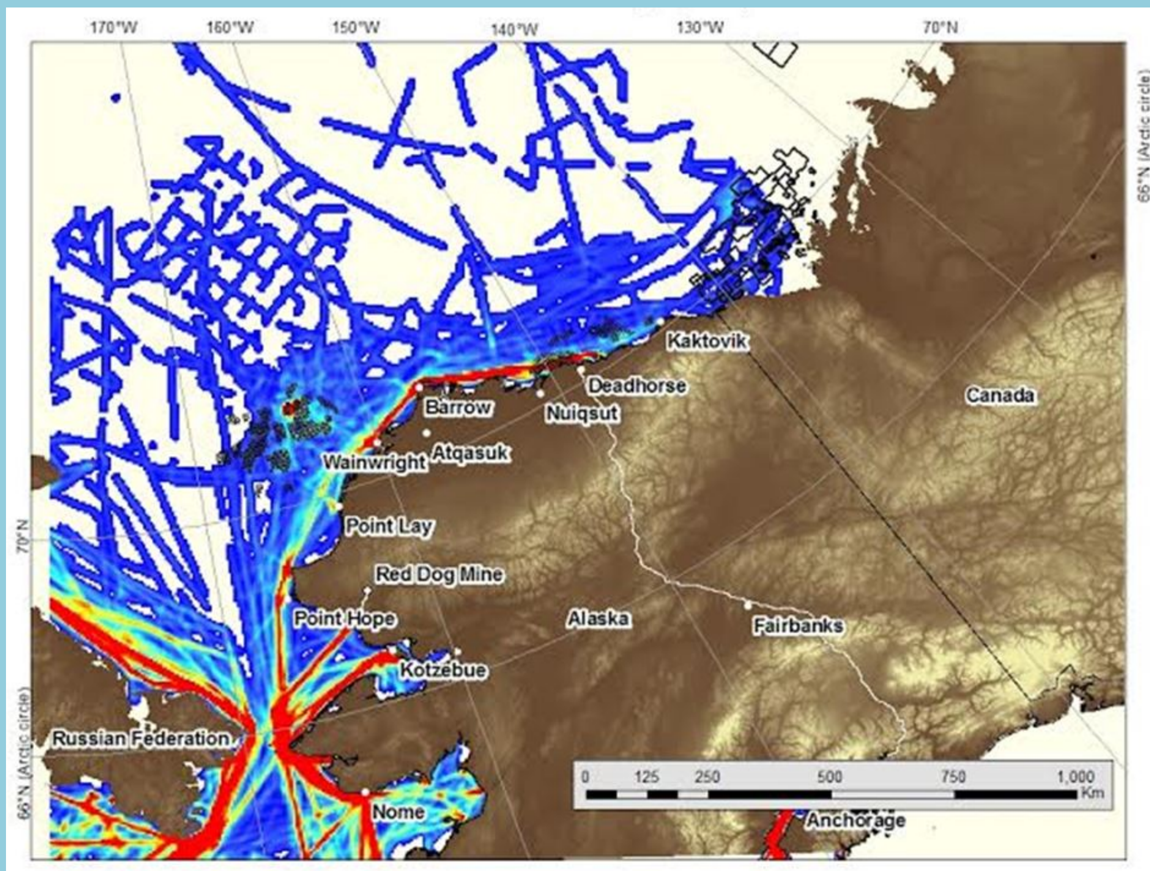
A 10-YEAR PROJECTION OF MARITIME ACTIVITY IN THE U.S. ARCTIC REGION



January 1, 2015

The International Council on Clean Transportation
1225 Eye Street NW Suite 900
Washington, DC 20005
(202) 534-1600 www.theicct.org

CMTS
U.S. Committee on the Marine Transportation System

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Prepared by:
The International Council on Clean Transportation
1225 Eye Street NW Suite 900
Washington, DC 20005

Dr. Alyson J. Azzara
Dr. Haifeng Wang
&
Dr. Daniel Rutherford

Contributors:
Mr. Brendan J. Hurley
George Mason University, Department of Geography and Geoinformation Science
&
Dr. Scott R. Stephenson
The University of Connecticut, Department of Geography

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This report is available on the CMTS website: www.cmts.gov

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Chapter 1: Introduction

Project rationale

This report directly supports the priorities outlined in the U.S. National Strategy for the Arctic Region (NSAR). Under the NSAR's subsequent January 2014 Implementation Plan, the Department of Transportation is listed as the lead agency for the Implementation Plan component "Prepare for Increased Activity in the Marine Domain." On March 31, 2014, Secretary Foxx directed the CMTS on behalf of the Department, to manage the three marine transportation-related action items under this component. The first action item is to complete a 10-year projection of maritime activity in the U.S. Arctic region.

Background

The United States is an Arctic nation. In total, Alaska accounts for 56 percent of the U.S. coastline,[1] with approximately 6,640 miles of coast for the entire state.[2] Three Arctic seas bound the state of Alaska: the Bering, the Chukchi, and the Beaufort. The surface of these Arctic seas is frozen for more than half the year. The general Arctic maritime season lasts only from June through October, and unaided navigation occurs within a more limited time frame. This pattern appears to be rapidly changing, however, as ice-diminished conditions become more extensive during the summer months.

On September 16, 2012, Arctic sea ice reached its lowest coverage extent ever recorded,[3] paving the way for the longest Arctic navigation season on record.[4] While this may increase the season available for navigation in the Arctic, it may also intensify the risks. A reduction in sea ice may impact hazards to navigation by creating more mobile sea ice. Sea ice also creates a dampening effect on wave action and storms in the Arctic; without the coverage, these will be more severe.[5]

Among the current domestic concerns that have come before Congress and other federal agencies, is a lack of Arctic infrastructure to support the growing industry in shipping, mining, oil and gas exploration, and tourism. Limited nautical charts, aids to navigation, communication, and rescue capabilities make operations difficult and often hazardous. Currently, the U.S. government has charted only a small percentage of the navigationally significant U.S. Arctic waters to modern standards to accurately determine water depths and all hazards to navigation.[6] Only about 11 percent of the Arctic has been charted using current technological means (multi-beam techniques).[7]

At a 2007 maritime conference in Iceland, participants weighed suggestions for how to approach future studies to assess the viability of Arctic maritime shipping, including recommendations for a study of Arctic shipping incorporating economic and natural variables such as vessel costs and ice conditions. They concluded that limited commercial voyages would start within a decade and year-round voyages within one to two decades.[8] In 2009, the Arctic Council published the Arctic Marine Shipping Assessment (AMSA) report. This report details 17 recommendations for maritime safety and marine environmental protection in the Arctic. The AMSA addressed the infrastructure deficit for supporting Arctic maritime safety, environmental protection, and sustainable development. The AMSA report's recommendations also specifically noted the need for Arctic states to support continued development of a comprehensive Arctic marine traffic awareness system, as well as to invest in hydrographic, meteorological, and oceanographic data to support safe navigation and voyage planning.

The 2013 U.S. National Strategy for the Arctic Region (NSAR)[9] and its associated 2014 Implementation Plan[10] recognizes the increase in access to the Arctic due to changes in climate and the likely development of maritime activity associated with natural resources development. The Implementation Plan for the NSAR includes the objective: "Establish a framework to guide Federal activities related to the construction, maintenance, and improvement of ports and other infrastructure needed to preserve the mobility and safe navigation of United States military and civilian vessels throughout the Arctic Region." This framework will be based on a coordinated approach toward improving and maintaining infrastructure in support of Federal maritime Arctic activities and encouraging partners and stakeholders to invest in regional infrastructure. The first step is to complete a 10-year projection of maritime activity in the region.

Definition of the Arctic

The Arctic is defined in many ways for different domestic and international venues. 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. (Figure 1-1).

Figure 1-1. Map of the Arctic from the Perry-Castaneda Library Map Collection. The red line indicates the definition used by the Arctic Council; the black line represents the tree line, or edge of habitat, following the 10-degree isotherm.[11]

In Section 112 of the Arctic Research and Policy Act of 1984 (Title I of P.L. 98-373 of July 31, 1984) the region is defined as follows: "… 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, which is codified at 15 U.S.C. § 4111, includes certain parts of Alaska below the Arctic Circle, including the Aleutian Islands and portions of central and western mainland Alaska, such as the Seward Peninsula and the Yukon Delta.[12] This is the definition widely used by U.S. agencies and departments, including the U.S. Coast Guard and Department of State.

Other definitions that focus on an operational approach are often similar to the definition used in the Department of Interior's 2013 report to the President, which focuses on the Arctic areas north of the Bering Strait, including the Red Dog Mine, because of their characterization as areas of increasing ice-diminishment and unique oceanographic conditions when compared to more southern regions of Alaska.[13]

The area of focus for this project is on Arctic vessel traffic through the Bering Strait and the North Slope of Alaska as influenced by potential growth in the Northern Sea Route (NSR) and Northwest Passage (NWP), in addition to resource exploration and development activities (Figure 1-2).

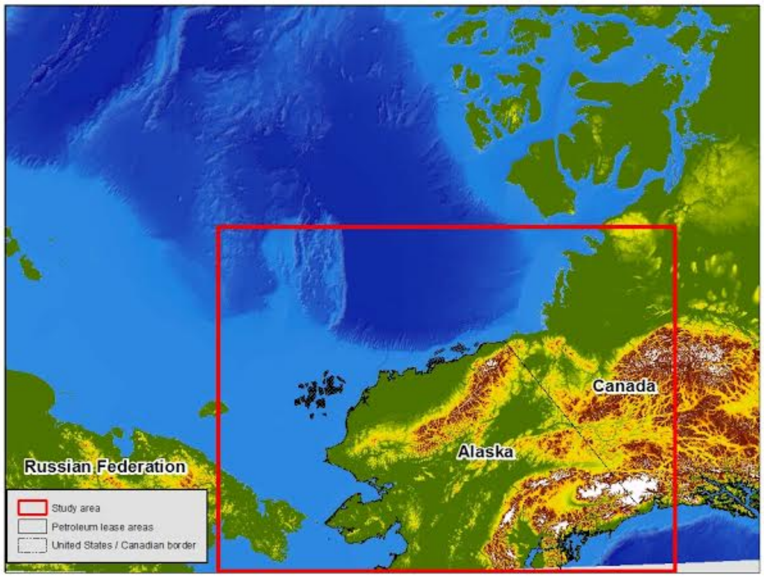


Figure 1-2. General area of study for this project inclusive of the Bering Strait, Chukchi Sea, and Beaufort Sea.

Study components

This study consists of a number of different elements; each element is designed to frame and inform vessel activity projections for the US Arctic in 2025. These elements are briefly introduced with additional detail provided in subsequent report chapters or in the report annex.

I. Literature review

The first component is a review of current publications that can be used to develop vessel traffic and ice modeling analysis. Resources assessed for this document include U.S. agency reports and strategies, collaborative working group publications, international reports from forums such as the Arctic Council, and peer-reviewed literature. The information presented in this document is limited to results that can inform the understanding of current expectations for Arctic growth's impact on shipping activity. The full literature review is included as Annex 1.

II. Baseline analysis

The baseline analysis consists of vessel traffic and climate modeling represented by ice extent models. These baselines do not represent comprehensive information on either topic; however, they do establish a baseline relative to the data available and provide context to compare current conditions with possible future conditions.

To focus on changes and vessel activity growth for the U.S. Arctic, the study area includes only the northern Bering Sea, the Bering Strait, and the Chukchi and Beaufort seas. Because the area around Dutch Harbor and Unimak Pass in the Aleutian Islands are high traffic areas, they were not included in order to focus on the lower volumes of traffic passing through the high Arctic.

The sea ice simulations used in this project are from the Community Climate System Model (CCSM4), a global climate model, and represent two different climate forcing scenarios and three vessel classes: Polar Class 3 (PC3), Polar Class 6 (PC6), and open-water (OW). Both absolute accessibility in the 2021-2030 timeframe and relative changes from a five-year (2011-2015) average will be examined for all three vessel types.

III. Traffic growth components

This chapter on forecasting explores information and reports that discuss growth potential or the specifics of future planned activities that could directly influence maritime activity in the U.S. Arctic. The sections consider natural resource development, growth of trade in the Arctic region, and the potential for diversion of vessel traffic from other international shipping routes as potential contributors to activity growth. These analyses will form the basis for the 10-year projection scenarios.

IV. Other considerations

This section discusses other considerations that could affect vessel activity in the Arctic but are not specifically included as quantitative variables in the projection scenarios. Considerations in this section include: economic drivers, other commercial and safety considerations, and geopolitical variables.

V. Arctic vessel traffic projections

The vessel traffic projection scenarios are based on a combination of the baseline vessel analysis, and the analysis of growth components. Each scenario is based on a set of assumptions for low, medium, and high growth that bound probable growth estimates for different sectors.

VI. Summary of findings

The last chapter of this project report is a summary of the findings combining vessel projections with an analysis of the assumptions used to produce them. The discussion will explore the feasibility of the projections taking into consideration climate and market variables that could impact their feasibility.

Chapter 2: Baseline Analysis

The baseline analysis consists of vessel traffic and accessibility modeling driven by automatic identification system (AIS) data and climate model output, respectively. These baselines do not represent comprehensive information on either topic; but, they do establish a baseline relative to the data available and provide context to compare current conditions with possible future conditions.

Vessel activity

To better understand vessel distribution and density as activity increases, satellite automatic identification system (S-AIS) data were analyzed for the U.S Arctic above the Aleutian Islands. Between 2008 and 2012, vessel activity in the U.S. Arctic went from 120 vessels to 250, an increase of 108 percent. This first set of analyses examines where activity is concentrated and inter-annual variability and growth for the Bering Strait, North Slope, and the outer continental shelf.

Vessels broadcasting an AIS signal transmit a position every 2–10 seconds that can be picked up by polar orbiting satellites within range. These positions can be analyzed by aggregating all points in a specific area or by connecting points from the same vessel to create tracks or transit lines. Satellite AIS data was available for July-November of 2011 and 2012, but only for August and September of 2013. This study uses track line analysis to determine the total kilometers traveled within a given area. Comparing track line distance between years provides a proxy to determine areas of high and low vessel traffic and changes in vessel distribution over time.

To focus on changes and growth for the U.S. Arctic, the study area includes only the northern Bering Sea, the Bering Strait, and the Chukchi and Beaufort Seas to the Canadian border. Since the area around Dutch Harbor and Unimak Pass in the Aleutian Islands are already high vessel traffic areas, they were not included in order to focus on the lower volumes of vessels transiting through the high Arctic (Figure 2-1).

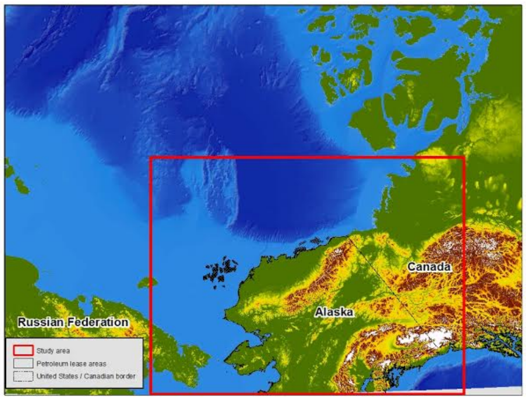


Figure 2-1. Focus area of the U.S. Arctic for the study.

The data were plotted using ArcMap 10.1 (ESRI) software on a 5-kilometer square grid. This resolution provides enough detail to isolate shipping corridors and to distinguish inshore and coastal routes that may be near to each other but distinctly separate. To analyze and display vessel activities, the report uses kernel density estimate analysis, a method used to represent shipping patterns.[14] A kernel density estimate (KDE) analysis with a 10 km smoothing window was applied to the vessel point and line data to show areas of higher and lower densities of vessels. The 10 km smoothing window was used to incorporate data from the nearest 5 km cell neighbor, but not farther. This approach creates a more vivid visual representation of the data without changing the fundamental values or interpolating over broad areas.

Both point density and line density analyses were conducted, but only line density results will be presented in this report. This decision was based on differences in available data and also annual differences in satellite coverage of the region. There are various reasons why the number of vessel point positions might increase or decrease without affecting the total distance traveled. To avoid additional correction factors or inaccuracies based on point density, that analysis is not included.

Figure 2-2 shows the results of the KDE analysis for vessel track lines constructed from the S-AIS position data. It is apparent from the inter-annual comparison that vessel activity increased significantly between 2011 and 2012. This growth is visible in the resolution of the transit lanes. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore Prudhoe Bay from oil and gas exploration activity is particularly pronounced.

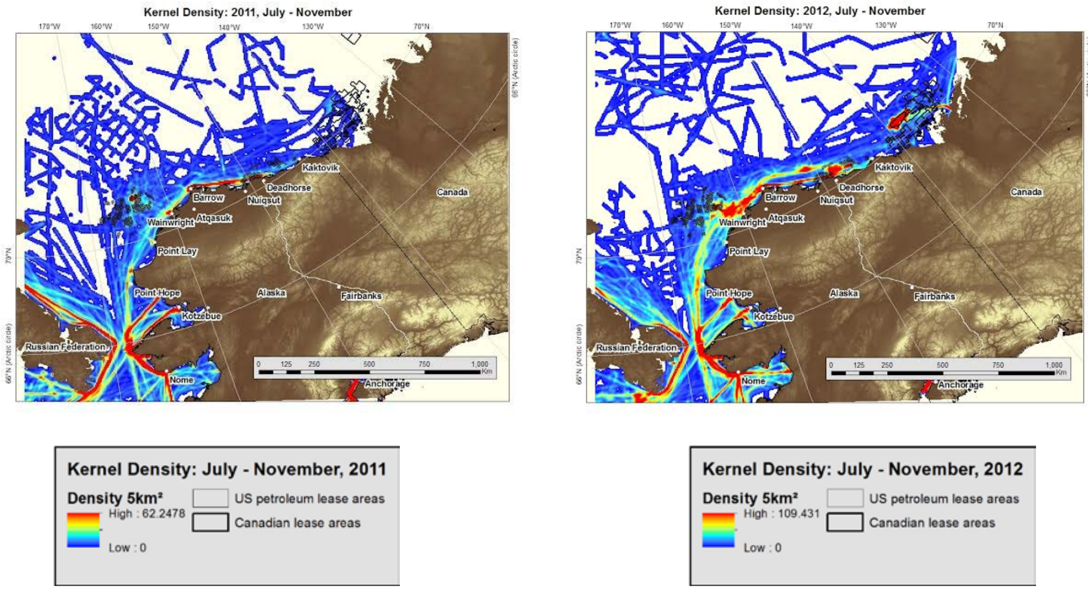


Figure 2-2. Line densities for 2011 (left) and 2012 (right) for U.S. Arctic vessel activity. Reds indicate areas of higher density, blues areas of lower density.

The density analysis using track lines provides resolution for determining traffic routes through the Bering Strait and onto the North Slope. There are two examples comparing 2011 and 2012 for areas where density differences are more noticeable. First, vessel traffic connecting the Red Dog Mine and Kotzebue to the Bering Strait decreased from 2011 to 2012. Second, the area along the North Slope between Prudhoe Bay, Barrow, and Wainwright noticeably increased in vessel traffic, as did the offshore lease area in the Chukchi Sea. One pattern, along the same North Slope area, that is particularly interesting is the bifurcation of vessels between Prudhoe Bay and Barrow. In 2011, the majority of traffic — likely tugs and community resupply ships — hugged the coastline. In 2012, however, there are two transit lanes, one following the same coastal route, and the other further offshore, likely representing support for offshore activities northeast of Prudhoe Bay.

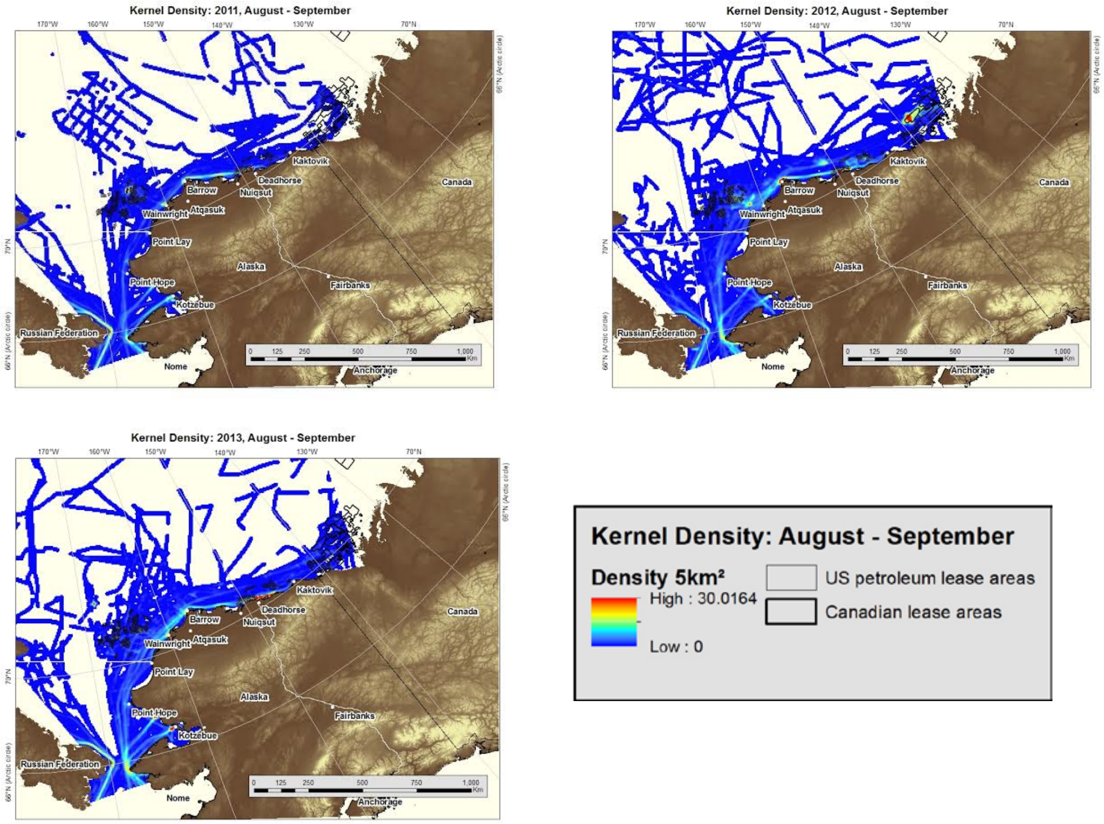


Figure 2-3. Difference in track line densities between 2011, 2012, and 2013 for August and September.

Vessel activity across the three years (Figure 2-3) is less well defined because data availability constraints allow a comparison only between August and September. Although less pronounced, there is a definite increase in activity in 2012, particularly offshore in the Chukchi Sea and the Canadian Beaufort, both over designated petroleum lease areas. The differences between 2011 and 2013 are subtle, but in 2013 the activity around the Red Dog Mine, north of Point Hope and depicted in Figure 2.5, appears increased, as does the activity approaching Barrow. The comparative decreases in natural resource related activity between 2012 and the other years are evident in the difference in offshore activity shown within the petroleum lease blocks.

To better understand these changes in vessel distribution, a direct comparison was made of July through November vessel locations for 2011 and 2012. Figure 2-4 highlights areas of percent change between the two years using the S-AIS point data on a 5 km grid with a 10 km smoothing window; increase and reduction are shown in warm and cool colors, respectively. There is a noticeable lack of data in the Canadian Beaufort Sea because of data constraints for 2011. The spatial mismatch in data limits the percent comparisons to areas where data existed for both years.

It is possible to highlight areas of obvious difference through this method of relative percent comparison. The most apparent pattern between years is the shift from coastal traffic to more offshore traffic. Of note, since this comparison is between 2011 and 2012, when Shell was involved in offshore drilling, much of this shift could be attributable to offshore supply and support for oil and gas exploration and drilling on the outer continental shelf of the Chukchi Sea.

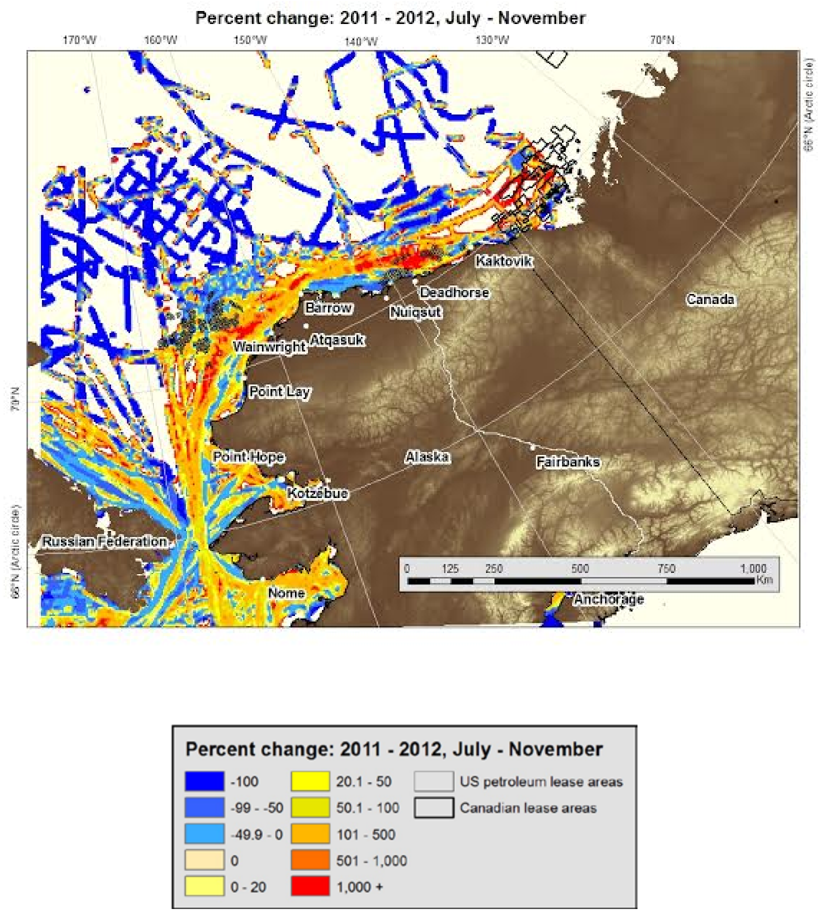


Figure 2-4. Percent difference in vessel activity from 2011 to 2012 using 5 km grid cells.

Figure 2-4 clearly shows growth along the coastal routes connecting North Slope communities as well as areas of offshore oil and gas exploration. The least variability is seen in the Bering Strait. This comparison can be expanded to compare 2011, 2012, and 2013. Although the time frame is reduced to August and September, key differences are apparent.

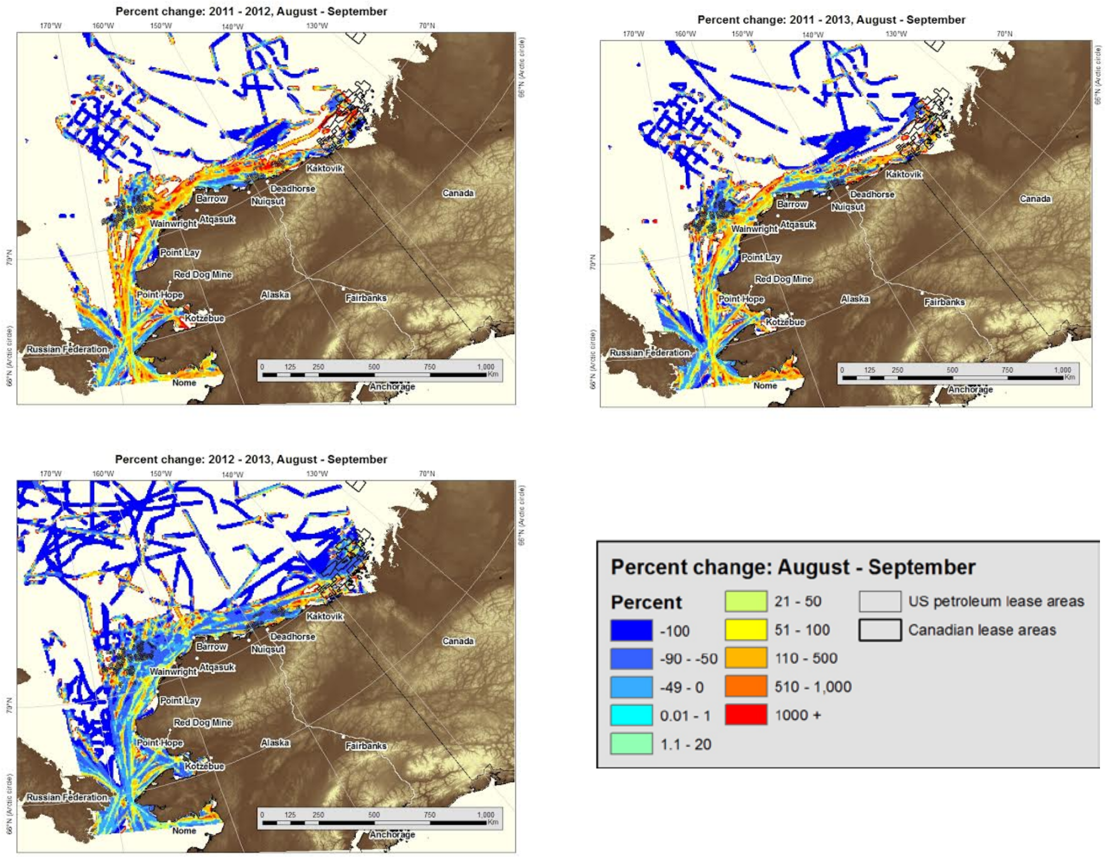


Figure 2-5. Comparison of percent change in vessel activity among 2011, 2012, and 2013 for the months of August and September.

Figure 2-5 is the multi-year comparison of percent difference for August and September between 2011-2012, 2011-2013, and 2012-2013, respectively. As was seen in the full July through November comparison, increases in activity are obvious between 2011 and 2012. The comparison between 2011 and 2013 also shows growth, but there is a clear lack of activity on the outer continental shelf where oil and gas activity was present in 2012. Much of the activity is coastal with some increases in different parts of the Canadian Beaufort and the southeast Chukchi Sea. This is most likely attributable to more limited seismic exploration, particularly for the Canadian areas. As would be expected, the comparison between 2012 and 2013 shows a net decrease in activity. There are, however, still areas of positive growth along coastal routes and near the shore. It is likely that some of this is attributable to the ongoing construction by Exxon at Point Thompson for a gas condensate facility, which has required barge deliveries from Prudhoe Bay. There are also exploration seismic programs in both the United States and Canada occurring east of Kaktovik, which likely explains the growth in that area.

Based on this comparison, it is possible to use either 2011 or 2013 as a reference scenario for years with limited to no offshore exploration drilling programs, although they would include an assumption for offshore seismic exploration. For years when offshore drilling activities are assumed, 2012 serves as an appropriate reference to highlight areas of relative increased activity. These assumptions will be further discussed in the projections section of the report.

Modeling accessibility in ice

In addition to establishing a vessel activity baseline for this study, it is important to establish a similar baseline for environmental factors affecting vessels, such as ice.

The sea ice simulations used in this project are from the Community Climate System Model 4.0 (CCSM4) global climate model and represent two different climate forcing scenarios: RCP 4.5, medium-low forcing; and RCP 8.5, high forcing. Models were created for a summer-fall shipping season covering July through November. Data covering a 20-year time period from 2011–2030 were obtained from the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive. / Ice type/age was approximated from ice thickness according to the Arctic Ice Regime Shipping System (AIRSS) guidelines. This system identified six ice types, in addition to an “open-water” class, that were used in the analysis. Three vessel classes were chosen to represent a range of capital investment in ice-strengthened capability: Polar Class 3 (PC3), an icebreaker capable of year-round operation that may include multi-year ice; Polar Class 6 (PC6), a moderately ice-strengthened ship capable of summer-autumn operation in medium first-year ice that may include old ice inclusions; and open-water (OW) ships with no ice strengthening (Annex 2).

Figure 2-6 shows the baseline accessibility for the three vessel types using the model results for RCP 4.5 and RCP 8.5 for the 5-year period between 2011-2015. As would be expected, PC3 vessels have greater access than open-water vessels, although there are differences in access between the two climate model outputs. Differences in climate forcing typically appear over longer time scales, closer to a 50 year-period.

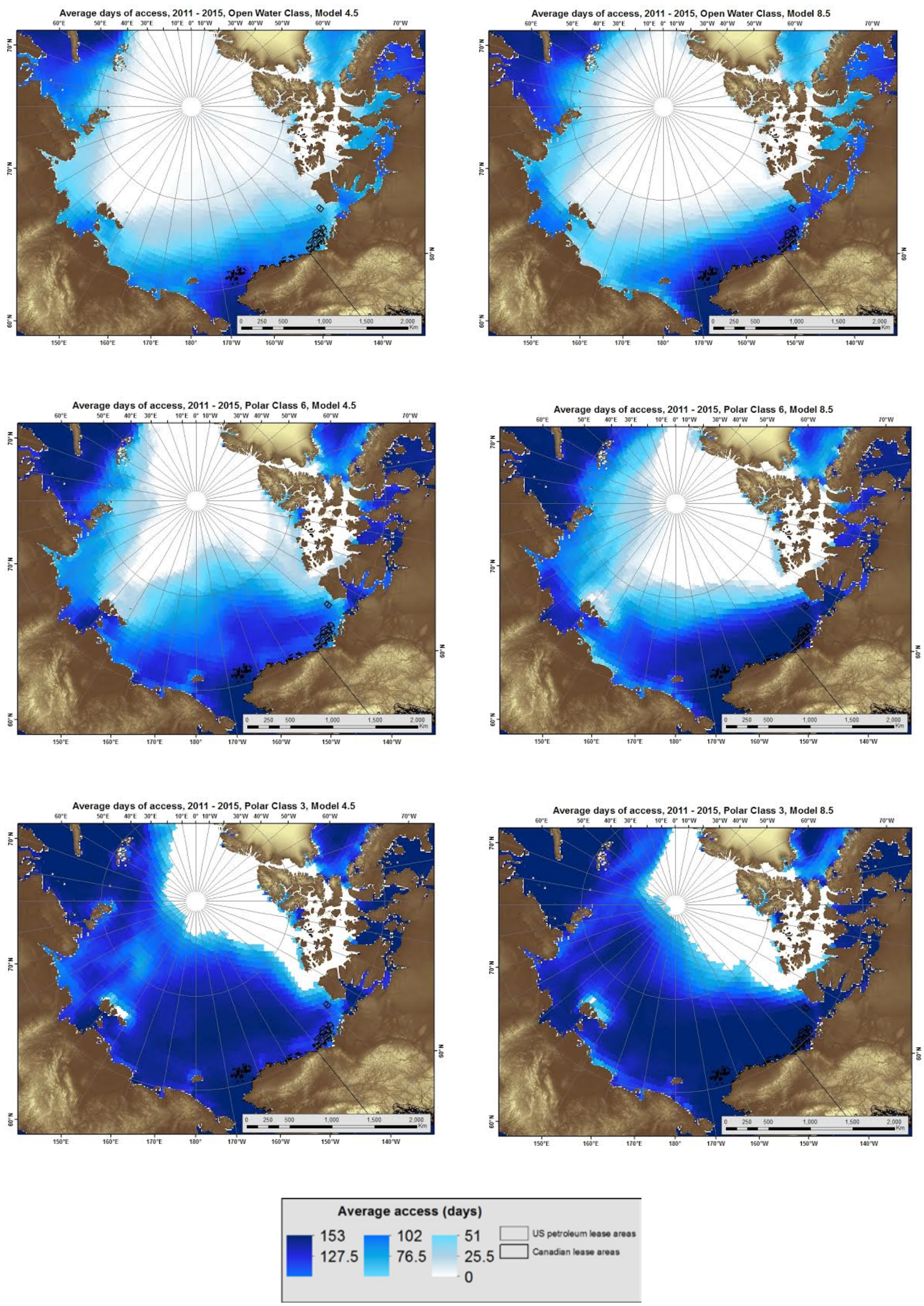


Figure 2-6. 5-year average accessibility (2011–2015) for open-water, PC6, and PC3 class vessels (from top to bottom) assuming climate forcing scenarios for RCP 4.5 (left column) and RCP 8.5 (right column).

Figure 2-7 shows the 10-year modeled access for 2021-2030 for the three vessel classes under the two climate forcing scenarios. There are apparent differences in the modeled access between the 2011–2015 average and the 2021–2030 average. Most notably, access to the Northern Sea Route is nearly unrestricted, particularly for ice-strengthened vessels. Access to the NWP also increases for PC6 and PC3 vessels, although there are still clear areas of limited navigability. There are more subtle differences in total days of access as well for different vessel classes. Although access may be possible in some areas for all three vessel types, the time frame for access will be a large determining factor for actual operations. This subsequent analysis makes some assumptions about accessibility needs and explores the feasibility of navigation for different vessels.

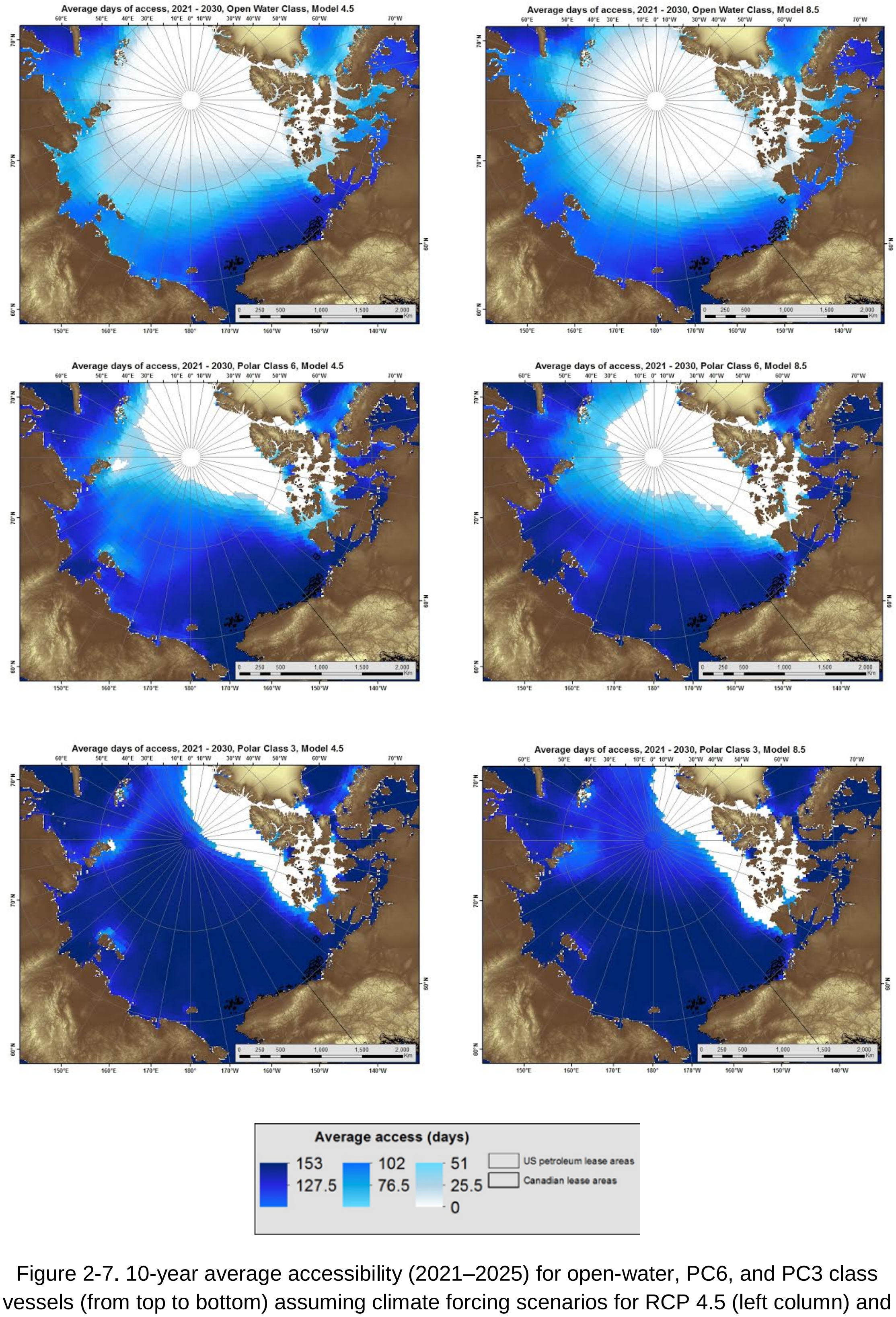


Figure 2-7. 10-year average accessibility (2021–2025) for open-water, PC6, and PC3 class vessels (from top to bottom) assuming climate forcing scenarios for RCP 4.5 (left column) and RCP 8.5 (right column).

For shipping and other activities in the U.S. Arctic, this study assumes that 60 days of accessibility is required for open-water vessels (non-ice-strengthened) for Arctic resupply or a round-trip Arctic voyage. This does not assume that all vessels will operate for the full 60 days, but rather provides a reasonable operating window and voyage-planning buffer for weather and sea ice conditions. Figure 2-8 is a series of maps for the three vessel classes under the two climate scenarios showing areas of access for greater than 60 days in the July through November season for the 10-year period from 2021–2030 (used to represent average conditions for 2025). In each map, colors indicate vessel class, with the darkest blues for open-water vessel access, medium blue for PC6 and PC3 access, and the lightest blue for PC3 vessel access only. The white area represents ice extent for each scenario where less than 60 days of access is available for all vessel types. Images on the left represent the 2011–2015 time frame, images on the right the 2021–2030 time frame. The top pair represents the RCP 4.5 climate scenario and the bottom the RCP 8.5 scenario for their respective time frames.

There are noticeable differences in access between the climate forcing assumptions. Unsurprisingly, the high climate-forcing scenario (RCP 8.5) shows greater accessibility, particularly for PC6 vessels. Although there is also an increase in accessibility for open-water vessels, they remain largely constrained to coastal waters. For ice-strengthened vessels, the Arctic is accessible under both scenarios; however, major routes through the Canadian Archipelago remain restricted even for the heavier ice-class PC3 vessels. That does not mean access through the NWP is impossible, but rather that 60 continuous days are unlikely.

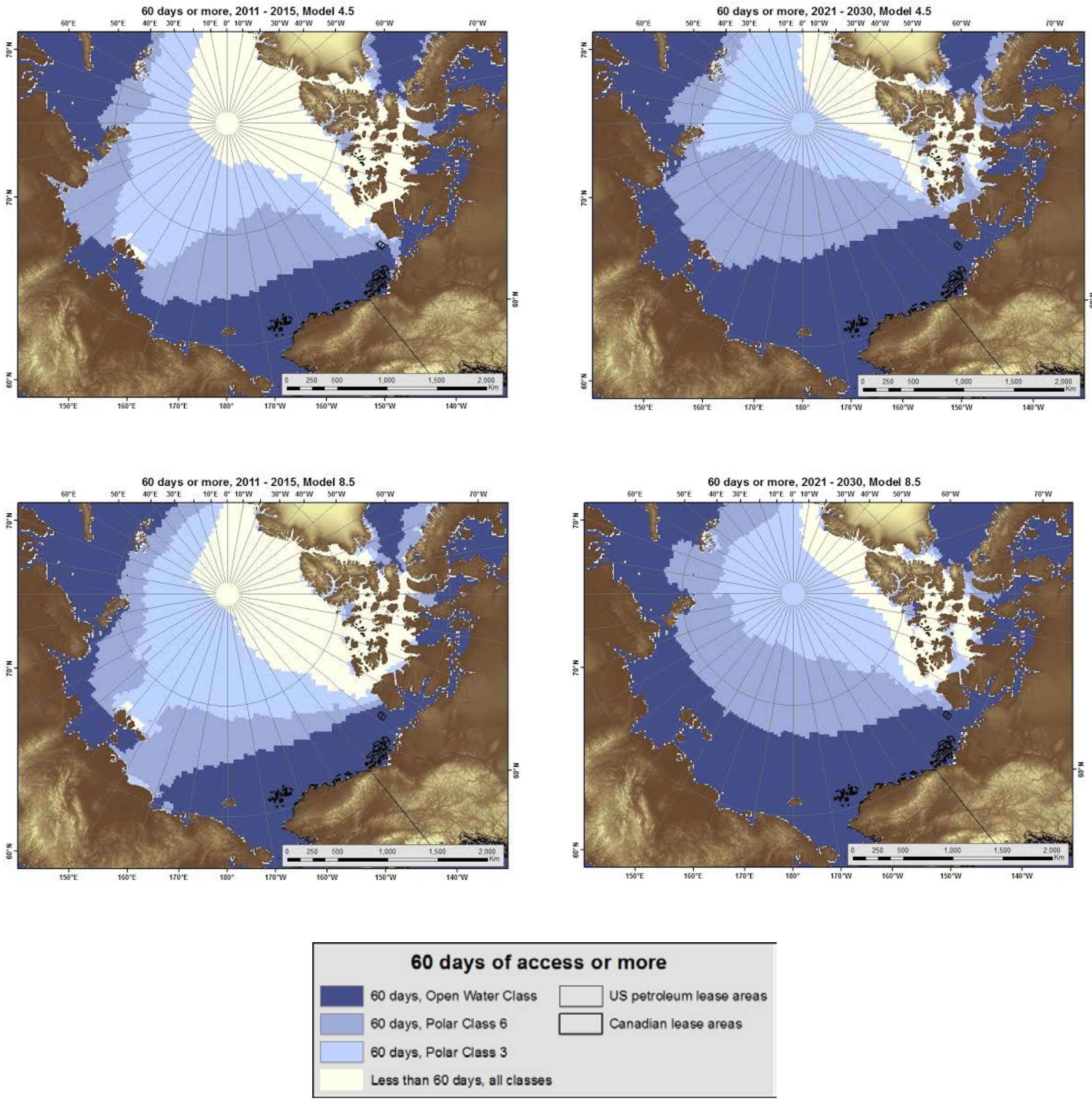


Figure 2-8. Areas of 60 days of accessibility or greater for each vessel type. The left images show accessibility for 2011-2015 for RCP 4.5 (top) and RCP 8.5 (bottom): the right images show accessibility for 2021–2030 for the same climate scenarios.

These models also have high potential degrees of uncertainty associated with them. Figure 2-9 shows variability represented by the standard deviation of the operating season from 2011–2030 for the three vessels classes under RCP 4.5 and RCP 8.5. For this analysis, blue areas represent lower standard deviation, or lower variability and red areas represent higher standard deviation. The figure demonstrates that the areas of highest variability depend on vessel class. For open-water vessels, the highest variability is for near-shore access, particularly just north of the shelf break. There is little uncertainty for these vessels near ice-covered areas, because access to those areas is consistently restricted based on the models. For PC6 and PC3 vessels, variability in access is highest along the ice edge and through the NWP because ice extent varies each year and the degree of that variation will determine access, particularly for PC6 vessels with only light breaking capacity. For the purposes of this study, the potential high year-to-year variability in the NWP is important, because it indicates that the route may be accessible for PC3 vessels, and even PC6 vessels, one year but not the next. This could have implications for vessel planning and for designation of a polar route or marine corridor that would depend on consistency in access.

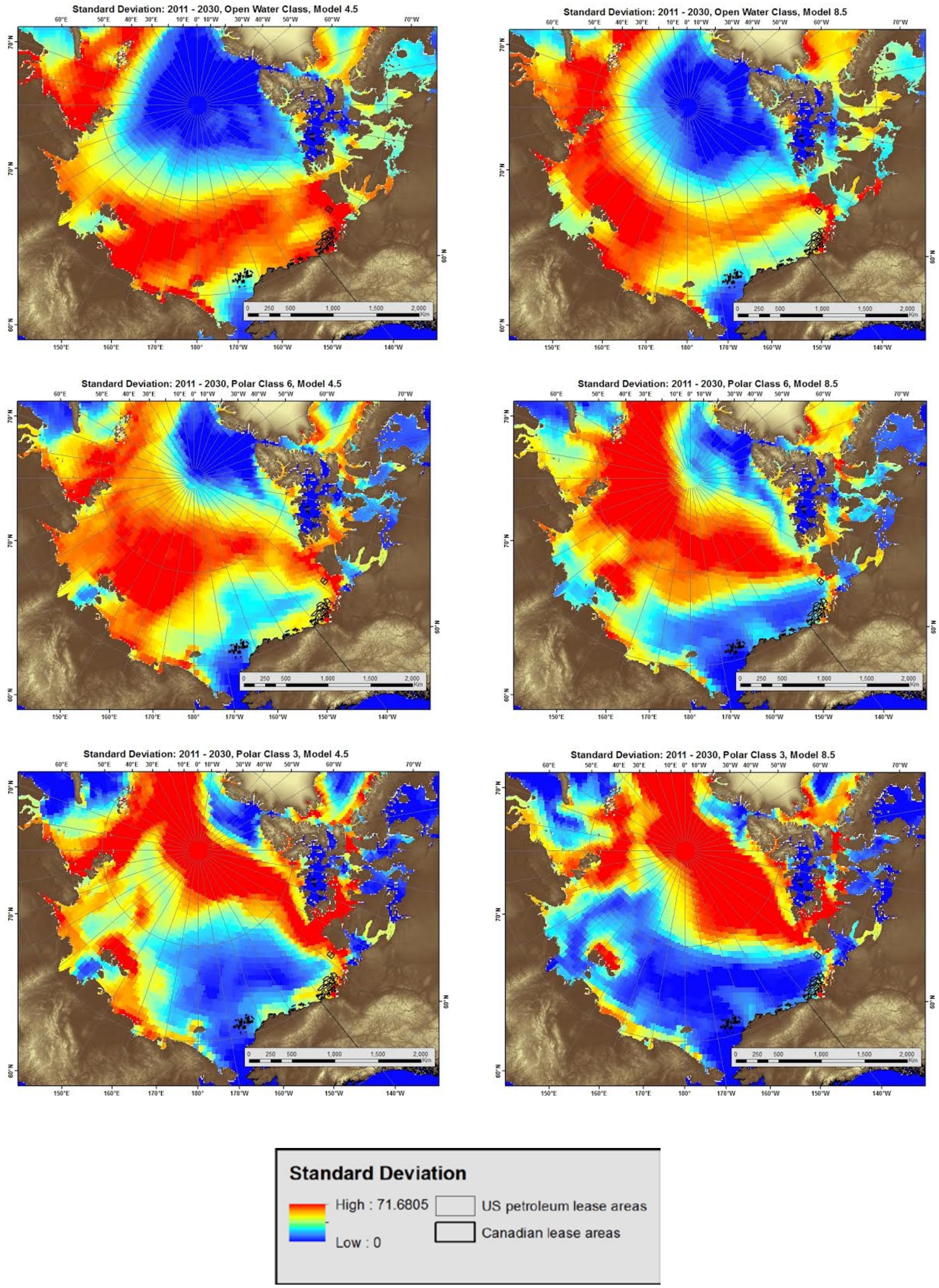


Figure 2-9. Standard deviations for vessel access in days by type (open-water, PC6 and PC3 top to bottom) and climate forcing scenarios, RCP 4.5 and RCP 8.5 (left to right) for 2011-2030

Summary

The first step to projecting future trends is to understand current conditions. Based on vessel data from 2011–2013, it is clear that activity is increasing in the U.S. Arctic. That increase depends on a number of components, with oil and gas research and development clearly having an important impact on not only the number of vessels operating but also their locations. Although the general oil and gas lease areas are specific, locations of operations between years are more variable because many of the operating permits and proposals that would affect activity in 2025 have yet to be finalized. It is, however, possible to project differences in activity between years with little oil and gas activity and years with heavy activity. Demonstrating growth from offshore activity will be contingent upon a number of assumptions, for example the type of activity (i.e., drilling or seismic exploration) and the location (i.e., Chukchi or Beaufort) The locations and accessibility will be influenced by environmental factors, in particular sea ice. Based on the variability analysis for open-water vessels (Figure 2-9), the Chukchi Sea shows lower variability, and the Beaufort Sea higher variability. This variability can be integrated and compared with projections for likely areas of activity to provide a better estimate of possible constraint for access and operations.

Natural resource development is not the only type of economic activity constrained by ice. Shipping, and in particular trans-Arctic shipping, will be constrained by accessibility. As demonstrated in the 60-day analysis, some areas are projected to be more reliably accessible than others. Projections will need to consider not only the potential growth of shipping, but also the feasibility of the activity. Although issues such as insurance and investment are beyond the scope of the analysis in this report, it is safe to conclude that economic considerations will impact investment behavior. Those considerations depend, in part, on risks associated with ice variability and the potential for damage or incident as well as reliable access. Other considerations include support and response from the U.S. Coast Guard and other vessels of convenience, which could also be constrained by ice conditions and ice-breaking capacity.

The next section considers components and methodology for projecting potential Arctic vessel growth. These include natural resource development, global shipping growth, and new potential for the Arctic as an international shipping corridor.

Chapter 3: Forecasting Oceangoing Vessel Traffic in the Arctic

The extent to which the Arctic will develop into a global shipping route is difficult to predict. Studies such as those by the Arctic Institute maintain that shipping in the region will remain limited and that an Arctic route will never be competitive for international trade. This is a direct response to Chinese assertions that the Arctic presents an opportunity to increase trade networks and to re-route 5-15 percent of China's trade value by 2020.[15] A risk report published by Lloyds and Chatham House, *Arctic Openings: Opportunity and Risk in the High North*, focuses less on the viability of international trade and more on the elements contributing to risk assessments and considerations for the shipping industry. Despite a lengthy list of risks, including infrastructure, insurance, and politics as well as the environmental and economic uncertainties, the report predicts that there will be substantial investment over the coming decade, potentially reaching $100 billion or more. This estimate is uncertain based on high risk-high reward potential, but the report found that the largest drivers and beneficiaries of such investment would be oil and gas, mining, and shipping. [16]

This section on forecasting explores information and reports that discuss growth potential or the specifics of future planned activities that could directly influence maritime activity in the U.S. Arctic. It approaches the issue by looking at shipping possibilities based on estimated growth. These estimates are all contingent upon other issues, such as accessibility due to changes in ice coverage that will be discussed in later sections. This section is broken up into three subsections addressing natural resource development, growth of trade in the Arctic region, and the potential for diversion of vessel traffic from other international shipping routes. These analyses will form the basis for combinations of growth (or the lack thereof) to inform the 10-year projection scenarios.

Extrapolation scenarios

The most straightforward way to assess growth is by extrapolation. By examining existing information—patterns or trends in the number of transits through the Northern Sea Route (NSR) and Bering Strait and the number of vessels operating in the U.S. Chukchi and Beaufort seas—it is possible to extrapolate a very basic growth projection. The annual growth for Bering Strait transits and Arctic vessels was calculated by averaging annual growth between 2008 and 2013, yielding 17 percent for Bering Strait transits and 16 percent for Arctic vessels (Table 3-1). Bering Strait transit records are for total transits where destinations could be the NSR or the North Slope of Alaska. Vessels transiting the NSR are a subset of the total transits and are analyzed separately based on transit statistics from the Northern Sea Route Administration.[17]

The NSR growth is more difficult to extrapolate because of the high relative percent growth over 2009–2013. Instead, an average of 2011–2013 was used (all voyages were in July-November, with the exception of two in 2013 that began on June 28), yielding 41 percent growth per year. The straight, extrapolated growth for 2025 yields 743 vessels transiting the NSR a subset of the, 3,825 transits through the Bering Strait, and 2,068 vessels operating in the U.S Arctic. Although not impossible, this direct extrapolation likely overestimates future vessel traffic growth.

Table 3-1. Increase in vessel activity and trade based on the data cited in the literature review (Annex 1).

Year	NSR transits	Cargo transported through NSR (thousand tons)	Bering Strait transits	U.S Arctic annual traffic
2008			220	120
2009	2		280	130
2010	4		430	160
2011	36	820	410	190
2012	46	1260	480	250
2013	71	1350	440	240
Annual growth rate	+41%	+30%	+17%	+16%

Another approach would be to use similar basic extrapolation for vessel classes under the assumption that it would better represent different commodities or markets. Exploring the expansion of destination traffic for resupply and community support can provide specific categories of vessels operating in the Arctic (Figure 3-1) for use as examples. The average annual growth for cargo vessels and tugboats from 2008–2013 was 17 percent; for tankers, it was 64 percent (Table 3-2). Extrapolation yields 697 cargo vessels and tugs and 14,384 tankers. From these simple examples, it is clear that extrapolation of current growth alone is unlikely to yield viable estimates for 10-year growth.

Table 3-2. Vessel numbers operating in the U.S. Arctic by year.

Year	Cargo & tugs	Tankers
2008	48	4
2009	52	8
2010	67	13
2011	81	24
2012	79	46
2013	106	38
Annual growth rate	+17%	+64%

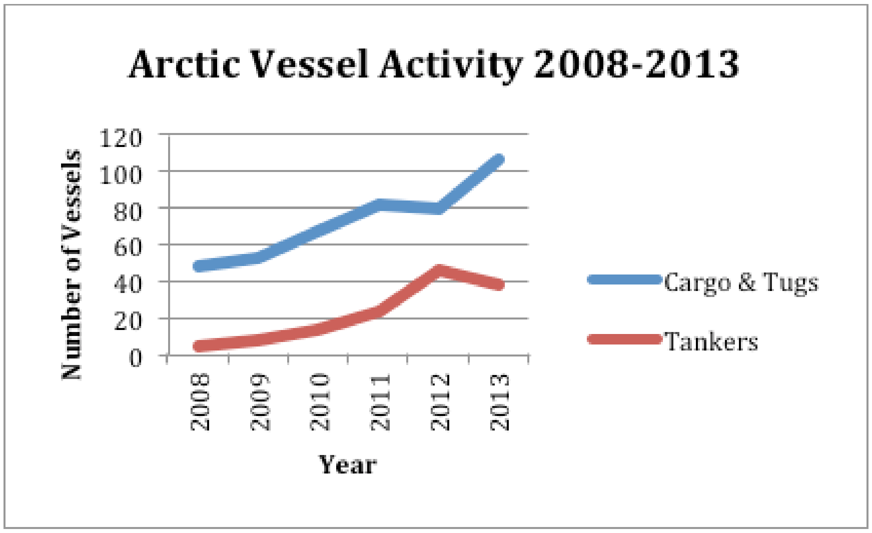


Figure 3-1. Graph of vessel numbers from Table 3-2

Activity-based analysis

To provide more realistic 10-year projections for Arctic vessel activity, factors contributing to growth need to be identified. These factors were divided into three groups: natural resources exploration and development, expansion of destination Arctic vessel traffic (i.e., supporting communities and intra-Arctic resource transport), and Arctic transit traffic diverted from other international shipping routes. These three factors were further broken down based on published projections, recommendations, or probability scenarios along with calculated growth rates based on past traffic data.

Natural resource exploration and development

One of the largest sources of variability in potential vessel activity is related to oil and gas exploration and production (E&P). The number of vessels in the U.S. Arctic increased 32 percent between 2011 and 2012, compared with an increase of only 26 percent between 2011 and 2013. Bering Strait transits increased 17 percent between 2011 and 2012, but only 7 percent between 2011 and 2013.[18] In 2012, the Shell exploratory drilling program used a fleet of 23 vessels to support its activity, which contributed to the increase in activity between 2011 and 2012. This would indicate that the activities of one company operating a modest exploration program could account for half the variability in a given year.

A number of documents explore opportunities available for these types of oil and gas E&P activities in the Chukchi and Beaufort seas. An economic analysis completed for Shell in 2009[19] found that there are a number of opportunities for Outer Continental Shelf (OCS) development.

The two major areas are the Burger Prospect in the Chukchi Sea and the Sivulliq prospect in the Beaufort Sea. This scenario-based analysis estimates that exploration for each of these locations will extend into the 2025 time frame for this study, with the additional possibility of some resource development and production beginning in the Beaufort around 2020 and the Chukchi around 2025. Given that the report was written five years ago, the time frames should be adjusted to reflect new developments in climate trends and in oil and gas market forecasting and development. The exploration plan would assume activity from July to November with one to two drill ships and associated support vessels to complete one to two wells per drill ship. The number of vessels supporting these activities is estimated to be about 20 for Beaufort exploration, which is similar to the number of ships Shell used in the 2012 season and reflected in their preliminary 2014 revised OCS exploration plan.[20]

In 2013, the National Marine Fisheries Service (NMFS) published a draft environmental impact statement for oil and gas activities in the Arctic.[21] They compared a number of different scenarios for exploration and drilling that will inform the scenarios developed for this project. Their report contains five alternative E&P scenarios for the Arctic Ocean. The options range from one exploratory drilling program in the Beaufort and Chukchi up to four drilling programs in each location (for a total of eight programs per year). There is also a focus on the first stage of seismic exploration in these areas, which allows a total of up to six two-dimensional (2D) or three- dimensional (3D) seismic surveys in the Beaufort and up to five in the Chukchi (with only one to occur in ice). The impact statement goes on to expand the detail expected for each type of activity. For exploratory drilling, the expectation is that a fleet of nine vessels would support each drill ship. Two additional vessels, one for support and one for mitigation and monitoring, would support seismic survey vessels. While these estimates are used for planning and impact assessments, they provide a range of possibilities for future oil and gas activities and, more importantly, bound the potential growth assumptions that can be made. They also provide specific requirements for vessels supporting potential activity that are key for comparing current Arctic oil and gas activity to what it could be.

To further explore how these development scenarios and requirements could actually advance, Shell's draft OCS exploration plan for the Chukchi was reviewed. The preliminary revised draft OCS exploration plan submitted by Shell to the U.S. Bureau of Ocean Energy Management (BOEM) lists the vessels and the expected activity for the proposed exploration. Many of the 22 support vessels such as tugs, anchor handlers, and ice management vessels would remain near the drill ship, contributing to on-site activity. However, offshore supply vessels are anticipated to make up to 30 round trips to Kotzebue and/or Dutch Harbor.[22] The plan supports two drill ships with the expectation of drilling up to six exploratory wells. This fits within the NMFS expectations for exploration as well as the projected plan in the economic assessment. Thus, for projections of potential activity, a combination of existing plans and future options will be used.

In addition to exploration phase activity, the production phase for any location should also be considered. Although it is unlikely that locations in the Chukchi Sea will produce oil in the next decade, the Beaufort Sea offers several opportunities as well as continued support for ongoing production. There are a few near-shore production sites in operation in the Beaufort and an additional site scheduled for development in the coming decade. Locations such as the Oooguruk, Northstar, and the Nikaitchuq fields are examples of near-shore oil production facilities supported year-round (Figure 3-2). In the winter, ice roads are used to access the facilities, and in the summer barge vessels serve for resupply. Similar to the already established Northstar production facility, there are plans for a new development on the Liberty Prospect. The environmental impact statement completed for an earlier Development and Production Plan for the Liberty Prospect includes information for similar projects and estimates of associated maritime support activity. According to this comparison, four to five monthly vessel round trips will be required during drilling operations and four to five seasonal round trips during operation and production activities at the Liberty location.[23] In anticipation of at least one additional production site, the projections will incorporate seasonal resupply traffic in near-shore areas of the Beaufort.

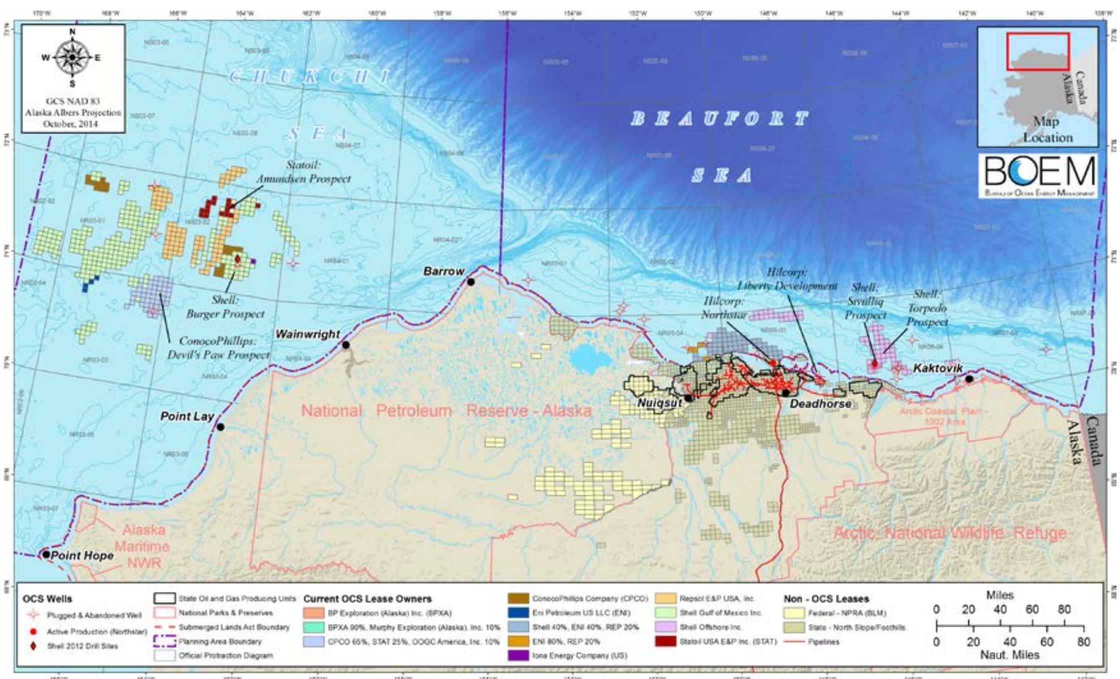


Figure 3-2. North Slope oil and gas lease areas (Map provided by BOEM)

A possible contributor to traffic in the U.S. Arctic is activity in the Canadian Beaufort Sea from resource exploration and production. In 2012, Chevron Canada Limited and GX Technology conducted two seismic surveys of an area east of Kaktovik, delineated in red in Figure 3-3. Although most of the activity appears between the survey areas and Tuktoyaktuk, there are areas of mid-level activity crossing into the U.S. Arctic. Based on an updated oil and gas forecast for the Beaufort Sea prepared for the Government of Canada,[24] resupply to these activities would likely come from a Canadian base, but fuel resupply and arrival and departure of seismic vessels and drill ships would likely come through the Bering Strait given the alternative options for overland resupply or resupply from eastern Canada. Current applications for exploration through 2020 have already been submitted, [25] and the 2013–2028 forecast anticipates activities including drilling and production in at least one additional location. The assumption that some activity, likely a combination of seismic exploration and drilling, in 2025 is applicable for future forecasts, including limited support activity in the U.S. Arctic.

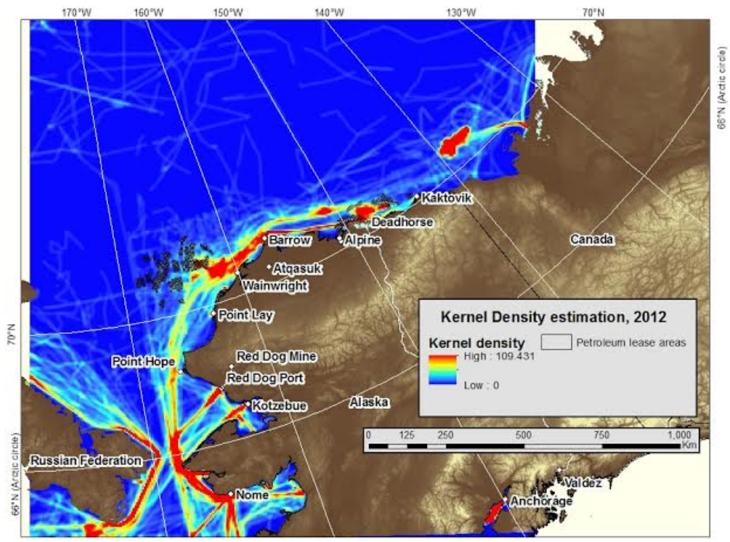


Figure 3-3. Kernel density estimate for vessel activity in the U.S. Arctic in 2012

In addition to offshore oil and gas, there are enormous mineral resources in the U.S. Arctic, including iron, gold, copper, and rare earth minerals. There are plans under consideration for two new mines in the Alaskan Arctic. These plans include the development of a copper mine in the Ambler Mining District, located 180 miles southeast of the Red Dog Mine, and a coal mine on the North Slope south of Point Lay. Production in Ambler would not begin for at least six years, and the coal development is likely contingent on a deep-draft port facility to load and transport the coal by sea. The effects of these developments on maritime traffic over the next decade are uncertain.[26,27]

For this analysis, it is assumed that development of the coal mine south of Point Lay is unlikely to affect maritime traffic in the next decade. While it is possible that the coal could be shipped through the Red Dog Mine port, a timeline for development of the resource has not yet been solidified. The Ambler Mine east of the Red Dog Mine is also unlikely to have a significant impact on maritime traffic in that time frame because it will take at least six years for production facilities to come online. Based on these uncertainties, mineral development in the U.S. Arctic will not be incorporated as a significant driver for increased maritime traffic for this study.

One of the benefits of increased development of offshore resources in the Arctic is the anticipated growth in employment and revenue. The same economic analysis of future development prepared for Shell not only discusses resource development timelines but also projects potential increases in employment opportunities. According to that report, development in the North Slope Borough would generate an estimated 4,500 annual jobs. This represents an average increase of 45 percent in onsite employment. It could also mean a sharp increase in the population of North Slope towns, at least seasonally. According to the U.S. Census Bureau, the current population of the North Slope Borough is 9,686. Thus, if employment were to increase 45 percent, the need for community resupply would likely also increase proportionately. This includes not only supplies flown or trucked in when possible, but also an increase in the number of vessels to resupply these communities. Over the past decade, the population of the North Slope Borough has risen by about 2,500 people. Offshore development has the potential to double that growth in the same amount of time. To account for this additional resource requirement, vessel activity along coastal resupply routes will be adjusted to estimate the likely required growth.

International shipping

The non-resource extraction growth in Arctic ship activity and transit is attributable to two major sources: business as usual (BAU) growth that comes with the development of international trade, and the diversion from other shipping routes, primarily the Suez and Panama canals.[28] In this section, the growth rates of each source are estimated separately to produce the total activity for oceangoing vessels (OGV) through the Bering Strait by 2025.

Business as usual growth

In order to estimate the BAU growth of ship activity in the Arctic region, a literature survey on historic and projected growth of international shipping and regional ship activities was conducted. Ship activity growth was also assessed independently, using regression analysis to validate the aforementioned shipping growth.

One indicator of ship activity growth is the increase in fuel consumption by the industry. The Second Green House Gas (GHG) Study, published by the International Maritime Organization (IMO) in 2009, estimated fuel consumption for international shipping grew from 149 million metric tons (mmt) in 1990 to 277 (mmt) in 2007, translating to an annual growth rate of 3.7 percent (Figure 3-4)[29]. It should be noted, however, that shipping activity recently decreased following the plunge in international trade during the Great Recession and has barely recovered to pre-crisis levels. It is unlikely that ship activity will grow as rapidly between now and 2025.[30]

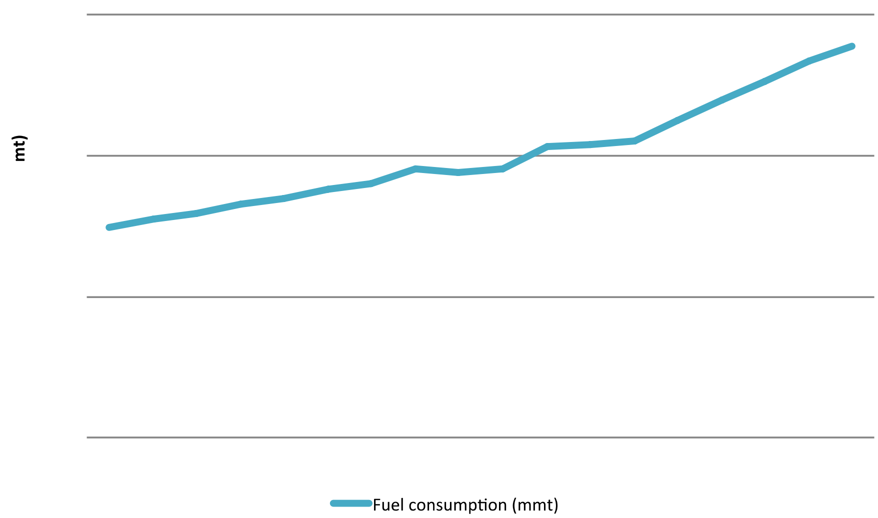


Figure 3-4. Global growth of fuel consumption between 1990 and 2007.

Similarly, the IMO's Third GHG Study, published in 2014, projected that bunker fuel consumption would grow from 250 mmt in 2012 to 280-310 mmt in 2020, depending on the penetration of liquefied natural gas (LNG) and the use of energy-saving technologies. This represents a 1.1–2.7 percent growth rate through 2020. The projection, however, does not assume a frozen technology scenario. The study did build in the efficiency gains that the industry has achieved between 2007 and 2012, which will lower the estimated fuel consumption. After removing the efficiency gains, the rate of annual activity growth would increase to 1.3–3 percent.[31]

Another fuel consumption indicator associated with this study comes from the U.S. Environmental Protection Agency (EPA). When the EPA applied for the designation of the North American Emission Control Area, the agency estimated annual growth in energy use of 3.3 percent in the east and west of Alaska between 2002 and 2020. The real growth rate has been lower than expected amid the financial crisis that slowed the shipping growth in the region.

Apart from the literature review, the growth rate of international shipping was assessed using a regression model that investigated the relationship between the growth of ship activities in ton-miles and the increase in world gross domestic product (GDP) between 2000 and 2013. (The ship activity data comes from the United Nations Conference of Trade and Development,[32] and the world GDP data is from the World Bank.[33]).

As shown in

Figure **3-5**, a strong correlation can be observed between the GDP growth and ton-mile growth, with a coefficient of determination or R^2 close to 0.8. An annual 3.7 percent growth in shipping activity, as shown in the IMO's Second GHG Report, implies a world GDP growth of 2.5 percent. With the global market still struggling to regain its economic footing after the recession, organizations such as the International Monetary Fund (IMF) and Organization for Economic Cooperation and Development (OECD) have lowered their economic forecasts. If the 2.2 percent GDP growth rate through 2025 is used,[34] as assumed by the OECD, the growth rate of shipping would fall to 3.2 percent.

Figure 3-5. Global growth rates of ship activity and world GDP.

The literature review and analysis are summarized in Figure 3-6. That figure shows bounded shipping activity growth that caps at around 3.5 percent and may be as low as 1.3 percent. In this study, 1.3 percent was used as the lower bound, 3.3 percent as the upper bound with, and 3 percent as the central estimate to estimate the BAU growth of the Arctic traffic. Figure 3-7 shows the ship numbers through the Arctic by 2025, using the range of growth rates and assuming no diversion of vessel traffic. The baseline year ship activities between 2008 and 2013 come from Huntington et al. (2015).[35]

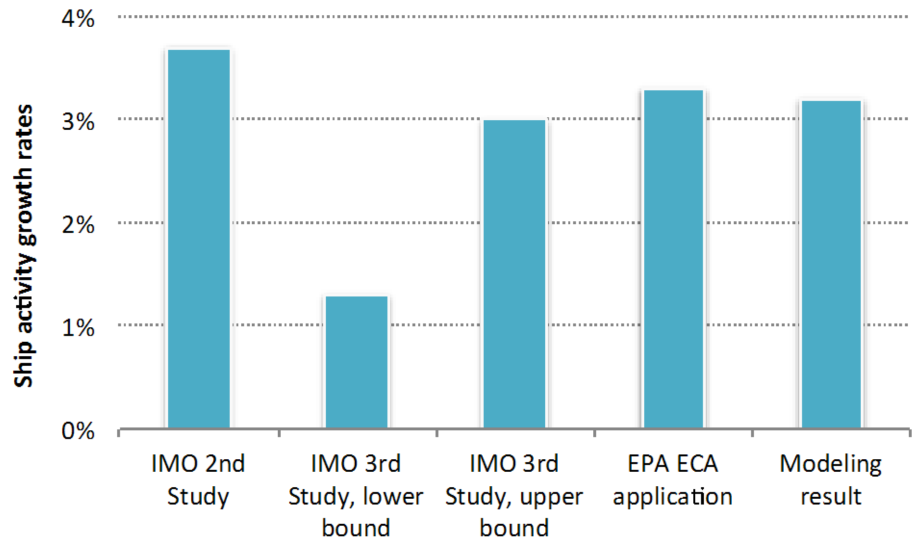


Figure 3-6. Global growth rates in the literature review and modeling.

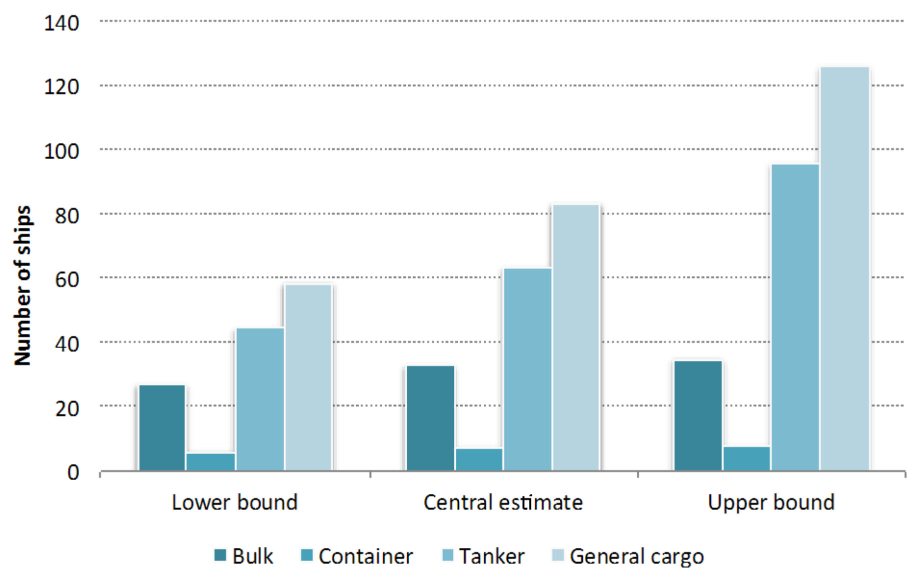


Figure 3-7. Number of ships by 2025 through BAU global growth.

Ship diversion

According to the German news publication Spiegel, and an article by Dr. Vijay Sakhuja, Director of the National Maritime Foundation, many, including Russian President Vladimir Putin, believe that Arctic shipping lanes, particularly the NSR, will emerge as a rival to the Suez and Panama canals. A voyage from Rotterdam to Shanghai via the NSR, for example, would be 22 percent shorter than the current route through the Suez. Navigating the NWP would cut the Suez distance by 15 percent.[36] Similarly, vessels going from the east coast of Canada to Finland through the NWP can save 1,000 nautical miles and load 25 percent more cargo.[37] Other international concerns about the safety of shipping through more traditional routes from threats such as piracy, may also contribute to the decision to divert to the Arctic.[38] It is likely that more vessels will be diverted from the Suez and Panama routes to the Arctic routes under the right conditions.

On the other hand, a transit through the Arctic is not the best fit for many ships that have zero to moderate icebreaking capability. The extra costs in insurance and escort will erode the savings from increased cargo and shorter distances. The savings in energy cost, in particular, will be influenced by forecasts of future fuel costs that are inherently difficult as the decline in crude oil prices in the fall of 2014 have highlighted. In addition, the Arctic will not be open to passage throughout the year. Depending on the ice conditions, ships could traverse the region between July and November, with September and October being the best months for crossing.

Given the economic and seasonal uncertainties, a 2–8 percent diversion rate between July and November was assumed,[39,40] with 5 percent being the best estimate, from the Suez and the Panama canals. Given the current ship profiles traveling across the region, forecasts are limited to four major OGVs: tankers, containers, general cargo and bulk carriers. Many general cargos often carry containers but are not dedicated to container transport and may carry number of other supplies.

Vessel traffic data for the Suez Canal between 2000 and 2013 are from the Suez Canal Authority,[41] while the Panama Canal data were obtained from the U.S. Department of Transportation (DOT).[42] The numbers were broken down by type of ship and month of transit. The average percentage of each month between 2011 and 2013 for the Suez Canal and between 2013 and 2014 for the Panama Canal were chosen to represent the share of each month for ship activity in the two canals (Table 3-3).

Table 3-3. Ship forecasts for 2025 through the Suez Canal and Panama Canal before diversion.

	Tanker	Bulk	General Cargo	Container
Suez Canal	4,424	3,037	865	7,328
Panama Canal	2,308	3,040	0	4,866

Ship traffic was also projected through the Suez and Panama canals in 2025 using the same average growth rate for the past decade. For example, the growth rate of Suez Canal shipping between 2013 and 2025 is assumed to be the same as the growth rate between 1998 and 2013. The expansion of both canals may lead to underestimates in ship activities, but factoring in the slower growth of overall shipping activity in the future may neutralize the underestimation. Figure 3-8 shows the projected diversion for tankers, bulk carries and container vessels from the Suez and Panama canals under three diversion percentage scenarios.

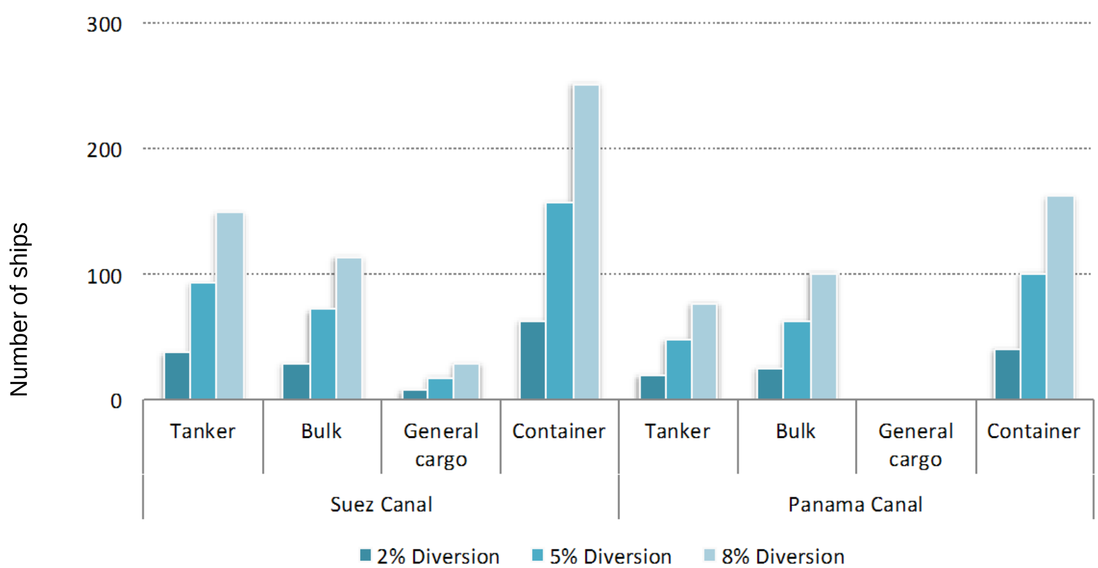


Figure 3-8. Projected potential diversion from the Suez Canal and Panama Canal by vessel type for the months of July through November.

Figure 3-8 shows the ship profile for total ship activities through the Suez Canal and the Panama Canal by 2025 between July and November. Figure 3-9 reports projected ship diversion from the two canals to the Arctic by 2025. August is the month with the highest ship traffic in both canals, representing more than 10 percent of the ship activity for the year. Of note, nearly half of the ships each month are container ships.

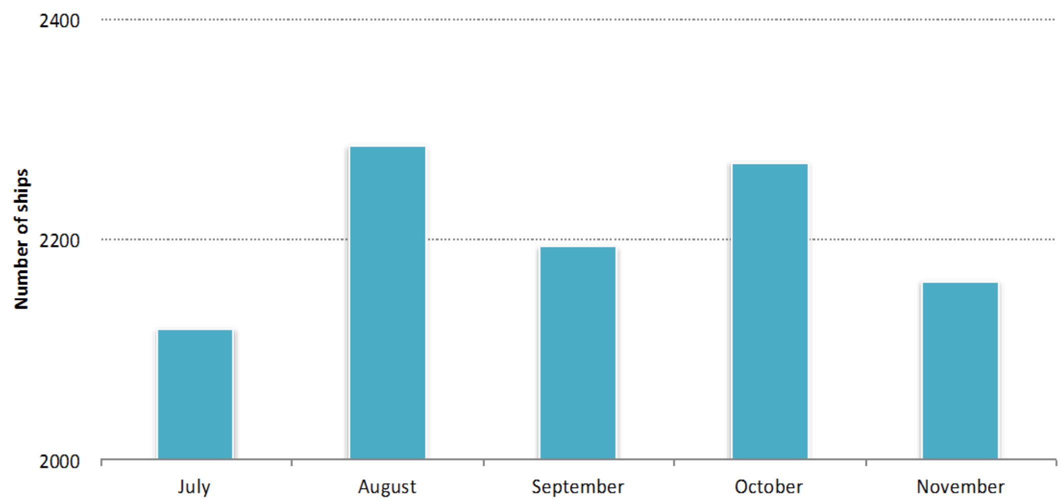


Figure 3-9. Ship numbers through Suez and Panama Canals by 2025, by month.

Table 3-4. Estimated possible ships diverted from Suez and Panama canals by 2025 (central estimate of 5% diversion).

	Tanker	Bulk	General cargo	Container	Total
July	27	24	4	51	106
August	29	27	4	55	114
September	28	27	4	51	110
October	29	29	4	52	113
November	28	28	5	49	108

Combining diversion with growth

By adding the BAU growth and diversion together, it is possible to project ship activity by ship type (Figure 3-10) and by month (Figure 3-11) crossing the U.S. Arctic. This forecasts approximately 750 ships traversing the U.S. Arctic in 2025, or a seven-fold increase from current transits for the vessel types considered. Recognizing that there is a significant uncertainty in terms of ship activity growth in the Arctic, further use of low and high growth rates provide a range of ship numbers as low as 400 and as high as 1,120.

Among vessel types, container ships represent more than a third of total oceangoing vessels (OGV) crossing the Arctic. This reflects the growing share of container ships in global transportation logistics. In September and October, two months when the Arctic is the most suitable for vessel traffic, there could be between 100 and 400 container ships passing through the U.S. Arctic.

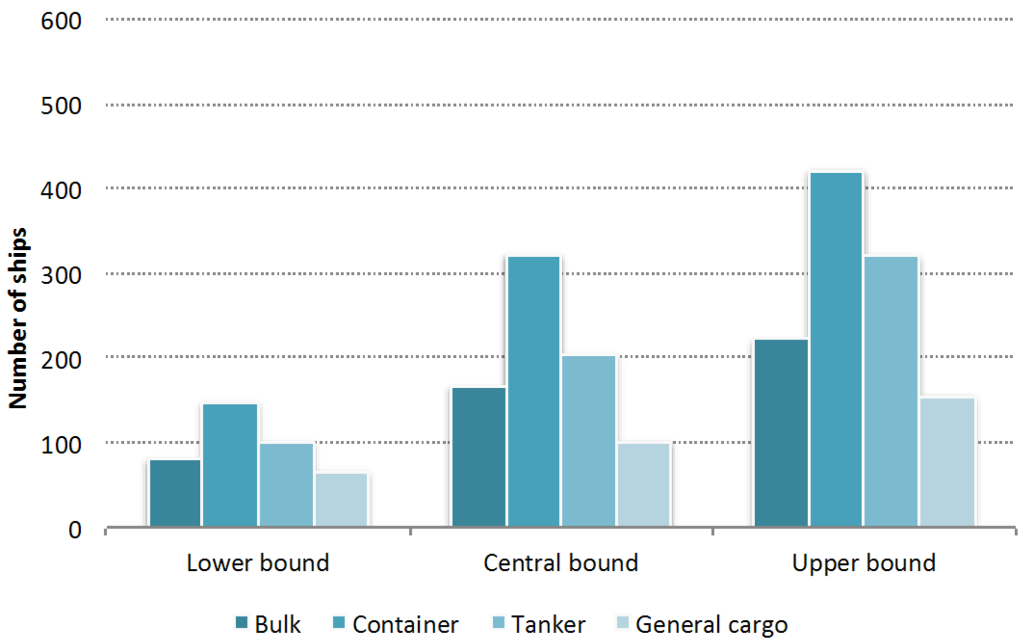


Figure 3-10. Estimated number of diverted ships, 2025.

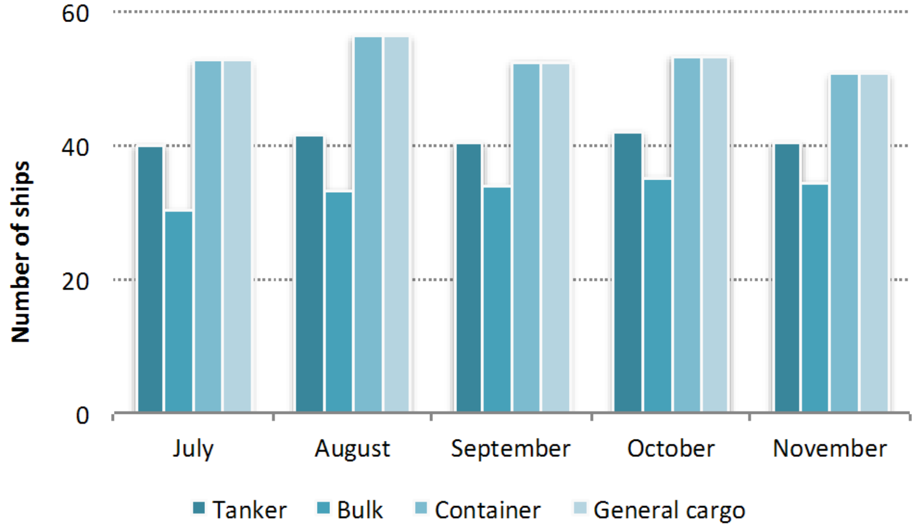


Figure 3-11. Number of ships broken down by month.

Conclusions

Based on the application of various growth and development scenarios, there is considerable variability in potential growth projections. Comparing the growth based on extrapolation to the estimates based on GDP and diversion constrained by time and vessel type, it is clear that straight extrapolation oversimplifies the variables and is not the best proxy for estimating likely potential traffic in the U.S. Arctic within the next decade. Therefore, the GDP-based scenario will be used. Based on global GDP growth, it is more likely that the rate of increase in activity is within the 1–3.5 percent range and that diversion of vessels from other international routes will increase gradually, possibly between 2 and 8 percent by 2025. A central estimate combining these two yields approximately 710 vessels in 2025 (Table 3-5).

Table 3-5. Vessel activity growth estimates for the U.S. Arctic in 2025.

	Lower bound	Central bound	Upper bound
BAU annual growth	1.3%	3%	3.5%
Annual diversion	2%	5%	8%
Natural resources	10%	25%	50%
Combined vessels in 2025	350	710	1150

The variability associated with resource extraction on the North Slope could create additional uneven growth and spikes in traffic from year to year between now and 2025. The exploration in 2012 boosted U.S. Arctic activity by 10 percent, or half the growth between 2011 and 2012. Depending on the number of exploration programs occurring in any given year, an additional 20 to 100 vessels could be active on the North Slope, contributing multiple trips (30 per program) for support and resupply. The next section of this report examines different combinations of activity and growth scenarios to provide insight into which areas of the U.S. Arctic are likely to experience the greatest increase in vessel activity.

Chapter 4: Other Considerations

A large number of variables influence vessel growth in the Arctic, not all of which could be integrated into this analysis. This section surveys three categories of such factors: economic drivers, other commercial and safety considerations, and geopolitical variables.

Economic drivers

The previous section discussing economic drivers focused on three major categories to estimate growth. Other considerations affecting growth were not incorporated into the analysis because of the difficulty associated with quantifying their potential influence.

The focus of this report is on growth in the U.S. Arctic. For that reason, estimates for natural resource activities were constrained to the western Alaska and the North Slope, and the Chukchi and Beaufort seas, with limited considerations for activities in the Canadian Beaufort. International resource development will also affect U.S. Arctic vessel traffic.

Ultimately, the number of vessels that operate in this region will be dependent upon the success of resource extraction for minerals and oil and gas. The timeline for these operations depends on a number of factors, including regulatory frameworks, permit requirements, investment and accessibility, in addition to international market drivers. Even if the development of resources is successful and profitable, the products may not be shipped through the Arctic depending on factors such as financial agreements, insurance premiums, the international regulatory framework and ultimately the profitability of trans-Arctic shipping in comparison with other international routes. Considerations such as piracy along the East Asia to Europe route via the Suez Canal are also not directly considered as a driver favoring potential Arctic transits.[43] This component would likely fall under a larger risk assessment for insurance considerations that impact Arctic shipping. Changes in capacity for the Panama Canal after completing the expansion in late 2015/early 2016 may also influence traffic by facilitating larger cargos, which could negate the competitive advantage of the shorter route. Although these factors are important considerations for projecting future growth, underlying uncertainties makes them difficult to quantify and therefore integrate into growth scenarios.

Climate change will also determine the accessibility, both geographic and temporal, of Arctic routes. Climate change may drive additional need for marine commodity transport to northern communities by reducing alternatives. A recent publication suggests that the overland winter transportation corridors used for trucking goods to remote communities may be adversely affected by warmer, shorter winter seasons, reducing overland accessibility by 11 to 82 percent.[44] These estimates are for the 2045-2059 timeframe, and so difficult to apply to the 2025 projection scenario. If there is a reduction in accessibility overland, it will likely require additional vessel resupply activities impacting the overall amount of vessel traffic in the U.S. Arctic.

Some of that demand for transportation and resupply by vessel could be supported by development of ports either in the Arctic or near the Arctic (e.g., in the Aleutian Islands). At least one Aleutian Island port, Port of Adak, is considering the potential for boosting trade by creating a container hub servicing the Great Circle Route as well as potential trans-Arctic routes. If the commercial commitments are made to the facility, it could be completed by the end of the next decade (2030), although a realistic best-case scenario would be ten years to build facilities. Once functional, there is an estimated potential for 250,000 20-Ft Equivalent Unit (TEU) containers in annual throughput, which could equate to an estimated 150 additional Arctic transits.[45] There is a related proposal for an Arctic marine corridor to serve as a designated shipping route through the U.S. and Canadian Arctic. With limited probability of development within the next decade, it is unlikely to significantly impact the 10-year projections. However, this kind of proposed infrastructure development could influence longer-term growth.[46] An element of this marine corridor would be one or more Arctic deep-water ports. While the potential location and feasibility of such a port has been a heated topic of discussion,[47] [48] reasonable timeframes for development are highly uncertain and unlikely to influence the 10-year projection.

Other commercial and safety considerations

The focus of this report is on commercial shipping through the U.S. Arctic, but other activities affect total vessel activity. Passenger vessels, including adventure tourism (small sailboats and yachts) as well as cruise ships, represent a small but growing number of vessels. For the NWP, ecologic tourism represents a significant number of complete transits, with 25 in 2013. Cruise companies have shown a small but growing interest in the Arctic, with one to four vessels crossing the NWP each year.[49] Growth projections will use baseline vessel activity for current years, and include cruise ships adventure, and ecologic tourism. Variability in the cruise industry can be quantified based on current numbers, but it is unclear how that growth will change in the coming decade. Fishing will provide an additional source of vessel activity. There is currently a moratorium on commercial fishing in the U.S. Arctic, which may be extended into other Arctic national waters in the near future.[50] This analysis assumes that there will be no additional fishing activity, including traditional whaling and other subsidence fishing, beyond that already captured in the baseline vessel analysis.

An important factor to consider when estimating growth or activity is the capacity for emergency response and vessel escort. Based on the current U.S. Coast Guard Arctic Strategy[51] and Arctic Shield,[52] there is no anticipated increase in Arctic assets available to support increased vessel activity, as confirmed at a recent Congressional hearing that denied funding for a new polar icebreaker.[53] Based on this information, projections will not incorporate increased U.S. Coast Guard or research vessel presence in the U.S. Arctic. This does not rule out additional assets for the Russian Arctic, particularly from a growing Russian icebreaker fleet, which may facilitate additional shipping through the NSR. An additional planning element for the region that could influence growth is the creation of an Arctic Waterway Safety Committee to set U.S. Coast Guard-recognized safety standards for the region. This group will engage the maritime industry in promoting safe vessel operations and developing best practices for Arctic navigation. These improvements could promote additional growth by removing existing barriers to vessel activity.[54] Those impacts have not yet been quantified and so are not directly incorporated into the projections.

Geopolitical variables

Global politics, policies, frameworks, and codes will also influence future vessel traffic in the U.S. Arctic. There are two major international legal regimes influencing Arctic maritime activity, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and the International Code for Ships Operating in Polar Waters (Polar Code) developed under the auspices of the International Maritime Organization (IMO). Currently, all Arctic nations with the exception of the United States are party to the UNCLOS and the U.S. adheres to the vast majority of UNCLOS as a matter of customary international law.

For the U.S. Arctic, under UNCLOS, all vessels have the right to engage in innocent passage through the territorial sea and high seas freedoms on the high seas, and so this law should not affect commercial shipping activity in the U.S Arctic. UNCLOS may, however, impact natural resource extraction in the U.S. Arctic and in other parts of the Arctic beyond the exclusive economic zone (EEZ) on the OCS. Any development of outer continental shelf resources by the U.S. or others could affect the U.S. Arctic through transport of materials to other foreign markets, increasing vessel activity in the Beaufort, Chukchi and Bering Seas. The Polar Code sets standards for construction and operation, including vessel planning and environmental concerns such as the discharge of oily water. These regulatory requirements could affect the accessibility of the Arctic for vessels that do not meet the Polar Code's more stringent requirements. It is unclear at this point whether the Polar Code will directly impact development in the U.S. Arctic and as such its impacts are not included in projection scenarios. The implications of these international regimes are complex and nuanced and should be more thoroughly analyzed for future projections incorporating a wider range of variables.

In addition to laws and policies, international politics can impact Arctic activities. For example, the economic sanctions imposed against Russia by the United States and the European Union as a result of its intervention in Ukraine is impacting the Russian economy.[55] Such restrictions can negatively impact resource extraction and investment as well as transfer of technologies that support resource development. The impacts of such sanctions on the Russian Arctic, and, by extension, the Bering Strait are unknown at this time.

Summary

Although difficult to quantify, these factors will impact U.S. Arctic vessel activity over the next decade. Some of these uncertainties are embedded within and will be reflected by the quantitative vessel projection scenarios introduced in the next section. As information on the impacts of the more uncertain variables becomes available, it should be accounted for in future scenario estimations.

Chapter 5: Vessel Projections

Vessel projections are compiled based on possible scenarios for global economic growth, vessel diversion, and natural resources exploration and production. The scenarios presented in this section are based on a variable set of assumptions. Generally speaking, these scenarios assume: 1) There may not be a U.S. Arctic deep-water port available in the next decade; 2) No increase in military presence or U.S. Coast Guard assets to the region; and 3) Numbers for research vessels, cruise ships and adventure/ecologic tourism will remain consistent with 2013 levels. Unless specifically stated, it is assumed that oil and gas development activity remains consistent at a 2011 level, which generally includes some seismic exploration and production activities but no active drilling programs. Lastly, activity from the Red Dog Mine will be held at a constant level, reflecting activity levels over the past five years and the forecast for continued steady production at current levels.

The projections are separated into three general categories of growth. The first is based on BAU growth reflecting the estimated growth in GDP and the associated growth in global trade. The second type of growth is based on the assumption that some international vessel traffic will divert from the Suez and Panama canals in favor of Arctic shipping routes. The third is based on the assumption that oil and gas exploration and production will increase in the next decade. For each type of growth, low, medium, and high scenarios are explored.

To demonstrate the impacts of each of these variables, the July through November 2011 activity map will be used as a baseline map with a general correction applied reflecting the activity in 2013, to estimate activity for scenarios where no additional oil and gas activity is assumed. This correction is needed because data for the full five-month Arctic shipping period were not available in 2013. The July through November 2012 vessel distribution map will be used as the baseline map for some assumptions including oil and gas development. Vessel activity occurring in 2012 meets the low growth rate assumption for oil and gas exploration and production.

Methodology

The methodology for this analysis is based on three major assumptions: first, BAU growth can be uniformly applied to the general region; second, 90 percent of vessel diversions from other international shipping lanes will use the NSR, not the NWP; and third, oil and gas exploration will occur in the Chukchi or Beaufort seas as estimated in the NMFS Draft Environmental Impact Statement, the BOEM draft Supplemental Environmental Impact Statement[56] for the Chukchi Sea, and be constrained generally to current leases. These assumptions are based on the best available information and serve only as potential scenarios, not predictions for the future.

The Study area has been divided into five general sections: 1) the Russian Arctic 2) the U.S. Arctic below the Bering Strait, 3) the North Slope community resupply route, 4) the NWP, and 5) the NSR (Figure 5-1). These areas were defined based on existing vessel data from 2011 and the voyage of the Nordic Orion in 2013.

BAU growth will be applied to all areas except for the Red Dog Mine, depicted in Figure 2.5, which is assumed to have a constant level of traffic through 2025, and the offshore North Slope, which is assumed to be affected primarily by oil and gas and will be held at the constant 2011 levels and includes the area defined as the NWP.

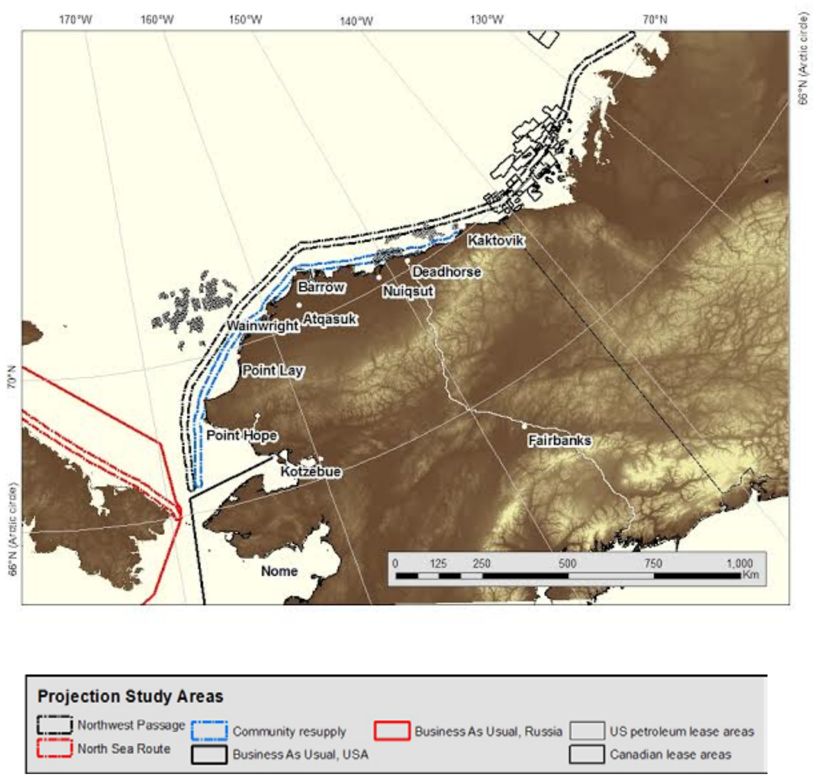


Figure 5-1. Map of study areas and general study regions.

The application for diversion of traffic will be based on vessel types and likely capacity of the Arctic shipping routes. For this analysis it is assumed that 90 percent of all cargo, bulk, and tanker vessels will go through the NSR and utilize the western Bering Strait. All container vessels will also use the western Bering Strait. The eastern Bering Strait and defined NWP are assumed to host only 10 percent of the diversion traffic from tankers, bulk and cargo vessels. These vessels will likely transit farther from shore than community resupply ships and tugs, and their transit path is modeled based on the path of the Nordic Orion in 2013.

Oil and gas activity will be constrained to the lease areas and a general attempt will be made to locate drilling operations either in areas that have known discoveries, or in prospective areas that are under lease. This study will use the Burger Prospect, the Devil's Paw Prospect, and the Amundsen Prospect to approximate possible oil and gas exploration and production scenarios. These examples do not suggest that this is where activity will occur, but rather a scenario where activity could possibly occur. The NMFS has outlined its estimates[57] for drill ship support, as has Shell in its Draft Exploration Plan 2014.[58] These will be used to guide the assumptions for vessel types and numbers. Since drilling operations require many types of support vessels, three assumptions will be made: 1) the drill ships, ice breakers, and general support vessels will remain near the location of the test well; 2) supply vessels will make trips between the nearest North Slope towns; and 3) additional trips will be made by tanker vessels through the Bering Strait throughout the season to support the project. Based on these, different growth assumptions will be used for the offshore North Slope, community resupply, and the NWP.

All growth components will use the same 5 km cells to average activity. Polygons representing each of the 5 areas will be created, which will allow different growth assumptions to be applied to different areas. Each projection scenario will outline the assumptions for that scenario and include maps demonstrating the impact of different growth possibilities.

Business as usual scenario

The business as usual (BAU) scenario assumes growth based on the GDP estimates from Chapter 3. Estimates applied a 1.3, 3.0, or 3.3 percent annual growth rate to the vessel numbers from 2013 provided by the U.S. Coast Guard and available in the literature review in Annex 1. For these assumptions, annual growth rates were applied only to container vessels (i.e. general cargo vessels carrying containers, or container class vessels), general cargo vessels (which includes bulk vessels not going to the Red Dog Mine), tugs, and tankers. Other vessel classes including, research (both academic and natural resources), adventure/ecologic tourism, government, and unknown were held constant based on current vessel numbers. Cruise vessels were treated as a special case, where the low and mid-range estimates assume four cruise ships and the high estimate assumes six vessels for the season. These numbers are based on a combination of patterns for the past five years and general expectations for limited cruise traffic in the U.S. Arctic (Table 5-1).

The estimated number of Bering Strait transits is based on the average relationship between number of vessels and number of Bering Strait transits for the past six years. Some years there are more vessels than transits, suggesting one-way voyages, and some years there are more transits than vessels, suggesting multiple trips. The broad assumption is that the number of transits equals twice the number of vessels (2.09 times). This should generally account for those vessels that make multiple trips and one-way passages.

Table 5-1. Scenarios for Business as usual growth based on GDP.

Business as usual			
Growth scenario	Low (1.3%)	Medium (3%)	High (3.3%)
2025 vessels	268	305	318
2025 transits	536	610	636

To apply these growth scenarios to the existing 2011 baseline map, three polygons were created. One polygon encompassed areas for the west Bering Strait and Russia, one polygon encompassed the Bering Sea south of the Bering Strait up to Kotzebue, and the final polygon encompassed the near shore resupply route for the North Slope. This route is based on the transit path used by tugs and barges with a 5 nautical miles (nm) buffer, creating a 10 nm general shipping lane (Figure 5-1).

The projections for this scenario use a consistent scale bar that holds values constant across all four maps. This means that the values associated with each color can be compared across maps. For Figure 5-2, red indicates high values equivalent to 62 km or more of track line per 5km square area. This means that a total distance of 62 km or more is traveled by all vessels within each 5 km square. The differences in these maps are very subtle which is expected given that the difference in growth between scenarios is only 2 percent between low and high and less than 1 percent between medium and high.

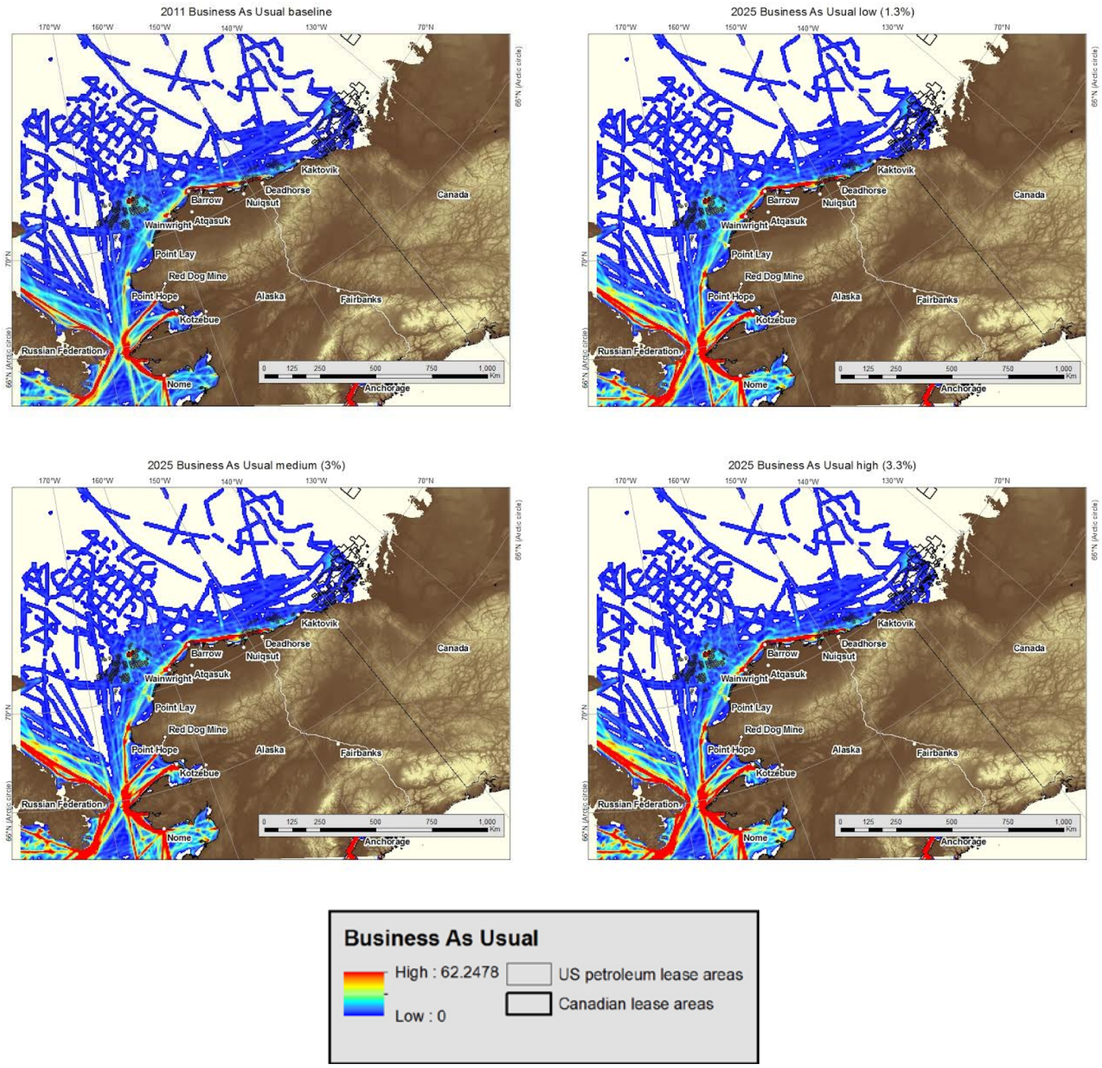


Figure 5-2. Business as usual growth scenarios showing the 2011 baseline and low, medium, and high projections for 2025.

Vessel diversion scenario

Vessel diversion assumes varying rates for vessels electing to use Arctic shipping routes in favor of either the Suez or Panama canals. This diversion is based on projected July-November passage trends for the two canals. Since the NSR is more established with lower variability in ice coverage, it is assumed that 90 percent of the diversion traffic will use this route. The NWP is more constrained by ice and seasonal variability, less developed than the NSR, and has had only one complete commercial transit in both 2013 and 2014. Based on this, the diversion scenario assumes only 10 percent of diverted vessels will use the NWP and container vessels would not be included. While this may seem high given the current annual commercial NWP traffic, the low scenario projects only 12 vessels, which is about twice the current traffic when cruise vessels, research vessels and icebreakers are considered. There is also uncertainty regarding the feasibility of the NSR as a container vessel route. To account for this, two scenarios will be shown, one with container diversions and one without (Table 5-2).

Table 5-2. Diversion scenarios for the NSR and NWP with and without containers based on low, medium, and high diversion.

	Diversion for NSR			Diversion for NSR no Containers			Diversion for NWP		
	2%	5%	8%	2%	5%	8%	2%	5%	8%
Tankers	51	127	203	51	127	203	6	14	23
Bulk carriers	48	121	193	48	121	193	5	13	21
General cargo	6	16	26	6	16	26	1	2	3
Container	103	258	413						
Total	**209**	**522**	**835**	**106**	**264**	**422**	**12**	**29**	**47**

To apply the diversion to the maps, two additional lanes were identified. The first is the NSR transit lane that follows the general path of offshore traffic branching from the Bering Strait up towards the Russian Arctic. The second is the NWP transit lane. This lane follows the route taken by the M/V Nordic Orion in 2013 and assumes a 5 nm buffer, creating a 10 nm sea lane Diversion calculations for the NWP transit lane begin just north of the Bering Strait because vessels could have destinations or origins from either the west or the east Pacific. These diversion scenarios also assume a general BAU medium growth rate of 3 percent.

For this set of projections, the same scale is used as for the BAU projection figures. The high value is equivalent to 62 km per 5 km cell. Figure 5-3 shows the difference between low, medium, and high scenarios with and without container vessel diversion through the NSR. The comparative growth in NSR traffic is the most apparent, as are differences between low and high NWP scenarios. Some differences are subtle which is based on the difference between total numbers of vessels. For example, the low diversion with containers is similar to the medium diversion without containers (209 versus 264 vessels) and medium diversion with containers is similar to high diversion without (522 versus 422 vessels). In contrast, high diversion with containers is nearly twice the high diversion without, which will be more apparent in figure comparison.

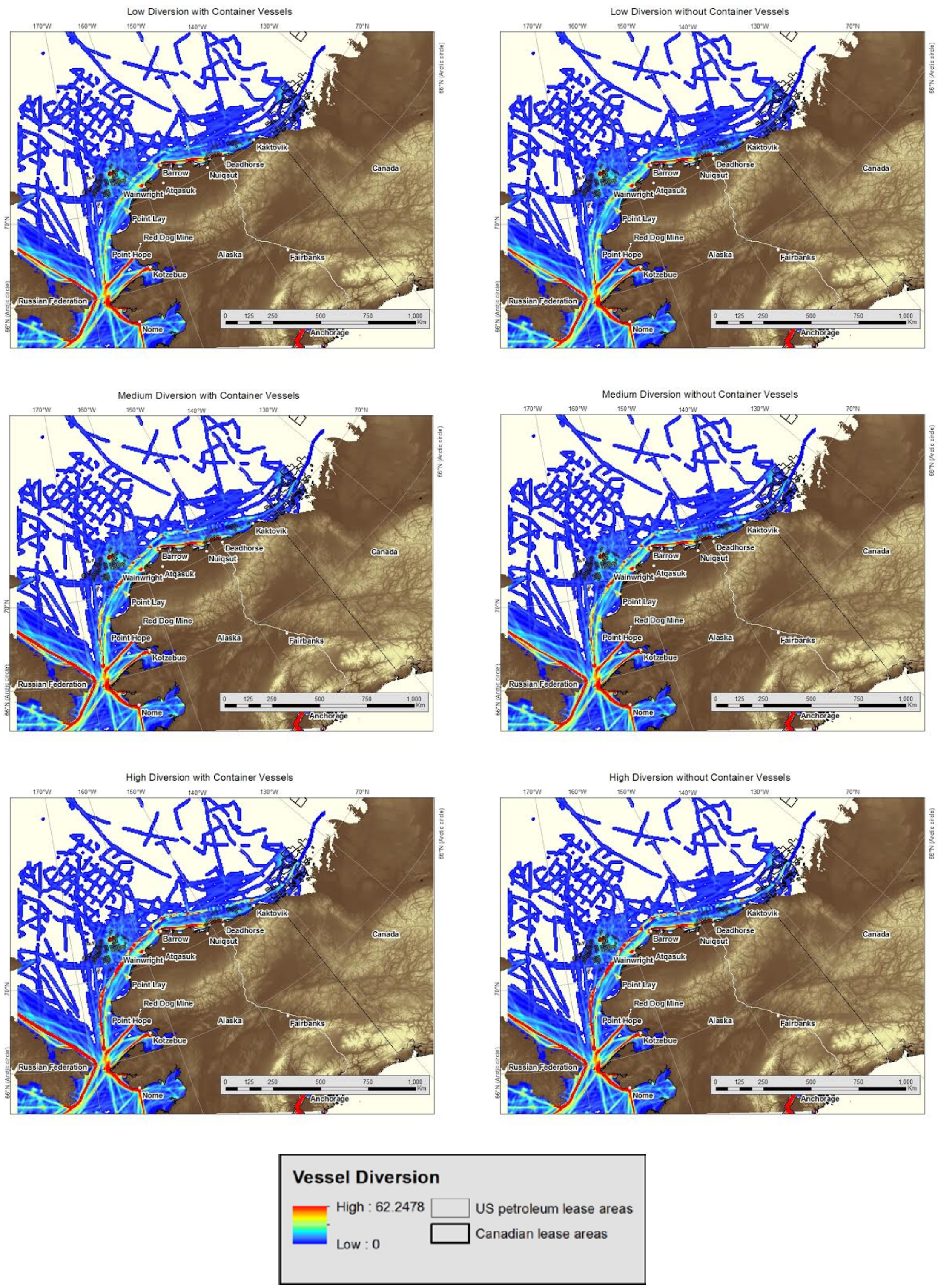


Figure 5-3. Vessel diversion scenarios for the NWP and the NSR; left represents diversion with container vessels and right represents diversion without container vessels.

Resource exploration scenarios

This scenario assumes only exploration activities for the Chukchi Sea including seismic and geotechnical surveys, drilling, and support activities and does not assume development and production activities in the Chukchi Sea during the ten-year period. Resource exploration uses the both the 2011 and 2012 KDE vessel activity maps as its baselines depending on the projection scenario (Tables 5-3 and 5-4). This includes the assumption that the Shell drilling project split its exploration efforts between the Beaufort and the Chukchi seas with approximately 10 vessels operating in each location. This allotment is consistent with the nine support vessels per drilling ship estimate used by NMFS in their Draft EIS. It is assumed that the area surrounding these activities is the general area in which future operations would occur. Additional activity projection use areas where there are existing leases for exploration. This is not an anticipation of definite future activity, but rather the use of probable locations as examples to support the projection scenarios.

Scenarios for seismic exploration will use the NMFS estimates for three vessels per operation, one seismic and two support vessels. It is assumed that this would represent 30 percent of the activity to support drilling. Scenarios also assume that seismic exploration will be limited in scope to a general area of a specific lease block similar to what would be used for drilling. In Shell's preliminary 2014 Exploration Plan, their ice management vessels are assumed to operate within a 17-26 nm reconnaissance zone surrounding the drilling platform; the assumption is that seismic operations would occur over a similar area.

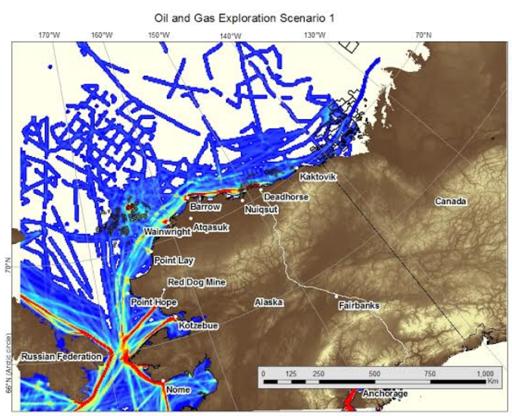
Four scenarios will be explored for oil and gas exploration with the first two representing low exploration cases reflecting activity in 2011 and 2012. The first is no exploration, which is represented by the KDE map for 2011. The second is light exploration activity with one drill program in the Chukchi Sea and one in the Beaufort Sea, represented by the 2012 KDE. The third, medium exploration activities, assumes seismic surveys in the Beaufort Sea represented by three vessels and two drill programs in the Chukchi Sea. The fourth, high exploration activities, assumes three drill programs in the Chukchi Sea, one drill program in the Beaufort Sea, and one seismic program. All oil and gas scenario projections assume BAU constant of medium (3 percent) growth and low diversion (2 percent) for both the NWP and NSR without containers (Figure 5-4).

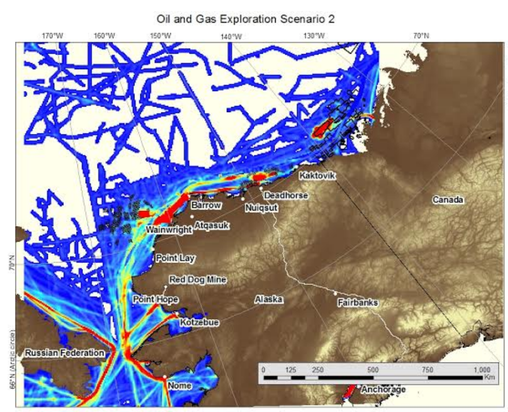
Table 5-3. Oil and gas activity scenarios and baseline maps.

Location Activity			
	Chukchi	Beaufort	Baseline activity map
Scenario 1	No additional programs	No additional programs	2011 vessel activity
Scenario 2	1 drill program	One drill program	2012 vessel activity
Scenario 3	2 drill programs	One seismic program	2011 vessel activity
Scenario 4	3 drill programs	One seismic and one drill program	2012 vessel activity

Table 5-4. Vessel number assumptions for oil and gas activity scenarios.

Vessels operating in 2025		
	Chukchi	Beaufort
Scenario 1	7	7
Scenario 2	17	17
Scenario 3	32	10
Scenario 4	42	20





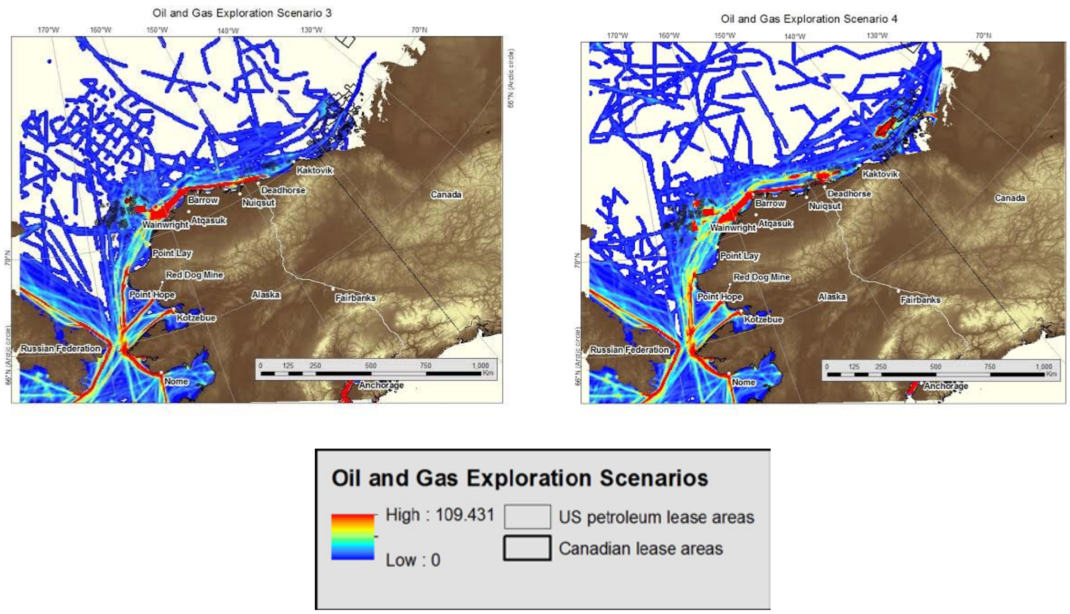


Figure 5-4. Oil and gas exploration scenarios for the Chukchi and Beaufort seas.

A fifth natural resources scenario was explored that would incorporate some of the variables incorporated into the November 2014 BOEM Draft SEIS for the Chukchi Sea Lease Sale193 area (Figure5-5). The draft scenarios in this SEIS are based on some aggressive assumptions, including no delays in construction, regulation, litigation, or funding, which would enable a wider range of activities than assumed in the first four scenarios for exploration. This scenario has up to 40 wells drilled in the exploration phase that could occur between 2018 and 2024. These would be from either mobile offshore drilling units (MODUs) or jack-up rigs, a floating barge fitted with long support legs that can be raised or lowered to be able to operate in shallow water, with the possibility of the installation of one gravity based platform by 2025 and drilling of an additional three delineation and service wells. This activity would be supported by a number of vessels which could make up to three trips per week from Barrow or Wainwright. This scenario also assumes the construction of a new shore base for offshore operations as well as construction of offshore pipeline to support production wells. Since of the complexity of these development variables, creating a visual representation of this scenario was not possible within this study. The projections presented in scenarios one through four rely on extrapolations of current exploration activity, which limited the ability of this study to reasonably project transit patterns for activities not yet underway.

One final projection scenario was explored that combines higher growth and activity possibilities from all three growth elements. Although this scenario is less likely than a more moderate one, it is important to evaluate the potential impacts if all growth factors were to combine. This projection assumes Scenario 4 oil and gas exploration activity, BAU high growth, high NWP diversion, and high NSR with container diversion. It is compared with the Scenario 1 for oil and gas exploration that assumes no change in activity from 2011. The change in activity is most apparent on the U.S. North Slope and areas north of the Bering Strait where not only oil and gas activity impact vessel transits, but the addition of NWP as a new transit path is clearly seen in the bifurcation just north of the Bering Strait and the increase in offshore transit traffic not associated with near shore community resupply.

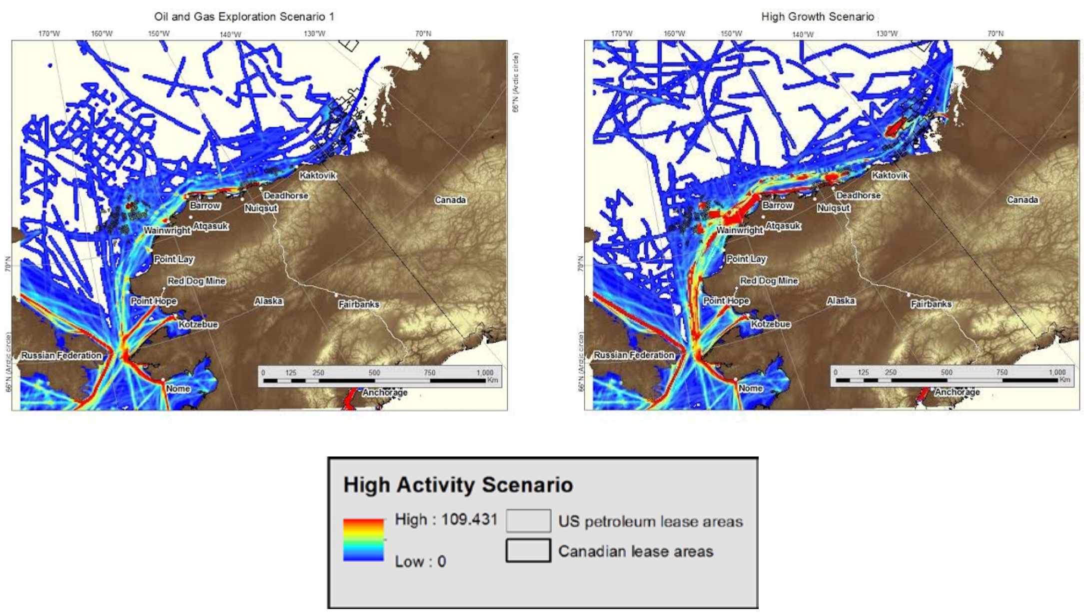


Figure 5-5. Combination of high growth vessel activity scenarios for 2025.

Additional factors

The projections above consider possible growth components that may influence vessel activity in the U.S. Arctic. Environment and infrastructure are among the other factors that could affect vessel activity. To further explore these issues, a comparison was done between Scenario 4 resource exploration incorporating medium BAU growth, low diversion for both the NWP and NSR without containers, and the modeled 60 day accessibility for vessels assuming average low to mid climate forcing (RCP 4.5) for 2021-2030. The full 60-day accessibility study is shown in Figure 8, Chapter 2. Based on the results (Figure 5-6), it is likely that open-water vessels will have more than 60 days of accessibility for the lease areas as well as near shore shipping and the U.S. Arctic portion of the NWP. This comparison is important to demonstrate not only the ability to project possible vessel activity but for those activities to actually take place based on environmental constraints and accessibility.

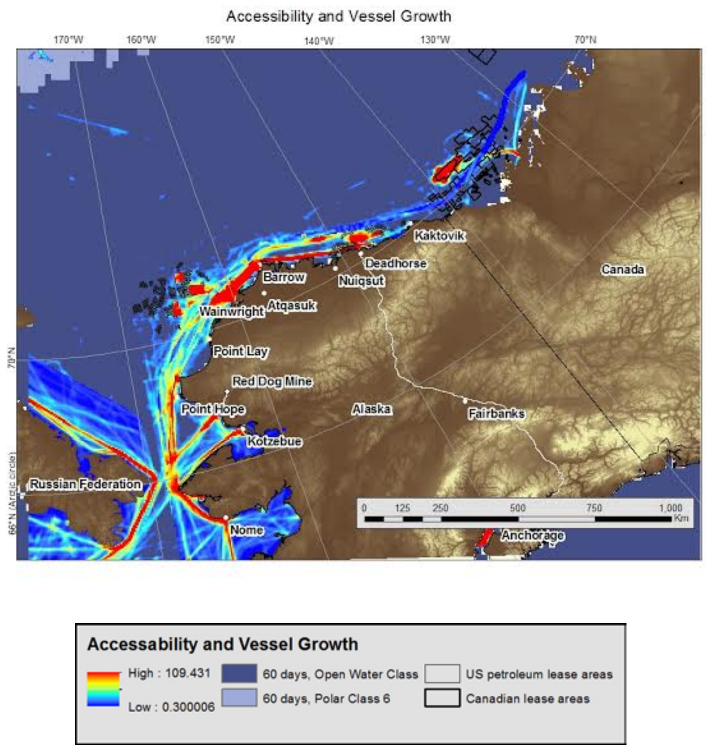


Figure 5-6. Scenario 4 resource exploration in 2025 combined with 2021-2030 climate model (RCP 4.5) for 60 or more days of accessibility.

A similar comparison to Figure 5-6 can be done using the same Scenario 4, but taking into account the variability associated with 2011-2030 modeled average accessibility. This comparison used the variability for open-water vessels under the low to mid climate forcing assumption (RCP 4.5). It assessed accessibility for open-water vessels because the majority of vessels engaged in resources exploration and production are open-water class (Figure 5-7). The variability is represented by the standard deviation of the days of accessibility projected by the model over 20 years (2011-2030). Average accessibility and variability are presented in full in Chapter 2, Figures 2-7 and 2-9. Comparing accessibility variation and activity projections shows that the lease areas in the Chukchi have increasing variability with increasing distance from shore. There is higher variability for the Beaufort Sea, likely impacting offshore exploration in the U.S. and Canadian Beaufort Sea and accessibility to the NWP. From this comparison, it is clear that projected vessel activity depends heavily on the yearly sea ice and weather conditions for the Arctic. It is more likely that some years will have increased accessibility than other years, which is an important consideration for planning exploration or shipping activities.

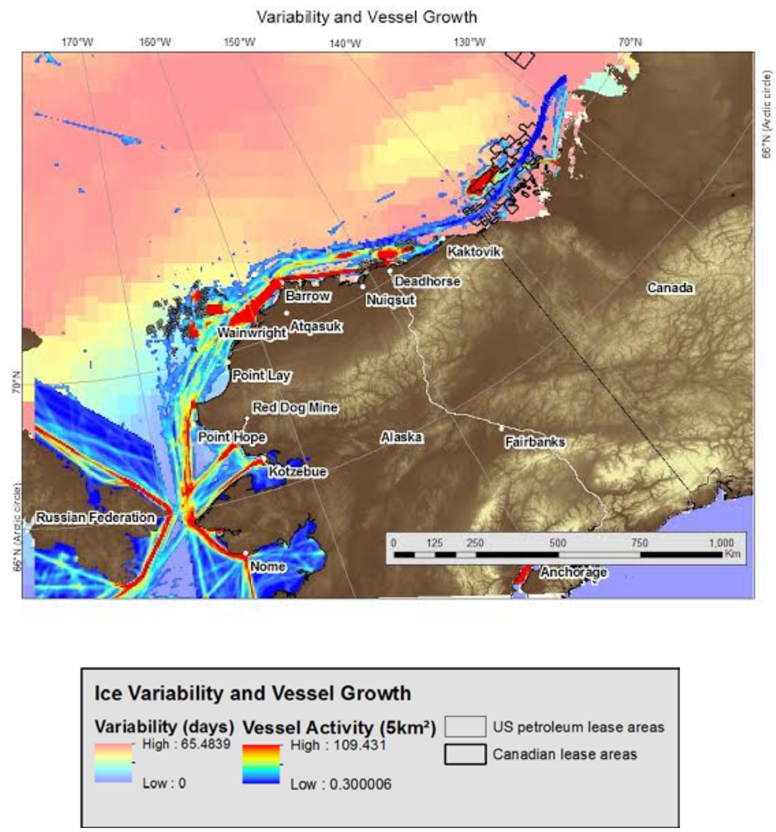


Figure 5-7. Variability represented by standard deviation in days for open-water vessel access on the U.S. North Slope for 2011-2030 under low-medium climate forcing (RCP 4.5).

In addition to environmental factors like sea ice, there are other risks associated with navigation in the Arctic. One of those is the availability of up-to-date nautical charts. The Office of Coast Survey for the National Oceanic and Atmospheric Administration ranked existing charts by level of confidence. Those areas in green are areas that have been recently surveyed and have charts that are up to date based on current multi-beam standards. The yellow, orange, and red areas indicate decreasing confidence in the available charts. Figure 5-8 shows that the majority of the North Slope, including both the inshore shipping lane and the potential NWP lane are generally within areas that are yellow, indicating reasonable confidence in the available charts. The figure also shows areas of incidents for vessels (i.e., collisions, groundings, mechanical failure, and environmental), indicated by the pink markers for the combined years of 2011-2013. These incidents show some clustering around high use areas like Barrow, Wainwright and Prudhoe Bay.

Lastly, a 260nm search and rescue (SAR) radius from Barrow has been added to demonstrate the limits of a single search and rescue sortie (250nm and return) by a Jayhawk helicopter. Forward operating locations (FOL) in the Arctic are only manned for a few months of the year during the summer shipping season. Recent U.S. Coast Guard Arctic Shield operations in Barrow have been equipped with two Jayhawk helicopters and supported by the Coast Guard Air Station in Kodiak (870 nm south). No mission in the Arctic is considered routine and requires a major response by the U.S. Coast Guard and partner agencies such as the Alaska Air National Guard and North Slope Borough SAR. By combining charts, incidents, shipping lanes, and SAR capabilities, the relative risks and existing infrastructure are more apparent, as are potential gaps and possible areas for prioritization.

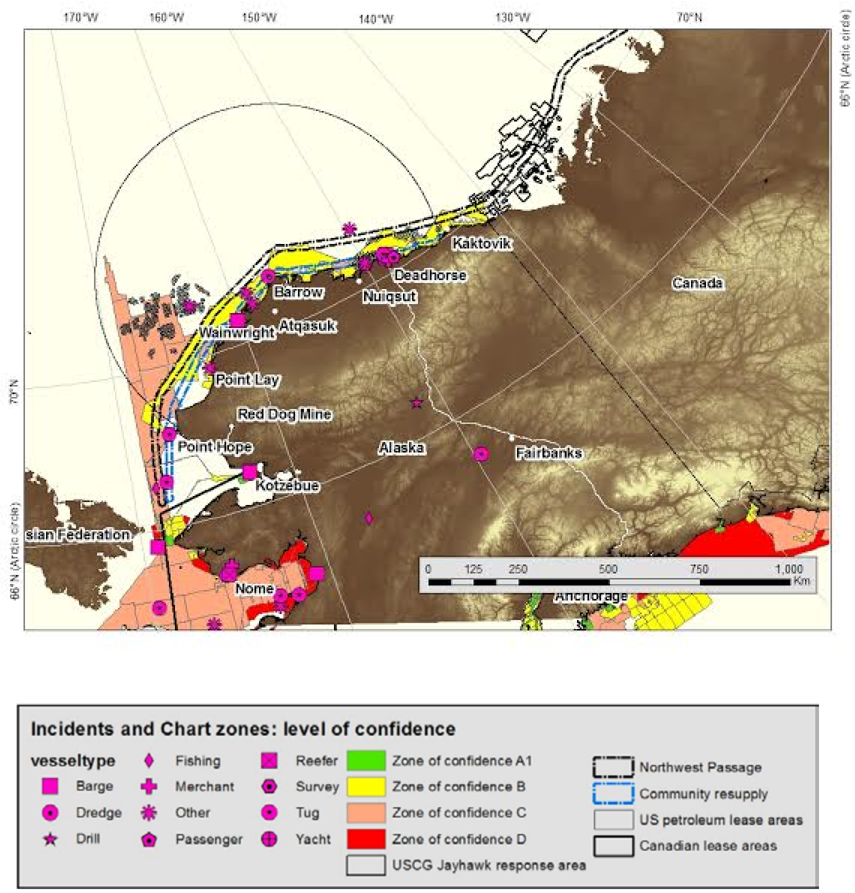


Figure 5-8. Chart confidence for the North Slope shown with 2011-2013 vessel incidents and the 260 nm Coast Guard SAR area from Barrow.

There are also social considerations for shipping in the Arctic. The Chukchi and Beaufort seas are ecologically rich areas and although they are not open for commercial fishing, subsistence fishing and hunting are permitted. Figure 5-9 shows the overlap in area use by projected vessel growth assuming scenarios 4 exploration, BAU medium, and low diversion for both the NWP and NSR without container ships and the average July to September relative abundance predictions of bowhead whales from 2000-2013.[59] The density highs for bowhead are most apparent along the eastern shore of Barrow and east of Deadhorse and Kaktovik, respectively. The purple outline shows the extent of the general subsistence hunt area averaged from 1995 to 2006, which is inclusive of bowhead whales, walrus, and seals from a study by the BOEM.[60] In this figure, vessel traffic density is shown in gray scale while bowhead abundance is shown in color. Warmer colors indicate areas of higher projected animal abundance. In projecting possible vessel activity it is important to take into consideration ecological impacts and social ramifications for the communities along the Bering, Chukchi, and Beaufort seas.

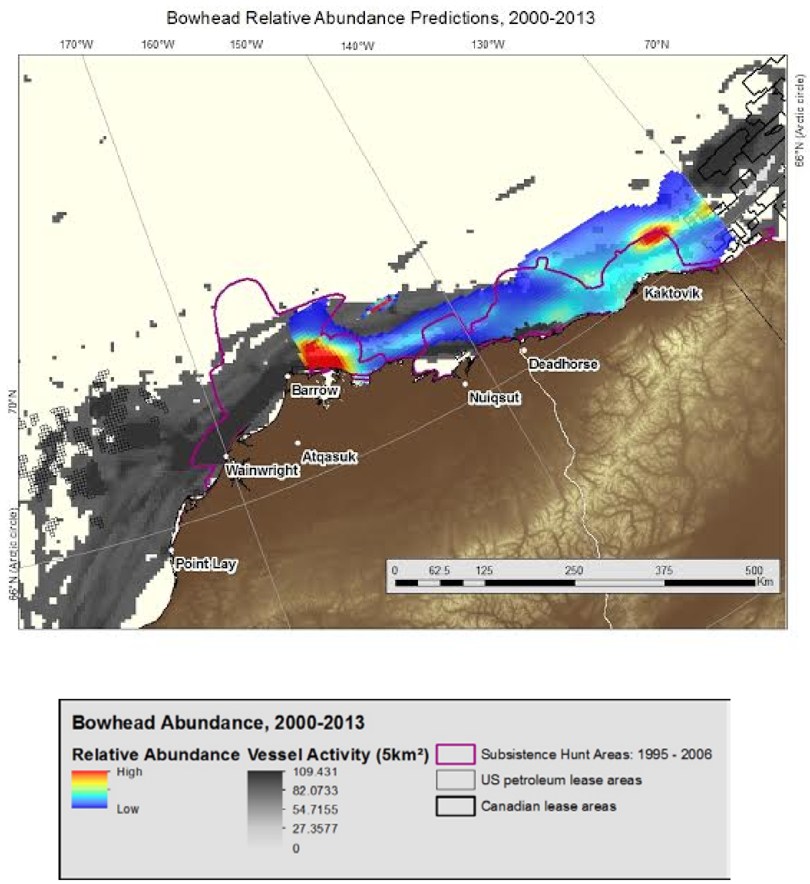


Figure 5-9. Overlay of projected vessel traffic in 2025 with average September bowhead whale distribution from 2000-2013. The purple outline represents subsistence hunt areas averaged from 1995-2006.

Summary

The projections in this chapter provide only a snapshot into the potential exploration and activity that could occur in the U.S Arctic. The scenarios represent growth assumptions based on the best available information. They span a range of intentionally conservative assumptions and less likely development patterns with higher rates of vessel diversion enabled by the increased accessibility of a melting Arctic.

Combining the variables above, Table 5-5 shows an estimate for low, medium, and high vessels and Bering Strait transits possible for 2025. These are not firm numbers, and given the amount of variability for transits supporting various oil and gas activities in the U.S. and Canadian Arctic, it is likely that the number of transits could be much higher without significant change in the number of vessels (Figure 5-10).

Table 5-5. Combined vessel numbers for all projection scenarios.

Combined vessel numbers				
Growth scenarios with containers	2013 Baseline	2025 Low	2025 Medium	2025 High
Vessels	239	523	898	1262
Percent change		120%	275%	430%
Transits	440	1093	1876	2637
Percent change		150%	325%	500%
Growth scenarios without containers				
Vessels	239	420	640	849
Percent change		75%	170%	255%
Transits	440	877	1337	1774
Percent change		100%	200%	300%

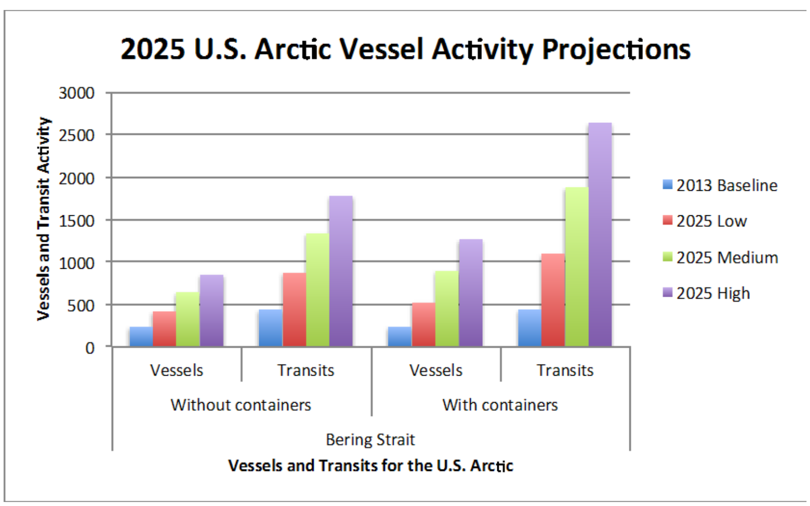


Figure 5-10. 2025 projected U.S. Arctic vessel numbers and transits for the Bering Strait.

Using the same assumption for growth, exploration activity, and NWP diversion, it is possible to approximate the number of vessels operating on the U.S. North Slope as well. Estimating this subset of the traffic is important because many of the transits through the Bering Strait will head into the Russian Arctic and NSR. This calculation uses counts of uniquely identified vessels based on AIS information for the U.S. North Slope in 2013. For 2013, there were 47 unique vessels identified. Table 5-6 shows the total number of vessels as well as the percent growth, which range from a low of nearly tripling the vessels to four and a half times as many vessels as estimated for 2013.

Table 5-6. Estimated vessel growth for the North Slope, U.S. Arctic.

North Slope Vessel Growth			
	Low	Medium	High
2025 vessels	124	170	208
Percent change	165%	260%	340%

Any combination of factors discussed is possible in addition to a host of factors and growth scenarios that were not explored. The probability of any of these combinations occurring in the next decade is unknown and depends heavily on economic factors, policies, and investment for both natural resources and shipping as well as environmental and climate factors. The U.S. Arctic is a dynamic place with many drivers for development, but it will also be affected by development and economic decisions made by other Arctic nations as well as the larger global market. Given the inherent uncertainty and limited ability to project the future, these scenarios provide possibilities that can be used in consideration with other factors to plan for the future of the U.S. Arctic.

Chapter 6: Conclusions and Next Steps

This study assesses possible scenarios for vessel activity in the U.S. Arctic over the next decade. This work fulfills the directive to the U.S. Department of Transportation and the U.S. Committee on the Marine Transportation System (CMTS) under Line of Effort #1 in the National Strategy for the Arctic Region (NSAR) Implementation Plan, "Prepare for Increased Activity on the Maritime Domain", Action 1.1.1. The Implementation Plan is designed to guide the activities and require the action of Federal Departments and agencies to protect U.S. national and homeland security interests, promote responsible stewardship, and foster international cooperation. Having the best available information regarding the number and location of vessels under certain conditions is the required first step to addressing the next marine transportation-related NSAR Implementation Plan action to the CMTS (1.1.2); a prioritization framework for U.S. Arctic infrastructure development is due in 2015.

Review of methodology

This study begins with a comprehensive review of current publications including U.S. agency reports and strategies, collaborative working group publications, international reports from forums such as the Arctic Council, and peer-reviewed literature. The literature review informs the vessel growth criteria analyzed to focus projections on the most likely drivers for increases in vessel activity over the next decade.

A baseline analysis for vessel activity from 2011-2013 was completed to evaluate current activity trends and inter-annual difference. This analysis also includes an assessment of Arctic ice modeling and potential access to the U.S. Arctic for three vessel classes likely to operate in Arctic conditions. Average accessibility analysis for these vessels showed likely accessibility to near-shore and offshore resources as well as the NSR and the NWP. These modeling projections are important for understanding the potential access facilitating activity as well as identifying areas of risk.

An economic analysis of variables was also conducted to evaluate the potential impacts of global growth on business-as-usual shipping in the Arctic as well as for diversion of traffic from other international shipping lanes. This analysis was limited to only the vessels likely to use Arctic routes, and only for the months of July through November, when the U.S. Arctic is increasingly accessible to shipping activity. The growth analysis also considered likely scenarios for oil and gas exploration on the North Slope of Alaska and the Canadian Beaufort. These estimates were incorporated as considerations for creating various projection scenarios for the next decade.

Results

Projections for U.S. Arctic vessel traffic considered different combinations of growth from BAU, to diversion of vessels from the Suez and Panama canals, to increased oil and gas exploration. The mid-range number of unique vessels operating in the Bering Strait and U.S. Arctic for 2025 is 640, or as many as 898 if diverted container traffic is included, this represents a 200 to 275 percent increase from 2013. The conservative estimate for 2025 is 420 unique vessels, resulting in approximately 877 transits though the Bering Strait, or an increase of 100 percent over current transit levels; and the number of vessels for the high-growth scenario - incorporating all of the maximum growth elements for 2025 is 1262, resulting in approximately 2637 transits, about a 500 percent increase in Bering Strait transits over current levels (Table 6-1, Figure 6-1).

Table 6-1. Summary table of estimated growth for the Bering Strait and the North Slope.

Vessel and Transit Growth for the Bering Strait and North Slope in 2025					
Type			Low	Medium	High
Bering Strait	% Change including container diversion	Vessels	120%	275%	430%
		Transits	150%	325%	500%
	% Change without container diversion	Vessels	75%	170%	255%
		Transits	100%	200%	300%
North Slope	% Change	Vessels	165%	260%	340%

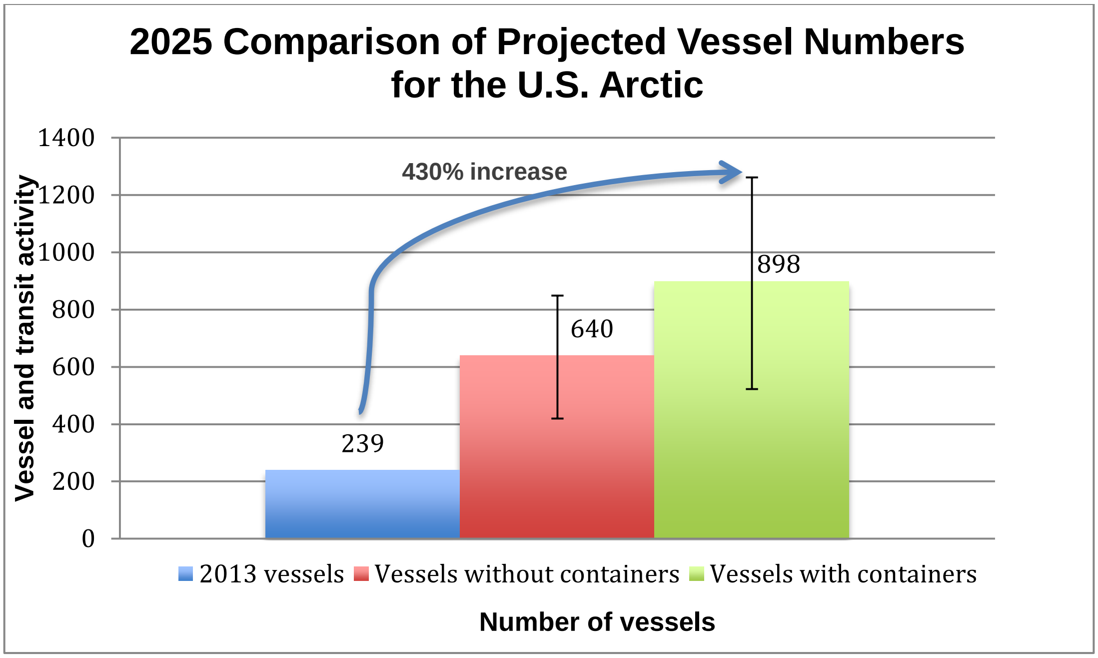


Figure 6-1. Comparison of projected vessel numbers in 2025 for the U.S. Arctic passing through the Bering Strait.

Although the total number of vessels and transits is small when compared with other major shipping routes such as the Great Circle Route in the Pacific, the relative increase in activity is significant for the region. As discussed, growth through the NWP and NSR depends heavily on economic factors and market drivers and is likely to expand slowly as resources, infrastructure, and investment become available. The more immediate source of growth is likely oil and gas exploration followed by potential development. As a comparison, the high diversion scenario for the NWP estimates the potential for 47 vessels to transit the Arctic in favor of either the Suez or Panama canals. In a single year, two exploratory drilling programs could increase vessel presence on the U.S. North Slope by 25 vessels with some of those vessels making 30 trips for resupply. The high scenario for oil exploration, Scenario 4, estimates a total of 62 vessels operating in the Bering and Chukchi Seas with additional resupply and support transits between North Slope communities and Dutch Harbor. In 2013 there were an estimated total of 47 unique vessels operating on the U.S. North Slope; a high exploration year would increase that by approximately 130 percent. These potentially rapid changes have important implication for infrastructure but also for environmental readiness and emergency response.

Next steps

Whether these or other more intermediate growth projections will be accurate in 2025 depends on a number of additional elements, one of which is the extent of ice-diminished conditions for the Arctic. This element was explored Chapter 2 with results suggesting that while numerically possible, such growth may be constrained by environmental and infrastructure limitations. General accessibility is one component of this, and is shown through the comparison for open-water vessels in Figures 2-6 and 2-7, but the availability of icebreaker and icebreaker support is also critical for seasonal expansion of shipping and increased natural resources exploration. These analyses assume consistent availability of icebreaker support or the use or provision of icebreakers or ice hardened vessels by those undertaking Arctic activities. Insufficient support for SAR activities or environmental emergencies may also constrain activity depending on the rate of growth and the rate of investment in this type of infrastructure and support services.

There are several additional factors influencing U.S. Arctic vessel traffic that were not quantified for this study. These include other economic and investment variables such as insurance and risk costs as well as changes in the shipping market through variables such as the opening of the Panama Canal expansion. Arctic access may also be affected by political and regulatory considerations, the impacts of which are difficult to forecast. Whether or not the continued pursuit of permits and activity by industry is warranted may also depend on market conditions and values for natural resources and for shipping. The assumptions used to predict global growth were based on the past 10 years of the global market and international shipping. Unforeseen changes and economic conditions could produce large variability in actual growth.

Climate change is a large determinant of the potential growth in the U.S. Arctic. Ice diminishment may facilitate shipping and resource development, although even ice-diminished waters contain significant hazards to navigation, including more (often submerged) sea ice. Climate change may also make navigation more challenging as weather anomalies and changing oceanographic conditions occur. It may also facilitate economic growth for the State of Alaska and its communities on the North Slope. These communities rely on summer resupply via inshore tug and barge as well as overland winter resupply via ice roads. Changes in climate and the reduction in overland support capacity may mean more vessels are required to support communities. The potential for increasing permanent and seasonal residents depending on future increases in oil and gas exploration and development, also means an increase in resupply that may result in additional vessel activity. It may also require additional community support and preparation to handle the changes in infrastructure needed from such activity. The projections in this report do account for some increases in supply for oil and gas activity, but they do not anticipate needs for new infrastructure or the potential limits to development based on current capacity. It explores the current nautical chart availability for safety of navigation and activity in reference to subsistence hunt and marine mammal distribution, but these are complex elements requiring more in-depth analysis than these projections provide.

The projections provided by this report, while not exhaustive, do incorporate a large number of variables to provide best estimates of U.S. Arctic vessel activity in 2025.

They may be used to complement and provide additional context for Arctic infrastructure, marine traffic systems, and navigational charts as well as environmental and community concerns. Future work to expand on the scenarios presented could include a more exhaustive analysis of natural resources exploration and development as well as integrating the possibilities into a more sophisticated model. There is also a need to better integrate market drivers for shipping, such as fuel costs, implications from the Panama Canal expansion, and risk analysis and insurance analysis to inform likely timeframes for shipping expansion through the NSR and NWP. In addition, a more complete scenario analysis for needed support infrastructure should be completed as a basis for determining probable future growth trends. Elements for this would include Arctic support assets such as icebreakers as well as communication and search and rescue support incorporating collaborative work such as that done by the Arctic Maritime and Aviation Transportation Infrastructure Initiative. Although touched on briefly, these elements were not fully explored or incorporated into this assessment but are recommended elements for continued consideration. This report should provide tools and considerations to support next steps for developing a coordinated approach towards improving and maintaining infrastructure in support of U.S. Federal Arctic maritime activities.

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