navigation, observation, and positioning services are important for safe and efficient maritime commerce, security, community re-supply of food and fuel, construction, and other commerce-related activities. Thus, nautical charts for Alaska and the Arctic are a key component of NOAA's nautical charting mission.

The major requirements for nautical charts are (1) accurate positioning, (2) coastal oceanography such as tides and water levels, (3) shoreline mapping, and (4) hydrographic surveying. As described below, NOAA is taking steps to improve the accuracy and reliability of these core capabilities in the Arctic and the nautical charting and navigation services they support.

NOAA released its National Charting Plan in 2017 to improve chart coverage and take full advantage of the capabilities of today's technologies, including digital Electronic Navigational Charts (ENCs). This national plan updates and incorporates NOAA's older Arctic Nautical Charting Plan. These plans are based on extensive outreach to users. They also are designed to ensure NOAA continues to lead and implement international requirements for surveying and ENC charting.

Positioning and the National Spatial Reference System

Nautical charts rely on accurate shoreline information and precise positioning, elevation, tide, and water level data, all of which are dependent on an accurate land-based reference framework. NOAA's National Geodetic Survey (NGS) provides the authoritative framework for all positioning activities in the Nation, known as the National Spatial Reference System (NSRS). This authoritative coordinate system defines latitude, longitude, height, gravity, and shoreline information, which supports a wide range of important activities, including mapping and charting, navigation, transportation, infrastructure, flood risk determination, national security, and ecosystem management.

[1] These reports are accessible online at https://www.cmts.gov/topics/arctic.

Land elevation and positioning data in Alaska currently have errors of up to a meter or more. To rectify this and modernize the NSRS, NOAA collects airborne gravity data under its Gravity for the Redefinition of the American Vertical Datum (GRAV-D) initiative. GRAV-D data collection for mainland Alaska was completed in 2018. GRAV-D plans on returning to Alaska in 2020 to complete surveys of the Aleutian Islands. NOAA is also working to provide improved positioning in Alaska through its network of Continuously Operating Reference Stations (CORS). These efforts are part of NOAA's 2022 update to the NSRS, which will enable up to centimeter-level accuracy for latitude, longitude, and height, using Global Navigation Satellite System survey techniques at any location.

Tides and Water Levels

As stated above, accurate water level data is essential for accurate nautical charts. NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) operates and maintains the National Water Level Observation Network (NWLON). In addition to providing data essential for surveying and charting, these long-term observations of coastal water levels improve understanding and predictions of coastal change, storm surge, and saltwater intrusion into freshwater systems that are urgently needed to inform decisions by increasingly vulnerable coastal communities in the Arctic. Presently, CO-OPS operates 27 long-term NWLON tide stations in Alaska, 10 of which are located in the Arctic. CO-OPS has identified over 30 gaps in NWLON coverage for Alaska, the majority of which are in the Arctic.

To supplement NWLON data, the Alaska Ocean Observing System (AOOS), which is a part of the NOAA-led Integrated Ocean Observing System (IOOS) program, has helped install portable, low-cost systems that help to fill observation gaps needed for NOAA's National Weather Service (NWS) storm surge warnings and forecasts in small coastal communities. NOAA is also collaborating with private industry to build a public data management system that parallels the CO-OPS website. This system will serve as an example for advancing nationwide access to external source water level data. Recently, the NWS funded CO-OPS to install an NWLON station in Unalakleet, Alaska, to provide real-time information for storm surge models, as well as navigation. The maintenance of this station, as well as others in Alaska, has been contracted out to a local Alaska company. NOAA also plans to replace the Port Moller station in the Aleutians, which burned down in 2017, with Fiscal Year 2019 dollars.

NOAA

Shoreline Mapping

Shoreline surveys are also critical to keeping nautical charts up to date. In 2018, NOAA updated 4100 miles of Arctic shoreline for its Continuously Updated Shoreline Product in conjunction with the rescheming of related NOAA ENCs. This data enables mariners to pinpoint their locations relative to the coast, navigate to and from ports safely, and find harbors of refuge when in need.

In conjunction with AOOS, the state of Alaska, and other partners, NOAA is also supporting the development of an Alaska Coastal Mapping Strategy for publication in 2019. This strategy will include Arctic priorities in its assessment of needs for coastal topography and nearshore bathymetry, along with other types of mapping. The effort is intended to identify state stakeholder priorities for new collections, the costs associated with mapping, and ways to leverage new mapping projects and partnerships.

Hydrographic Surveying

The scale of the hydrographic survey requirement in Alaska and the Arctic is vast, with 426,000 square nautical miles within the U.S. Exclusive Economic Zone and nearly half of that significant to navigation. Soundings on some nautical charts in the Arctic are still from Captain Cook.

Through the Office of the Coast Survey, NOAA continues to prioritize and undertake hydrographic surveying in the expansive, remote and harsh Arctic environment. Over the past three years, NOAA and its contract partners have acquired nearly 1,500 square nautical miles of hydrographic survey data in the Arctic. For 2019, our survey plans include an extensive set of project areas in Kuskokwim Bay. NOAA's survey contractors are an essential component of the balanced hydrographic survey program NOAA employs in Alaska and across the nation. The 51-year old NOAA Survey Vessel *Fairweather* will also survey around Cape Newenham.

NOAA also works with private sector partners and academia to develop and deploy unmanned surface vessels (USV) for chart-quality surveys. For the past two years, our contractor in Alaska has employed USVs to conduct hydrographic surveys. In August 2018, NOAA and researchers from the University of New Hampshire's Center for Coastal and Ocean Mapping made the first successful launch of a USV for an operational hydrographic survey from a NOAA vessel in the Arctic. NOAA also tested four Saildrone USVs in the Bering and Chukchi Seas and is further investigating the use of Saildrones as an additional, cost-effective survey capability. Based on the success of that mission, we are currently updating our Bering Sea charts with the USV data.

Weather and Sea Ice Forecasts

The ability to transmit timely weather and accurate information and sea ice forecasts depends heavily on the ability to predict inclement weather and changes in currents or ice cover and extent. One side effect of an ice-diminished Arctic is a reduction in the dampening effect of ice on waves. As spring and fall storms intensify, wave action increases due to a lack of ice cover. In addition, diminished fall and spring sea ice also has the potential to intensify high latitude storms as both moisture and heat are exposed with the open water. Thus, early warning of impending storms is important for both ships and coastal communities in the Arctic.

NOAA's NWS is increasing targeted in-situ observations, both surface-based and aloft, to improve model assimilation of observed data, situational awareness, and scientific understanding of the Arctic. NWS is also leveraging new remote sensing capabilities, such as unmanned aerial systems (UAS), unmanned aerial vehicles (UAV), and satellite technology in addition to next generation autolaunching, upper air systems at all NWS Alaska Region sites. The NWS Alaska Region has also proactively addressed both current and emerging operational forecast gaps by establishing and resourcing the Alaska Environmental Science and Service Integration Center, which will support both regional and international Impact Decision Support Services.

Moreover, NOAA is focusing on the science fundamentals to improve coupled water, ice, atmosphere models. Much of the focus of model improvements to date have been on the mid- and lower-latitudes. Areas of specific improvement are the stable Arctic boundary layer, interactions between the oceans, ice, and atmosphere in the marginal ice zone, riverine impacts to ice, and troposphere-stratosphere interactions. These activities will improve NOAA's ability to forecast the weather and Arctic sea ice.

The National Ice Center (NIC), a partnership among NOAA, the U.S. Navy, and U.S. Coast Guard, provides sea ice assessments for the Arctic. The NIC produces a daily, 48-hour Marginal Ice Zone forecast in text format. The NWS Alaska Sea Ice Program also produces a short-range, sea-ice forecasting capability with 5-day sea ice graphical and text forecasts. Besides short-range products, NOAA NWS is developing experimental weekly sea ice forecasts that include sea ice extent, concentration, and sea ice melt and freeze dates.

The NIC uses data from NOAA Joint Polar Satellite System and Geostationary Operational Environmental Satellites-West (GOES-West), and Department of Defense (DoD) weather satellites, as well as leverages data from European and Japanese, and purchases data from the commercial sector to support its mission. These data sets inform the timing and accuracy of weather and hazard forecasts out to seven days, including better predictions for fog, ice formations, and ice breaking in the Arctic. In addition, researchers at NOAA's Earth System Research Laboratory have developed a fully-coupled ice-ocean-atmosphere model focused on 0-10 day forecasts. Currently, this modeling team is working with the NWS to advance Arctic sea ice forecast capabilities.

Oil Spill and Hazard Preparedness and Response

Decreasing summer sea ice is contributing to growth in commerce, tourism, and energy exploration in the Arctic. According to another CMTS study of vessel traffic in 2015 (which the CMTS is now working to update as well), shipping transits through the Bering Strait are expected to increase 500 percent by 2025. This increased activity heightens the risk of accidents and discharges of oil and hazardous materials. NOAA's Alaska regional Scientific Support Coordinator provides scientific support to the federal on-scene coordinator for oil spills and other emergencies such as search and rescue. NOAA's contributions include modeling the fate and movement of spills, identifying natural resources at risk, and providing software, mapping tools, and data management capabilities. By law, NOAA is also a trustee for natural resources that have been injured by oil and chemicals spills and conducts damage assessment and restoration of these resources.

NOAA participates in joint training and workshops with interagency partners and other Arctic nations on activities such as the use of mechanical recovery, dispersants, and *in situ* burning following transboundary spill events. NOAA compiles baseline information on natural resources in the Arctic and promulgates standard techniques and guidelines for observing and measuring oil spills and assessing shorelines.

NOAA Office of Response and Restoration (ORR) also maintains the Arctic Environmental Response Management Application (ERMA®) to integrate and synthesize data into a single interactive map, provide quick geospatial visualizations, and improve communication and coordination among multiple responder agencies. As a common operational picture, ERMA® brings together all of the available information needed for an effective emergency response. In 2017, with funding assistance from the Bureau of Safety and Environmental Enforcement, NOAA improved its display for the Arctic by adding polar projection base maps. This provides a less distorted display of the region while maintaining accurate bearings to the coastline and provides a better tool for pan Arctic data sharing and perspectives.

Interagency preparedness exercises are essential for critical improvements in spill response procedures. In August 2018, NOAA participated in the Mutual Aid Deployment (MAD) exercise on Alaska's North Slope oil field. The 2018 exercise was hosted by Exxon Mobil and included over 200 industry and state and federal representatives. NOAA provided support with oil spill trajectory modeling, weather forecasts, resources at risk and sensitive areas information, facilitation of the Endangered Species Act Section 7 consultation, Shoreline Cleanup Assessment Techniques planning, ERMA®, in-situ burn planning, and data management planning. NOAA, with other members of the Alaska Regional Response Team's Food Safety Workgroup, also led the development of the "Ensuring Food Safety Following an Oil Spill in Alaska: Regulatory Authorities and Responsibilities" report that was released in December 2018.

International oil spill exercises are also important. In November 2018, NOAA ORR staff traveled with colleagues from the U.S. Coast Guard and the State of Alaska to Yuzhno-Sakhalinsk, Russia, to participate in a "Seminar on Understanding Maritime Pollution Threats and Response Systems in the Russian Federation-United States Trans-Boundary Area." The meetings concluded with an international tabletop exercise to test and practice the provisions of the existing "Joint Contingency Plan of the United States of America and the Russian Federation on Combating Pollution in the Bering and Chukchi Seas."

During the United States chairmanship of the Arctic Council for 2015 and 2016, NOAA chaired the Emergency Prevention, Preparedness, and Response (EPPR) Workgroup. Under this leadership, the U.S. delegation to the workgroup delivered several important projects including a Pan-Arctic Oil Spill Response Equipment Database, a Circumpolar Oil Spill Response Equipment Viability Analysis, an updated Guide on Oil Spill Response in Ice and Snow Conditions, and further advancement of exercise procedures for the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response. Currently, NOAA is a member of U.S. Delegation for EPPR and provides the current state of the art of response techniques, particularly on the use of dispersants in Arctic environments.

NOAA Research Supporting the Arctic MTS

NOAA continues to observe and model long-term changes occurring in sea ice thickness and extent which are important both for global climate modeling and understanding how access to the Arctic is changing with reduced seasonal ice cover. Deployed Seasonal Ice Mass Buoys provide near real-time data on ocean and air temperature through the sea ice that, combined with data from the atmosphere and ocean, contributes to the fundamental understanding of the role of the sea ice cover in the global climate system. These observations enable seasonal to decadal predictions in sea ice cover.

International, Interagency and Local Engagement

NOAA, in collaboration with numerous other agencies, has supported U.S. participation in the international Arctic Council since its establishment in 1996. The U.S. served as the second chair of the council from 1998 to 2000 and chaired the Council again from 2015 to 2017. Through the Council's Protection of the Arctic Marine Environment working group and other efforts, NOAA has supported coordination of efforts to promote safe Arctic navigation. Last year, the Council launched a public website to assist in the implementation of the Polar Code. To better address Arctic hydrographic and nautical charting challenges, NOAA has also participated in the Arctic Regional Hydrographic Commission since 2010.

NOAA serves as Vice Chair of the U.S. Arctic Observing Network Board after serving as Chair and has continued work towards a sustained and well-defined network of Arctic observations across NOAA, other Federal agencies, the State of Alaska and Alaska Native Tribes, academia, industry, and international partners, such as the Sustaining Arctic Observing Network. NOAA is a long-standing sponsor of the Arctic Report Card, an annual, peer-reviewed report developed by 85 scientists across 12 countries. The Arctic Report Card issued its 13th report in December 2018. The publication's annual update provides reliable data and observations to support local and regional decision makers in making informed decisions for Arctic communities, national security, industrial growth, environmental health, and food security.

On a local level, the increase in vessel traffic through the Bering Strait into the Chukchi and Beaufort Seas is of concern to Alaska Native coastal communities in the region. These communities rely on subsistence hunting of marine mammals, which are critical to their nutritional, cultural, mental and spiritual well-being. NOAA has been working with the Arctic Waterways Safety Committee (AWSC), as well as Alaska Native Organizations and regional bodies, to ensure the increase in research vessel traffic does not negatively impact the ability of the communities to hunt marine mammals. Since 2015, NOAA has requested community input for summer survey plans with the AWSC. During these briefings on planned work, NOAA also details its findings from its prior year surveys.

Looking to the Future: Enhancing NOAA's Core Missions in the Arctic

While NOAA's core missions remain the same, advances in technology are providing opportunities to greatly enhance the accuracy, timeliness, and integration of our products and services, including those that inform and support marine navigation and transportation in the Arctic. To ensure that we consider the needs of and challenges facing our Arctic stakeholders, NOAA continues to look for innovative partnerships with the private sector and other stakeholders, including the ability of the private sector to incorporate NOAA data and services to develop new applications to enhance operations and efficiency.

Conclusion

NOAA plays a unique and important role in providing critical information infrastructure to support safe, reliable, and efficient marine transportation. Rapidly changing conditions and increased accessibility bring new urgency to NOAA's work to support increased activity in Arctic waters. Local, state, federal, and international partnerships are critical to achieving successful Arctic operations in this unique and challenging environment. NOAA is working to develop and apply technology and data in innovative ways to improve our navigation products and services. Thank you again for the opportunity to testify today. I appreciate the Subcommittee's time and attention and look forward to answering your questions.