Draft: A Ten-Year Projection of Maritime Activity in the U.S. Arctic Region, 2020-2030

U.S. COMMITTEE ON THE MARINE TRANSPORTATION SYSTEM

JULY 2019
This report was developed by the U.S. Committee on the Marine Transportation System’s Arctic Marine Transportation Integrated Action Team, which includes representatives from:

- Bureau of Ocean Energy Management
- Bureau of Safety and Environmental Enforcement
- Bureau of Transportation Statistics
- Environmental Protection Agency
- Maritime Administration
- National Oceanic and Atmospheric Administration
- Oceanographer of the Navy
- National Maritime Intelligence-Integration Office
- National Geospatial-Intelligence Agency
- Office of Science and Technology Policy
- Office of the Secretary of Transportation
- U.S. Arctic Research Commission
- U.S. Army Corps of Engineers
- U.S. Coast Guard
- U.S. Committee on the Marine Transportation System Executive Secretariat
- U.S. Department of State
- U.S. Transportation Command

Preface

This document is a draft of the U.S. Committee on the Marine Transportation System’s report, “A Ten-Year Projection of Vessel Activity in the U.S. Arctic Region”, developed by the Arctic Marine Transportation Integrated Action Team for public and interagency review. Questions, comments, and corrections to this document are requested on or before July 31, 2019 to ArcticMTS@cmts.gov. The final version of this report is expected by September 2019 and will be made available via www.CMTS.gov.

Acknowledgements

The authors of this report would like to thank the many organizations and individuals who have provided support to this project. Sincere thanks go to the U.S. Arctic Research Commission (USARC), which provided funding both for this report and for the 2018 CMTS & USARC Technical Workshop on Arctic Vessel Activities. Additional thanks go to the co-leads and members of the CMTS Integrated Action Team, the participants of the 2018 CMTS & USARC Technical Workshop, and the Woodrow Wilson International Center for Scholars’ Polar Institute for their expertise and documentation to assist this work. Special thanks for to the following individuals for their expertise, guidance, and assistance on this project: Sarah Harrison, Alyson Azzara, PhD, Alison Agather, PhD, Professor Lawson Brigham, PhD, Helen Brohl, John Farrell, PhD, Marin Kress, PhD, Tricia Hooper, Mike Sfraga, PhD, and Kyle Titlow.
Executive Summary

The Arctic is undergoing unprecedented change on multiple fronts, including the region’s growing maritime traffic. In the last decade, the number of vessels operating in waters north of the Bering Strait has increased by 128% or 2.3 times larger than the number of ships passing through the region in 2008. These vessels have been engaged with a variety of activities, including natural resource exploration and extraction, commercial shipping, oceanographic research, and tourism in waters which previously were ploied only by ships resupplying remote communities along the sparsely populated coastlines of western and northern Alaska.

This report by the U.S. Committee on the Marine Transportation System (CMTS) U.S. Arctic Marine Transportation Integrated Action Team (Arctic IAT) is an update to the 2015 CMTS report, “A 10-Year Projection of Maritime Activity in the U.S. Arctic”. This report is an overview of past and current vessel activity patterns in the U.S. Arctic and surrounding waters and also projects how much vessel activity will change over the next decade.

Efforts to update the 2015 CMTS report began in November 2018 with a 2-day technical workshop hosted by the CMTS, together with the U.S. Arctic Research Commission (USARC), about drivers of vessel activity in the Arctic, included in Section II of this report. Workshop participants included experts from government, the shipping industry, academia, and the Arctic region and provided the report with a rich data set of quantitative sources of vessel growth, as well as new perspectives about how non-quantitative factors may affect vessel activity in the region. One key take home from this workshop was that a predictable operating environment is required to support growth of vessel activity in Arctic region.

Section III of this report provides an overview of recent vessel activity trends in the U.S. Arctic region. Automatic identification system (AIS) data revealed that 255 ± 26 vessels transited through the U.S. Arctic and surrounding region from 2015—2017. By vessel type, over 50% of these vessels are tug, towing, and cargo vessels; other vessels included fishing vessels (10%), tourism (9%), tankers (7%), government/law enforcement/SAR (6%), research (5%) and other vessels (5%). By flag, U.S. flag vessels are the largest fleet in the U.S. Arctic region, by a considerable margin, but the number of flag states transiting through the region has climbed from 25 flag states in 2015 to 32 in 2017. The number of ships operating in the U.S. Arctic region is about 12% of all the unique vessels in the Pan-Arctic. Furthermore, vessel traffic in the region has grown by steadily over the last decade, according to U.S. Coast Guard data,
but after Royal Dutch Shell withdrew from offshore exploration in 2015, the growth in the number of vessels in the area has plateaued. Despite no large changes in the total number of ships using these waters during this period, the length of the navigation season grew by as much as 10 days each year, as measured by AIS, which is nearly ten-times faster than estimates from other studies.

Section IV provides a detailed overview of the new method developed for this report, which brings together both qualitative and quantitative data about the region for four projection scenarios of vessel activity. This method estimates the number of ships expected in the region over the next decade and was developed specifically for this study and utilizes publicly available data from 29 different sources of growth. These sources of growth include new ice class vessels, rerouted shipping through the Arctic, and planned infrastructure and/or natural resource projects.

The four scenarios included in this study are the Reduced Activity Scenario, Most Plausible Scenario, Optimized Growth Scenario, and Accelerated, but Unlikely Scenario. Each provides a different possibility for vessel activity in the U.S. Arctic to change over the next decade, ranging from annual growth rates of 0.35% to 4.9% and total annual vessel counts of 289 ships to 523 vessels. The Most Plausible Scenario anticipates that vessel activity will grow at an annual rate of 2.32%, reaching 377 ships by 2030 or a value of just over 3 times larger than the level of vessel activity measured in 2008.
Over the next decade, it is anticipated that natural resource development in the Arctic, particularly the growth of liquefied natural gas (LNG) shipments from Russia and vessels needed to resupply mining operations in northern Canada, will play a large role in the volume of traffic transiting through the Bering Strait. Ice-strengthened ships and vessels engaged in trans-Arctic shipments are also expected to steadily increase the volume of vessel traffic in the region over the next decade. Infrastructure development, repair, modification, and relocation activities will also contribute to vessel activity in the region. This growth, however, will be better measured by the large numbers of transits or longer operating hours instead of by additional ships, due to the unique logistical challenges of transporting materials to the region. Additionally, because of rapidly changing environmental conditions which threaten the viability of infrastructure in the region, this source of growth may rapidly change over the next decade, leading to uncertainty in the projections included here.

Finally, while this report has aimed to be as comprehensive as possible, its reliance on AIS data means that this report does not account for or project smaller crafts, such as small commercial fishing operations or subsistence hunting activities. Excluding subsistence hunting, for example, may underrepresent actual vessels in the U.S. Arctic region by 40%. Understanding both the magnitude and diversity of vessel activities in the region is critical to deconflicting the current uses of these waterways and planning for future changes in the region.
List of Abbreviations

AIS  Automatic Identification System
AISAP Automatic Identification System Analysis Package
ASTD Arctic Ship Traffic Database
ASV Autonomous Surface Vehicle
BBL Barrel (42 U.S. gallons or 160 liters)
BEN Bathymetric Explorer and Navigator
BOEM Bureau of Ocean Energy Management
BTU British Thermal Units
BUILD Better Utilizing Investments to Leverage Development Transportation Discretionary Grant Program
CMTS U.S. Committee on the Marine Transportation System
EIA Energy Information Administration
FCC Federal Communications Commission
G&G Geological and Geophysical
IMO International Maritime Organization
LE Law Enforcement
LNG liquefied natural gas
MLLW mean low level water
MMSI Maritime Mobile Service Identity
MTS Marine Transportation System
NAIS Nationwide Automatic Identification System
NAVCEN U.S. Coast Guard Navigation Center
NOAA National Oceanic and Atmospheric Administration
NSAR National Strategy for the Arctic Region
NSR Northern Sea Route
NSRA Northern Sea Route Administration
NWP Northwest Passage
OCS Outer Continental Shelf
OCSLA Outer Continental Shelf Lands Act
PAME Protection of the Arctic Marine Environment
Polar Code International Code for Ships Operating in Polar Waters
SAIS Satellite Automatic Identification System
SAR Search and Rescue
UNCTAD United Nations Conference on Trade and Development
USACE U.S. Army Corps of Engineers
USARC U.S. Arctic Research Commission
USCG U.S. Coast Guard
VHF Very High Frequency
The U.S. Committee on the Marine Transportation System

The U.S. Committee on the Marine Transportation System (CMTS) is a Federal Cabinet-level, inter-departmental committee chaired by the U.S. Secretary of Transportation. The purpose of the CMTS is to create a partnership of Federal departments and agencies with responsibility for the Marine Transportation System (MTS). In 2010, the CMTS was directed by statute to coordinate transportation policy in the U.S. Arctic for safety and security, and established the CMTS Arctic Marine Transportation Integrated Action Team (Arctic IAT) to address infrastructure requirements supporting the U.S. Arctic Marine Transportation System, among other activities.

The National Strategy for the Arctic Region (NSAR) Implementation Plan directed the U.S. Department of Transportation to execute the tasks under the objective Prepare for Increased Activity in the Maritime Domain. The Office of the Secretary delegated these tasks to the CMTS in 2014. Subsequently, the CMTS delivered the following reports:

- **A 10-Year Projection of Maritime Activity in the U.S. Arctic** in January 2015
- **A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic** in April 2016

Taken together, these three reports provide a framework to support a growing Arctic MTS with an understanding of future vessel activity, infrastructure required to support future vessel activity, and mechanisms to support the development of such critical infrastructure.

This document is an update of the 2015 report, **A 10-Year Projection of Maritime Activity in the U.S. Arctic**. This report was developed by the CMTS Arctic IAT, with financial support from the U.S. Arctic Research Commission.

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1 U.S. Coast Guard Authorization Act of 2010 (Public Law 111-281 § 307(c); 14 U.S.C. §90)
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Note: Unless otherwise stated, all figures and tables were made by Sarah Harrison using data sourced from publicly available sources.
Section I: Introduction

PROJECT RATIONALE

This report is an update to the 2015 report, *A Ten-Year Projection Study of Maritime Activity in the U.S. Arctic*, which projected the volume of vessel activity in the U.S. Arctic out to 2025 as part of the U.S. National Strategy for the Arctic Region. This report projects the potential growth of marine transportation in the U.S. Arctic out to 2030, utilizing in-depth analysis of historical vessel activity and an exploration of current and future drivers for vessel activity through four scenarios.

In the four years since the publication of the 2015 CMTS report, *A Ten-Year Projection Study of Maritime Activity in the U.S. Arctic*, much has changed in the region. This update aims to provide decision makers and regional stakeholders with a comprehensive portrait of potential changes in vessel activity in the region over the next decade.

BACKGROUND

The United States is an Arctic Nation, with over 46,600 miles (75,000 km) of shoreline in Alaska, including the Aleutian Islands. Three Arctic seas bound the State of Alaska: the Bering, the Chukchi, and the Beaufort. Historically, these seas are frozen for more than half the year, typically limiting the Arctic maritime season from June through October, with unescorted and non-ice class navigation within a more limited time frame. However, this pattern appears to be rapidly changing as ice-diminished conditions become more extensive during the summer season. On September 16, 2012, Arctic sea ice reached its lowest coverage extent ever recorded, opening the way for the longest Arctic navigation season on record. Additionally, the four lowest winter maximum ice extents in the satellite record (1979–2018)

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have occurred in the past four years (2015–2018), with multi-year ice comprising less than half of what was measured in the mid-1980s.\textsuperscript{8,9} In the U.S. Arctic, seasonal sea ice loss has been especially notable in the northern Bering Sea. Historically, sea ice extended from the Bering Strait southward to the Aleutian Islands, covering much of the Eastern Bering Sea shelf. Sea ice coverage for the Eastern Bering Sea for 2018 and 2019 was the two lowest years on record, amounting to 50% and 65% sea ice coverage, respectively, and resulting in ice-free waters in March as far north as Norton Sound.\textsuperscript{10,11} (Figure 1)

**Figure 1: Median sea ice extent for March (left) and September (right).** Study area of interest outlined in black; median sea ice extent for 1981-2010 is presented in white, while years 2010 and onward are color coded according to label on right. Sea ice index data sourced from the National Snow and Ice Data Center.\textsuperscript{12} Map plotted with Google Earth Pro.

While the loss of sea ice may increase the accessibility of Arctic marine transportation and natural resource extraction, accessing and operating within the region remains challenging. Both annually and spatially variable sea ice can pose serious hazards to vessels transiting Arctic waters, and thus, most vessel activity is concentrated in a narrow seasonal operating window, extending from the summer to early fall. Although transiting Arctic waters has been eased by ice retreat, there are still unpredictable ice floes and inclement weather (e.g., extreme cold, heavy fog, severe storms). Further, some models suggest that wind speeds and wave height in the Arctic will increase in the absence of sea ice, posing further hazards to vessels in the region.  

STUDY AREA OF INTEREST

The Arctic, writ large, is defined in many ways for different domestic and international purposes. Common definitions are 1) the areas above the Arctic Circle (66° 32’N); 2) areas delineated by the 10-degree isotherm; and 3) the definition used by the Arctic Monitoring and Assessment Program Working Group of the Arctic Council. In accordance with the Arctic Research and Policy Act of 1984, the U.S. legally defines the Arctic 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”.  

This definition includes parts of Alaska well below the Arctic Circle, including the Aleutian Islands, which is part of an important Great Circle shipping route between the east Asia and the Pacific Northwest of the United States.

The 2015 CMTS vessel projection report, this report’s predecessor, focused on vessels north of St. Lawrence Island in the Bering Sea, through the Bering Strait, as far west as Wrangel Island in the Chukchi Sea, across the North Slope of Alaska as far east as Banks Island in the Beaufort Sea and Amundsen Gulf, and as far North as the extent of the U.S. exclusive economic zone (EEZ). This current study extends the

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area of interest southward to 60°N, in alignment with the Polar Code definition of the Arctic for the Bering Sea and capturing vessel activity at Nome, a regional hub.

**Figure 2: Map of the study area of interest and 2015 CMTS report study area of interests.** The present study’s area of interest is outlined in black, the study’s predecessor area of interest is outlined in yellow, the U.S. EEZ is outlined in white, and the U.S. legal definition according to the Arctic Research Policy Act of 1984 is outlined in red. Map plotted with Google Earth Pro.

**STUDY COMPONENTS**

This study consists of an overview of drivers of vessel activity in the Arctic (Section II), an analysis of past and present vessel activities in the Arctic (Section III), a projection of vessel activity for the U.S. Arctic to 2030 (Section IV), and a summary of findings (Section V).
Section II: Drivers of Vessel Activity in the Arctic

Change in the Arctic is both multifaceted and multivariable, and no single driver can predict overall vessel activity in any region, but especially not in the Arctic. To better understand the variety of motivations for transiting to and through the Arctic, the CMTS with support from the U.S. Arctic Research Commission and the Woodrow Wilson Polar Institute hosted a 2-day workshop November 14–15, 2018 on drivers of vessel activity, hereafter this workshop is referred to as the 2018 CMTS & USARC Technical Workshop. This event brought together 41 experts from industry, academia, government, and the Arctic region. Participants identified and ranked over 70 different drivers of vessel activity, across nine different categories, including:

- Natural Resources
- The Global Economy
- Changing Geopolitics
- Regulatory Changes
- Infrastructure
- Improved Technology and Operations
- Environmental Change
- The Human Element
- Changing Fuel Landscape

While the workshop did not seek consensus between participants, information provided by participants served as the foundation for this report and in crafting the projections featured in Section IV.

One important take away from the workshop was that there are many reasons why vessels are transiting through the Arctic. Therefore, scaling all growth up or down according to a single indicator would oversimplify the complex dynamics of the region. Accurately projecting how these vessels are expected to change over the next decade requires delving into the granular details of what is most likely to contribute to (or detract from) growth. Participants provided specific examples throughout the workshop, including examples of (1) natural resource development projects, (2) infrastructure development projects, (3) details about ships on order and expected to join the Arctic fleet, and (4) the feasibility of seasonally rerouting ships through the Arctic. These examples were critical input for calculating the projections featured in this study.

There are also a multitude of factors which may affect vessel activity, but could not easily be translated into quantifiable metrics for this study’s projections. Workshop participants noted the global economy, the geo-strategic location and growing importance of the Arctic, the regulatory environment, and the ‘social license’ to operate in the region as elements which certainly have and will continue to
impact how vessels in the region operate. One common theme surrounding these issues is the role that each can play in creating risk and uncertainty for operators sailing through the Arctic. For example, any operator engaged in natural resource development and extraction requires a degree of certainty on multiple fronts, such as the nature of regulatory requirements, the market’s demand for the resource, and about whether the resource can be extracted and brought to market in a timely and economical fashion. Operators in the Arctic, however, must also deal with the unique challenges of the region, which include the extreme and rapidly changing nature of the environment, the high cost of mobilization, and the lack of extensive existing infrastructure. These challenges are not unique to the natural resource industry; the shipping, tourism, and investors looking to finance large-scale infrastructure projects in the region also face a high cost of entry to operate in the region.

Mitigating the risks of operating in the region, therefore, is paramount to enabling the growth of vessel operations in the region. Some of this risk mitigation includes expanded informational infrastructure to support the marine transportation system, such as accurate nautical charts for the Arctic region and comprehensive weather forecasts featuring fog and sea ice forecast. Other elements include expanded and reliable communications networks and harbors of refuge, for vessels to seek out during inclement weather. The marine insurance industry can also play a vital role to offset the risks incurred with vessel operation, with can include coverage for lost cargo, environmental damages, rescue, and salvage operations. Workshop participants noted that the development of a standardized system of marine insurance catered toward vessel operators in the Arctic could mitigate the risk of operating in the Arctic and eventually incentivize participation in the Arctic marine transportation system. Regulatory action can also play a role to mitigate risk, such as the International Maritime Organization’s International Code for Ships Operating in Polar Waters (Polar Code). The Polar Code entered into force in 2018 and builds upon other existing treaties to address safe operating requirements for vessels transiting through waters at latitudes above 60° at both poles. The Polar Code is broad in scope, addressing elements of ship design, construction, and required equipment, training and operational concerns, search and rescue, voyage planning, and protection of the Arctic ecosystem.

Guided by this reasoning, the scenarios included this report each assume different degrees of certainty for operators and planners in the region. The more risk that can mitigated and the more certainty operators have about the region, the greater the growth potential for vessel activity in the Arctic.
**Section III: Overview of Past and Present Vessel Activities in the Arctic**

The volume of vessel activity in the study’s area of interest was examined using historical automatic identification system (AIS) data, in conjunction with the annual traffic summaries by vessel type for the U.S. Coast Guard’s Arctic area of interest, historical traffic from the Northern Sea Route, and the Northwest Passage, and with the recently established Arctic Ship Traffic Data (ASTD)\(^{15}\) project. Understanding historical and current trends of vessel activity is integral to understanding the future composition of vessel traffic.

**METHODS**

AIS data from satellite automatic identification system (SAIS) and the Nationwide Automatic Identification System (NAIS) was obtained from the U.S. Coast Guard Navigation Center (NAVCEN) from January 1, 2015-December 31, 2017. AIS utilizes the marine very high frequency (VHF) radio band to transmit information about a vessel’s position automatically every 2—10 seconds in a self-organizing network.\(^ {16}\) Other data encoded in AIS data transmissions include the vessel’s maritime mobile service identity (MMSI) number, which can be used to identify the vessel name, flag, and type of ship.

SAIS and NAIS obtained from NAVCEN were passed through a spatial filter to limit the data to AIS pings from within the study area of interest (Figure 3). The data was again filtered to remove MMSI numbers (and corresponding location data) which had only 1 data point (of either SAIS or NAIS) and those numbers which were only detected by one type of AIS receiver. These steps reduced the size of the data considerably, and by limiting the data only to those vessels which were detected by both satellite and terrestrially-based AIS receivers, these filtration steps narrowed the analysis to ocean-going vessels and vessels transiting through the Bering Strait. The MMSI numbers were then passed through one final filter,

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\(^ {15}\) The Arctic Ship Traffic Data Project is a Project of the Protection of the Arctic Marine Environment Working Group of the Arctic Council, which brings together ship traffic data across the whole, Polar Code definition of the Arctic. Please see p.18 of this report for more information.

to limit the range of MMSIs from 201000000 to 775999999, corresponding to those MMSIs broadcast by ships.\textsuperscript{17}

MMSIs obtained from this filtration step were annotated with vessel name, vessel type, and flag through cross referencing the MMSI against publicly available sources of data, including MarineTraffic.com, VesselFinder.com, and Federal Communications Commission (FCC) Ship License Search.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{map.png}
\caption{Map of the study area of interest. The present study’s area of interest is outlined in black, the U.S. EEZ is outlined in white, and the U.S. legal definition according to the Arctic Research Policy Act of 1984 is outlined in red. Map plotted with Google Earth Pro.}
\end{figure}

To understand the intra-annual variation of vessel activity, NAIS data from January 1, 2016-December 31, 2018 was analyzed for the study area using the Automatic Identification System Analysis Package (AISAP), developed by the U.S. Army Corps of Engineers, to explore further granular information about vessel track patterns and the duration of the shipping season in the study area of interest AISAP is a

A web-based tool for acquiring, analyzing, and visualizing near-real-time and archival data from the U.S. Coast Guard, and was developed with input from the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) and the U.S. Coast Guard. Total number of unique MMSIs (as a proxy for ships) by day were examined to further understand the seasonal navigation season of the region.

RESULTS

After geographically restricting the combined SAIS and NAIS data, a total of 1,944 unique MMSIs within the study area of interest were detected between January 2015 to December 2017. Filtering the data by the standards for ship MMSI resulted in 1,870 unique MMSIs corresponding to ships. Of those, 876 unique MMSIs had 2 or more detected pings within the study area of interest, and 582 unique MMSIs were detected on both NAIS and SAIS. Of these 582 total MMSIs, there was an average of 255 ± 26 (mean ± standard deviation) unique MMSIs detected within each year, 2015–2017, within the study area of interest. Further results of vessels by flag and type are presented in Tables 1 and 2; discussion of selected trends is included in the following pages.
Table 1: Summary of vessels within the study area of interest by vessel type, 2015—2017

<table>
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<tr>
<th>Vessel Types</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Mean ± SD</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Cargo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk Carrier</td>
<td>61</td>
<td>97</td>
<td>79</td>
<td>79 ± 18</td>
<td>31.0%</td>
</tr>
<tr>
<td>Container Ship</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Deck Cargo Ship</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1 ± 0.6</td>
<td>0.3%</td>
</tr>
<tr>
<td>General Cargo</td>
<td>16</td>
<td>20</td>
<td>16</td>
<td>17 ± 2</td>
<td>6.8%</td>
</tr>
<tr>
<td>Heavy Load Carrier</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>4 ± 4</td>
<td>1.7%</td>
</tr>
<tr>
<td>Landing Craft</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>5 ± 2</td>
<td>2.0%</td>
</tr>
<tr>
<td>Pallet Carrier</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1 ± 0</td>
<td>0.4%</td>
</tr>
<tr>
<td>Reefer</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1 ± 1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Ro-Ro</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Unspecified Cargo</td>
<td>11</td>
<td>36</td>
<td>26</td>
<td>24 ± 13</td>
<td>9.6%</td>
</tr>
<tr>
<td>Towing/Tug</td>
<td>64</td>
<td>59</td>
<td>36</td>
<td>53 ± 15</td>
<td>20.8%</td>
</tr>
<tr>
<td>Towing</td>
<td>32</td>
<td>42</td>
<td>26</td>
<td>33 ± 8</td>
<td>13.1%</td>
</tr>
<tr>
<td>Tug</td>
<td>32</td>
<td>17</td>
<td>10</td>
<td>20 ± 11</td>
<td>7.7%</td>
</tr>
<tr>
<td>Fishing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard A (Major)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Hazard B</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1 ± 0.6</td>
<td>0.5%</td>
</tr>
<tr>
<td>LNG Tanker</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Oil Tanker</td>
<td>18</td>
<td>13</td>
<td>14</td>
<td>15 ± 3</td>
<td>5.9%</td>
</tr>
<tr>
<td>Shuttle Tanker</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1 ± 1</td>
<td>0.3%</td>
</tr>
<tr>
<td>Gov't/LE/SAR</td>
<td>16</td>
<td>13</td>
<td>17</td>
<td>15 ± 2</td>
<td>6.0%</td>
</tr>
<tr>
<td>Adventure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasure Craft</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5 ± 1</td>
<td>1.8%</td>
</tr>
<tr>
<td>Sailing</td>
<td>5</td>
<td>11</td>
<td>11</td>
<td>9 ± 3</td>
<td>3.5%</td>
</tr>
<tr>
<td>Yacht</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1 ± 0.6</td>
<td>0.3%</td>
</tr>
<tr>
<td>Research</td>
<td>15</td>
<td>8</td>
<td>14</td>
<td>12 ± 4</td>
<td>4.8%</td>
</tr>
<tr>
<td>Small Craft from R/Vs</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>2 ± 3</td>
<td>0.8%</td>
</tr>
<tr>
<td>Research Vessels</td>
<td>14</td>
<td>8</td>
<td>9</td>
<td>10 ± 3</td>
<td>4.1%</td>
</tr>
<tr>
<td>Offshore Supply Ship</td>
<td>14</td>
<td>12</td>
<td>3</td>
<td>10 ± 6</td>
<td>3.8%</td>
</tr>
<tr>
<td>Passenger</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td>9 ± 1</td>
<td>3.5%</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>19</td>
<td>8</td>
<td>13 ± 6</td>
<td>5.2%</td>
</tr>
<tr>
<td>Anchor Handling Vessel</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2 ± 2</td>
<td>0.8%</td>
</tr>
<tr>
<td>Anti-Pollution Equipment</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1 ± 1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Cable Layer</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1 ± 1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Drill Ship</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Drilling Unit</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Factory Trawler</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>4 ± 5</td>
<td>1.6%</td>
</tr>
<tr>
<td>Fishery Patrol Vessel</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Icebreaker</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2 ± 0.6</td>
<td>0.9%</td>
</tr>
<tr>
<td>Port Tender</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Salvage</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Special Craft</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1 ± 0.6</td>
<td>0.3%</td>
</tr>
<tr>
<td>Supply Vessel</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Utility Vessel</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 ± 0.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4 ± 1</td>
<td>1.4%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>245</td>
<td>284</td>
<td>235</td>
<td>255 ± 26</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Table 2: Summary of vessels in the Area of Interest by Flag State, 2015 -- 2017

<table>
<thead>
<tr>
<th>Flag State</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Mean</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>133</td>
<td>97</td>
<td>82</td>
<td>104</td>
<td>40.8%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>41</td>
<td>82</td>
<td>58</td>
<td>60</td>
<td>23.7%</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>1.4%</td>
</tr>
<tr>
<td>Bahamas</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1.2%</td>
</tr>
<tr>
<td>Bermuda</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Canada</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>2.7%</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td>China</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0.7%</td>
</tr>
<tr>
<td>Cook Islands</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Croatia</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Curacao</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0.8%</td>
</tr>
<tr>
<td>Cyprus</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1.3%</td>
</tr>
<tr>
<td>Finland</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1.2%</td>
</tr>
<tr>
<td>Germany</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1.0%</td>
</tr>
<tr>
<td>Greece</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.3%</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1.0%</td>
</tr>
<tr>
<td>Japan</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>0.7%</td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Liberia</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>1.8%</td>
</tr>
<tr>
<td>Malta</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>2.2%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
<td>17</td>
<td>4</td>
<td>9</td>
<td>3.5%</td>
</tr>
<tr>
<td>Netherlands Antilles</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0.3%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Norway</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>Panama</td>
<td>8</td>
<td>19</td>
<td>18</td>
<td>15</td>
<td>5.9%</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Singapore</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2.0%</td>
</tr>
<tr>
<td>South Korea</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>St. Kitts and Nevis</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td>Sweden</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1.3%</td>
</tr>
<tr>
<td>Virgin Islands</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Wallis and Futuna</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0.8%</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0.7%</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>245</strong></td>
<td><strong>284</strong></td>
<td><strong>235</strong></td>
<td><strong>255</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
NUMBER OF VESSELS BY TYPE AND YEAR

An average of 255 unique vessels were found to have operated within the area of interest from 2015–2017, with 245 vessels detected in 2015, 284 in 2016, and 235 in 2017. By type, the two largest constituents of unique vessels operating in the region are cargo ships, tugs, and towing vessels, comprising just over 50% of the vessels operating in the region on average across 2015–2017. The remaining 50% is spread across fishing vessels (11%), passenger and adventure vessels (9%), tankers (7%), research ships (5%), offshore supply vessels (4%), and a variety of specialized vessels (categorized as ‘Other’, 5%).

Within this ‘Other’ category, individual ships operating in the region are attributed to specific surges of activity in the region. For example, the drill ship, anchor handling vessels, and anti-pollution ships in the study area in 2015 are directly attributed to Shell’s exploration of the Burger Prospect in the Chukchi Sea, which was discontinued prior to the start of the 2016 shipping season. Cable-laying vessels in 2016 and 2017 are likely related to Phase 1 of Quintillion’s Subsea Cable System, which includes a subsea fiber optic network stretching from Prudhoe Bay to Nome.18

It is difficult to interpret any temporal trends from this limited data set; however, it is likely that the total peak in 2016 is related to higher numbers of heavy load carriers and unspecified cargo ships operating within the area of interest, which may be related to expansion of infrastructure along the Northern Sea Route or to Shell’s demobilization efforts. Across the three years featured in this study, vessels related to fishing and adventure activities increased each year, while the total number of offshore supply vessels fell each year.

VESSELS AND FLAG STATES

A total of 38 unique flag states sailed vessels through the area of interest from 2015–2017. By flag, the U.S. has the largest number of unique ships operating within the confines of the study’s area of interest, with tugs and towing vessels comprising the largest type of U.S. vessels. Second behind the U.S. is Russia, which has a number of small cargo ships and tankers operating within the region, servicing Russian communities in the region which face the same constraints of resupply and limited infrastructure

as communities in western and northern Alaska. All other flag states comprised, on average, less than 5% each of the total number of ships in the region. While the total number of vessels oscillated between the three years examined, the number of flag states has increased over the three years included in this baseline analysis, from 25 states in 2015 to 32 in 2017.

**Duration of the Shipping Season**

Analysis of MMSIs within the area of interests by time reveals a distinctly seasonal operating window, with vessel traffic decreasing to less than 3 MMSI hits/day in December–May, and rapidly increasing in mid-May to peak in August each year. (Figure 4, top). There is no official start of the shipping season in this region, like there is for the St. Lawrence Seaway and Great Lakes; for this analysis, it is assumed that the shipping season is defined as the period when there are more than 10 vessels on the water broadcasting AIS. Using this definition, the shipping season for the area of interest, it is noted that the start of the shipping season appears to be starting earlier each year (Figure 4, lower left). Similarly, the close of the shipping season also appears to be happening later each year (Figure 4, lower right). Thus, the shipping season grew from 159 days in 2016 to 171 in 2017, and 180 in 2018 or about 10 days longer each year. This rate is about ten times faster than the findings of a previous study, which projected that the coastal ice-free season may lengthen by 1.3–1.7 days/year in the central (60°–65°N) and 1-1.5 days/year north (> 65°N).

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Figure 4: Plot of the number of unique MMSIs detected in the area of interest via NAIS by calendar day.

Data plotted for 2016–2018 for the entire year (top), May 1–June 15 (lower left), and November 1–December 15 (lower right). MMSI and time in area of interest data obtained through USACE’s AISAP for the study area of interest. Dashed vertical grey lines on top figure correspond to the annual ice extent maximum (mid-March) and minimum (mid-September).
DISCUSSION

COMPARING BASELINE DATA WITH OTHER RELEVANT DATASETS

To contextualize these results, the data obtained for the study area of interest was compared with historical data on the level of vessel activity for similar regions during overlapping time periods.

U.S. COAST GUARD AREA OF INTEREST

U.S. Coast Guard District 17 (USCG D17) has released an annual count of vessels by type within the Coast Guard’s Arctic area of interest since 2008. A summary of these data is presented in Figure 5.

**Figure 5: Vessel counts by year and type in the U.S. Coast Guard Arctic area of interest.** Note data for 2018 is through November 2018, and is not considered final; additionally, oil and gas (O&G) research and research vessels were combined for a single research count in 2018. Data provided and plotted by USCG D-17.

The Coast Guard’s Arctic area of interest extends from the Bering Strait, north to the North Pole, east to Banks Island and west to New Siberian Islands. The vessel counts for this area of interest have steadily climbed since data collection began in 2008, resulting in a 128% growth in 2018 over 2008 levels. The total number of vessels in the area peaked in 2015 at 300 vessels. This coincided with Shell Oil’s exploratory drilling efforts at the Burger Prospect in the Chukchi Sea. In early 2016, Shell announced its
intent to not pursue further exploration and withdrew from its leases in the Beaufort and Chukchi Seas. In the years since Shell’s withdrawal, total vessel activity levels have decreased from the peaks observed in 2015 to an average of 278 ± 11 vessels for 2016 – 2018. As vessels related to oil and gas have decreased, vessels attributed to research and government activities (e.g. law enforcement (LE) and search and rescue (SAR)) have increased.

The overall number and distribution of ships within the USCG data set is in close agreement with the distribution of vessels found in this study’s area of interest, and may serve as a valuable corollary data set for this report’s area of interest. One notable difference between the USCG dataset and the data gathered for this study area of interest is in relation to fishing vessels.

NORTHERN SEA ROUTE

The Northern Sea Route Administration (NSRA) is the government agency for the Russian Federation that oversees passage through the Northern Sea Route, which includes Russian waters extending from the Kara Sea to the Bering Strait. Historical data for complete transits of the Northern Sea Route by vessel name, flag, and vessel type were compiled from 2014–2018 from data made available by the Northern Sea Route Information Office (Figure 6 and 7).

The total number of unique vessels Russian flagged ships make up the largest share of vessels utilizing the route, though in 2018, transits completed by cargo vessels owned by COSCO (general cargo ships flagged to China and Hong Kong) were equal to the number of transits completed by Russian flagged ships. The data presented here certainly underestimates the volume of traffic along the Northern Sea Route, as it only includes complete transits, rather than all vessels operating along the route, including ice-breaking LNG tankers transporting LNG from the Yamal peninsula to Europe and Asia or vessels suppling smaller communities along the route. There is value, however, in comparing the level of activity detected in this study’s area of interest with historical NSRA transit data. Fifteen unique ships transited the Northern Sea Route in 2015, sixteen in 2016, and twenty-five in 2017, represented 6.1%, 5.6%, and 10.6% of the total number of unique vessels in the study’s area of interest in 2015, 2016, and 2017, respectively.

Figure 6: Tally of Northern Sea Route Transits by Year and Flag. Data obtained from the Northern Sea Route Administration via the Center for High North Logistics.

Figure 7: Tally of Northern Sea Route transits by year and type. Data obtained from the Northern Sea Route Administration via the Center for High North Logistics.
NORTHWEST PASSAGE

Historical traffic of the Northwest Passage was obtained from Headland et al., which includes an extensive record going back to Amundsen’s historic expedition in 1906, though most of the focus for this comparison is on the vessel traffic of the last decade (Figure 8).\footnote{Headland, R.K. et al. (2018). Transits of the Northwest Passage to End of the 2018 Navigation Season: Atlantic Ocean ↔ Arctic Ocean ↔ Pacific Ocean. Scott Polar Research Institute. Accessed from \url{https://www.spri.cam.ac.uk/resources/infosheets/northwestpassage.pdf}}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{ships_transiting_northwest_passage}
\caption{Tally of ships completing transits of the Northwest Passage by year, 2008 – 2018. Data obtained from Headland et al. (2018).}
\end{figure}

Vessels transiting the Northwest Passage have predominantly been small, adventure-type craft or small, ice-strengthened cruise ships. Only eight of the total 222 complete transits were for transporting commercial cargo through the Northwest Passage, while all but nine of the transits of the Northwest Passage from 2015–2017 were tourism or adventure-related activities.\footnote{Ibid.} Notably, there was a sharp drop

\begin{thebibliography}{9}
\end{thebibliography}
in vessel activity in 2018, due to extensive icing of the Northwest Passage, making the route inaccessible for all but three vessels.

As with the data compiled for the Northern Sea Route, this volume of vessel activity likely underestimates the total vessel activity, but does serve as a valuable touchpoint for the vessels within our area of interest. Nineteen unique ships transited the Northwest Passage in 2015, twenty in 2016, and thirty-three in 2017, represented 7.7%, 7.0%, and 14% of the total number of unique vessels in the area of interest in 2015, 2016, and 2017, respectively.

ARCTIC SHIP TRAFFIC DATA PROJECT

Contextualizing the number of ships in the study’s area of interest with the rest of the Arctic region is now possible through the Arctic Ship Traffic Data (ASTD) Project, launched in early 2019 by the Protection of the Arctic Marine Environment (PAME) Working Group of the Arctic Council. Through a cooperative agreement among the Arctic States, the ASTD Project brings together ship traffic data across the whole, Polar Code definition of the Arctic. Analysis of ASTD traffic data found that a total of 2,043 vessels transmitted AIS in the Arctic in 2017, with 1,584 of those vessels registered to Arctic States (77.5%)\(^{23}\). In total, the vessel traffic of the pan-Arctic is comprised of dry bulk vessels (16%), oil or product tankers (13%), cargo vessels (8% including containerized cargo), fishing vessels (5%), gas tankers (5%), offshore service vessels (5%), passenger vessels (1%), with the remaining vessels categorized as other.

Comparison of the data from the ASTD with 2017 for this study’s area of interest reveals that the number of unique vessels in this study’s area of interest account for 11.5% of the total number of unique ships operating in the Polar Code definition of the Arctic. Notably, by vessel type, the number of unique passenger ships accounts for 53% of all the passenger vessels operating in the Arctic, while the number of unique fishing vessels accounts for 31% of all fishing vessels in the Arctic. Comparing our results with the data available through the ASTD Project can help contextualize the growth of the U.S. Arctic and surrounding region with the wider, Pan-Arctic growth.

\(^{23}\) These data and analyses were provided during the 2018 CMTS & USARC Technical Workshop on Arctic Vessel Activity, held in Washington, D.C., 14–15 November 2018.
LIMITATIONS OF AIS DATA AND OVERLOOKED VESSEL ACTIVITIES

The analysis presented here includes only those vessels broadcasting AIS information. In 2002, the International Maritime Organization (IMO) made it mandatory for AIS to be fitted aboard all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages, and all passenger ships irrespective of size.\(^{24}\) Although the analysis of AIS data can provide insights into the kinds of activities in the region, it does not capture all activities, including small fishing vessels and small crafts launched from research or passenger ships.

By filtering the data to remove MMSIs attributed to small crafts,\(^{25}\) four small passenger vessels related to two cruise ships and two support crafts related to cable laying vessels were removed from the data set. However, several small crafts associated with U.S. flagged vessels were included in the data set, despite such filtering. This is because there is no provision in the U.S. to assign MMSIs to these vessels other than obtaining a unique MMSI specifically assigned by the Federal Communications Commission (FCC). These vessels included several of the small skiffs used by research vessels *Fairweather* in 2015 and 2017 and *Sikuliaq* in 2017. These inclusions have inflated the volume of vessels attributed to research activities, while also discounting the true footprint of larger cruise vessels and crafts launched from these vessels in the region. Understanding the number of these small support crafts associated with research and passenger activities is required to more accurately constrain the total number of vessels in the region.

One other type of activity excluded by using AIS data exclusively is the vessel activity related to subsistence hunting, the longest ongoing type of vessel activity in the Arctic. While some subsistence hunting does not require the use of vessels, the harvest of marine mammals and some fishing activities do require watercraft, the most familiar of which is the *umiak* or *umiaq*, an open skin boat used in traditional subsistence whaling. Whaling activities vary by community and by season, following the migration patterns of the whales through the region. The Bowhead whale, an important subsistence and cultural resource for many subsistence communities in the region, has a spring migratory corridor


\(^{25}\) According to USCG’s Navigation Center, stations used on craft associated with a parent ship, such as a launches, tenders, towed vessels, etc. may use the format 9182M34D5X6X7X8X9 where the digits 3, 4 and 5 represent the MID and \(X\) is any figure from 0 to 9. However, no provision currently exists for assigning these identities in the United States. For more, please see https://www.navcen.uscg.gov/?pageName=mtmmsi
between the Bering Strait and Cape Bathurst, and a fall migratory corridor between Hershel Island and Utqiagvik.26

There is little data available on the volume of vessel activity associated with subsistence hunting, but what data is available suggests that this baseline analysis (which is reliant on AIS exclusively) missed a considerable portion of the total number of vessels in the Arctic by excluding subsistence vessels. Among the 11 whaling communities in the northern Bering Sea and Alaskan Arctic, there are 165 registered whaling captains.27 Further data is needed to understand the number of ships utilized by subsistence hunters, but given the importance and the wide spread practice of subsistence hunting to communities along the Bering Strait and the North Slope, it is imperative to close this data gap. Assuming each captain uses a single vessel, the total number of vessels based on AIS alone within the study area of interest may underrepresent actual vessels by 40% by excluding subsistence activities. Understanding the magnitude of all types of vessel activities in the region is critical to deconflicting the current uses of these waterways and planning for future changes in the region.

**POTENTIAL CHANGES IN THE COMPOSITION OF VESSEL ACTIVITY**

The region of interest for this study has undergone unprecedented changes over the past decade, and the analysis of vessels over the last few years presented in this chapter may hint at further changes to come in the region, including autonomous vessels, container ships

Within the 2018 data obtained via the U.S. Army Corps of Engineer’s AISAP, there were two notable vessels, whose presence may indicate that the composition of vessels moving through the region may change considerably. First, one MMSI in 2018 was found to correspond to the Bathymetric Explorer and Navigator (BEN), an unmanned surface vehicle used for the first time to assist in collecting data for hydrographic surveys vessels for NOAA.28 While there may not be autonomously piloted ships through

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this part of the Arctic in the next decade, it is highly likely that there will be more autonomous vessels used for research activities in the future, especially as the demand for real-time environmental data in the region increases.

Secondly, in September 2018, Maersk’s Venta Maersk sailed through the Northern Sea Route, crossing through the study area of interest. Smaller container ships have sailed along the Northern Sea Route before, but this shipment was the first trans-Arctic shipment of containerized cargo. At the time, Maersk itself did not see the passage as feasible because of the limited navigation window. However, ongoing discussions since Maersk’s successful maiden voyage raise the prospect of whether containerized cargo might one day regularly transit through the Arctic. The United Nations Conference on Trade and Development (UNCTAD) estimates that container ships are among the fastest growing types of ships engaged in international waterborne commerce and are expected to grow 6% annually from 2018-2023. Such a development would likely dramatically alter the spread of vessel types transiting through the Bering Strait and the study area of interest.

Additionally, within both AIS data sets for the area of interest, fishing vessels were a considerably larger portion of vessels than anticipated. Some of these fishing vessels are simply vessels of opportunity used for research activities in the region, owing to the shapes of their track lines. Commercial fishing in the study area of interest is only currently allowed in U.S. waters south of the Bering Strait and non-U.S. waters, yet these waters are adjacent to the Bering Sea, one of the largest and most productive commercial fishing grounds in the U.S. This region is undergoing unprecedented environmental change, and as the water temperature in the region increase, commercial fishing vessels may move farther north, expanding further into waters included in this study area of interest. Within the three years sampled here for the baseline analysis, the number of unique ships categorized as fishing vessels climbed from 18 in 2015 to 34 in 2017. These data alone cannot confirm that fishing activity is increasing in the area, because

AIS is only required on vessels larger than 300 gross tons and many fishing-related vessels are below the size requirement for AIS carriage. Additionally, while the international moratorium on commercial fishing in the central Arctic Ocean is slated to remain in place for sixteen years and the ban within U.S. waters north of the Bering Strait has been in place since 2009, it is anticipated that before commercial fishing operations arrive, there will likely be an influx of research vessels in the region to accurately assess potential stocks in these currently unfished waters.

CONCLUSION

This section has provided an overview of the kinds of vessels within the study area of interest in the context with other relevant data sets. An average of 255 vessels broadcasting AIS transited through the area of interest annually between 2015 and 2017, and on average 31% of these vessels were cargo vessels, 21% tug and/or towing vessels, 11% fishing vessels, 9% tourism related vessels (passenger and adventure ships) 7% tankers, and the remainder split between government (LE and SAR), research, and a variety of other activities. By flag state, U.S. flag vessels make up 40% of the vessels in the study area of interest, Russian flag vessels make up 24% of the vessels, and the remaining 36% of vessels are from 35 other flag states, each with a considerably smaller percentage than Russia or the U.S. The navigational window is highly seasonal in the waters included in this area of interest. The number of vessels broadcasting AIS increases sharply in mid-May/early-June, peaks in mid-August, and then decreases through the fall, with the season ending in mid-November. Within the few years analyzed, it appears that the length of this shipping season is getting longer, growing by 10 days each year, even as the total number of vessels in the area does not change substantially.

Finally, using AIS to understand how many and what kinds of ships operating in the region overlooks two huge waterway users that must be accounted for: smaller fishing vessels and those vessels used for subsistence hunting. Closing these gaps is an important step to developing a comprehensive understanding of civilian uses of the waterways in the U.S. Arctic and surrounding waterways.
Section IV: Projections of Vessel Activity in U.S. Arctic Region, 2020 – 2030

Given the myriad of drivers behind vessel activity and the observed types of vessel activity in the U.S. Arctic and immediate surrounding areas, projecting the volume of vessel activity is challenging. Previous studies, including the 2015 CMTS vessel projection report, have developed estimates by extrapolating historic vessel activity and global shipping or economic indicators into the future, linked with supporting data to constrain the final numbers. This report utilizes a new method, developed specifically for this project. It combines four major, quantifiable sources of growth to manually estimate the number of ships operating in the region over the next decade. This method can be readily modified to incorporate more data or to update the projections, and may also be easily adapted for other areas of interest in the Arctic.

This section includes a discussion on the methodology, followed by detailed discussion of the quantifiable sources of growth, which were used to calculate and project number of vessels expected to transit through the study area of interest. The section ends with a discussion of the four projections included in the report.

METHODS

Sources of growth from four different sources of growth were combined and added to an established baseline of vessel activity to manually obtain a total number of ships each year. A schematic of this is summarized in Figure 9.

![Figure 9: Schematic of methodology to manually forecast projections](image-url)
To account for uncertainties associated with each constituent, several values were assigned to each source of growth, corresponding to the four scenarios developed for this report: Reduced Activity Scenario, Most Plausible Scenario, Optimized Growth Scenario, and Accelerated, but Unlikely Scenario. This final scenario, Accelerated, but Unlikely, was developed to understand what the maximum growth of vessel activity could be for the region given the source of growth considered.

**Baseline**

For the projections included in this study, it is assumed that the vessel traffic would build upon the baseline of established vessel activity in the region. The baseline used for the projections included in this report is 255 ± 26 unique vessels, which is the average number of vessels plus/minus the standard deviation of unique vessels operating in the study area of interest in 2015–2017 detected on both SAIS and NAIS. Further discussion of how this was calculated is included in Section III of this report.

**Source of Growth**

A wide number of factors that could contribute to growth (or decline) of vessel activity were considered as part of the 2018 CMTS & USARC Technical Workshop on Arctic Vessel Activity. Over 70 individual drivers of vessel activity were identified by workshop participants and considered for incorporation, however, only quantifiable drivers that could be readily translated into vessel activity were considered sources of growth in the projections. These sources of growth fall into four key categories: (1) natural resource development; (2) infrastructure development; (3) expansion of the Arctic fleet; and (4) expansion of seasonally rerouted shipping through the Arctic.

To determine the volume of vessel activity related to natural resource and infrastructure developments, in-depth analysis of proposed and planned natural resource and infrastructure development projects were examined, utilizing publicly available data, such as those found in environmental impact statements and permit applications, and assigning a range of values for the associated vessel activity for each activity across the four scenarios. Sources of growth related to the expansion of the Arctic fleet were obtained from news articles and vessel order books, and assigned ranges which were then assigned to one of the four scenarios in the same manner as the previous two types of growth. For the growth of seasonally rerouted shipping through the Arctic, data from the
Panama Canal and the United Nations Conference on Trade and Development (UNCTAD) were used to formulate ranges of ships utilizing the Arctic in place of trans-oceanic routes.

**SCENARIOS**

This study features four scenarios which explore how all these sources of growth may converge over the next decade to shape the type of vessel activity within the U.S. Arctic and immediate surrounding region.

- The **Reduced Activity Scenario** assumes that the high risks of operating in the region are not able to mitigated over the next decade, and this uncertainty limits the volume of growth in the region. To reflect this, this scenario incorporates the lowest amount of traffic for each source of growth and assumes that activities required to stimulate vessel growth will not proceed at speeds anticipated or estimated in the available literature.

- The **Most Plausible Scenario** assumes that some of the risks for operating in the region will be mitigated. This scenario incorporates the most reasonable estimates of traffic growth and vessel counts into a single scenario.

- The **Optimized Growth Scenario** assumes that much of the risks for operating in the region will be mitigated over the next decade. This scenario incorporates the upper end of growth rates, with the intent to capture vessel counts and growth rates in the realms of what is possible, but not necessarily most probable.

- The **Accelerated, but Unlikely Scenario** assumes that the risks of operating in the region are completely mitigated and incorporates all sources of growth for the region, including components which may be unlikely according to best available data. This scenario is meant to act as a ceiling for the projections in this study; while theoretically possible, this combined scenario is highly improbable.

**ASSUMPTIONS**

This methodology rests on two key assumptions. First, it assumes that the vessels included in the baseline of recent vessel activity (252 ± 26) will continue to transit through the study area of interest every year for the next decade. These vessels include ships related to community resupply (tugs, towing
vessels, tankers, and a portion of the total cargo vessels), research and hydrographic survey vessels, and cruise and adventure tourism—all of which are expected to either maintain their existing presence in the region, with some year to year variability. Bulk cargo carriers related to the Red Dog Mine, which have ranged from 23—27 vessels annually over the last decade, are also expected to remain constant throughout the mine’s lifetime. While there may be some fluctuations in the total number of vessels (such as the number of offshore supply vessels), it is likely that these fluctuations will be within the observed standard deviation between 2015—2017, 26 vessels or about 10% of the mean.

Second, the results of this method assume that all sources of growth have been reasonably accounted for and included in the projections. As part of the 2018 CMTS & USARC Technical Workshop on Arctic Vessel Activity, participants identified over 70 drivers of vessel activity, including projects which ranged widely with respect to being ‘shovel-ready’. Despite attempts to include such projects, there may be projects which have not yet been proposed and which could contribute to vessel activities in the study area of interest, especially towards the latter half of the decade. However, this method is easily adapted to reflect potential sources of growth as information becomes available.
SOURCES OF GROWTH

This section will detail the categories of growth incorporated into projections. The four types of growth included in this study are: (1) natural resource development, (2) domestic infrastructure development (3) expansion of the Arctic fleet, and (4) seasonally reallocated shipping through the Arctic. Within each type of growth are multiple line items which were incorporated into the projections. A summary of the sources of growth is included in Table 3.

Table 3: Overview of sources of growth considered for vessel projections

<table>
<thead>
<tr>
<th>Type of Growth</th>
<th>Sources of Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Resource Development</td>
<td>Offshore Geological and Geophysical Research (US)</td>
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<tr>
<td></td>
<td>Liberty Hilcorp Project (US)</td>
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<tr>
<td></td>
<td>Beaufort Sea Exploration from Spy Islands Drillsite (US)</td>
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<td></td>
<td>LNG Production on the North Slope (US)</td>
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<td>Yamal LNG Project (Russia)</td>
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<td></td>
<td>Arctic LNG 2 Project (Russia)</td>
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<td></td>
<td>China’s Icebreaking LNG Tankers</td>
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<td></td>
<td>Expansion of Red Dog Mine (US)</td>
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<td></td>
<td>Graphite One Resources (US)</td>
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<td></td>
<td>Hope Bay Gold Mine (Canada)</td>
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<tr>
<td></td>
<td>Back River Gold Mine (Canada)</td>
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<td></td>
<td>Mary River Mine (Canada)</td>
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<tr>
<td></td>
<td>Offshore Geological and Geophysical Research for Offshore Wind Development (US)</td>
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<tr>
<td>Infrastructure Development</td>
<td>Port of Nome Modification</td>
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<tr>
<td></td>
<td>Lower Yukon River Regional Port and Road in Emmonak, AK</td>
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<tr>
<td></td>
<td>Construction of the Kotzebue to Cape Blossom Road</td>
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<tr>
<td></td>
<td>Road Improvements in Utqiagvik, AK</td>
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<td></td>
<td>Road Improvements in Nome, AK</td>
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<td></td>
<td>Road Improvements in Selawik, AK</td>
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<tr>
<td></td>
<td>Airport Repair in Alaska</td>
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<tr>
<td></td>
<td>Onshore Renewable Wind Development Projects</td>
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<tr>
<td></td>
<td>Relocation of Kivalina, AK</td>
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<tr>
<td></td>
<td>Relocation/Protection-in-Place of Shishmaref, AK</td>
</tr>
<tr>
<td>Expansion of the Arctic Fleet</td>
<td>Launch of USCG Polar Security Cutters</td>
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<tr>
<td></td>
<td>Launch of Russian Icebreakers</td>
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<tr>
<td></td>
<td>Launch of Canadian Icebreakers</td>
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<tr>
<td></td>
<td>Launch of the Xue Long 2</td>
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<tr>
<td></td>
<td>Expedition Fleet Expansion</td>
</tr>
<tr>
<td>Seasonally Reassigned Shipping</td>
<td>A Panamax-sized Fleet of Select Vessel Types</td>
</tr>
</tbody>
</table>
NATURAL RESOURCE DEVELOPMENT

The Arctic holds vast natural resources, and development of the American Arctic has been closely associated with Arctic natural resources since the Gold Rush era. These resources, and those from neighboring Arctic States, are likely to continue to play a key role in the fate of the Arctic, as new resources are made accessible by changing environmental conditions and changing energy demands. A summary how these natural resource developments are anticipated to add to vessel traffic in the study area of interest is summarized in Figure 10.

![Projected Vessel Growth from Natural Resource Development](image)

Figure 10: Combined sums of vessel traffic related to natural resource development in the Arctic by scenario.

OIL AND GAS DEVELOPMENT

Development of oil and gas resources in the Arctic have the potential to greatly transform the amount of vessel activity in this study’s area of interest. Within the U.S., development of these resources will likely depend on availability of Federal waters and on the oil and gas prices. The prospect of both remain uncertain. In 2017, the Bureau of Ocean Energy Management (BOEM) developed the 2019–2024
National Outer Continental Shelf Oil and Gas Leasing Program, which includes plans for oil and gas lease sales in the Beaufort Sea in 2019, 2021, and 2023 and Chukchi Sea in 2020, 2022, and 2024.\textsuperscript{32} However, prior to leaving office in 2016, President Obama removed all submerged Federal lands of the Chukchi Sea and a majority of the Beaufort Seas from future leasing activities under the Outer Continental Shelf Lands Act (OCSLA).\textsuperscript{33} Efforts to overturn this action via Executive Order were not upheld in a recent court decision, making future exploration and development of oil and gas in the Chukchi and Beaufort Seas uncertain.\textsuperscript{34}

Beyond the regulatory certainty, oil and gas developers would also require market certainty. When Royal Dutch Shell began its exploration of the Burger Prospect in the Chukchi Sea, oil prices were at record high levels, averaging close to $95/barrel (bbl) from 2011–2014, before dropping to less than $50/bbl in 2015.\textsuperscript{35} In 2018, spot prices reached $65, and are projected to range from $54–$60/bbl over the next two years.\textsuperscript{36} Taken together, this evidence suggests that there is only a moderate chance for offshore oil and gas development within this study’s timeframe.

One notable exception, however, is the potential for development of LNG, which, as discussed below, is likely to transform dynamics of Arctic marine transportation considerably over the next decade.

Oil and Gas Development within the U.S.

\textit{Offshore Geophysical and Geological Surveys}

Offshore geophysical and geological (G\&G) surveys are used to locate offshore marine mineral resources, and are among the first requirements prior to oil and gas exploration and production or

\begin{itemize}
\item \textsuperscript{34} Thuanawala, Sudhin. (2019). “Judge restores Obama-era drilling ban in Arctic”. AP News. Accessed from: https://www.apnews.com/6631cf4aed3348a7b767c0c2b7445ca4
\item \textsuperscript{35} Energy Information Administration. (2019). West Texas Intermediate Crude Oil Spot Prices. Accessed from: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=A
\end{itemize}
offshore infrastructure siting. Based off recent applications for the Alaskan Arctic, each G&G survey would require a fleet of approximately 9 vessels, including vessels to house the crew due to the limited onshore infrastructure available on the North Slope. Such large-scale operations may also require additional fuel sources, and likely, an additional tanker would be required to supply the fleet with fuel via lightering, raising the total count of vessels for each operation to 10 vessels per G&G permit.

In April 2018, the TGS-NOPEC Geophysical Company applied for a permit to conduct geophysical exploration for mineral resources in waters of the Beaufort Sea outer continental shelf (OCS) Area. The proposed program was to start July 15 and be completed by October 31, 2019, and be repeated in 2020 in the same region. As outlined in TGS-NOPEC’s Plan of Operations, the G&G survey would utilize 9 vessels each year, including two multipurpose landing crafts for the two seismic sources, one large vessel for crew housing and mitigation, and six smaller vessels for transport and deployment of crew and equipment. In late May 2019, TGS-NOPEC withdrew its application from BOEM, indicating that G&G survey activities would not contribute to vessel growth in the region for 2019 and 2020. As of June 2019, there are no pending G&G permits for the Alaskan Arctic or remaining permits to be fulfilled.

Using the recent developments of G&G survey permits and the greater uncertainty surrounding offshore oil and gas development, it is assumed that no G&G surveys will be conducted in the Reduced Activity Scenario over the next decade. In the Most Plausible Scenario, it is assumed that one survey with 10 ships will be conducted in the Beaufort Sea every even year over the next decade within the region where leasing has historically been beginning in 2022, per the draft proposed lease schedule for the 2019–2024 National Outer Continental Shelf Oil and Gas Leasing Program. In this scenario, it is assumed that no surveys will be conducted in the Chukchi Sea, conferring the projection with an oscillation throughout the next decade. The Optimized Growth Scenario is expected to the same pattern as the Most Plausible Scenario, but assumes that there will be surveys in the Chukchi Sea, too, contributing 10 ships to the annual count. The Accelerated, but Unlikely Scenario assumes that there will be surveys in both the Chukchi and Beaufort Seas, with 1 survey of 10 ships in the Chukchi Sea every even year, and 2 surveys of 10 ships in the Beaufort Sea every odd year.


Hilcorp Alaska LCC proposed to construct an artificial gravel island and 5.6 miles of connecting subsea pipeline in the shallow waters of the North Slope to the west of Prudhoe Bay. Construction of the project would require 1–2 of seagoing barges, ocean class tugs, coastal barges, assist tugs, and crew boats, as well as a bathymetric vessel for surveying and a hovercraft for crew transport. During construction of the artificial island, connecting pipeline, and other facilities, there would be 7–12 vessels per annum operating in the immediate region. The requirement for vessels would drop off following the completion of construction in Year 4 of the project, and oscillate from 5–7 vessels each year for production operations of the facility. In 2018, the Department of Interior approved the oil and gas development and production plan for the project, but before construction could begin, the project encountered two major issues. In November, construction was stalled due to a lack of shorefast sea ice, which the project planned to leverage for the initial construction of the artificial gravel island. In December 2018, the Federal government’s decision to approve Hilcorp’s Liberty project was challenged in a Federal lawsuit, which remains ongoing.

Given the legal and logistic challenges with this project, the start date of the Hilcorp Liberty Project is explored in each of the four scenarios. In the Reduced Activity Scenario, it is estimated that this project will not start construction until after 2030. In the Most Plausible Scenario, it is assumed that construction will begin in 2028, adding 11–12 vessels each year through the end of the projections. In the Optimized Growth Scenario, it is assumed that construction will begin in 2024, adding 11–12 vessels for four years before dropping off to 5–7 vessels at the end of the decade as the project transitions into normal production operation after Year 4 of the project. In the Accelerated, but Unlikely Scenario, it is assumed that construction will proceed in 2019, adding 11–12 vessels each year until 2023, when the level will decrease and remain at 5–7 vessels annually for the remainder of the decade.

Eni’s Beaufort Sea Exploration from Spy Islands Drillsite

Eni US Operating Co. Inc. is the only entity in Alaska with active, ongoing exploration plans. Eni has proposed and received approval to conduct exploratory sideways drilling of Eni’s Nikaitchuq North Project in Federal waters in the Beaufort Sea from Eni’s Spy Island Drillsite, an artificial island within state waters located offshore of Oliktok Point. As part of the Exploration Plan filed in 2017, Eni’s operation would require only three ships to transport goods and crew to the Spy Island Drillsite in the open water season. These three ships, along with other vessels used for resupply, were accounted for as part of the baseline, and therefore are not included as a potential source of growth in any of the projection scenarios.

Production of LNG from the North Slope

There are believed to be 3.3 trillion cubic feet of natural gas in Alaska, and currently natural gas production volumes from the North Slope far exceed local demand, with much of the extracted gas reinjected to maintain crude oil production rates from facilities on the North Slope. According to 2016 estimates by BOEM, there may be a further 105 trillion cubic feet in Federal waters of the Chukchi and Beaufort Seas. Taken together, there may be 2.5 times as much natural gas off the north coast of Alaska as there are estimated to be in reserve for the Yamal LNG Project on the Sabetta Peninsula in the Kara Sea. There has been some discussion about how to move this gas off the North Slope, and whether it makes sense to move it via ship or pipeline. Constructing a pipeline to connect to existing liquefaction facilities has been proposed, and would not likely contribute any vessel activity through the study area of

42 Note, these are leases OCS-Y-1753, OCS-Y-1754, and OCS-Y-1757
interest. Shipping LNG, however, would impact the area of interest’s vessel activity substantially. If such a project were able to utilizing existing oil and gas infrastructure, it might be possible for an LNG export operation to be established on the North Slope within the next decade. Such an operation, modeled off of the Yamal LNG Project in Russia, could require 15 icebreaking LNG tankers, making 2–3 roundtrips each per season, crossing the Bering Strait 36 times in a season to deliver fuel to Asia, or many smaller trips to deliver LNG fuel to harbors and ports within Alaska, including regional hubs like Dutch Harbor or Nome.

Given how little information there is about potential for LNG export off the North Slope, this source of growth is only considered in the Accelerated, But Unlikely Scenario. It is estimated that construction of an offshore, deep-water LNG terminal, pipelines, and onshore liquefaction facility would require 2 ships each year beginning in 2022, with other supplies hauled to the site via the Dalton Highway. It also assumes that five LNG icebreaking tankers could be built and be made available for exporting gas by 2025, adding an additional 1 additional icebreaking LNG tanker each year for the remainder of the decade to have a total of 10 vessels servicing the facility by 2030.

Oil and Gas Resources Outside the U.S.

Over the last decade, Russia has made extensive progress in the development of natural gas resources on the Yamal Peninsula. Construction on the Yamal LNG project, jointly developed by Novatek, Total, China’s CNPC and Silk Road Fund, began in 2013, and the first shipment of LNG was completed in December 2017. The Yamal LNG plant is expected to produce 16.5 million tons of LNG each year, with 1.2 million tons of LNG expected to be shipped annually to markets in Europe and Asia via specially built icebreaking class tankers. The Russian Transport Ministry announced in early 2019 that 70% of the total of 92.7 million tons of goods handled by regional seaports and along the Northern Sea Route were oil products and LNG. Growth in the LNG sector in Russia is expected to directly impact the amount of vessel activity in this study’s region of interest, as vessels exporting LNG to the far East from the Yamal Peninsula must pass through the Bering Strait to reach Eastern markets.

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Yamal LNG

To support export of LNG from Yamal, 15 icebreaking LNG tankers were ordered from South Korea’s Daewoo Shipbuilding & Marine Engineering Co. to support year-round navigation along the Northern Sea Route.\textsuperscript{51} As of 2018, eight of these ships were in operation, two were conducting sea trials, four expected to be delivered from late 2019 to early 2020, and the final ship remains under construction. It is anticipated that by 2021 all 15 ships will be in operation, passing through this study’s area of interest during the summer months.

Assuming each ship has the capacity to carry 73,000 tons of LNG and that the operational window for shipping LNG to the east via the Northern Sea Route is only 92 days annually, it is estimated that 15 icebreaking LNG tankers could make a total of 36 roundtrips to Asia, crossing the Bering Strait 72 times annually during a short operational window. Such values represent an equivalent of 10% of the ships and 12% of the transits through the Bering Strait in 2018 according to data provided by the U.S. Coast Guard.

For the four scenarios included in this study, it is assumed that icebreaking LNG tankers originating from the Yamal peninsula will continue to add to vessel traffic in the region. The Reduced Activity Scenario assumes that the number of vessels will grow from 4 to 6 vessels annually over the decade. The Most Plausible Scenario assumes that one additional vessel will be diverted east every two years, until 10 of the 15 ships conduct eastbound shipments by 2030 In the two highest growth scenarios, it is assumed that all vessels will carry LNG eastward during the summer season as soon as they are delivered, which is assumed to be 2023 for the Optimized Growth Scenario and 2022 for the Accelerated but Unlikely Scenario, and will maintain that level through 2030.

Other Russian LNG Projects

There may be additional development of LNG along the Northern Sea Route, specifically as Russia looks to develop the Arctic LNG 2 project. Located on the Gydan Peninsula, to the east of Yamal, the facility could be expected to operate similarly to the Yamal LNG facility by 2022–2023, provided that

sufficient investment can be secured. Such a facility would generate a similar level of vessel activity, potentially doubling the footprint of LNG icebreaking tankers in the region.

Due to the paucity of available information about the plans for the Arctic LNG 2 project, it is only assumed to add vessels to the region in the Optimized Growth and Accelerated, but Unlikely Scenarios. In these scenarios, it is assumed that 2–3 ships will be required for construction in 2020 and 2021, and additional LNG tankers carrying gas from the finished project would increase from 3 to 15 ships at two different rates (1–2 ships/year for Optimized Growth Scenario; 2–3 ships/year for Accelerated but Unlikely Scenario).

Beyond production facilities, there is also considerable discussion about a transshipment hub at Kamchatka to optimize the logistics of LNG shipments from the Arctic. The proposed terminal is anticipated to have an annual capacity of 20 million tons, a sufficient capacity to support the combined east-bound shipments of the Yamal LNG and Arctic LNG 2 projects.\(^{52}\) Construction of this facility is not expected to contribute to vessel activity through the region of interest, because the proposed facility is south of the study area of interest. Upon its completion, however, this facility may stimulate further activity in the region, as ships moving LNG from Yamal would have shorter transits to deliver their cargo. If completed as planned in 2023, the transshipment hub would allow Yamal’s 15 LNG icebreaking tankers to make 43 complete trips to the facility, transiting the Bering Strait 86 times in a single season. Investment decisions about both the Arctic LNG 2 and the transfer facility at Kamchatka are expected later in 2019, but if advanced, these projects could transform the shipping expected through the Bering Strait.

**China’s Icebreaking LNG Tankers**

China’s demand for LNG is also expected to play a role in the coming decade. In early June 2019, Cosco Shipping Holdings Co. and PAO Sovcomflot announced a joint venture to move LNG from the Arctic to China, adding as many as 21 new icebreaking LNG tankers to the region, with 12 from Sovcomflot and Cosco and an additional 9 from China Shipping LNG Investment Co.\(^{53}\) Sovcomflot has already secured

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financing for 3 LNG-fueled tankers, which will be delivered in 2022–2023 and operate under a 20-year charter with Novatek, the operator of the Yamal LNG facility.\textsuperscript{54} It is estimated that delivery of the remaining 19 ships from Sovcomflot, Cosco, and China Shipping LNG Investment Co. could range from 1–3 ships/year.

Different growth rates are explored in the four scenarios, with the Reduced Activity Scenario adding 0 ships after 2023, the Most Probable Scenario adding 1 ship/year after 2023, and the two final scenarios adding 1–2 ships/year (Optimized Growth) and 2–3 ships/year (Accelerated, but Unlikely).

**MINERAL RESOURCES**

The Arctic is home to considerable mineral resources besides petroleum, and marine transportation is a primary way to export these resources and to support the extraction efforts to obtain these resources. In the following section, mineral resources projects which may contribute to vessel activity in the region over the next decade are discussed.

**Mineral Resources within the U.S.**

*Red Dog Mine and the Potential for Expansion*

The Red Dog Mine, located in the Northwest Arctic Borough near Kivalina and operated through an agreement between Teck American, Inc. and the NANA Regional Corporation, is one of the largest zinc and lead mines in the world. In 2018, Red Dog Mine produced 545,000 metric tons of zinc and 97,000 tons of lead in 2018, accounting for 97% of zinc and 66% of lead production for the state of Alaska.\textsuperscript{55} Shipment of ore from the mine has consistently contributed 23-27 bulk carrier ships to the annual inventory of vessels transiting through this study’s area of interest, and this volume of activity is expected to remain constant through 2031, the expected lifetime of the mine without expansion.\textsuperscript{56} In 2018, Teck American Inc. submitted a draft environmental evaluation document to the U.S. Army Corps of


Engineers\textsuperscript{57} and a permit with Alaska Department of Natural Resources\textsuperscript{58} for its proposed exploration of the Anarraaq and Aktigiruq prospect, located 8 miles north of the existing Red Dog Mine. The volume of vessel activity associated with expansion remains unclear, but a feasibility study for the Lik Mine, a deposit located 17 miles from the Red Dog Mine, found that that reserve could produce 350,000 short wet metric tons annually over a nine-year production life, translating to 6 additional bulk carriers transiting through the study area of interest annually.\textsuperscript{59}

This theorized expansion is explored in the Optimized Growth and Accelerated, but Unlikely Scenarios, which each add 6-8 vessels each year for nine years, before dropping off to zero additional vessels.

\textit{Graphite One Project in Nome}

The Arctic’s rare-earth elements, platinum-group elements, and graphite deposits are also key natural resources for Arctic planners to consider. There is a growing demand for these mineral resources, which can be used in rechargeable batteries, radar systems, avionics, and satellites\textsuperscript{60}, but there is only one rare earth mine within the U.S.\textsuperscript{61} Graphite One Resources, Inc., has proposed extracting graphite on the Seward Peninsula from Graphite Creek, the largest large-flake graphite deposit in the U.S. The site is located about 37 miles north of the City of Nome.\textsuperscript{62} According to the company’s preliminary economic analysis report, the Graphite One Project would mine 60,000 metric tons per year of graphite concentrate, which would be loaded into containers and transported by truck to the Port of Nome for

loading onto barges during the navigation season. Assuming 18 tons of concentrate is loaded into each container, and each large barge can accommodate 200 containers, the Graphite One Project would ship 16–17 barges each year to its product manufacturing plant in Washington State. Such a value would double to current number of large barges calling on Nome. A construction decision is slated for 2020, and if advanced, construction of the mine would be expected to take six years before shipping out its first product. Construction of the mine would likely require an annual sealift of 4 ships to supply the mine construction with requisite fuel, equipment, and consumables.

In all vessel growth scenarios except the Reduced Activity Scenario, it is assumed that the Graphite One Project will advance and that construction will begin in 2020, adding 4 additional ships each year for fuel, equipment, and consumables for six years. In 2026, it is assumed that the mine will begin production, and in the Most Plausible Scenario is that the Graphite One Project will ship 5 barges each year, while the Optimized Growth Scenario will ship 10 barges each year. In the Accelerated but Unlikely Scenario, it is assumed that the mine will open in 2026 and begin shipping concentrate at its maximum rate the same year (17 barges/year) and maintain that rate through 2030. Additionally, it is assumed across all scenarios that the mine will require 2–4 ships annually to resupply the mine with fuel, consumables, and equipment.

Mineral Resources Outside the U.S.

The development of mineral resources in western and northern Canada may impact vessel activity in this area of interest, primarily through annual sealift to resupply the mines with fuel and equipment.

Hope Bay Gold Mine

The sealift associated with the Hope Bay Gold Mine in Nunavut, Canada is likely to add to vessel activity within the study area of interest over the next decade. TMAC Resources Inc. first produced gold

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from the region in 2017 and estimates that there are a total of 4.9 million ounces of gold in the mine. While much of the gold will likely be flown out of the site, the fuel, equipment, and consumables for the mine are expected to be moved via ship to the mine during a narrow 10 week navigational window.

According to experts gathered at the 2018 CMTS & USARC Technical Workshop, the mine is currently serviced by 4–6 freight barges and 1–2 cargo ships each year. As of 2019, only one of the three deposits of the site is operational, but expansion to the other two deposits on the site is expected in 2020 and 2022, likely increasing the sealift with mine expansion.

In the Reduced Activity Scenario, it is assumed that the sealift to supply the Hope Bay Gold Mine will remain steady at 5 vessels annually, while the Most Plausible Scenario assumes that the sealift will increase from 6 to 7 ships total over the next decade. The two highest growth scenarios assume that the sealift to support the Hope Bay Gold Mine will reach 9 ships annually (Optimized Growth Scenario) and 11 ships annually (Accelerated, but Unlikely).

**Back River Gold Mine Project**

Sabina Gold and Silver Corporation’s Back River Gold Mine Project, located in Bathurst Inlet in Nunavut, Canada, is also likely to contribute to increased vessel activity over the 2020s. The project is expected to transition from advanced exploration and permitting to early development in 2019. Pending further discovery of minerals in the region, the project is estimated to have a 10-year operating life, followed by 11 years of reclamation, closure, and post-closure activities. As part of the project’s final Environmental Impact Statement, operators estimated that mine resupply would require 3–5 vessels annually, originating at either Bécancour, Quebec in the east or Vancouver, British Columbia in the west.

The operation would also likely use lightering barges to transfer cargo and fuel from larger ships to the site’s marine laydown area during the open-water season. In 2018, Sabina Gold and Silver

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Corporation expanded its Marine Laydown Area and completed its first sealift, comprised of three cargo barge, one fuel barge, and one other vessel loaded with equipment and consumables. Development of nearby reserves or infrastructure required to explore nearby reserves may ultimately increase the annual sealift to a total 6–10 vessels annually over the next decade, according to experts who attended the 2018 CMTS & USARC 2018 Technical Workshop. However, an east-bound option from the mine is available, so it is unlikely that all vessels would approach transit through this study’s area of interest.

Various diversion rates were explored across the four scenarios. The Reduced Activity Scenario assumes that the all resupply will come from the east, adding 0 ships to the projected vessel count for the study area of interest. The Most Plausible Scenario assumes that 3 vessels will transit to the site from the west, crossing through the study area of interest, while the Optimized Growth Scenario assumes 5 vessels annually for resupply from the west. The Accelerated but Unlikely Scenario assumes that the annual sealift for this project will add 5 vessels to the area of interest from 2019—2022, and then will increase to 10 vessels annually by 2024.

Mary River Mine

The Mary River Mine, owned and operated by Baffinland Iron Mines Corporation, is an open pit iron ore mine on Baffin Island in Nunavut, Canada. The mine began shipping iron ore from its location in northern Canada in 2015, increasing its output from 0.917 million tons in 2015 to 5.1 million tons in 2018. Vessels used to ship the ore have likewise increased, from 13 Panamax-sized vessels in 2015 to 71 in 2018. All shipments to date have moved eastward from Baffin Island to Europe, but in 2018, two shipments were delivered to Taiwan and Japan via the Northern Sea Route. In Phase 2 of Baffinland Iron Mines Corporation’s plans for the Mary River Mine, the mine will expand its output to 12 million tons

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annually by 2025, raising the annual number of ore carrier voyages to 176, resupply transits to 48, and tug transits to 20.\textsuperscript{70}

Most of this traffic is not expected to contribute to vessel activity in U.S. Arctic or pass through the Bering Strait. However, as the mine’s output and the ice-free season expands over the next decade, it is possible that several ore carriers will pass through the Northwest Passage, transiting through this study’s area of interest on route to Asia.

Reflecting this potential, vessels associated with the Mary River Mine have been incorporated to all scenarios, except for the Reduced Activity Scenario. In the Most Plausible Scenario, it is assumed that 1–2 bulk carriers will pass through the study’s area of interest each year. In the Optimized Growth Scenario, two additional ships are expected to utilize the route, growing by two additional ships every three years, reaching 8 additional ships by the end of the decade. In the Accelerated, but Unlikely Scenario, this rate is accelerated, totaling 12 ships by 2030.

OTHER NATURAL RESOURCES

Other mineral resources in the region include a large deposit of high quality coal in northwest Alaska, however development of this resource is unlikely given the decline in coal consumption in the U.S. and continuing decline in coal shipments from the U.S.\textsuperscript{71, 72}

Beyond mineral and petroleum resources, other natural resources and related activities may also contribute to vessel activity in U.S. Arctic waters, provided they are found to be economically viable, which is unlikely to be determined within the next decade. Some of these activities include expanded aquaculture and mariculture, seafloor mining, pharmaceutical bioprospecting from the Arctic marine environment, and offshore wind development in the Bering Sea.

Of these activities, offshore wind development may be among the most plausible of these developments. Offshore Alaska has a net wind potential 68% higher than all other states combined, and development of this resource could close key energy gaps for communities and energy-intensive industries in western and northern Alaska. To reflect this resource potential, the Accelerated but Unlikely Scenario includes G&G surveys related to offshore wind development, with 10 vessels conducting G&G surveys in 2025 followed by 2-4 ships each year for the following 5 years.

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**Infrastructure Development**

Infrastructure development in the U.S. Arctic is another critical source of growth for vessel activity in the region. Building, repairing, and replacing infrastructure in the area may require sealift to supply construction efforts, and once built, some of this infrastructure may beget further vessel activities in the region. A summary of the projected growth of overall vessel traffic related to infrastructure development is detailed in Figure 11.

![Projected Growth of Vessel Traffic Related to Infrastructure Development, 2019-2030](image)

Figure 11: Combined sums of vessel counts related to infrastructure development in the U.S. Arctic area of interest by scenario.

To estimate the volume of vessels anticipated due to infrastructure development, anticipated port, road, airport, and other types of infrastructure development, including or repair, replacement, modification, and relocation projects from state and Federal databases were considered and evaluated. Infrastructure planning data sources include the U.S. Army Corps of Engineers, the Alaska’s Statewide Transportation Improvement Plan, the Northwest Arctic Regional Transportation Plan, and the Yukon-Kuskokwim Regional Transportation Plan.
This section is divided into three parts: (1) infrastructure development and modification projects in reaction to the rapidly changing Arctic climate; (2) planned infrastructure directly related to marine transportation; (3) planned infrastructure development that is reliant on the marine transportation system for success.

INFRASTRUCTURE DEVELOPMENT IN REACTION TO A RAPIDLY CHANGING CLIMATE

Although there is not as much infrastructure in place in the high U.S. Arctic, much of this existing infrastructure is under threat due to a rapidly changing climate. The 4th National Climate assessment noted that the changing environment, including loss of shore-fast ice combined with stronger weather events, has contributed to widespread erosion along the coastlines and rivers of Alaska, with rates of up to 59 feet per year along Alaska’s northern shoreline. Beyond changes at the coast, nearly 70% of the current infrastructure in the pan-Arctic’s permafrost domain is at risk due to the high thaw potential which could impact near-surface infrastructure, such as the Dalton Highway, the Trans-Alaska Pipeline, and Distant Early Warning Line Sites. Thirty-one Alaska Native Villages have been identified as facing imminent flooding and erosion threats by federal and state officials, and 15 of these villages are located along the coastline in this study’s area of interest (Figure 12). Total cumulative damages to infrastructure statewide in the next century could amount to $5.5 billion, with most damages to roads, buildings, and airport runways. The sealift requirements to respond to these threats in the U.S. Arctic remains unclear, but this projection incorporates two planned projects into its scenarios.

Figure 12: Map of communities and select infrastructure threatened by climate change in relationship to the study area of interest.

Relocation of Kivalina: Construction of Evacuation and School Site Access Road

Kivalina is a small village which has been listed as imminently threatened by flooding and erosion and is one of 12 such villages exploring relocation options. The village is located on the southern tip of a 7.5-mile-long barrier island between the Chukchi Sea and a lagoon at the mouth of the Kivalina River, about 80 miles (130 km) northwest of Kotzebue in the Northwest Arctic Borough. Efforts to fortify the village against erosion include the installation of a rock revetment in 2010 by the U.S. Army Corps of Engineers, which reduced the size of the village but provided the community with time to decide and secure funding for relocation. In 2018, Kivalina secured funding to construct a school at Kisimigiqtuq Hill, a site situated 7 miles inland which would provide the start of the communities relocation inland, as

well as funding for an access route to the site, which doubles as an evacuation route from severe storm. Construction for the access route is slated to begin in 2019. This construction project will include a 7.7 mile, two-lane gravel road and a 3,200-foot lagoon crossing. Much of the material for the gravel road can be sourced locally, utilizing the abundance of alluvial fill available in the region, but this project will still require some sealift support. The proposed project is estimated to require 2-3 barges of material for the project, including steel for the 188-foot single span steel girder bridge, geotechnical fabric, and materials for the gravel road construction, and is expected to cost $30.25 million. Construction plans for the proposed school at Kisimigiiqtuq could not be located, but it is assumed that an additional 1-2 ships would be required to complete the construction of the school, and that such construction would only commence after the gravel road is completed.

Over the next decade, the relocation of Kivalina could contribute substantially to the vessel traffic patterns of this study’s area of interest, however, it will depend on how well the effort is funded. The evacuation route construction project will cost $30 million, while the total cost to relocate Kivalina is estimated to cost $100-$400 million. In the Reduced Activity Scenario, it is assumed that funding is not secured beyond the 2019 season, limiting the community’s ability to relocate inland. In the Most Plausible Scenario, it is assumed that relocation efforts will happen incrementally, with surges of 2-3 ships every three years as funding is delivered. In the Optimized Growth Scenario, it is assumed that this effort adds 1-2 barges annually. In the Accelerated but Unlikely Scenario, it is assumed that all necessary funding is secured without delay, and that the relocation of Kivalina contributes 2-3 barges every year over the next decade to provide materials and equipment needed to relocate the village 7 miles inland.

Community Relocation and Protect-In-Place: Shishmaref

The community of Shishmaref is also actively exploring relocation options, which could impact the level of vessel activity over the next decade. Shishmaref is located on a barrier island in the Chukchi Sea just north of the Bering Strait, and is under severe threat due to rapid rates of coastal erosion. Over the last 15 years, the Bureau of Indian Affairs, the City of Shishmaref, and the US Army Corps of Engineers

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have invested in shoreline protection for the community, including 1380 feet of shoreline protection installed from 2004 to 2007. In 2009-10, a rock-wall barrier was constructed for protection along significant portions of the coast fronting the community. Nevertheless, an estimated one-third of the community, including the airport, residential structures and community infrastructure, remain exposed. Further protection projects are anticipated later this summer, as the Alaska Department of Transportation & Public Facilities included rebuilding, resurfacing, and armoring portions of the Shishmaref Landfill Road to address damage sustained from a storm in 2013 as part of the 2019 Northern Region Construction Season.

Considering the continued damages to existing infrastructure, the community has actively been exploring relocation options. A U.S. Army Corps of Engineers study from 2004 estimated that relocating Shishmaref to the Alaska mainland would cost $180 million. In 2016, the city of Shishmaref completed a feasibility study of potential relocation sites, which include the Old Pond site and the West Tin Creek Hill, both located several miles inland. The Alaska Department of Transportation and Public Facilities has also begun a planning and environmental linkages (PEL) study to “identify obstacles impeding sustainable community infrastructure”, including locally sourced material required for protecting existing infrastructure and for building new infrastructure for relocation.

There is much uncertainty about how much vessel traffic relocating or protecting-in-place Shishmaref may require. The only planned vessel activity includes bathymetric surveys in 2019 of the immediate region surrounding Shishmaref as part of the PEL study, and it is anticipated that construction on the Shishmaref Landfill Road will warrant 1 barge of supplies and equipment.

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The additional vessel requirements for relocating Shishmaref remain unclear, and this uncertainty is reflected in the projection scenarios. In the Reduced Activity Scenario and the Most Plausible Scenario, it is assumed that funding and planning for this relocation will not be secured within the next decade. In the two other scenarios, it is assumed that further developments will happen in the latter half of the 2020s. In the Optimized Growth Scenario, it is assumed that funding is secured by 2027, with 1–2 barges utilized each year after through 2030. In the Accelerated, but Unlikely Scenario, it is assumed that plans are designed and funding for relocation and/or protect-in place infrastructure are secured by 2025, and 2–3 barges are utilized each year thereafter for this purpose.

PLANNED MARINE TRANSPORTATION SYSTEM INFRASTRUCTURE PROJECTS

Modification of the Port of Nome

Since 2008, state and Federal officials have investigated where in the U.S. Arctic would be most conducive for another deep-draft port, as the only deep-draft port in the region is located at Dutch Harbor in the Aleutian Islands. The 2013 Alaska Deep Draft Arctic Port System Study shortlisted Nome, Port Clarence (Teller), and Cape Darby as all-purpose candidate sites for a deep-draft port. The draft integrated feasibility report, environmental assessment, and finding of no significant impact for the Alaska Deep Draft Arctic Port System provided detailed analyses on the three listed sites and proposed a tentatively selected plan to expand the Port of Nome. This project was paused in late September 2015, after Royal Dutch Shell announced plans to cease exploratory drilling in the Chukchi Sea. In 2018, the U.S. Army Corps of Engineers- Alaska District entered into an agreement with the City of Nome to

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examine the feasibility of constructing navigation improvements for the Port of Nome.90 A draft of the Port of Nome Modification Feasibility Study was released in May 2019, outlining the tentatively selected plan for the project.91 Proposed modifications in this plan include extending the existing west causeway by 3,484 feet; removing the existing east breakwater and replacing it with a new 3,900-foot causeway; deepening the existing Outer Basin from 22.5 to 28 feet below mean lower low water (MLLW); creating a Deep Water Basin to 30 or 40 feet below MLLW; and constructing 5 new docks.92 This effort is estimated to cost between $419–$451 million, split between the Federal government and the project’s non-Federal sponsor.

For this study’s projections, it is assumed that the project will require 1 vessel for 1 year of pre-construction research and that construction would last 4 years, utilizing 1 vessel in the first year and 4 vessels (assuming 1 dredger, 1 barge for lightering dredged material, 1 equipment barge, and 1 additional tanker for fueling) in each subsequent year of construction until completion. Across the scenarios, it was also assumed that the project would have different construction start dates. The Reduced Activity Scenario assumes the modification would begin construction in 2025 and be completed in 2028; the Most Plausible Scenario assumes that construction would begin in 2024 and be completed in 2027; the Optimized Growth Scenario assumes that construction would begin in 2023 and be completed in 2026; and finally, the Accelerated, but Unlikely Scenario assumes construction would begin in 2022 and be completed in 2025.

Additionally, to meet the demands of the expanded port, this study’s projections also estimate that after the modification of the port is completed, the port will also need to construct an adequate port reception facility. Port reception facilities are facilities to which ship operators may send contaminants which cannot be discharged at sea, such as residues, oily-water mixtures, garbage, sewage, and effluent from scrubber systems. Currently, there are no ports operating along the Bering Strait with formal waste

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92 Ibid
A Preliminary Engineering Report for a Port Waste Reception Facility in Nome recommended construction take place over three phases, with Phase 3 requiring the construction of a lift or pump station at the proposed deep water dock with a force main pipe to connect to the city’s sewage lagoon. The current study estimates that an additional two ships each year for two years following completion of the port modifications would be required for construction of a port reception facility to support the expanded traffic at Nome.

**Lower Yukon River Regional Port and Road Project in Emmonak**

In 2018, the Lower Yukon River Regional Port and Road Renovation Project in Emmonak, Alaska was awarded $23 million as part of the Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grants. This grant is expected to be centered on improving infrastructure in Emmonak, a small city within the Kusilvak Census Area, which, because of its location on the delta of the Yukon River, serves as a redistribution hub for barges moving cargo to communities along the Yukon River. The funding will be used to repair and upgrade approximately 3.5 miles of high-use service roads as well as construct a permanent barge and landing craft ramp and dock/wharf with up to two berths capable of handling 500-ton barges. This project was previously identified by the 2018 Yukon Kuskokwim Delta Transportation Plan. Further details about the sealift required for this project are not available as of June 2019, but per the requirements of the BUILD award, the funding must be obligated by September 2020 and will expire in September 2025, it is anticipated that construction will be complete by 2025.

For the scenarios, it is estimated that this project will likely begin construction in 2023, utilizing 1 vessel for hydrographic surveys of the channels used to approach Emmonak, and 1–2 barges of materials...
and equipment for two years of construction to be completed by 2025. In the two high growth scenarios (Optimized Growth Scenario and Accelerated, but Unlikely), it is anticipated to add 2 barges per year, while the two lower growth scenarios (Reduced Activity Scenario and Most Plausible Scenario) will utilize 1 barge per year for equipment. Additionally, because this effort is intended to improve existing infrastructure, it not anticipated that this project will trigger immediate growth in the use of Emmonak as a regional hub for communities along the Yukon River.

OTHER PLANNED INFRASTRUCTURE DEVELOPMENT PROJECTS

According to existing state and regional transportation plans, there are several planned infrastructure construction projects which will require sealift, including road construction and modification, airport improvements, and renewable energy projects.

Construction of the Kotzebue to Cape Blossom Road

The construction of an 11-mile gravel road to connect Kotzebue to Cape Blossom on the Baldwin Peninsula in the Northwest Arctic Borough will add to the vessel activity of the U.S. Arctic. The project will connect the city to the Kotzebue Electric Association Wind Farm and to Cape Blossom, where deeper water may allow access for larger ships servicing the community. Construction for the project began in 2017, with the barging and staging of construction materials. The next phase of construction is slated to begin during the winter season of 2020-2021, continue during winter 2021-2022, with final construction completed in summer 2024. The entire project is estimated to require 799,500 tons (533,000 CY) of material, some of which must be transported to the peninsula via ship. According to project plans, 94% of the material may be sourced locally, but the 49,500 tons (33,000 CY) required for Phase 3 would require 248 trips using a single barge loaded to 200 tons, which is the typical size used for deliveries to Kotzebue. The shallow waters surrounding the peninsula limit the size of barges able to bring material to the construction site, as the primary approach to Kotzebue is a narrow channel, with 5-7 feet depth and constantly changing sandbars at the mouth of the Noatek River.99 If all the materials for the project had to be barged, it would take an estimated 8-16 shipping seasons just to stage the material necessary to

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build the road. Such an operation would likely utilize 1-2 barges, but require hundreds of transits to and from the source in the Noatak River.

In the proposed scenarios, it is assumed that only the fuel to support the construction and the non-locally sourced material (49,500 tons) would need to be shipped to the site. In the Reduced Activity Scenario, it is assumed that all materials, fuel, and equipment are in place and no additional sealift will be required for construction. In the Most Plausible Scenario, it is estimated that 1 additional ship would be needed from 2020 to 2023 to supply the construction with sufficient fuel and equipment; in the Optimized Growth and Accelerated but Unlikely Scenario this is extended to 2 ships annually, with the Accelerated but Unlikely Scenario requiring one additional ship to barge additional construction materials (which were assumed to have already been barged and staged in the other three scenarios).

Road Improvements in Utqiagvik

In 2020, Utqiagvik is expected to begin construction on road improvements to rehabilitate and pave 0.625 miles of Ahkovak Street, including drainage improvements. This project is estimated to cost $7.15 million, with a further $6.5 million required after 2021. It is anticipated that this project will likely require sealift, as the materials required for paving roads are unlikely to be sourced locally. It is anticipated that this project will require 1 ship in 2020 for all scenarios, and an additional ship in 2022 and 2024 for both the Optimized Growth Scenario and the Accelerated, but Unlikely Scenario.

Road Improvements in Nome

According to the Statewide Transportation Improvement Program database, the City of Nome is expected to have $50.8 million in road improvement projects, beginning in 2019 and continuing past 2021. These projects include the rehabilitation, repair, and construction of pedestrian paths and drainage improvements along Seppala Drive ($21.7 million), Bering Street ($4 million), the Port Road ($12.6 million), and the Center Creek Road ($12.6 million).

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100 $799,500 tons * 1 trip/200 tons * 1 day/2 trips = 2000 days to move * 120 days/season = 17 seasons; if 100,000 tons/season can be moved, this changes to $799,500 tons * 1 season/100,000 tons = 7.95 seasons to complete with one barge.
This construction, like many road improvement projects in the region, will likely require sealift to supply the necessary materials for this project. The Reduced Activity Scenario assumes all material will be sourced locally or will be small enough so as not to require an entire ship of materials, therefore these projects will not add any additional vessels to the region. In the Most Plausible Scenario, there will be 2 additional vessels each year from 2019 – 2021, with one additional vessel annually until 2025. In the Optimized Growth Scenario, it is assumed that there will be 2 vessels each year from 2019 – 2021, with an additional vessel each year through 2030 to support other repairs. In the Accelerated but Unlikely Scenario, it is assumed that the road improvement projects at Nome will contribute an additional 2 vessels each year, beginning in 2019, and that funding will continue through the rest of the decade to support other road improvements in the city.

Road, Boardwalk, and Footbridge Improvements in Selawik

The Statewide Transportation Improvement Plan includes funding for improvements in the small village of Selawik in the Northwest Arctic Borough, beginning in 2019. One element is the rehabilitation of two footbridges, which is anticipated to be completed in 2019 and is unlikely to require any additional sealift support. The second element is the rehabilitation of the existing barge landing access road and the construction of a new gravel barge staging pad. This second project is expected to cost $5.1 million dollars and expected to be completed by 2021. It is anticipated that this second component may require additional vessel support; accordingly, 1 additional ship in 2019–2021 included in the two highest growth scenarios to reflect this construction project.

Airport Improvements

Aviation is a vital mode of transportation for the Northwest region of Alaska, providing linkages to remote communities without road access. Within this study’s area of interest, it is anticipated that construction related to airport improvements is likely to impact the volume of vessel activity through 2030. Within this study’s area of interest, there are a total of 49 airports near the coast which could have sealift demands impacting the volume of vessel activity in the region.\(^{101}\) The 2004 Northwest Alaska

Transportation Plan reviewed which airports in the northwest region of the study area of interest would require upgrades or expansion through 2025, and the recently published Yukon Kuskokwim Delta Transportation Plan identified three airports in need of improvements in southwest region. Additionally, the Statewide Transportation Improvement Plan identified six airport construction projects within the study area of interest slated for construction in 2019. These projects include:

- Installation of beach erosion control at the Kivalina Airport
- Skewing and extending the runways as part of reconstructing the Kiana Airport
- Repaving the runway, taxiway, and taxi lane and construction of a Maintenance and Operations facility at the Utqiagvik Airport
- Repairing settlement areas, installing a perimeter fence, and access road at the Nome Airport
- Rehabilitating the White Mountain and Holy Cross Airports with surfacing, dust palliative, lighting system, and aviation aids to navigation

Additionally, it is anticipated that more airport repairs will be conducted in the near-future, including at the Deering Airport and Kotlik Airport in 2020 and at the Kotzebue Airport in 2021.

Furthermore, runways must meet strict construction standards, meaning much of the material must be barged in for the project specifically. For example, details about the plans for the Kotzebue Airport project in 2021 were provided by the Alaska Department of Transportation and Public Facilities. For that future project, an estimated 35,500 cubic yards of material needs to be barged to the site to repave the main apron, taxi lanes, and taxiways. Moving this quantity of material may require many multiple trips back and forth from the source of the material; smaller barges must be used in many of these remote communities due to the shallow waters nearshore and the lack of current bathymetric data.

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for much of the region. For example, during a recent renovation of the Kotzebue Airport, 100 loads of 1000 tons of rocks were sailed and staged during a 75-day operating window.

Taking these data together, this study estimates that airport construction projects are likely going to continue throughout the next decade. Inundation of runways by erosion or precipitation may accelerate the rate at which runways need to be repaired, thereby also accelerating the volume of vessel traffic associated with airport repair. In this projection study, it is estimated that the number of airport repair projects that require ocean-going sealift in the study’s area of interest will range from 3–6 projects annually and that each project will require 1 barge for paving materials. In the Reduced Activity Scenario, it is assumed that 3 vessels will be added to the study area of interest; in the Most Plausible Scenario, it is assumed that 4 vessels will be added; in the Optimized Growth Scenario, it is estimated that 5 vessels will be added; and in the Accelerated but Unlikely it is estimated that 6 vessels will be added. Extrapolating to transits, it is anticipated that these ships may take hundreds of transits in a single season, depending on the bathymetry around the construction sites. This could greatly expand the amount of activity in the region when examined by transit as opposed to vessel count alone.

Onshore Renewable Wind Projects

Most the energy used by communities and industries in western and northern Alaska is fuel oil brought via tankers and lightered onto smaller barges delivered during the short summer navigation season. Efforts to expand the diversity of energy sources, particularly of renewable energies, may require vessels to bring in equipment and large pieces of infrastructure in the coming years. In 2016, the Department of Energy awarded nearly $1 million for the installation of renewable energy sources in Kotzebue, Buckland, and Deering, Alaska. Several wind turbine projects for communities in western

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105 For more about bathymetric data gaps in the Arctic, please see: NOAA Office of Coast Survey. (2018). "NOAA surveys the unsurveyed, leading the way in the U.S. Arctic". Accessed from: https://www.nauticalcharts.noaa.gov/updates/?p=171043
Alaska have been funded by the Department of Energy, in partnership with the Alaska Village Electric Cooperative (AVEC), including Stebbins and St. Michael, Pitka’s Point and St. Mary’s, and Unalakleet, with one of these projects still under construction. This effort is expected to add 1 cargo ships in 2019 to deliver the main body of the turbine in Stebbins and St. Michael in 2019. These renewable energy projects are not expected to replace the need for tankers and lightering barges to supply fuel to the region, as these energy projects are likely to augment, rather than replace, the existing energy infrastructure. In the Accelerated, but Unlikely Scenario, it is assumed that further renewable energy projects will be funded over the next decade, adding 2 ships every three years to supply materials for renewable energy installations. In all other scenarios, it is assumed that no additional vessels will be required after 2019.
EXPANSION OF THE ARCTIC FLEET

Another source of growth for the volume of vessel activity in the Arctic are the vessels expected to join the global fleet with capability to sail and/or transit Arctic waters. These vessels include new Polar Security Cutters, icebreaking LNG tankers, and an assortment of other vessels with ice capability. A summary of the total number of vessels expected to be added to the area of interest by this source of growth is depicted in Figure 13.

Figure 13: Combined sums of vessel counts related to fleet expansion in the U.S. Arctic area of interest by scenario.
EXPANSION OF ICEBREAKERS

USCG Polar Security Cutters

In recent years, U.S. Coast Guard (USCG), together with the U.S. Navy, has been working to jointly fund the building of new Polar Security Cutters to expand the Federal government’s capacity for icebreaking services in the Antarctic and U.S. Arctic. The 2019 U.S. Federal Budget included $655 million to start the construction of the first heavy icebreaker of six proposed Polar Security Cutters, along with an additional $20 million to purchase long lead-time materials for the construction of a second heavy icebreaker. The USCG plans to have three heavy polar icebreaking ships in operation by 2026, though the first of these heavy polar icebreakers will likely be deployed to the Antarctic to replace the aging USCGC Polar Star.

For the four growth scenarios, it is assumed that the first new addition to the fleet will operate exclusively in Antarctica. The remaining two icebreakers are assumed to be delivered in 2025 and 2029 in the Most Plausible Scenario, while the Optimized Growth Scenario assumes delivery in 2025 and 2026. The Accelerated, but Unlikely Scenario assumes the two vessels will be delivered and operational in 2024 and 2026, which requires there to be no issues with securing funding and an on-time delivery for both vessels.

Russia’s Icebreakers

Russia is also slated to expand its icebreaking fleet, with the launch of three new nuclear-powered icebreakers over the early 2020s as part of Project 22220. The first of the new ships, Arktika is slated to be commissioned in the 2019, season, with sister ships Sibur and Ural expected to follow in 2020 and 2021, respectively. This effort moves Russia closer to its stated goal of having at least 13 heavy

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duty icebreakers, including 9 nuclear-powered icebreakers, by 2035. This translates to the launch of approximately one new icebreaker each year until 2035, though it is unlikely that all vessels will be used in the study’s area of interest.

Given how close Russia is to launching the first three ships, it is assumed across all four scenarios that there will be 3 Russian icebreakers operating in this study’s region of interest by 2021. Further growth of the icebreaker fleet is assumed in 2027 and beyond (for all scenarios except the Reduced Activity Scenario), with a total of five vessels in operation by the end of the decade with different rates of growth expected across these three scenarios.

**Canadian Icebreakers**

In August 2018, Canada purchased and awarded a contract to convert 3 medium icebreakers to assist in icebreaking missions in Atlantic Canada, the St. Lawrence and Great Lakes, and Arctic regions. The three vessels, from the Offshore Supply Vessel operator Viking Supply Ships, will be converted by Chantier Davie Shipbuilding and enter into service shortly thereafter. The first, *CCGS Captain Molly Kool*, entered into service in December 2018, servicing Canada’s Atlantic region, with the other two vessels expected to be delivered in 2019.

It is unlikely that these new icebreakers will become an annual component of vessel traffic in this study’s area of interest, given the large icebreaking mission of the Canadian Coast Guard. In the Reduced Activity Scenario, it is assumed that none of these new icebreakers transit through the region, while the most probable scenario estimates that one icebreaker will transit through every other year. The Optimized Growth and Accelerated, but Unlikely Scenario posits that this rate will be slightly higher, adding, at most, three additional vessels to the total count every other year.

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In late 2018, China launched its first locally-built icebreaker, *Xue Long 2*, expanding the nation’s icebreaking research vessels to two. The Polar Class 3 vessel, powered by diesel, is expected to be commissioned in 2019, likely joining the *Xue Long* in Arctic and Antarctic research missions annually. This assumption informed the estimation for the scenarios, which all assume that the *Xue Long 2* will become a yearly visitor to the region.

EXPANSION OF POLAR CLASS CRUISE AND ADVENTURE SHIPS

Tourism in the Arctic has largely been centered in the European and Russian Arctic, but is expected to expand into the U.S. Arctic and this study effort in the years to come. By 2022, it is anticipated that 28 new, special designed expedition ships will add to the world-wide fleet of 80 expedition ships. These vessels are smaller than traditional cruise ships, accommodating around 200 guests each. Of the 28 new expedition vessels, several will meet Polar Class (PC) requirements, including Ponant’s LNG-powered *Le Commandant Charcot* (PC 2), Vantage Cruise Lines’ *Ocean Explorer* and *Ocean Odyssey* (both PC6), and Hurtigruten’s hybrid 530-passenger ship *Roald Amundsen*.

It is anticipated that many of these vessels may service the European Arctic and Antarctic, but may expand to the U.S. and Canadian Arctic to accommodate passenger demands for unique destinations and experiences. In the Reduced Activity Scenario, it is assumed that ships from this expedition fleet will not transit through the study area of interest, working under the auspices that tours will be confined to Svalbard, Iceland, and the east coast of Greenland and that the adventure ships currently servicing the region will continue to do so. In the Most Plausible Scenario, it is anticipated that this expanded fleet will begin to become a growing component of traffic in the region, adding 1-2 vessels every 1-2 years.

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117 Ibid.
Optimized Growth Scenario anticipates that about half of the fleet will eventually become regular fixtures of the area of interest’s vessel count, while the Accelerated, but Unlikely Scenario estimates that all 28 will pass through the area of interest annually by 2026.

EXPANDED SERVICES FOR COMMUNITY RESUPPLY

Alaska Marine Lines (AML) will expand its service to the Arctic region in 2019 through a new partnership with Bowhead Transport to provide the destination services at the North Slope villages of Point Hope, Point Lay, Wainwright, Utqiagvik, and Kaktovik. 118 AML will also service Deadhorse with 2 annual sealifts, along with Naknek, Dillingham, Nome, Bethel, and Kotzebue and more than 65 villages along the western coast of Alaska. 119 This expansion will likely not add more vessels to the fleet servicing communities in the region, but will increase the number of transits made by the fleet throughout the narrow shipping season. Other vessels servicing communities include Crowley’s Western Alaska Fleet of tug and barges. 120

SEASONALLY REROUTED SHIPPING THROUGH THE ARCTIC

The fourth and final quantifiable source of growth incorporated into the projections is the volume of traffic transiting through Arctic waters as an alternative route to established trans-oceanic routes. One of the major appeals of utilizing the Northern Sea Route and Northwest Passage for shipping is the promise that these routes would trim costly time from transoceanic shipping routes. For shipping between northern Europe and the far East, the Northern Sea Route saves 35–60% of the distance compared to other, more traditional routes, such as the Suez Canal. However, these routes are only shorter if the sea ice is minimal and environmental conditions are favorable to maintain ship speeds comparable to other transoceanic routes.

In the 2015 CMTS Arctic vessel projection report, this growth was referred to as diverted global traffic and it was assumed that the shorter distances and reduced piracy risks of the northern routes would outweigh the environmental and logistical challenges to operate in the Arctic. The 2015 CMTS report assumed this diversion would apply to approximately 5% of the July–November transoceanic traffic, in line with other published estimates at the time. Additionally, the report limited to only include the current ship profiles traveling across the region (tankers, containers, general cargo and bulk carriers).

This approach, however, does not take into consideration the unique demands of operating in the region. In addition to meeting build and operating requirements of the newly established Polar Code, vessels must also meet the draft requirements to transit through the shallow region. The Northern Sea Route extends about 4740 nautical miles with a controlling draft of 41 feet (12.5 m), while the Northwest Passage runs 5225 nautical miles and a controlling draft of 33 feet (10 m). This report assumes that the

shallow waters of the region limit the kinds of vessels able to fully utilize the Northwest Passage and the Northern Sea Route to Seawaymax, Handysize, Handymax, Qatarmax, and Panamax sized vessels.\textsuperscript{125,126,127}

To estimate the growth of vessels related to this type of activity, historical data from the Panama Canal and from the Northern Sea Route along with projected global growth rates were used to model how the region may be used by vessels as an alternative trans-oceanic route during a limited, seasonal operating window.

Per vessel traffic data from the Northern Sea Route from 2014–2018, the average number of vessels transiting through the Northern Sea Route in 2017 and 2018 with origins and destinations outside of Russia was 12 vessels in 2017 and 16 vessels in 2018. Taking an average of the two, it is assumed that 14 vessels is the baseline of vessels being seasonally reallocated through the Arctic.

Transit data from the Panama Canal and projected growth rates of international seaborne trade for specific vessel classes for 2018–2023 developed by the United Nations Conference on Trade and Development (UNCTAD) were combined to estimate the pool of suitable candidates to be rerouted through the Arctic. Only vessels transiting the canal that met the right seasonal (July – November), size (Panamax), and type (bulk carriers, tankers, general cargo, refrigerated cargo\textsuperscript{128} and container ships) were considered for the requirements to transit through the Arctic.\textsuperscript{129}

The baseline of total ships meeting the candidate requirements was generated from mean historical data from the Panama Canal from the 2017 and 2018. There was an average of 3,975 ± 128 total Panamax sized-ships that met the candidate requirements in 2017 and 2018. Applying the vessel-specific growth rates from UNCTAD, this volume of traffic is expected to grow 62\% over baseline 2017—2018 values (Table 4).

\textsuperscript{125} Various Bulk carrier sizes and employment guide. (2010). Accessed from: \url{http://bulkcarrierguide.com/size-range.html}


\textsuperscript{128} Though not included in the 2015 report, 11 reefers have transited the NSR since 2015, with 2 meeting the non-Russian origin/destination requirement of this model, indicating that that some refrigerated cargo could feasibly be routed through the Arctic.

<table>
<thead>
<tr>
<th>Panamax Vessels Utilizing the Panama Canal*</th>
<th>FY 2017</th>
<th>FY 2018</th>
<th>Average (FY17–18)</th>
<th>Projected Growth*</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container</td>
<td>1,539</td>
<td>1,395</td>
<td>1,467</td>
<td>6.00%</td>
<td>1,555</td>
<td>1,648</td>
<td>1,747</td>
<td>1,852</td>
<td>1,963</td>
<td>2,081</td>
<td>2,206</td>
<td>2,338</td>
<td>2,478</td>
<td>2,627</td>
<td>2,785</td>
<td>2,952</td>
</tr>
<tr>
<td>Chemical Tankers</td>
<td>1,955</td>
<td>2,035</td>
<td>1,995</td>
<td>2.60%</td>
<td>2,047</td>
<td>2,100</td>
<td>2,155</td>
<td>2,211</td>
<td>2,268</td>
<td>2,327</td>
<td>2,388</td>
<td>2,450</td>
<td>2,513</td>
<td>2,579</td>
<td>2,646</td>
<td>2,715</td>
</tr>
<tr>
<td>Liquefied Petroleum Gas</td>
<td>337</td>
<td>407</td>
<td>372</td>
<td>2.60%</td>
<td>382</td>
<td>392</td>
<td>402</td>
<td>412</td>
<td>423</td>
<td>434</td>
<td>445</td>
<td>457</td>
<td>469</td>
<td>481</td>
<td>493</td>
<td>506</td>
</tr>
<tr>
<td>LNG</td>
<td>4</td>
<td>-</td>
<td>2</td>
<td>2.60%</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
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<td>2</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td>Crude Tankers</td>
<td>607</td>
<td>583</td>
<td>595</td>
<td>1.70%</td>
<td>605</td>
<td>615</td>
<td>626</td>
<td>637</td>
<td>647</td>
<td>658</td>
<td>670</td>
<td>681</td>
<td>692</td>
<td>704</td>
<td>716</td>
<td>728</td>
</tr>
<tr>
<td>General Cargo</td>
<td>724</td>
<td>658</td>
<td>691</td>
<td>3.80%</td>
<td>717</td>
<td>745</td>
<td>773</td>
<td>802</td>
<td>833</td>
<td>864</td>
<td>897</td>
<td>931</td>
<td>967</td>
<td>1,003</td>
<td>1,041</td>
<td>1,081</td>
</tr>
<tr>
<td>Refrigerated</td>
<td>868</td>
<td>779</td>
<td>824</td>
<td>3.80%</td>
<td>855</td>
<td>887</td>
<td>921</td>
<td>956</td>
<td>992</td>
<td>1,030</td>
<td>1,069</td>
<td>1,110</td>
<td>1,152</td>
<td>1,196</td>
<td>1,241</td>
<td>1,288</td>
</tr>
<tr>
<td>Passengers†</td>
<td>239</td>
<td>236</td>
<td>238</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roll-on/Roll-off†</td>
<td>779</td>
<td>793</td>
<td>786</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other†</td>
<td>322</td>
<td>348</td>
<td>335</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Panamax</td>
<td>10,164</td>
<td>9,710</td>
<td>9,937</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candidates for the Arctic, by Type</td>
<td>8,824</td>
<td>8,333</td>
<td>8,579</td>
<td></td>
<td>8,925</td>
<td>9,287</td>
<td>9,665</td>
<td>10,060</td>
<td>10,473</td>
<td>10,905</td>
<td>11,357</td>
<td>11,830</td>
<td>12,324</td>
<td>12,841</td>
<td>13,382</td>
<td>13,948</td>
</tr>
<tr>
<td>Candidates for the Arctic, by Type &amp; Season‡</td>
<td>4,066</td>
<td>3,884</td>
<td>3,975</td>
<td></td>
<td>3,570</td>
<td>3,715</td>
<td>3,866</td>
<td>4,024</td>
<td>4,189</td>
<td>4,362</td>
<td>4,543</td>
<td>4,732</td>
<td>4,930</td>
<td>5,136</td>
<td>5,353</td>
<td>5,579</td>
</tr>
<tr>
<td>Candidates for the Arctic, by Type &amp; Season†, without containers</td>
<td>3,530</td>
<td>3,333</td>
<td>3,431</td>
<td></td>
<td>2,948</td>
<td>3,055</td>
<td>3,167</td>
<td>3,283</td>
<td>3,404</td>
<td>3,530</td>
<td>3,661</td>
<td>3,797</td>
<td>3,938</td>
<td>4,086</td>
<td>4,239</td>
<td>4,398</td>
</tr>
</tbody>
</table>

* Panama Canal data obtained from the Panama Canal Authority. Annual Projected Growth values obtained from the UNCTAD Review of Maritime Transport, 2018.
† These types of vessels were assumed not to be diverted or captured through the Arctic and therefore, are excluded from projection calculations.
‡ 40% of the traffic, on average for FY 2017–2018, moved through the Panama between July – November.

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For the scenarios included in this report, a selected percentage of these projected traffic through the Panama Canal was added to the baseline of vessels to explore different potential growth rates of the captured Arctic fleet. The established baseline of vessels using the Arctic for trans-oceanic shipment was 14 vessels, which represents 0.41% of the current pool of vessels that could possibly be rerouted. This percentage was used to inform the values selected for the four scenarios. The Reduced Activity Scenario assumes that vessels rerouted through the Arctic will maintain the current value of 0.41% of the seasonal Panamax traffic until 2030. The Most Plausible Scenario assumes this pool will grow to 0.75% of the candidate pool over the next decade, while the Optimized Growth Scenario assumes that 1.0% will be rerouted. Finally, the Accelerated, but Unlikely Scenario assumes that 1.5% of the seasonal Panamax traffic may be rerouted through the area of interest by 2030.

Using these assumptions, the number of additional vessels related to rerouted ships is expected to grow across all four scenarios. In the Reduced Activity Scenario, the number of additional ships expected is 9 vessels by 2030. The Most Plausible Scenario projects that an additional 28 vessels will pass through the area of interest by 2030. The Optimized Growth Scenario projects that an additional 42 vessels will transit the area of interest by 2030. Finally, the Accelerated, but Unlikely Scenario estimates that 70 vessels will cross through the area of interest by 2030. A summary of how these rerouted vessels are expected to change over the 2020s is presented in Figure 14.

![Projected Growth of Vessel Traffic from Rerouted Commercial Shipping, 2019 –2030](#)

**Figure 14:** Summary of additional vessels related to the seasonal rerouted ships through the Arctic.
COMBINING SOURCES OF GROWTH TO PROJECT ADDITIONAL VESSELS

In the next step of the process, the estimated vessel counts associated with each discrete source of growth were totaled together for each year to calculate the amount of additional vessel traffic expected annually through 2030. A summary of this compilation is presented in Figures 15 and 16.

The sum of each source of growth by year was then added to the assumed baseline of vessel activity to generate a total value of projected vessels by year for each scenario. As previously discussed, this assumed baseline of vessel activity is 255 vessels. A summary of this is presented in Figure 17.
Figure 15: Additional vessels by type of source of growth for the four scenarios. The colored line on each graph is the trace of the total annual growth in additional vessels. Note that the y-axes are the same scale for all scenarios, except the Reduced Activity Scenario (top left).
Figure 16: Projected values of additional ships by scenario. Each plotted data point is the sum of the combined sources of growth projected for each year.

Figure 17: Projected values of unique vessel counts in area of interest from 2019 -- 2030, by scenario. The values of each colored line represent the sum of the additional projected traffic with the assumed baseline level of vessel activity, the average annual number of unique vessels from 2015–2017.
DISCUSSION

The volume of unique vessels operating in the study area of interest is expected to range between 283–523 vessels across the four scenarios explored in this study (Figure 17).

COMPARING SOURCES OF GROWTH

NATURAL RESOURCE DEVELOPMENT

Consistently, across the scenarios, natural resource development related traffic was found to be the largest contributor to projected traffic growth among the four types of sources of growth assessed. By 2030, natural resource development is expected to contribute 10 vessels in the Reduced Activity Scenario, 66 vessels in the Most Plausible Scenario, 94 vessels in the Optimized Growth Scenario and 140 vessels in the Accelerated, but Unlikely Scenario. More than 50% of this natural resource-related growth in all four scenarios is anticipated to be growth from the development of non-U.S. natural resources. This result suggests that the Bering Strait is expected to become a major gateway for the Arctic’s natural resources over the next decade, particularly for Russian exports of LNG and mineral resources from Canada.

SEASONALLY REROUTED SHIPPING THROUGH THE ARCTIC

Second behind natural resource development is the growth of vessels rerouted through the Arctic, which this study has modeled to grow linearly with time. By 2030, this study estimates that transshipment through the Arctic will contribute 9 vessels in the Reduced Activity Scenario, 28 vessels under the Most Plausible Scenario, 42 vessels in the optimized growth scenario, and 70 vessels in the Accelerated, but Unlikely Scenario. Additionally, the scenarios presented here all include containerized cargo ships, but this volume is expected to be a very small to the overall volume of vessel activity, ranging from 2—11 container ships by 2030. These estimates also do not account for any vessels attempting to cross the Arctic via the Transpolar Sea Route, which even under high climate forcing models, is not
expected to be accessible to ships less than Polar Class 6 vessels before the mid-century.\textsuperscript{132} It is expected that the use of this route will increase, however, once the Arctic Ocean is seasonally ice free, and when it is accessible, growth from this source of vessel activity in the U.S. Arctic will likely grow faster than these rates have estimated, because the Transpolar Sea Route does not have the same draft restrictions as other trans-Arctic passages.

**EXPANSION OF THE ARCTIC FLEET**

The expansion of the Arctic fleet, which includes icebreakers and ice-hardened cruise ships, is the third largest source of growth among the elements considered. By 2030, it is anticipated that there will be an additional 4 vessels added to the fleet in the Reduced Activity Scenario, 15 vessels in the Most Plausible Scenario, 23 vessels in the Optimized Growth Scenario, and up to 39 vessels in the Accelerated, but Unlikely Scenario. While there is a high probability that these vessels will be launched and transit polar waters, it remains to be seen how much these vessels ply waters around the Bering Strait.

Icebreaking vessels launched by Russia and Canada are likely to provide services along the Northern Sea Route and Northwest Passage, respectively, and therefore are expected to spend the least amount of time in the study area of interest. However, those icebreakers that will transit through the Bering Strait, including the USCG Polar Security Cutters and the *Xue Long 2*, are likely to spend considerable time in the region, and so measuring future vessel activity by unique ships may significantly underestimate the volume of activity attributed from these vessels.

Ice-hardened cruise and adventure ships have the potential to be the largest source of unique vessels added to the Arctic fleet over the next decade. Although the 28 new adventure cruise ships expected to be launched by 2024 may be used for cruises to the Antarctic, European Arctic, or Central Arctic oceans, the demand for extreme destinations is only growing and shaping the cruise industry.\textsuperscript{133} The long-term viability of this growth, however, depends on multiple factors, such as the growth of


marine transportation system infrastructure to support tourists, the health of the economy to support
the larger tourism industry, and the social license to operate in the region.

INFRASTRUCTURE DEVELOPMENT

As measured by additional unique vessels, the smallest source of growth considered in this study
is related to infrastructure development. While all other types of growth were found to have a close
linear relationship with time, infrastructure development sources of growth did not appear to have any
correlation with time. This source of vessel activity was very challenging to predict, given the complexities
of financing, staging, and construction in the region. Additionally, this projection primarily accounted for
the projects with a sealift requirement planned for the first half of the 2020s. Vessel activity related to
infrastructure development, particularly efforts to replace, repair, and/or armor existing infrastructure,
may increase dramatically over the next decade as environmental change along the coastline and
onshore shorten the lifespan and/or threaten the existing infrastructure in the region.

By transits, however, this source of vessel activity may grow to become one of the largest over
the next decade. The current vessels that supply coastal communities along western and northern Alaska
are largely small tug/towing vessels with shallow drafts, including landing crafts, designed to be beached
onshore to offload goods (See Table 1). In Kotzebue, one of the larger communities in the study area of
interest, it takes 3 different lightering vessels to get commodities to the community. The first includes
transferring to smaller vessels in Nome, sailing to Kotzebue, and then lightering again onto smaller, 200
dwt landing craft vessels capable of reaching shore. One example included in the USACE Kotzebue Harbor
Feasibility Study noted the final stage of transfer can be as much as 10—15 lightering trips per sailing to
fully unload. 134 Given all this, this source of vessel activity remains the most difficult to constrain among
the ones considered in this study.

Improvements at Cape Blossom”. Accessed from
s.pdf?ver=2019-01-09-152556-093
COMPARING THE PROPOSED SCENARIOS

The four scenarios featured in this study each assumed different outlooks about how the risk associated with operating in the region may be mitigated, resulting in four different trajectories about how vessel activity in the U.S. Arctic region might develop over the next decade.

- The Reduced Activity Scenario assumes that the high risks of operating in the region are not able to mitigated over the next decade and to reflect this, the lowest amount of traffic for each source of growth were assumed. The Reduced Activity Scenario totaled 289 vessels in 2030, a value just slightly higher than the margin of error assumed for the scenario’s baseline, 255 ± 26. The scenario had an average annual growth rate of 0.35%, which is on par with the average annual growth rate for the State of Alaska from 2010—2017 (0.59%)\(^\text{135}\), a period of rapid growth followed by a state-wide recession triggered by the crash in the price of oil and large state deficits.\(^\text{136}\) The largest sources of growth included in this scenario come from the growth of non-U.S. flagged vessels, most notably, the Chinese vessel *Xue Long 2*, icebreaking LNG tankers delivering Russian LNG to Asia, as well as vessels required to resupply Canadian mining operations.

- The Most Plausible Scenario incorporates the most reasonable estimates of traffic growth and vessel counts into a single scenario, assuming that operators will have enough certainty to advance growth in the region. By 2030, under this scenario, it is expected that the region will have 377 vessels transiting through the area of interest, a value that represents a 48% increase over the projection baseline (2015—2017) and just about three times larger than 2008’s numbers of vessel activity. The average annual growth for vessels in the region from 2019–2030 under this scenario is expected to be 2.22%. This rate is in line with cargo trends at the Port of Nome from 2010–2018 (2.35%)\(^\text{137}\) and with the U.S. economy over the same period (2.32%).\(^\text{138}\) In this

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\(^\text{137}\) Personal communication, Joy Baker, Port Director, City of Nome, February, 2019.

scenario, it is assumed that development moves forward for several U.S. natural resource projects in addition to many more non-U.S. resource projects. Vessels associated with infrastructure development, particularly related to infrastructure repair, replacement, and armament, are assumed to be few in number and sporadic in deployment. Additionally, it is anticipated that tourism-related traffic is expected to grow modestly and that planned infrastructure projects will progress on or near scheduled.

- The **Optimized Growth Scenario** assumes that much of the risk for operating in the region will be mitigated and incorporates the upper end of growth rates from the available data. This scenario captures vessel counts and growth rates in the realms of what has been proposed, but these quantities may not necessarily be the most probable. From the elements of growth incorporated in this study, it is assumed that the total number of vessels transiting through the U.S. Arctic region will be 430 vessels by 2030, a value which is nearly 70% higher than the projection’s baseline (255 vessels) and nearly 3.5 times higher than the number of ships transiting through the region in 2008. The projected average annual growth rate required to reach this level is 3.46%, which is consistent with pre-recession rates of cargo through the Port of Nome (3.58% from 2010–2015), indicating that this region has sustained this rate of growth before and may be able to do so in the future. This scenario builds on the Most Plausible Scenario, adding more vessels for each element of growth at faster rates. Notably, this scenario includes vessels related to ambitious projects which have been proposed but still have a large degree of uncertainty about their feasibility. These projects include the Arctic LNG 2 facility and offshore exploration of the Chukchi Sea for oil and gas.

- The **Accelerated, but Unlikely Scenario** incorporates all sources of growth for the region, including components which may be unlikely according to the best available data. This scenario is meant to act as a ceiling for the projections; while theoretically possible, this combined scenario is highly improbable. Under this scenario, the number of ships transiting the U.S. Arctic region in 2030 is 523 vessels, which is over twice the average number of ships in the area in 2015—2017 and 4.4 times higher than 2008 numbers of vessels. To reach this total, this scenario grows on average of

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139 Personal communication, Joy Baker, Port Director, City of Nome, February, 2019
4.88% each year, a rapid rate which outpaces the projected rate of the Global GDP from 2019–2023 (4.06%). The difference between this scenario and the Optimized Growth Scenario arises from the inclusion of both onshore and offshore renewable wind projects, additional icebreaking assets from neighboring Arctic States, and shipment from LNG from the North Slope.

COMPARING THE RESULTS WITH HISTORIC TRENDS IN THE REGION

Although there is little historical data for the study’s complete area of interest, there is considerable overlap between this study’s area of interest and the U.S. Coast Guard’s Arctic area of interest. The Coast Guard’s Arctic area of interest extends from the Bering Strait, north to the North Pole, east to Banks Island and west to New Siberian Islands, and since 2008, USCG District 17 has compiled vessel counts for this region (see Figure 5).

Comparing the projected data with the historical data from the USCG’s area of interest reveals that three highest growth scenarios are in close agreement with mathematical regressions of the available historic data, indicating that the projects growth align with trends in the region over the last decade (Figure 18). The Accelerated, but Unlikely Scenario vessel projection values are in very close agreement with the linear regression from the USCG data set. The Most Plausible Scenario vessel projection values are in close agreement with the logarithmic regression of the same historic data set. The historic data has a slightly better fit to the logarithmic regression ($R^2 = 0.89$) compared to the linear regression ($R^2 = 0.83$), indicating that the Most Plausible Scenario has the best agreement with the historic data available. If true, the shape of this curve would suggest that the region will enter a period of slower, but more constant growth over the next decade than what was observed in the past decade.

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Figure 18: Historic and projected number of annual vessels by scenario, 2008–2030. Historical data from the Coast Guard’s Arctic Area of Interest (black line), along with the projected values of unique vessel counts in area of interest from 2019–2030, with and without container ships for the Accelerated but Unlikely (ABU), Optimized Growth Scenario (OGS), Most Plausible Scenario (MPS) and the Reduced Activity Scenario (RAS). The dotted line is the assumed baseline of vessel activity, measured from the 2015–2017 mean number of ships in the study area of interest. Linear and logarithmic regressions are fitted to the historic USCG data sets.

\[ y = 81.317 \ln(x) + 95.524 \]
\[ R^2 = 0.89 \]

\[ y = 17.636x + 119.09 \]
\[ R^2 = 0.8294 \]
Section V: Conclusion

This report provides further information about how the potential growth of vessel activity in the U.S. Arctic may change over the next decade. This effort updates and expands on the 2015 CMTS report, “A 10-Year Projection of Vessel Activity in the U.S. Arctic”. This report explored the drivers of vessel activity in the Arctic through the 2018 CMTS & USARC Technical Workshop (Section II of this report) and probed recent vessel trends with AIS data to understand recent trends in the region (Section III of this report). Both components underscored the complex dynamics at work in the U.S. Arctic region, and quantitative and qualitative elements from these efforts were used to construct and calculate four potential growth scenarios (Section IV of this report). A summary of these results, in the context of growth from current levels and from our earliest record of AIS data from the region is presented in Table 5. These scenarios suggest that growth will add 34—268 additional vessels to the U.S. Arctic area of interest by 2030, increasing the number of ships in high U.S. Arctic waters and the surrounding region by 140—330% over the 2008 level.

Table 5: Summary of the scenario projection results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Additional Vessels in 2030</th>
<th>Total Vessels in 2030</th>
<th>Projected Average Annual Growth Rate</th>
<th>Change from 2008 Baseline Level</th>
<th>Change from Current (2015—2017) Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Activity Scenario</td>
<td>34</td>
<td>289</td>
<td>0.35%</td>
<td>141%</td>
<td>13%</td>
</tr>
<tr>
<td>Most Plausible Scenario</td>
<td>122</td>
<td>377</td>
<td>2.22%</td>
<td>214%</td>
<td>48%</td>
</tr>
<tr>
<td>Optimized Growth Scenario</td>
<td>175</td>
<td>430</td>
<td>3.46%</td>
<td>258%</td>
<td>69%</td>
</tr>
<tr>
<td>Accelerated, but Unlikely Scenario</td>
<td>268</td>
<td>523</td>
<td>4.88%</td>
<td>336%</td>
<td>105%</td>
</tr>
</tbody>
</table>

As with any projection effort, the values projected can be improved as more data becomes available and is incorporated into the model. For this study, further information about any of the twenty-nine quantified elements of growth incorporated in the projection will improve the values assigned across the scenarios and in turn the accuracy of these projections. Additionally, this study recognizes that while AIS is a tremendously powerful tool for analyzing vessel activity, it is not without limitations. The AIS inventory used as the baseline for these vessel projections does not account for vessels not using AIS, such commercial fishing vessels less than 300 dwt, subsistence hunting and fishing related vessels, and pleasure crafts transiting the area. Further information about these activities to incorporate into both the baseline analysis and the projection scenarios will also increase the accuracy of these projections and our understanding of the immense changes unfolding in the U.S. Arctic region.