Bering Sea Vessel Traffic RISK ANALYSIS

December 2016

Nuka Research and Planning Group, LLC

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EXECUTIVE SUMMARY

Ocean Conservancy contracted Nuka Research and Planning Group, LLC to conduct a qualitative study of vessel traffic risk in the Bering Sea. The Bering Strait represents a chokepoint between the Arctic and Pacific Oceans, and is expected to see increasing vessel traffic as Arctic sea ice retreats and both trans-Arctic shipping and the extraction of resources from Arctic countries grows. At the same time, the Bering Sea is recognized as one of the world's most productive ecosystems, and the expansion of shipping activity is occurring in a place where people and wildlife are already experiencing the effects of climate change. Layered on this changing and complex system are international, federal, and state laws, policies, and practices, and complex relationships between the US and Russia.

This study provides an overview of vessel traffic and potential hazards associated with shipping activities in the northern Bering Sea and Bering Strait area. It relies primarily on data from vessels that are equipped with Automatic Identification Systems (AIS). Vessel movements are analyzed and the potential exposure to oil spills and other impacts are presented to inform the ongoing consideration of risk mitigation measures appropriate to the area.

Bering Sea Resources

The Bering Sea is one of the most productive ecosystems in the world, including hundreds of species depending on Bering Sea habitat either seasonally or year-round (The National Academies, 1996). Subsistence uses of Bering Sea resources are critically important to thousands of people throughout the Bering Sea region. Marine species are particularly important to the human communities of the Bering Sea, including polar bears and other marine mammals, sea birds, fish, and shellfish. In 2014, five of the top 10 most valuable commercial fisheries in the U.S. were based in or near the Bering Sea. Any threat to fish or other animals and their habitat in the Bering Sea threatens both the food security of local communities and the significant fisheries that support U.S. and international markets.

Vessel Traffic

Bering Sea shipping overall is currently dominated by traffic through the Aleutian Islands between North America and East Asia. Commercial fishing vessels also operate in the southern Bering Sea year-round, delivering their catch to communities with fish processing plants. Containerships and refrigerated cargo ships then move the processed seafood to global markets. Tankers, general cargo ships, and barges move throughout the eastern Bering Sea serving coastal and inland communities. Vessels also support industrial activities and resource extraction in the region, or move goods or materials through the area to European, Asian, and other North American ports. The Alaska Marine Highway ferry serves the communities of the Aleutian Islands archipelago and the adjacent Alaskan Peninsula. The occasional cruise ship passes through the area. Research vessels, U.S. Coast Guard and other government vessels, and pleasure craft operate here as well.

For this study, Nuka Research analyzed vessel traffic Automatic Identification System (AIS) data from 2013-2015 for the Bering Strait region. The dataset included 532 unique vessels operating for a total of 18,321 days in the area. While fishing vessels were most common, tankers and bulk carriers made up most of the deep draft (larger) vessels. Due to the extensive use of barges to serve ports on the U.S. side, tugs are far more prevalent there than in Russian waters. Similarly, fishing vessels are more common on the Russian side where there is less sea ice coverage and different fishing rules. The figure below shows cumulative tracks over the three years for each vessel type studied.

Figure ES-1. AIS tracks recorded in Bering Strait region 2013-2015

Vessel tracks were examined for tankers, bulk carriers, and other cargo ships to determine the activities in which they were likely engaged. For vessels operating primarily in U.S. waters, those calling at U.S. ports spent 2,221 operating days (740 of which were spent by vessels serving Red Dog mine, the busiest port for deep draft vessels in the region). Vessels passing through the area spent only 112 operating days by comparison. This aligns with the general knowledge that, although shipping through the Bering Sea is on the rise in recent years, today's traffic is still dominated by vessels serving communities and industrial activity in the area. On the Russian side, vessels serving ports in the area similarly dominate operating days (1,790). There are more (434) operating days associated with transits in Russian waters than seen on the U.S. side. Finally, 159 operating days were associated with vessels serving the Russian fishing industry.

In addition to the ship activity described above, barges carrying both oil and other cargo play a key role in serving U.S. ports. Barges are not required to carry AIS transmitters, though most of the tugs that move them do. In addition to transporting cargo in and out of the region, they also make fuel deliveries to outlying communities from the hub port of Nome, or from tankers that bring the fuel into the area. The tankers remain offshore (outside state waters) and transfer the fuel to barges for delivery to communities. The tanker and tug activity in our dataset confirms that this has been a common practice, begun just prior to the years included in our dataset, in 2012.

Oil Exposure

All vessels in the dataset carry oil on board as fuel or, in the case of tankers, also as cargo. Barges rely on tugs for propulsion, but in some cases can carry more oil cargo than a small tanker. Based on vessel particulars and AIS data showing the amount of time spent in the area, Nuka Research estimated an overall oil exposure for each vessel type. Tankers dominate overall oil exposure due to their size and the fact that they have oil cargo in addition to the fuel used for their own propulsion. Currently, at least on the U.S. side, this oil cargo is all "non-persistent" (Types 1 and 2) oil carried for use in communities or industrial activity in the region. Most large ships currently use heavy fuel oil for their own propulsion. This "persistent" oil (Types 3 and 4) typically lasts longer in the environment if spilled than a non-persistent type. Vessels carry less volume of oil for their own fuel than a tanker does in cargo, but the largest of the bulk carriers in the dataset has more than 30,000 bbl fuel capacity, which is more than most tank barges carry and more than a third the cargo capacity of the smallest tankers.

To consider the proportionate contribution of different vessel types to oil exposure in the region, total exposure was estimated based on persistent or non-persistent oils. Tankers account for 90% of non-persistent oil exposure, while bulk carriers represent 38% of persistent oil exposure (closely followed by other cargo vessels with 36% and tankers with 25%). When exposure for both oil types is combined, we multiply the persistent oil volume by a factor of 1.64 to account for the longer duration of persistent oil in the environment and thus greater potential impact. (This factor was used in a recent marine risk assessment conducted for the National Oceanic and Atmospheric Administration in Alaska; other values could be used, and no such value should be interpreted to mean that a non-persistent spill could not also have significant adverse consequences).

Figure ES-2 shows the portion of oil this "weighted" oil exposure (combination of non-persistent and persistent oils, with persistent volumes adjusted by a factor of 1.64) based on vessel activity for the three large ship types. Tankers calling at U.S. ports (either directly or via transfer to barges) account for 46% of overall oil exposure in the region for the three years studied. Tankers and bulk carriers calling at Red Dog mine on the U.S side account for an additional 19%. In both cases, this exposure refers only to the volume of oil on the vessels (both as fuel and, for the tankers, also oil cargo) and the time they spend in the area; it does not further incorporate potential exposure from the transfer of oil to barges and the operation of those barges.

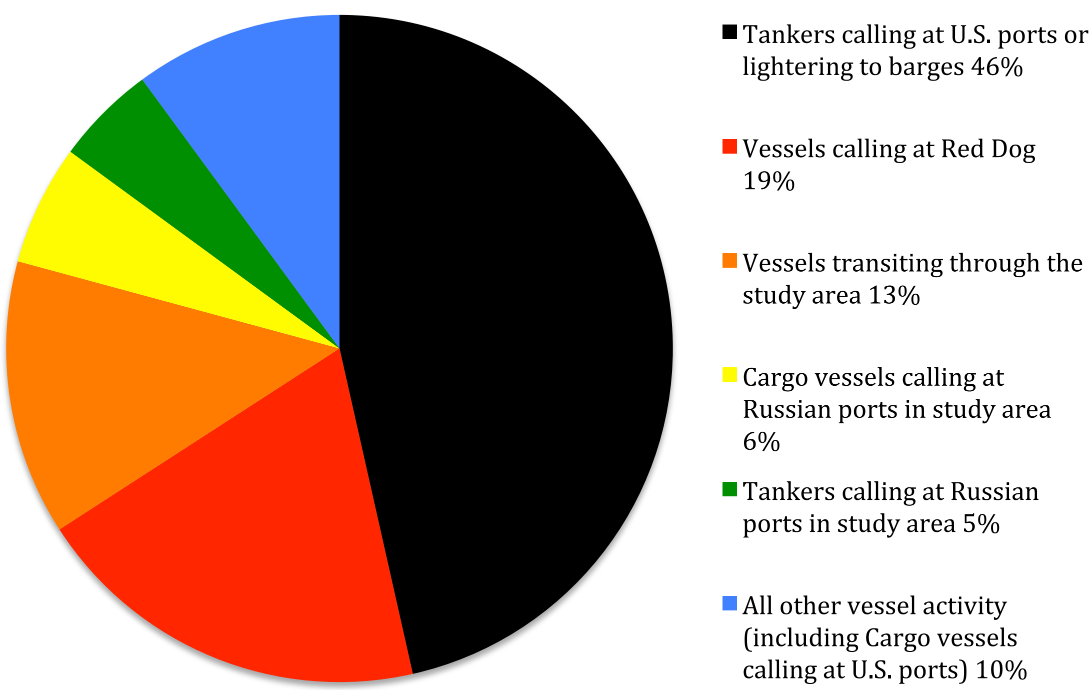


Figure ES-2. Percentage of overall ***weighted oil exposure*** *attributed to activities. Note that the 46% of Tankers calling at U.S. ports (or lightering) does not include those serving Red Dog mine.*

Potential Impacts

The analysis of vessel traffic in the Bering Strait region identified vessels of the general type and size that have been known elsewhere to strike marine mammals, disturb or endanger marine mammals with engine and hull noise, and release pollutants to the water and air.

A range of potential consequences from shipping-related hazards is possible. The consequences associated with a hazard such as underwater noise may be that species people rely on (including commercially-fished species, though this study did not explore the literature related to vessel noise and fish) suffer health effects that reduce their population or modify their behavior in such a way that harvest is reduced or impossible. The impact of marine mammal strikes, on the other hand, is likely limited to the subsistence-based communities that depend heavily on walrus and other marine mammals. Without more data we cannot know if there may be a population-level effect on marine mammals from vessel strikes, although this is not necessarily a prerequisite to mitigating risk.

Finally, the contamination of food from vessel waste or oil spills is of concern whether fish, mammals, or birds are consumed locally or commercially-harvested species are consumed thousands of miles away. In both cases, there is the potential for impacts in the event that humans consume tainted seafood. Even the *perception* of contamination can cause harm either because of people avoiding an area or particular species for subsistence uses, or a reduced market for a commercially-caught species.

Findings

A suite of international, federal, and state policies are in place regarding the safety of navigation, waste management, and oil spill preparedness and response. Attention to the Arctic in recent years also brings many ongoing efforts. Nuka Research identified the following key findings to inform decisions about how best to prepare for and mitigate risks associated with current and potential future shipping activity in the study area:

- In the southern Bering Sea today, most oil exposure is associated with vessels transiting through the area, while in the northern Bering Sea, most oil exposure today is associated with calls to ports (or lightering) in the region.
- Tankers serving U.S. ports and bulk carriers and tankers serving Red Dog mine constitute approximately 65% of weighted oil exposure for the Bering Strait area.
- Bulk carriers and other ships transiting the Bering Strait represent the most likely area of growth in oil spill exposure in the near future.
- Even without an accident, vessels can impact Bering Sea resources.
- There is extensive local knowledge available about the Bering Sea ecosystem that can inform the development of mitigating measures and response planning.

Recommendations

Based on the findings of this study, Nuka Research recommends that further attention to the safety of the relatively new lightering activities may be warranted, especially where these vessels operate outside state waters and are therefore exempted from state oil spill response preparedness requirements. Risk reduction measures that consider events such as loss of steering or propulsion are also important, and may incorporate measures such as vessel routing, planning for places of refuge, and analyzing the ability to mount a rescue based on resources in the region.

Continuing to build meaningful engagement of local communities in oil spill response planning and preparing them for participation in a response is also important. As those who will suffer the most immediate consequences if a spill occurs, community engagement in planning, response decision–making, and identification of priority areas for protection is important. Continuing to build on local and traditional knowledge to increase understanding of the other impacts of shipping and evaluate the effectiveness (or unintended consequences) of mitigation measures will also be critical.

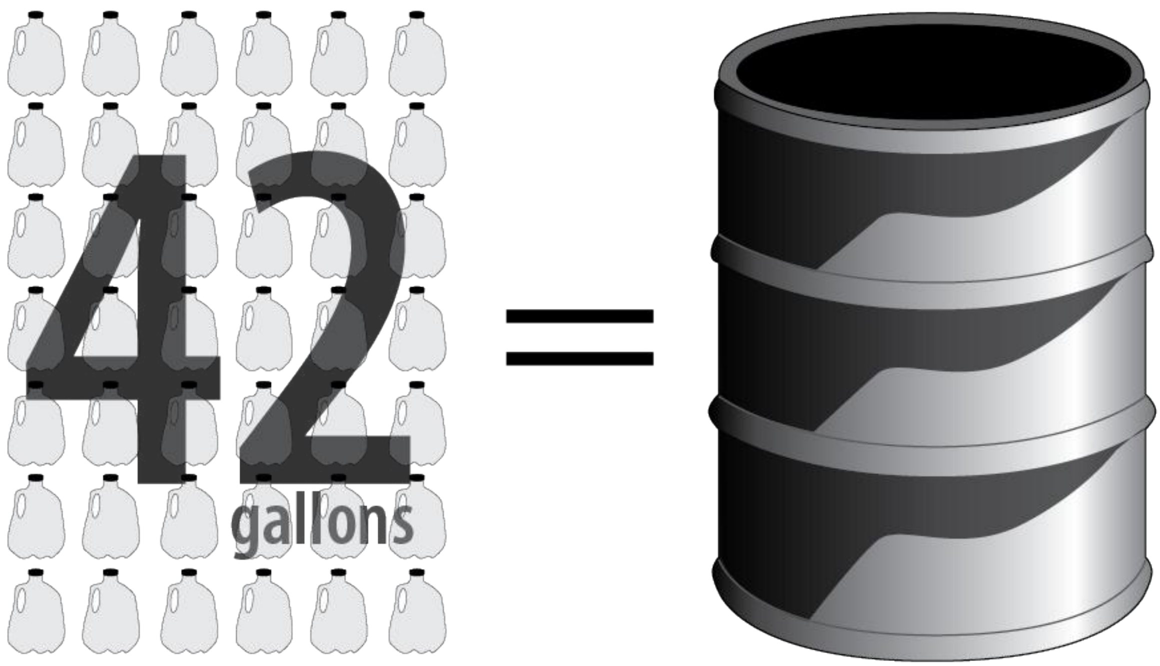
Efforts to mitigate risk should be developed with the best possible information available about actual shipping activities, combined with input from technical experts and local stakeholders. The Arctic Waterways Safety Committee, Subarea Committee(s), and Arctic Council can serve as forums for engaging diverse inputs, with contributions from ad-hoc collaborative efforts especially helpful to foster a shared understanding of hazards and potential consequences, generate ideas for risk mitigation, and explore options outside formal channels when appropriate. Relationships across the Strait between U.S. and Russian communities have already been activated to facilitate the collection of information about vessel activities and impacts, as well as response to emergencies. Collaborations also provide the opportunity to weigh potential unintended consequences, and to acknowledge that the costs or impacts may be experienced differently by various groups.

Conclusion

The Bering Sea has long been important to the people who live and work there, and is becoming even more important as an international shipping route. This study analyzes current vessel traffic movements through the region and considers the relative risks from various types of vessels to inform risk mitigation. Efforts to mitigate today's risks can only help to mitigate the risks of tomorrow as well, even as long-term planning is underway for a future of increased shipping transits through the Bering Sea.

This study uses "barrels" (bbl) to refer to the volume of oil carried by a vessel as cargo or fuel.

One barrel of oil equals 42 gallons.



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1 Introduction

Ocean Conservancy contracted Nuka Research and Planning Group, LLC to conduct a qualitative study of vessel traffic risk in the Bering Sea. The purpose of this study is to investigate potential risks to the marine environment from vessel traffic and provide a framework for considering risk mitigation options in the context of expected increases in vessel traffic activity in the region. The report considers risks associated with vessel traffic generally, Bering Sea resources at risk, current vessel activity in the northern Bering Sea and Bering Strait region, and potential mitigation measures to address these risks.

This study focuses on the activities and potential impacts of ships and other vessels operating in the northern Bering Sea and Bering Strait area. These potential impacts are layered on a region which is home to one of the largest marine migrations on the planet, and where climate change and reduced sea ice are altering the ecology of the region and causing shifts in seasonal patterns. These changes impact migration, feeding, and breeding of the animals that live in the region and, in turn, threaten the people who have evolved their behaviors and cultures to these natural rhythms over thousands of years and depend on marine resources for food security, livelihood, and culture (Arctic Council, 2009).

1.1 Project Scope

This study provides an overview of vessel traffic and potential hazards associated with shipping activities in the northern Bering Sea and Bering Strait area. It particularly focuses on vessels that are equipped with Automatic Identification Systems (AIS). Vessel movements are analyzed and the potential exposure to oil spills and other impacts are presented to inform the ongoing consideration of risk mitigation measures appropriate to the area. While we provide information about all types of vessels equipped with AIS, we emphasize activities and potential impacts associated with bulk carriers, other cargo ships, and tankers as these are typically the largest vessels in the study area. They also represent the types of vessels most likely to increase their activity as shipping via the Arctic Ocean and associated waterways expands.

1.2 Organization of this Report

This report provides background on several key topics regarding shipping-related risk in the Bering Sea: an overall approach to thinking about risk in the marine environment; Bering Sea wildlife, subsistence resources, and commercial fisheries; and potential hazards to the marine environment related to shipping operations (oil spills, vessel noise, waste, marine mammal strikes, and air emissions). The report then provides the methodology and results of characterization of vessel activity for 2013-2015. Following a brief overview of the regulatory context, the report concludes with a discussion of potential additional accident and oil spill mitigation measures for future consideration.


CHUKCHI SEA
Russia - U.S. Maritime Boundary (EEZ)
Kivalina
Red Dog Mine
Kotezbue
ARCTIC CIRCLE
Bering Strait
Egvekino
RUSSIA
Chukotka
Anadyr
Provideniya
Diomede Islands
Nome
U.S.
Alaska
Gulf of Anadyr
Norton Sound
Russia - U.S. Maritime Boundary
St. Lawrence Island
Bethel
BERING SEA
Dillingham
King Salmon
Bristol Bay
International Waters
Pribilof Islands
Cold Bay
Gulf of Alaska
Unalaska
Unimak Pass
Russia - U.S. Maritime Boundary (EEZ)
Buldir Pass
Adak
Amchatka Pass
Amutka Pass
U.S. Exclusive Economic Zone (EEZ)
PACIFIC OCEAN
300 mi
300 km
BERING SEA
version: October 19, 2016
= Maritime Boundary
= Aleutian Basin
= 1979-2000 Median Sea Ice Extent (NSIDC, 2016)

2 Background: Considering Risk

In the wake of the 2004 grounding of the *M/V Selendang Ayu* off Unalaska Island, the Transportation Research Board (TRB) of the National Academies recommended a specific approach to a marine traffic risk assessment for the Aleutian Islands (Transportation Research Board of the National Academies, 2008). While that approach is beyond the scope of this study, we summarize it here to frame a general approach to thinking about risk in a complex marine system. The TRB (2008) defines risk as the "combination of the likelihood and consequences of an undesirable event" and poses three questions to explain the process:

1. What can go wrong? Anywhere that vessels operate, there is the potential for accidents and oil spills. Normal vessel operations can also cause impacts.

2. How likely is it? Likelihood describes a probability of occurrence, and is often quantified. It relates directly to the extent that a resource or receptor is exposed to a hazard or potential hazard. For this qualitative study, information is provided that could inform a future quantitative analysis, but we do not estimate the likelihood of adverse events occurring. Relevant information to estimate probability includes, for example, the number and type of vessels operating in the area, where and when they operate, the quality of information available for safe navigation, how much petroleum they carry (either as fuel or cargo), and information about past incidents.

3. What are the consequences? We also identify – but do not quantify – potential vessel-related impacts to people and the environment. Quantifying potential impacts can best be done with input from those with direct knowledge of the resources that may be impacted, or those who may be impacted themselves.

Risk is usually assessed for the purpose of identifying or evaluating mitigation measures, either by minimizing hazards or minimizing consequences. Mitigating oil spill risk, for example, requires considering potential events that may result in an oil spill, and how a chain of events can be disrupted before oil reaches sensitive resources. This "accident chain" concept provides a framework spanning basic or root causes through to impacts (Harrald et al., 1998). This approach emphasizes the importance of "layering" mitigation measures in an attempt to disrupt a potential accident chain at more than one point. We apply this concept as summarized in Figure 2-1 when discussing risk mitigation measures in Section 7.

The subjective way that risk is perceived can challenge the quantification of consequences. For example, many may consider a light sheen of oil in a coastal area to have very low consequences as compared to a large crude oil spill, but that sheen could still contaminate someone's food source or create uncertainty about its safety. Risk perception, in this case, may depend very much on one's relationship to that food source at the time of the spill.

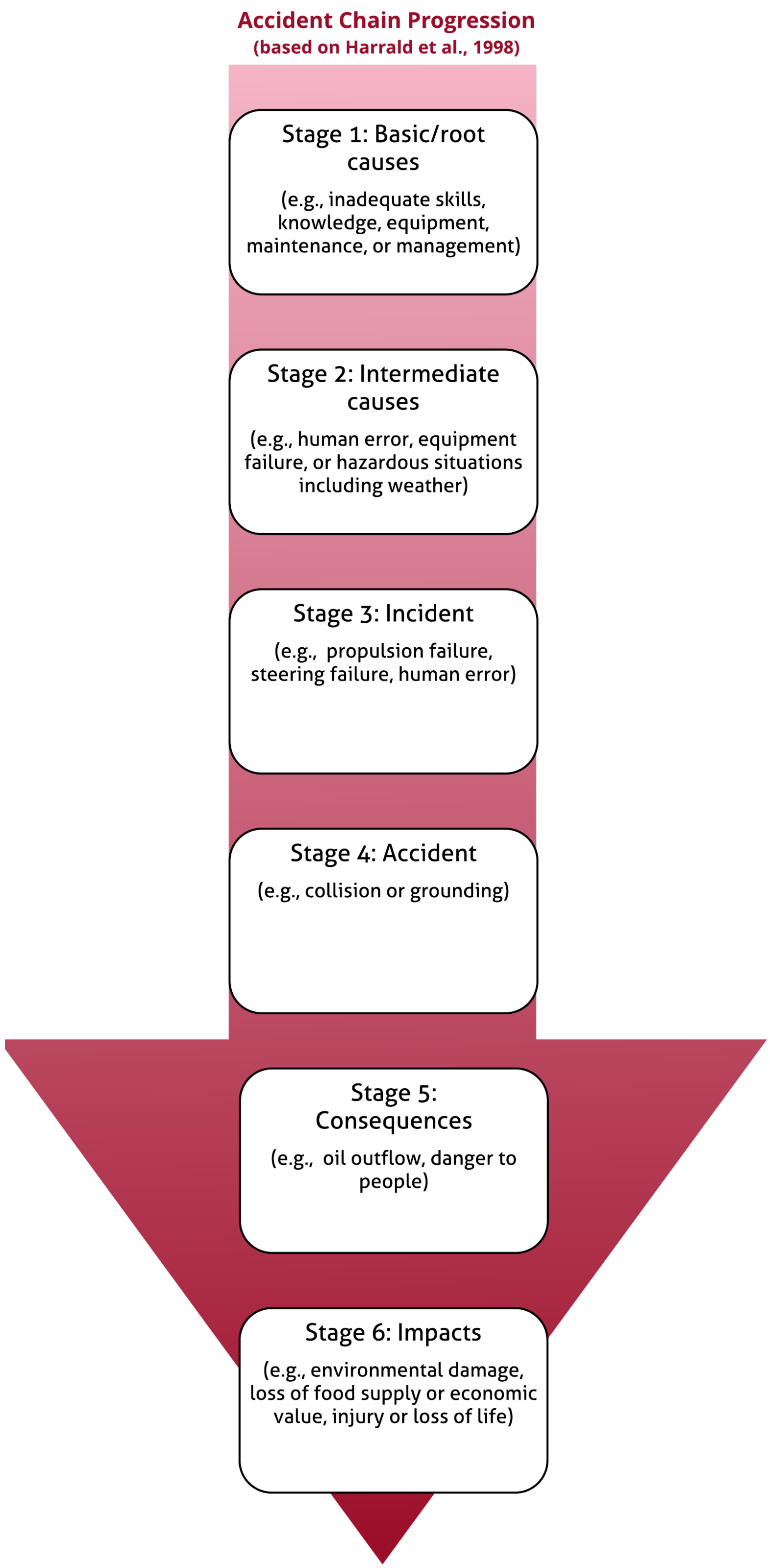

Figure 2-1 Marine accident chain framework based on Harrald et al., 1998

3 Bering Sea Resources

It's just like a refrigerator out there when I look out – the whole Sound. It's just like a refrigerator. When we get hungry, we go out there and get some crabs, tomcod, and fish.

Charles Saccheus, Sr., Elim
(Oceana & Kawerak, Inc., 2014)

The Bering Sea, a semi-enclosed northern extension of the North Pacific Ocean, contains a tremendous variety of biological resources, including at least 450 species of fish, crustaceans, and mollusks; 50 species of seabirds; and 25 species of marine mammals. The plentiful fish and game of the Bering Sea have supported the lives and livelihoods of people on both the Asian and the North American continents since prehistoric times.

The Bering Sea Ecosystem
(The National Academies, 1996)

Shipping activity on the Bering Sea is undertaken against a backdrop of resources critical to the subsistence-dependent communities whose lives, cultures, and livelihoods depend on the marine mammals, fish, birds, and plants hunted or gathered from the sea and shore. Commercial fisheries provide livelihoods and food for many more within Alaska and around the world. This section provides a very brief summary of some of the critical resources present in the area.

The Bering Sea exists as both the northern Pacific Ocean and the southern extent of the Arctic region, as "Arctic" is defined both by the U.S. government[1] and by the cycles of sea ice coverage, daylight, and temperatures that characterize the region. The Bering Strait is the gateway between the Chukchi Sea and Arctic Ocean and the Bering Sea and the rest of the Pacific Ocean. Ocean currents and the nutrients and wildlife that follow them pass through this 53-mile wide stretch of water. Sea ice covers most of the northern Bering Sea each winter, providing habitat for polar bears and other ice-associated animals, while in summer whales arrive from warmer waters as far away as Mexico and Hawaii. While seasonal variations of wildlife dominate the region, the Bering Sea is also a year-round home to cities and villages on both the U.S. and Russian sides, and to a variety of birds; finfish, crustaceans, and shellfish; and marine mammals on which those communities depend (The National Academies, 1996; NOAA, 2014; Lisitsin, 2007).

[1] *Arctic Research and Policy Act of 1984*

Both the International Date Line and the border between the U.S. and Russia transect the Bering Sea, putting two countries with a tumultuous history just over two miles apart between the Diomede Islands – close enough for a swim crossing (Cox, 2004) yet a day apart on the calendar (Bergeron, 2015). Under international law, the waters of the Bering Sea are divided into a regulatory patchwork of international waters, Exclusive Economic Zones, territorial waters, and, on the U.S. side, State of Alaska waters.

People have traveled over the Bering Sea ice for thousands of years, but more recently travel through the sea ice is possible with icebreaking vessels that are capable of breaking through 4-foot thick ice (USCG, 2016a). Likewise, marine vessels ranging from Umiaks (traditional open skin boat) covered in seal or walrus skins to large ships carrying freight on international voyages have traveled the Bering Sea. Vessel types and movements have changed over time with technological advancements, human activities and markets, and changes in sea ice coverage.

3.1 Wildlife

The Bering Sea is one of the most productive ecosystems in the world, including hundreds of species depending on Bering Sea habitat either seasonally or year-round (The National Academies, 1996). Wildlife and the habitats on which they depend have been catalogued by Audubon Alaska (Audubon Alaska, 2015) and various state and federal agencies. Kawerak, Inc. and Oceana (2014) have also compiled information about the location and abundance of marine species important to subsistence. To provide just a few examples of widespread geographic areas that have been identified as important, this section includes maps of important habitat for some of the Bering Sea marine mammals (walruses, polar bears, ice-based seals), areas of particular importance for subsistence, and important bird areas.

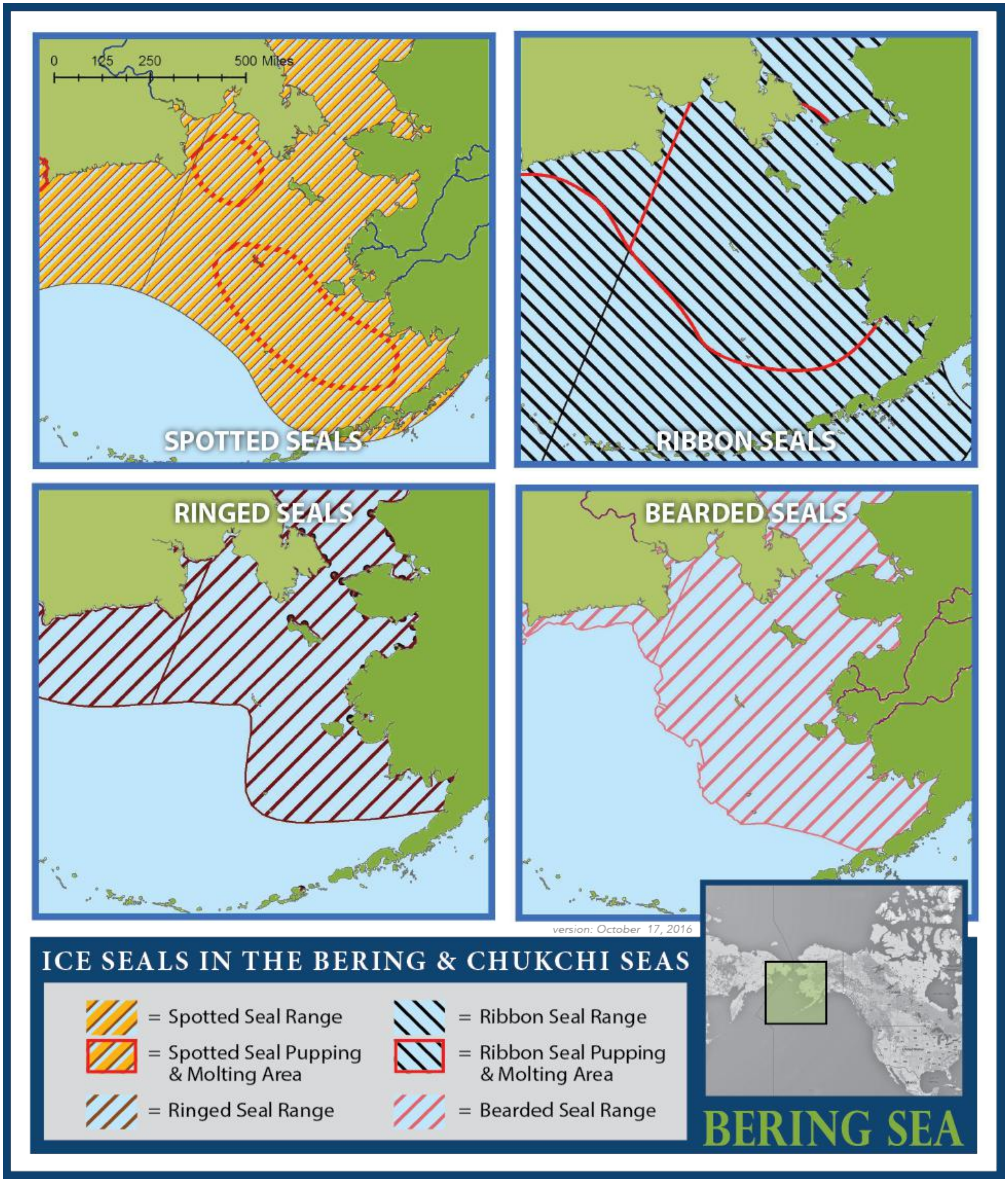

Figure 3-1 Areas important to ice-based seals in the Bering Sea[2]

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[2] NOAA fisheries, Alaska Fisheries Science Center, Polar Ecosystems Program, GIS Shapefile. Retrieved from: http://www.afsc.noaa.gov/nmml/polar/research/ice_seal_distribution.php.

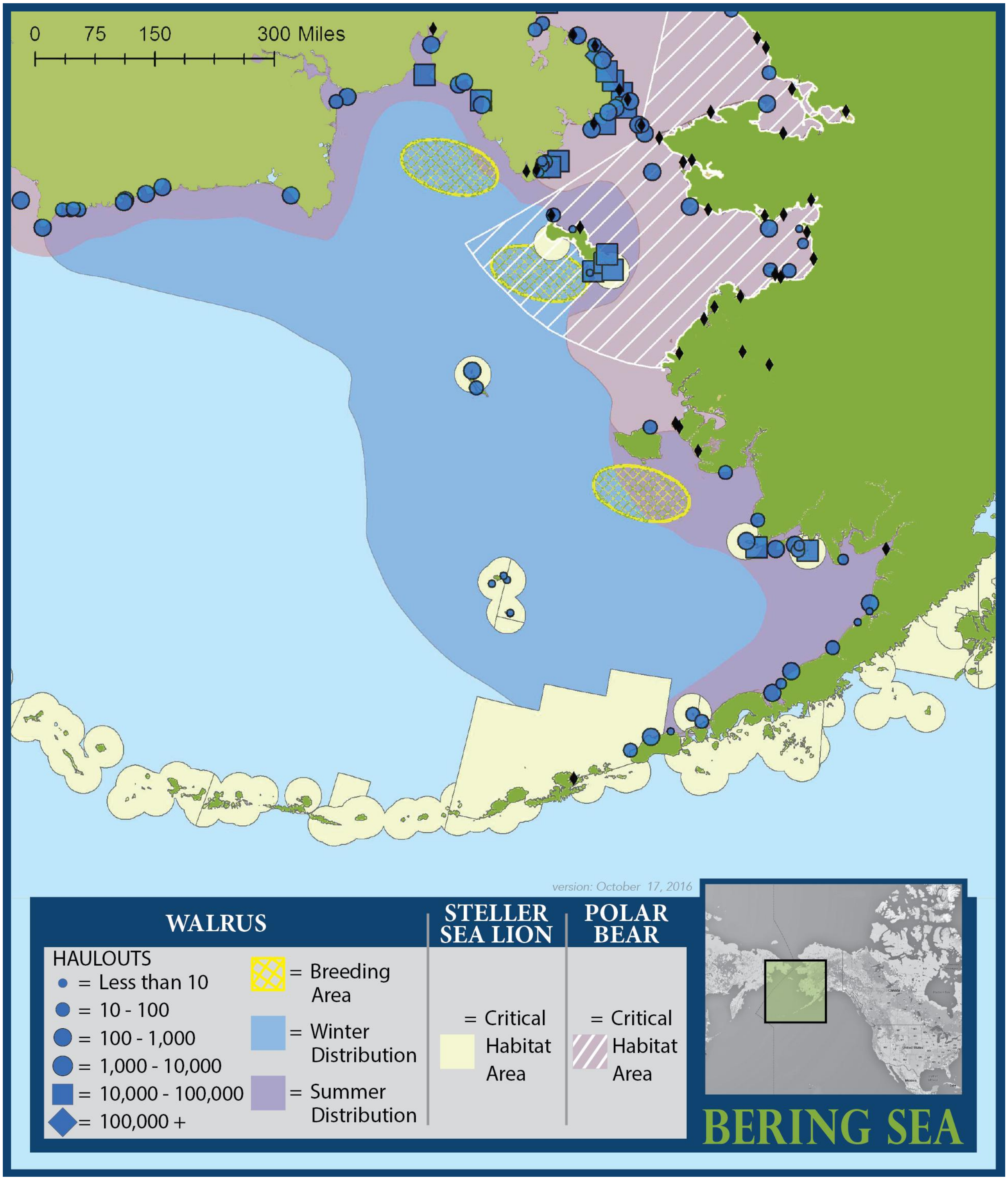


Figure 3-2 Areas important for walrus, sea lions, and polar bears in the Bering Sea[3]

[3] Fischbach, A.S., Kochnev A.A., Garlich-Miller, J.M., Jay, C.V, 201607, Pacific Walrus Coastal Haulout Database 1852-2016: U.S. Geological Survey, Alaska Science Center; US Fish & Wildlife Service, Marine Mammals Management, Polar Bear Critical Habitat and Steller Sea Lion Critical Habitat

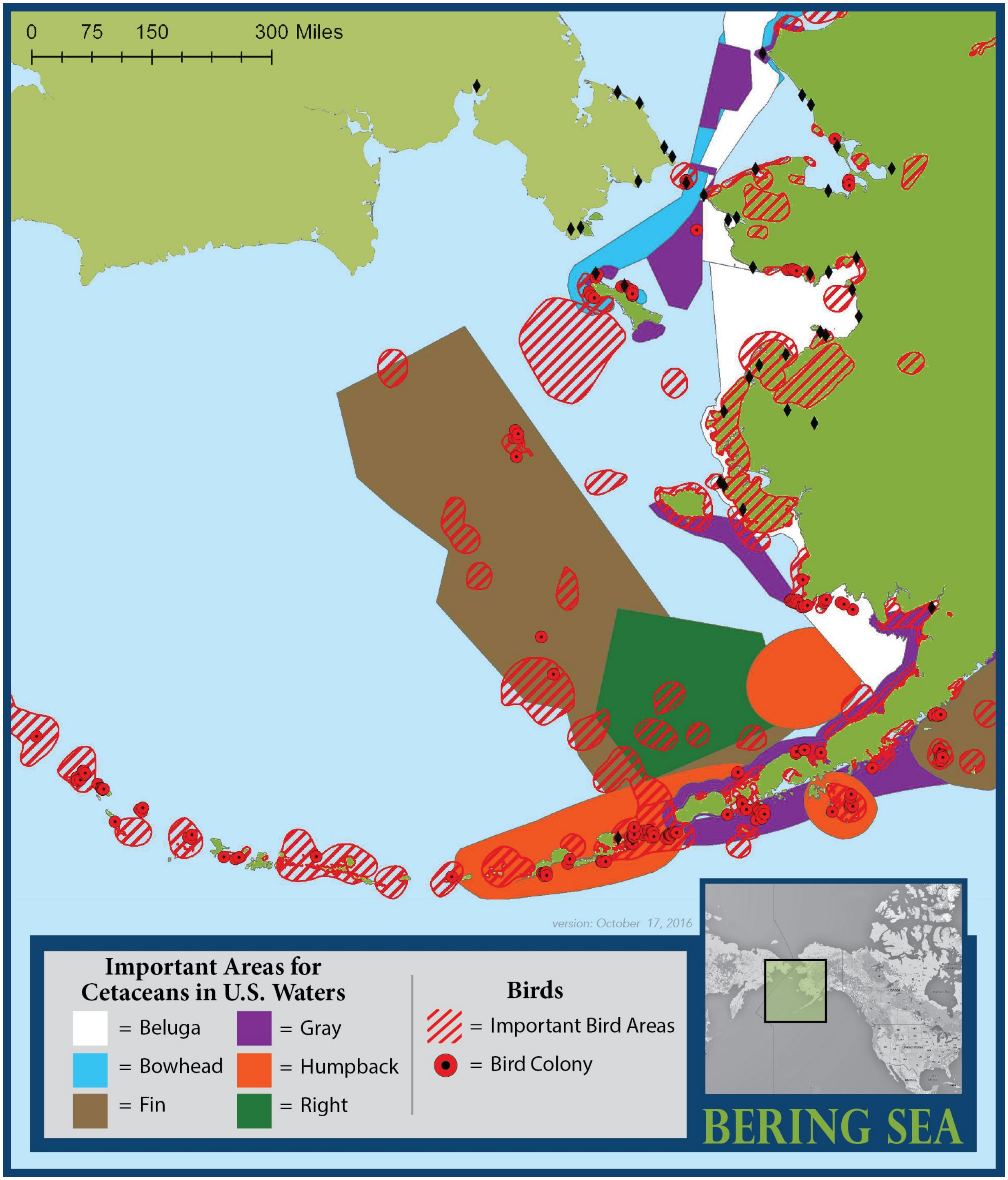


Figure 3-3 Areas important to cetaceans (whales) and Important Bird Areas and bird colonies in the Bering Sea[4]

[4] *Van Parijs, S. M., Curtice, C., & Ferguson, M. C. (Eds.). (2015). Biologically important areas for cetaceans within U.S. waters. Aquatic Mammals (Special Issue), 41(1), 1-128; Audubon Alaska, 2014. Important Bird Areas of Alaska, v3. Audubon Alaska, Anchorage, AK.*

3.2 Subsistence

Subsistence uses of Bering Sea resources are critically important to thousands of people throughout the Bering Sea region. Any threat to animals and their habitat in the Bering Sea also threatens the food security of the people who depend on them. This applies to commercial uses, such as fisheries, but there is no more direct connection between the health of wildlife and the health and food security of people than through the subsistence practices that are widespread in the area. Alaska statute [(AS 16.05.940(32)] defines subsistence uses of animals and plants as, "non-commercial, customary and traditional uses," whether for personal or family consumption, customary trade, barter, or sharing with other individuals or families for their consumption.

Marine species are particularly important to the human communities of the Bering Sea, including polar bears and other marine mammals, sea birds, fish, and shellfish. Kawerak, Inc., a non-profit association providing services to Native communities in the Bering Strait region, surveyed almost 1,200 households regarding their subsistence use in 2005-2006. The average household harvested more than 3,700 pounds of subsistence food during the year. Marine mammals made up 67.5% of that food by weight, followed by salmon at 10.4%. (Oceana & Kawerak, Inc., 2014). *The Bering Strait: Marine Life and Subsistence Use Data Synthesis* (2014) provides extensive information about subsistence practices and important areas in the northern Bering Sea.

Food is one of the most important subsistence uses, but it is not the only one. For example, Pacific walruses are an important source of food (both the walrus meat and the clams sometimes found in their stomachs), but walrus hides are also used to make traditional fishing boats and lines, and the tusks carved for tools or into sculpture or jewelry that can be sold. The sharing of subsistence resources and celebration of, for example, a hunter's first seal, are important elements of local culture (BSEAG, 2011).

In addition to the nutritional and cultural value of subsistence foods, they are also relatively healthy, do not require the expense or oil exposure associated with shipment, and do not generate packaging waste (which then requires management in remote communities).

In their reliance on species such as fish, whales, or walrus, subsistence users also rely on the health of an ecosystem beyond their immediate communities or hunting areas. With the migratory patterns of species through the Bering Sea, and the crossroads that the Bering Strait represents in the marine ecosystem, the food security of a community of a few hundred people can be linked to the health of wildlife and their habitat for an area of hundreds of thousands of square miles or more (Huntington et al., 2013).

3.3 Commercial Fisheries

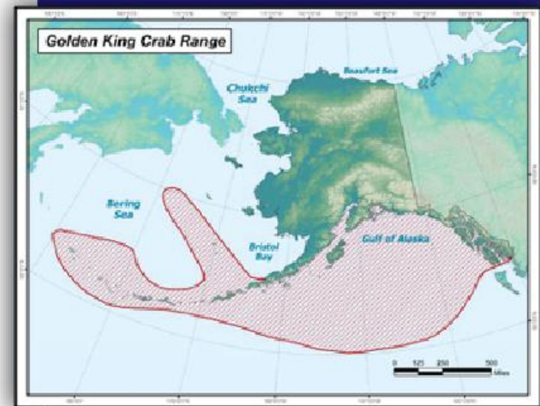
In 2014, five of the top 10 most valuable commercial fisheries in the U.S. were based in or near the Bering Sea, landing almost 16 billion pounds of fish that year worth more than $600 million (NMFS, 2014).[5] The largest commercial salmon fishery in the world is based in Bristol Bay, where more sockeye salmon are harvested than in Russia, Canada, Japan, and the Lower 48 states combined in a typical year (ADF&G, 2013). Fisheries are important throughout the area, though currently the northern Bering Sea is closed to bottom trawling (NPFMC, 2011). Commercial fisheries are managed through a combination of federal, state and international management regimes.

Figure 3-4 summarizes some of the commercial fisheries active in the area to illustrate the distribution of valuable fisheries throughout the Bering Sea and the distribution of activity throughout the year. The list is not exhaustive, but is intended to illustrate the economic value of the fisheries in this region and geographic areas where commercial fisheries are active. Federally-managed commercial fisheries in the Bering Sea also allocate a portion of the harvest to Community Development Quota groups which provide benefits from commercial fisheries to Western Alaska communities. (NOAA, n.d.-a).

[5] *Dutch Harbor, Naknek, Bristol Bay, and other Aleutian Islands and other Alaska Peninsula*

BERING SEA COMMERCIAL FISHERIES

Unless otherwise noted, economic figures are based on Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions (Aydin et al., 2015). The most recent economic data are provided where available.



◀ CRAB ▼

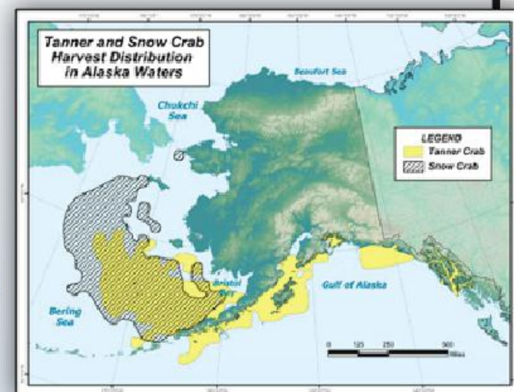
Species: King, Tanner, snow (Opilio)
Value: $225 million (2014 ex-vessel value)
Season: August 15-May 31 (varies by species) (NOAA, n.d.-b)

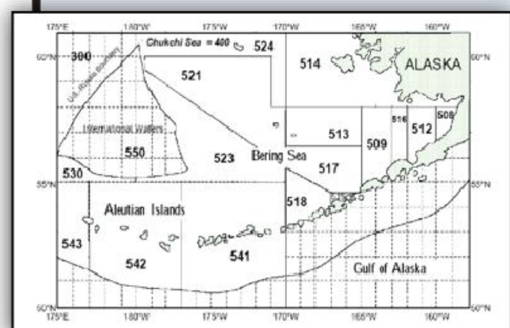
GOLDEN KING CRAB

Golden (brown) King crab range (ADF&G, 2016a); represents largest portion of King crab landings (NPFMC, 2016)

TANNER & SNOW CRAB

Tanner and snow crab harvest range (ADF&G, 2016d)





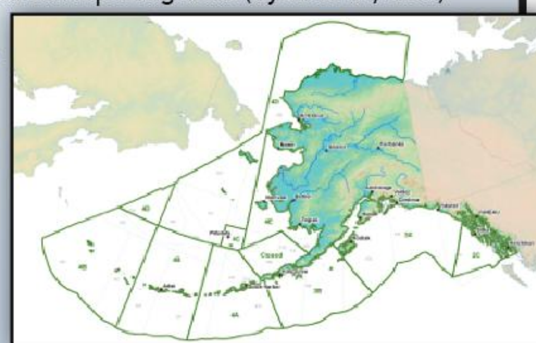
◀ GROUNDFISH

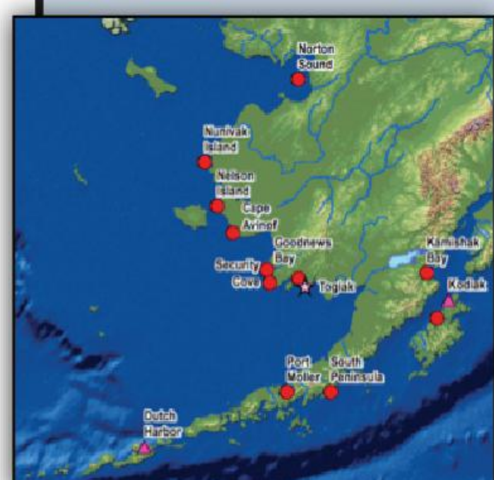
Species: Pacific cod, sablefish, sole, flounder, Pollock & others
Value: $2.35 billion (first wholesale value in 2014)
Season: 22 distinct seasons through the year

Groundfish statistical and reporting areas (Aydin et al., 2015)

HALIBUT ▶

Species: Pacific halibut
Value: $106.7 million
Season: March 14 – November 7 in 2015 ("Halibut Commission Completes 2015 Annual Meeting," 2015 International Pacific Halibut Commission reporting areas (NOAA, n.d.-c))





◀ HERRING

Species: Bering Sea herring (distinct from Gulf of Alaska herring); includes harvest of sac roe

Sac roe harvest areas (red dots); as well as spawning (Togiak) and harvest for food/bait (Dutch Harbor); figure excerpted from ADF&G, 2016b

▼ SALMON

Species: Chinook (king), Sockeye, coho (silver), chum (ADF&G, 2016c)
Value: $546 million
Season: Throughout summer; variable by species and fishery

Salmon fishing activities are undertaken throughout the region.

Figure 3-4 Some of the commercial fisheries of the Bering Sea

4 Vessel Traffic in the Bering Sea

The likelihood, scope, and potential impacts of vessel traffic are directly related to the quantity, type, and location of vessels moving through the region. Sections 5 and 6 will provide a detailed characterization of vessel traffic through the northern Bering Sea and Bering Strait. This section provides a general overview of Bering Sea traffic as a whole. It includes activity in the Aleutian Islands area, because it is applicable to a broad consideration of shipping risks in the Bering Sea, and is also a current driver for some of the mitigation measures discussed in Section 8.

4.1 Overview of Vessel Traffic in the Bering Sea

Bering Sea shipping overall is currently dominated by traffic through the Aleutian Islands between North America and East Asia. Commercial fishing vessels also operate in the southern Bering Sea year-round, delivering their catch to communities with fish processing plants. Containerships and refrigerated cargo ships then move the processed seafood to global markets. Tankers, general cargo ships, and barges move throughout the eastern Bering Sea serving coastal and inland communities. Vessels also support industrial activities and resource extraction in the region, or move goods or materials through the area to European, Asian, and other North American ports. The Alaska Marine Highway ferry serves the communities of the Aleutian Islands archipelago and the adjacent Alaskan Peninsula. The occasional cruise ship passes through the area. Research vessels, U.S. Coast Guard and other government vessels, and pleasure craft operate here as well. Figure 4-1 illustrates some of the types of vessels found in the Bering Sea.

Figure 4-1 Example vessel types operating in Bering Sea

Figure 4-2 shows an overview of vessel activity throughout the Bering Sea from a study undertaken by the Aleutian Islands and Bering Sea LCC, Wildlife Conservation Society, and University of Alaska Fairbanks' SNAP. The two maps include only two types of ships – tankers and bulk carriers – to show the primary routes taken by deep draft ships in the region. These data generally portray the high volume of shipping activity in the Aleutian Islands as compared to the northern Bering Sea, including the prevalence of bulk carriers among the deep draft vessels along the North Pacific Great Circle Route. Bering Strait activity is further explored in the analysis presented in subsequent sections of this report, including the prevalence of tankers on the Russian side shown in Figure 4-2.

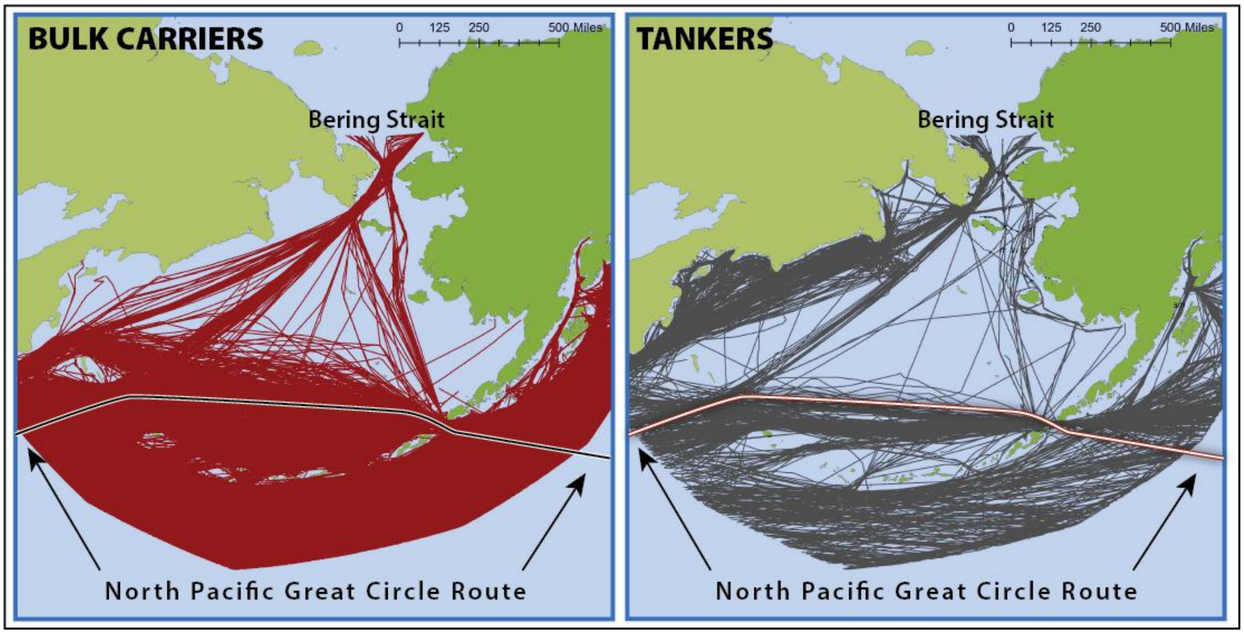


Figure 4-2 Bulk carrier (left) and tanker (right) routes through the Bering Sea (based on July 2010 - August 2013 satellite AIS data compiled by the Aleutian Islands and Bering Sea LCC, Wildlife Conservation Society, and University of Alaska Fairbanks' SNAP using exactEarth data). For more information on these data, see: https://absilcc.org/.

4.2 Aleutian Islands Vessel Traffic

The Aleutian Islands Risk Assessment (AIRA)[6] found that while fishing vessels made the most trips in and out of ports in the area, nearly 75% of the individual vessels operating in the Aleutian Islands archipelago were ships traveling between North America and Asia. More than 70% of these were heading west towards Asia, indicating that most of the vessels that stay south of the islands are doing so on an eastbound voyage. Bulk carriers made up more than 40% of the ships identified, followed by large container ships, which made up just over 15% (DNV & ERM-West, Inc., 2010). As discussed in Section 8.1.1, about half these large vessels

[6] *www.aleutianislandsriskassessment.com*

were in "innocent passage"[7] and not subject to U.S. oil spill response planning regulations (Nuka Research and Planning Group, 2014).

Unless they stay south of the Islands altogether, most, though not all, of the vessels transiting the Aleutians region use Unimak Pass and one of a handful of other passes[8] as they travel north and then south again along a Great Circle Route. The AIRA study used 2006-2009 data, identifying approximately 3,500-4,500 total trips through Unimak Pass for each of those years (DNV & ERM-West, Inc., 2010). A follow-up analysis found just over 4,500 transits through the Pass in 2012 (Nuka Research and Planning Group, 2014).

Even as they have increased, there are still many fewer transits of the Bering Strait than of Unimak Pass. While there were more than 4,500 transits of Unimak Pass in 2012, there were just 480 transits of the Bering Strait that year (Nuka Research and Planning Group, 2014; U.S. Committee on the Marine Transportation System, 2016). However, although the Bering Strait saw just over 10% of the number of transits that Unimak Pass did that year, Bering Strait transits in 2012 had more than doubled since 2008.

Table 4-1 Comparison of number of transits through Unimak Pass in the Aleutian Islands and the Bering Strait, 2006-2015 (Nuka Research and Planning Group, 2014; U.S. Committee on the Marine Transportation System, 2016).[9]

	Unimak Pass Transits	Bering Strait Transits
2006	3491	*n/a*
2007	4471	*n/a*
2008	4231	220
2009	3974	280
2010	*n/a*	430
2011	*n/a*	410
2012	4615	480
2013	*n/a*	440
2014	*n/a*	340
2015	*n/a*	540

[7] *Vessels flagged to another country and passing through U.S. waters without stopping at a U.S. port are in "innocent passage" or, when using a traditional strait, "transit passage." These vessels are not subject to U.S. regulations when on such voyages.*

[8] *With the establishment of IMO guidelines designating areas to be avoided, there are now three passes "recommended" to be used, and vessels in international transit are supposed to otherwise stay at least 50 nm offshore (Nuka Research and Planning Group & Pearson Consulting, 2016).*

[9] *Transit data are taken only from two sources to illustrate a general comparison. "N/a" indicates years for which data were not available from the referenced sources. Unimak Pass transits for 2006-2009 were based on fiscal rather than calendar year.*

5 Potential Hazards Associated with Shipping Activities

The migration corridors used by marine mammals and birds correspond broadly with the main shipping routes into and out of the Arctic. Currently, there is limited overlap during the spring migration as all shipping activity will typically occur later in the spring than the animal migrations. In the fall, there is likely more opportunity for interaction between ships and migrating species, as both are leaving the Arctic ahead of the formation of the pack ice. As the Arctic climate continues to change, it is very likely that the shipping season could extend earlier in the spring and later into the fall. The spring migration corridors are particularly sensitive and vulnerable areas to oil spills, ship strikes and disturbances, and could be a time of vulnerability for marine mammals and birds. In the future, there will be a need to consider the potential risk and interaction between ships and animals during this vulnerable period."

-- Arctic Marine Shipping Assessment (Arctic Council, 2009)

Vessels and animals both use the narrow corridor of the Bering Strait to travel between the Arctic Ocean and Bering Sea. This creates an overlap between the human and animal communities in the region and the noise, air emissions, waste, and potential for whale strikes or oil or other hazardous substance spills associated with vessel activities. This section discusses the potential for *exposures* to some of these hazards associated with vessel activities in the Bering Sea. *Receptors* for these impacts are identified in general terms. As noted previously, this report does not predict the likelihood of any particular impact. That said, this type of quantitative analysis could be conducted in future, and we identify some datasets and resources that could be used.

5.1 Accidents and Oil Spills

Most biological communities are susceptible to the effects of oil spills. Plant communities on land, marsh grasses in estuaries, and kelp beds in the ocean; microscopic plants and animals; and larger animals, such as fish, amphibians and reptiles, birds, and mammals, are subject to contact, smothering, toxicity, and the chronic long-term effects that may result from the physical and chemical properties of the spilled oil.

- *Wildlife and Oil Spills (U.S. EPA, 1999)*

Anywhere vessels use, transport, or store oil or oil products, the potential for oil spills exists (National Research Council, 2001). The potential for accidental oil or cargo spills in the Arctic environment is a serious concern (Arctic Council, 2009). This section discusses the potential for exposures to oil spills in the Bering Sea.

5.1.1 OIL SPILL FATE AND EFFECTS

Numerous factors interact to determine where an oil spill will spread, how the oil will change over time, and how it could affect species or people it contacts. These include, but are not limited to, the type and quantity of oil spilled, location, and conditions at the time (winds, waves, currents, temperature, tides, and ice).

When oil of any type is spilled to the marine environment, it will begin to spread with the tides, currents, and wind, and at the same time it will undergo physical and chemical changes referred to as "weathering." The nature and extent of these processes will depend on the oil type and properties and the conditions during and following the spill. Figure 5-1 shows typical physical, chemical, and biological processes involved in oil weathering: spreading, evaporation, dispersion, dissolution, emulsification, oxidation, sedimentation, and biodegradation.

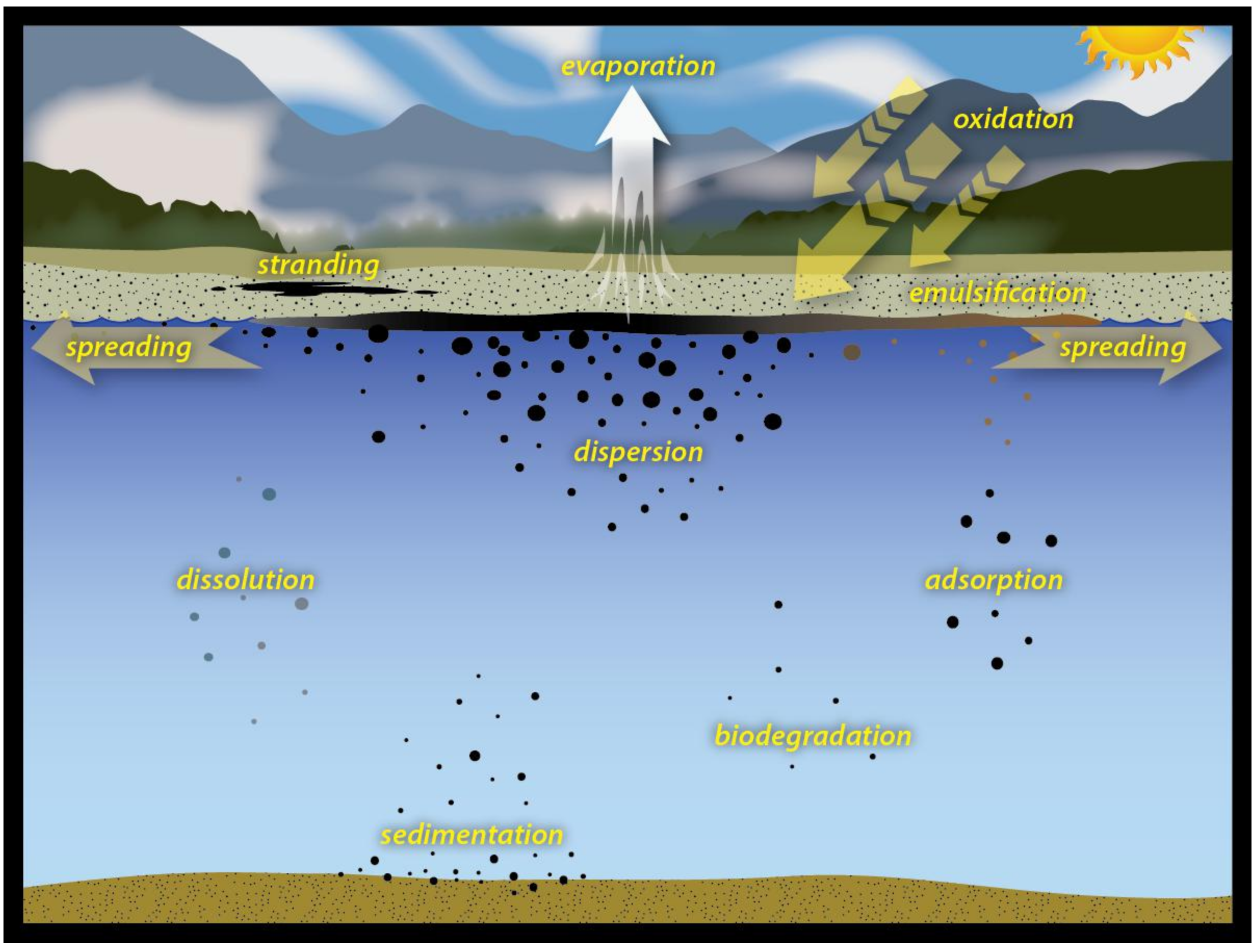


Figure 5-1 Typical oil spread and weathering processes. The way oil behaves when it reaches the marine environment will depend on the oil type and conditions during and after the spill (ITOPF Ltd., 2011; NOAA, n.d.-d).

The conditions during and following an oil spill will also influence the way spilled oil interacts with the environment. Conditions may also affect any attempt to respond to the spill, and possibly limit response options or prevent a response.

There are many different types of oil, based on the product into which it is refined, or where it was extracted. When oil is spilled to the marine environment the characteristics of the oil itself and that environment determine how the spreading and weathering processes will unfold. NOAA (2016) summarizes the four types of oil most commonly referenced for spill response planning, excerpted below:

Type 1: Very Light Oils (Jet Fuels, Gasoline)

- *Highly volatile (should evaporate within 1-2 days)*
- *High concentrations of toxic (soluble) compounds*
- *Localized, severe impacts to water column and intertidal resources*
- *No cleanup possible*

Type 2: Light Oils (Diesel, No. 2 Fuel Oil, Light Crudes)

- *Moderately volatile; will leave residue (up to one-third of spill amount) after a few days*
- *Moderate concentrations of toxic (soluble) compounds*
- *Will "oil" intertidal resources with long-term contamination potential*
- *Cleanup can be effective*

Type 3: Medium Oils (Most Crude Oils, Intermediate Fuel Oils)

- *About one-third will evaporate within 24 hours*
- *Oil contamination of intertidal areas can be severe and long-term*
- *Oil impacts to waterfowl and fur-bearing mammals can be severe*
- *Cleanup most effective if conducted quickly*

Type 4: Heavy Oils (Heavy Crude Oils, No. 6 Fuel Oil, Bunker C, Heavy Fuel Oil)

- *Little or no evaporation or dissolution*
- *Heavy contamination of intertidal areas likely*
- *Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion)*
- *Long-term contamination of sediments possible*
- *Weathers very slowly*
- *Shoreline cleanup difficult under all conditions*

Figure 5-2 provides a very high level overview of some wildlife impacts that have been observed from oil spills. The list is not exhaustive, nor does it include pathways and effects associated with response activities or techniques used.

Known exposure pathways and effects of oil on general species categories (U.S. EPA, 1999)

Fish

Pathways:

- Contaminate gills
- Intake or absorb toxic chemicals in water column (eggs, larvae, juveniles)
- Ingestion/food contamination

Effects:

- Changes in heart and respiratory rate
- Enlarged livers
- Reduced growth
- Fin erosion
- Reproductive and behavioral changes
- Genetic abnormalities
- Cancers

Birds

Pathways:

- Direct contact/coating
- Ingestion/food contamination

Effects:

- Unable to stay warm
- Loss of buoyancy
- Reproductive effects

Whales, seals, and walrus

Pathway:

- Inhalation
- Direct contact/coating
- Ingestion/food contamination

Effects:

- Unable to stay warm (fur seals)
- Lung injuries
- Irritation of eyes and mucous membranes
- Long-term chronic effects (not specified)

Sea Otters

Pathway:

- Inhalation
- Direct contact/coating
- Ingestion/food contamination

Effects:

- Unable to stay warm
- Loss of buoyancy
- Lung injuries
- Digestive tract bleeding
- Liver and kidney damage

Figure 5-2 Examples of pathways and effects for different species in the presence of spilled oil

Oils are categorized as non-persistent and persistent based on how long a spill is likely to remain recognizable in the marine environment. Persistent oils are generally assumed to have a greater potential to impact the environment when spilled, including coating or smothering wildlife. Persistent oil (Type 3-4) is more likely to spread as a slick or strand on shore than non-persistent oils (Types 1-2) such as jet fuel or gasoline. Non-persistent oils will evaporate or dissolve in the water, where their uptake by fish or other species may harm species or the people who consume them. Generally, lower persistence correlates with higher toxicity (The Glosten Associates & Environmental Research Consulting, 2012) though one study shows that heavy fuel oil, can also be significantly more toxic to fish embryos than some lighter crude oils (Bornstein et al., 2014). In the northern Bering Sea and Bering Strait, most of the non-persistent oil currently moving on board vessels is Type 2 from the list above (diesel and marine diesel) being moved as both vessel fuel and cargo. Most of the persistent oil is Type 4 (heavy fuel oils or Bunker C), which is used as vessel fuel in some of the larger ships. This is discussed further in Section 8.

5.1.1.1 Past spills

We identify two sources of historical data on oil spills and marine accidents in the Bering Sea as a whole for potential consideration in future analyses. It is important to note that just because a spill has not happened before in the area does not mean that it couldn't happen in the future; likewise, just because a certain cause or size of spill has happened before does not mean it will be repeated. Thus, these two examples of historical data should be understood as illustrative and not predictive.

- Coast Guard investigations. The U.S. Coast Guard has collected data on their investigations of marine incidents or accidents since 1972 (for pollution incidents) and 1982 (for marine casualties). They make some of these data available for researchers (U.S. Coast Guard, 2015).[10] Investigations include both accidents and other pollution releases (without an associated accident). In the Bering Sea from 1999-July 2015, there were 34 investigations of vessel accidents resulting in "Damage to the Environment," 31 of which included spilled oil.[11] There were many more (275) cases where the vessel operator acknowledged that the vessel was the source of pollution but no actual accident occurred.[12] Almost 80% of all investigations noted for "Damage to the Environment" involved fishing vessels, followed by 5% tank barges, 5% tugs,[13] and 4% freight or cargo ships.
- Alaska Department of Environmental Conservation (ADEC) spills database. The ADEC database tracks spills reported to the state. All spills to water and any spill to land greater than 1 gallon must be reported to the state (ADEC, 2011). Similar to the Coast Guard data, most of the spills in the ADEC database are small spills associated with fishing vessels. See Table 5-1.

Table 5-1 Summary of Aleutian Island and Bering Sea Spills in ADEC database from August 1994 - March 2013 (ADEC, 2013)

Vessel Type	Number of Spills	Total Spill Volume (gallons)
Barge	3	502
Cargo	10	*335,823
Fishing	**59	11,980
Other	2	6
Total	74	348,311

*335,732 gallons from 2004 *M/V Selendang Ayu* spill in the Aleutian Islands
**55 of these were associated with fishing vessels less than 400 GT

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[10] *Incomplete investigations are not included, so the data as published is unreliable for yearly totals since investigations from recent years are the most likely to be ongoing and therefore omitted from the public data.*
[11] *Other types of damage were hazardous materials release (2) and air pollution (1).*
[12] *These two categories cover the majority of investigations noting Damage to the Environment. There were also some cases where the pollution source is, for example, suspected but not acknowledged.*
[13] *Tug and barge investigations are separate incidents and not duplicates even though the two are often operating together.*

5.2 Exposures to Other Impacts in the Bering Sea

This section discusses some of the other types of impacts that may occur during normal vessel operations: vessel noise, release of waste materials, marine mammal strikes, and air pollution. This list is not exhaustive, and each section provides a high level description of the issue and identifies information available for, or applicable to, the Bering Sea based on a literature review.

Ongoing pollution of the marine environment, often from unknown sources, is highlighted as a concern of subsistence users in the Bering Strait region. Subsistence experts have observed impacts to the behavior, safety, or availability of the species they eat due to the unnatural introduction of sounds, liquids or materials, and smells and other air emissions from shipping activities (Oceana & Kawerak, Inc., 2014).

5.2.1 VESSEL NOISE

> *Walrus and seals, they are all sensitive to noise. They could hear your footsteps on ice, they could hear you tap on water.*
>
> \- *John Ahkvaluk, Diomede (Oceana & Kawerak, Inc., 2014)*

> *The transition from wind-driven to mechanized shipping became the first step in what was to be a continued increase in the introduction of sound to the oceans...Over the last 40 million years, marine mammals have evolved specializations for using underwater sound…At some point as humans introduce more sound into the oceans, the conflict with evolutionarily-adapted marine mammal sound-sensing systems seems inevitable.*
>
> \- *Marine Mammal Populations and Ocean Noise (National Research Council, 2005)*

Marine mammals' use of sound to interpret their environment has been likened to people's use of sight and visual cues: not only do they use sound to communicate with each other, but many species use sound to understand what is around them through echolocation.[14] The volume of noise added to the underwater environment by ships and other industrial activities is significant and growing. The wide-ranging potential impacts of underwater noise on whales and other species have been widely documented if still not fully understood (Peng et al., 2015).

Noise travels far under water, and the typically low-frequency rumble of a ship in motion may be heard over hundreds of square miles of ocean depending on depth, salinity, ice, temperature,[15] and other factors. There is growing evidence that such sound can negatively impact whales and fish (Williams et al., 2014). Impacts range from modified behavior, including communications, to hearing damage or stranding. The extent to which these impacts cause population-level effects is unknown, though it is more likely in when species are clustered in relatively small, discrete population groups (Weilgart, 2007).

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[14] *In addition to shipping, other industrial activities such as dredging, drilling, and pile driving contribute to subsea noise; also sonar used for military or oil and gas operations.*

[15] *Noise is heightened in the cold waters typical of the Arctic environment (Katz, 2016)*

Different whale species are susceptible to different sound frequencies. In July 2016, the U.S. government issued guidance for determining the thresholds at which different marine mammals may suffer impacts from underwater sound (hearing the sound, temporary hearing damage, or permanent hearing damage). The guidance divides species into groups based on the range of frequencies they typically hear. Generally, baleen whales such as humpbacks and grey whales hear at lower frequencies (7 Hz – 35 kHz) than toothed or beaked whales (150 Hz – 160 kHz) (NMFS, 2016).

Different ships also make different sounds underwater. Ships that are newer or smaller tend to be quieter than older or larger ships. Hull design also affects sound. Vessels are typically louder when they are traveling faster, though slowing down increases the duration of exposure for species in the area (Sullender, 2016). In addition to the sound generated by the vessel's engine and propeller, activities such as ice-breaking can also make sound. In one of the earlier studies of the issue, beluga whales started making alarm calls when an icebreaking ship was more than 50 miles away. The whales began to leave the area when the ship approached to roughly 25-40 miles, traveling 50 miles away and staying away from the area for a day or two. (LGL Limited et al., 1986)

Analysts at Audubon Alaska are currently studying the potential frequencies and decibel levels of underwater sound generated by vessel traffic in the U.S. Arctic Ocean and Bering Strait area to consider how these align with the NOAA guidance for both baleen and toothed/beaked whales. Preliminary results indicate that while both types of whales would be expected to be able to hear the sound (and so may be modifying their behavior as a result), the permanent injury thresholds are not being exceeded at the frequency band of 0.2 kHz. Sound exposure levels have been found to be much closer to the permanent injury threshold for the bowhead (baleen) whales than the beluga (toothed) whales. Vessel noise has the highest amplitude at low frequencies and, because bowhead whales have much more sensitive hearing than both beluga and pinnipeds at low-frequencies, this preliminary analysis predicts that acoustic impacts are likely to be greater for baleen whales than the toothed whales. (Ben Sullender, personal communication)

The International Maritime Organization (IMO), an international body that regulates shipping, has developed voluntary guidelines to recommend changes to new ship design that will reduce underwater noise generated by moving the location of the propeller, buffering the engine, moving parts from the hull, and modifying the hull design (IMO, 2014).

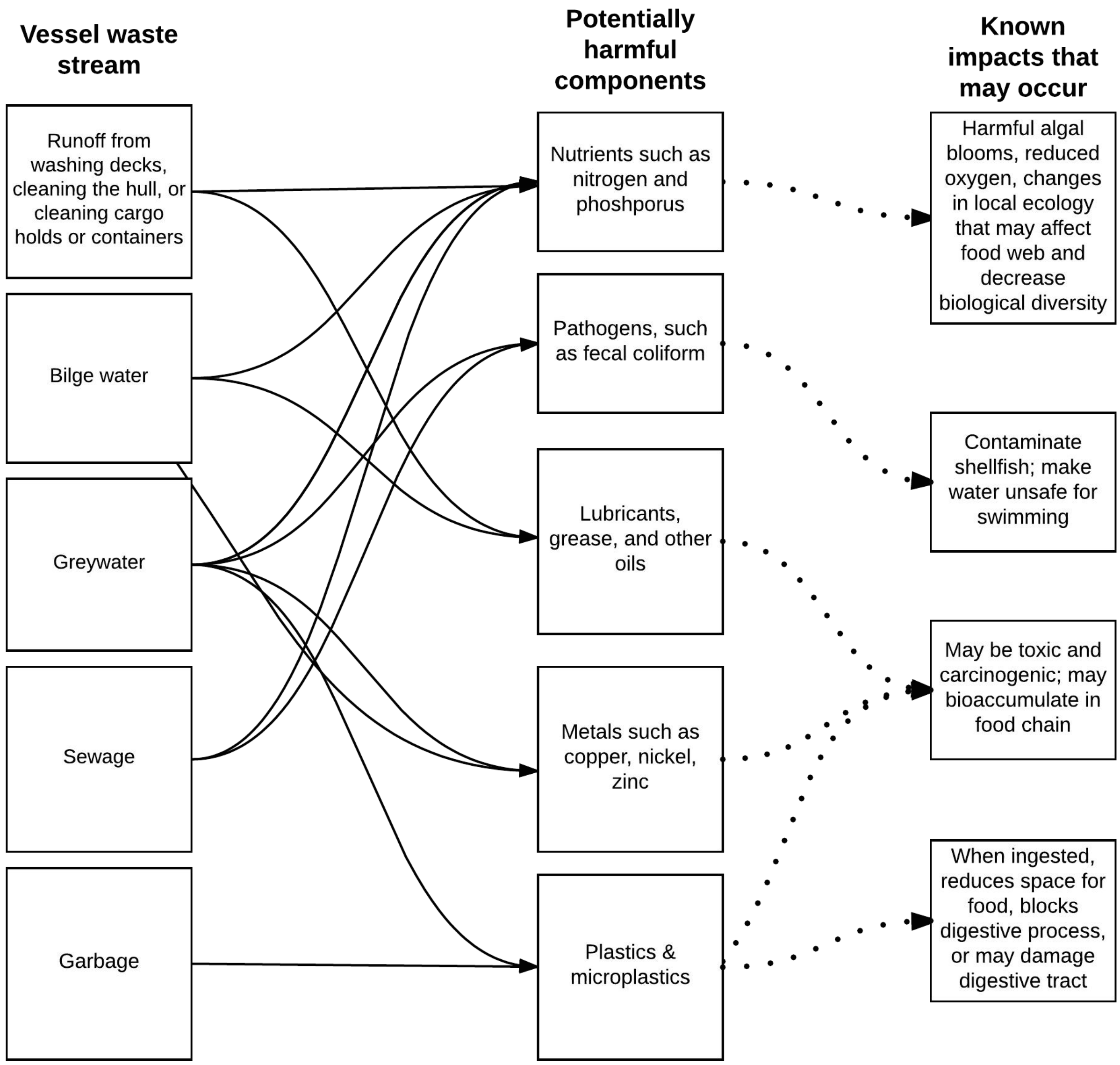
5.2.2 VESSEL WASTE

> *[Contaminants] affect the fish. The seals eat the fish, and we eat the seal.*
>
> \- *Albert Johnson, Nome*
> *(Oceana & Kawerak, Inc., 2014)*

> *Prevalence of debris ingestion among seabirds is suggestive of a broad and significant ecological impact, at least in some regions such as the North Pacific Ocean.*
>
> – *Tackling Marine Debris in the 21st Century*
> *(National Research Council, 2009)*

People generate waste anywhere they spend time, including sewage, wastewater, food scraps, and packaging waste or other garbage. Vessel waste may also include residues in cargo holds or containers, and bilge water (the mixture of seawater and oil, grease and other contaminants that collects in the bottom of a ship's hull). Thus, the type and relative quantities of wastes generated will depend on the kind of vessel, as well as its size (which can be both an indication of the scale of potential waste streams as well as determining how the vessel is regulated). Vessels operating in the region are just one potential source of waste pollution, which can also originate from vessels in other regions, as well as offshore operations or the intentional or unintentional release of both solid and liquid wastes from land-based sources, either in the region or elsewhere (National Research Council, 2009; Condino, David, n.d.) This section focuses on wastes from vessels, though we note that not all marine debris or pollutants come from vessels.

When waste materials are released, they may negatively affect the health of the environment that supports people and wildlife. The nature and extent of these impacts will vary widely, depending on the waste stream, quantity, location, and timing. Many vessel wastes are regulated depending on the vessel type and where it is located. Figure 5-3 provides a summary of some of the primary waste streams associated with normal vessel operations (on the left), potentially harmful components of these waste streams (in the middle), and impacts that are known to occur (on the right). Some of these impacts are already documented in the Bering Sea region, such as the ingestion of plastics by seabirds (which may or may not be associated with vessels in the region), and others, such as wastes from cruise ships, which have already raised concerns farther south in Alaska and are raising concerns in the Northern Bering Sea as more large passenger vessels enter the area.



Based on:

U.S. Environmental Protection Agency (2013). *Final Issuance of National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for Discharges Incidental to the Normal Operation of Vessels: Fact Sheet*

National Research Council (2009). *Tackling Marine Debris in the 21st Century.* National Academies Press.

Figure 5-3 Waste and other pollution streams associated with vessels and potential impacts to people and wildlife

Some aspects of vessel waste management have been regulated in international law, at least for larger vessels.[16] Exact requirements depend on the vessel, waste stream, and location. In general, plastics and other garbage (including ash from incineration) may not be discarded overboard anywhere. However, most other types of waste (cargo residues, food waste, raw sewage, and greywater) can be released into waters as long as the vessel is at least 12 nm offshore (IMO, 2013). The IMO's Polar Code, a recent update to international mandates related to pollution prevention and safety, adds prohibitions against the disposal of food waste onto sea ice and equates sea ice with land regarding the prohibition on disposing of ground up food wastes within 12 nm. It also prohibits the disposal of sewage in Arctic waters (IMO, 2016b). The Polar Code is in effect in the Bering Sea north of 60 degrees North (see Figure 8-1).

Where vessels comply with the garbage disposal requirements by storing wastes on board until they can be properly handled at a port facility, there will be no local marine impact (though the more global potential impacts of waste management will still apply). Coastal nations, such as the U.S., are required to provide collection and management facilities for regulated waste streams in port, thereby reducing the incentive for illegal dumping. This positive incentive only helps, however, when facilities are convenient to the ship's route and accessible to the vessel. With no deep draft port north of Dutch Harbor in the Aleutian Islands, the growing number of vessels that may transit the Bering Sea on voyages through the Arctic Ocean will need to be equipped to store wastes for the duration of their journey. This will add stress to the waste management capacities of the ports serving the vessels at the end of their Arctic journey (Condino, David, n.d.).

5.2.3 VESSEL STRIKES

Marine mammals such as whales and dolphins must breathe and may also rest, feed, bask, or engage in other behaviors at or near the surface, creating the potential for collisions, or ship strikes. These collisions may result in injury or death for the animal; they may be dangerous for smaller vessels yet go unnoticed by larger ones. There are many reasons why it is difficult to quantify the potential risk of ship strikes in the Bering Sea, and why ship strikes are likely to go unrecorded (Monnahan et al., 2015).[17] This section identifies some of the factors that will

[16] The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the primary international law related to pollution of the marine environment from ships. It was first adopted in 1973, then updated in 1978 even before it first entered into force (IMO, 2016a).

[17] A ship strike is only known to have occurred if the injured or dead animal is examined (and sufficient evidence of the cause of injury or death is apparent), or if the vessel operator or a reliable observer is able to make an accurate report. The size, depth, and relatively remote shoreline of the Bering Sea make it very unlikely that all impacted animals will be found and reported, and the resources required to examine those that are identified will inhibit the collection of comprehensive data. Some vessels, especially large ones moving a high speeds, may not realize or be able to confirm that they struck an animal, or may not know that it should be reported (or how to do so). They may also be reluctant to report such incidents. Thus, the collection of reliable data on the location, species, vessel type, vessel speed or operations at the time of a strike, and impact to the animal is likely to indicate only a fraction of the incidents that occur. (International Whaling Commission, 2016; Neilson et al., 2012)

influence the risk of marine mammal strikes in the Bering Sea, as they relate to the interplay between marine mammal species' location and behavior and vessel operations.

Humpback whales have suffered the highest number of *recorded* vessel strikes in Alaska, most of which have occurred in Southeast Alaska. The only Bering Sea whale strike in the 1978-2011 database analyzed was also a humpback whale (Neilson et al., 2012). The database identified strikes elsewhere in Alaska of other species that are known to spend time in the Bering Sea, as shown in Table 5-2. While this list is not exhaustive, it illustrates that whale species known to be in the area are potentially susceptible to vessel strikes if vessel traffic increases.

Table 5-2 Bering Sea whale species known to have been struck by vessels in the Bering Sea or elsewhere in Alaska (1979-2011)

Species	Known strikes, 1979-2011 (Neilson et al., 2012)	
	Bering Sea (Neilson et al., 2012)	***Elsewhere in AK***
Beaked whales		✔[18]
Blue whale	No, but recorded in WA (Douglas et al., 2008) and CA (Berman-Kowalewski et al., 2010)	
Humpback whale	✔	
Grey whale		✔
Fin whale		✔
Sperm whale		✔

There is general agreement that vessel speed is a significant factor in ship strikes (International Whaling Commission, 2016). Studies have reached different conclusions in seeking to pinpoint a direct relationship between vessel speed and either likelihood or consequence (to the animal) of a strike. One study found that most "lethal or severe" injuries occur when the vessel is 80-feet or longer or traveling 14 knots or more, based on reviewing known strikes (Laist et al., 2001). Another study took a statistical approach to the data, identifying 11.8 knots as the point above which there is a 50% or greater chance that a whale will be killed if struck (Vanderlaan & Taggart, 2007). In an effort to protect the Northern Right Whale along the U.S. east coast, a 10-knot speed limit was imposed for vessels of 65-feet or longer in seasonal management areas. Indications are that this has been effective in eliminating or reducing whale strikes in these areas (Laist et al., 2014). Figure 5-4 plots these relevant vessel speeds from the literature on marine mammal strikes as compared to the average speeds of different vessel types from an analysis conducted for the Aleutian Islands Risk Assessment (DNV & ERM-West, Inc., 2010).

[18] *Possible/probable*

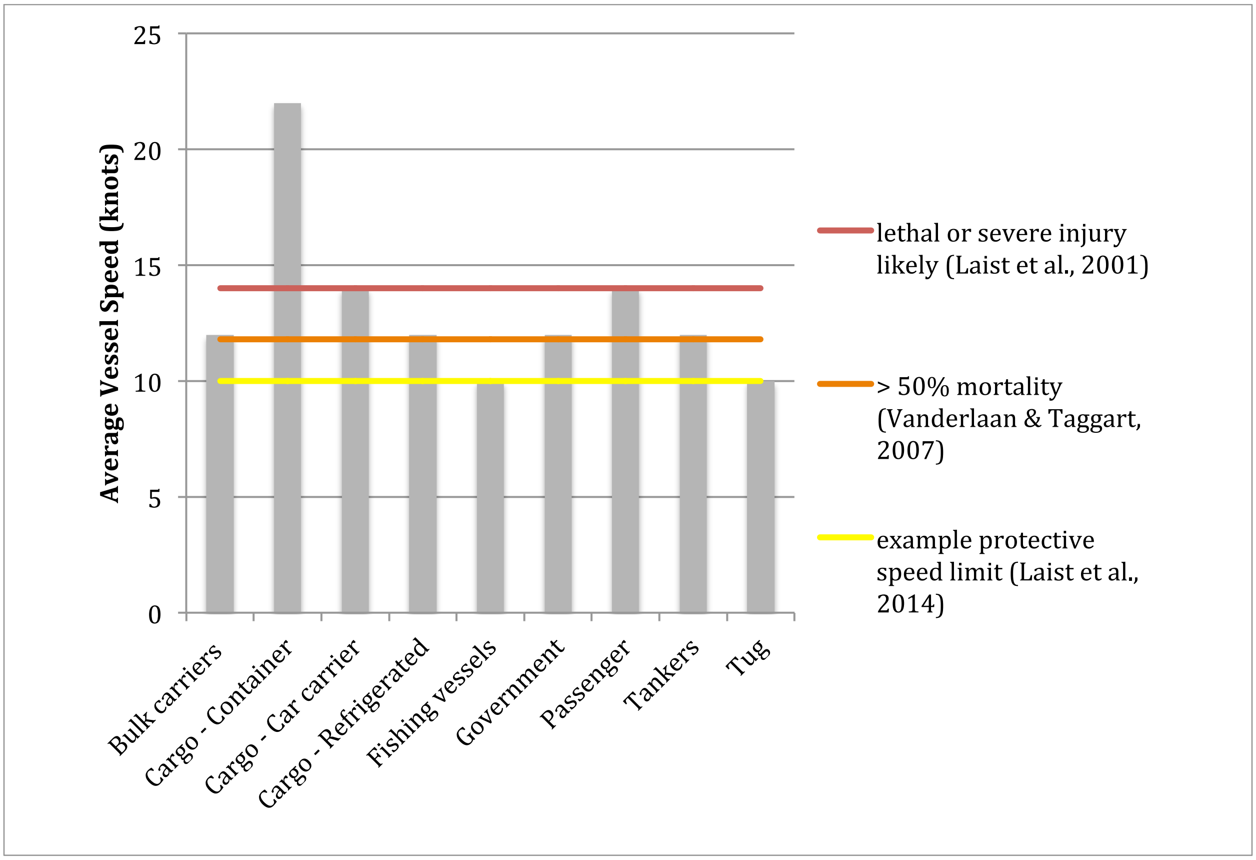


Figure 5-4 Average speeds of different vessel types, based on Aleutian Islands traffic analysis (DNV & ERM-West, Inc., 2010). Colored lines represent vessel speeds identified in literature related to severity or prevention of marine mammal strikes.

For any collision to occur, the two colliding entities must be in the same place at the same time. In the case of the Bering Sea, corridors such as the Bering Strait or Aleutian Islands passages that are used by both whales and the relatively larger vessels of primary concern for potential ship strikes warrant attention as shipping activity increases and/or shipping season lengthens as sea ice forms later and retreats earlier. For one example, the Wildlife Conservation Society, UAF-SNAP, and Aleutian and Bering Sea Islands LCC have taken a preliminary look at this issue by plotting examples of the known presence of two whale species (based on tagged animals) in the Bering Strait relative to ship traffic activity occurring during the same season. While less than one-half of one percent of animals are believed to be tagged, these data indicate that there is a high likelihood that grey whales, active in the area in throughout the summer, will use the same waters as vessels going to and from the Red Dog mine that time of year. (Robards et al., 2014).

5.2.4 AIR EMISSIONS

Vessels burn different types of oil, which can release hazardous pollutants. Effects may be global (e.g., greenhouse gases such as CO_2), transferred to other regions (e.g., acid rain caused by sulfur emissions), or local (e.g., human health impacts or increased ice melt from black carbon). Marine vessels transporting freight or cargo often burn residual oils, such Heavy Fuel Oil (HFO) and Intermediate Fuel Oil (IFO), which may not burn as cleanly. Combustion of these fuels can release large amounts of particulates such as black carbon (soot), sulfur aerosols, ash, and heavy metals into the air (Arctic Council, 2009). Diesel is also commonly used. The exhaust from diesel engines contains tiny particulate matter that can lead to ozone pollution, acid rain, climate change, or toxic air pollutants (U.S. EPA, 2016).

Black carbon, or soot resulting from the incomplete oxidation of fuels burned, is a particular area of focus for the Arctic. This type of particulate can reduce the reflectivity of sea ice and snow. When solar radiation reaches ice and snow, reflectivity is reduced, causing a significant increase in the rate of melting. In the Arctic it is estimated that 1,180 metric tons of carbon are released annually. Because of the Arctic's unique environment small amounts of black carbon could potentially have a disproportionate impact on melting ice (Arctic Council, 2009).

Air pollutant exposures in the Bering Sea as a whole are primarily generated by the vessel traffic on the North Pacific Great Circle Route through the Aleutian Islands. Vessel traffic on the North Pacific Great Circle Route in the southern Bering Sea had the highest volume of CO_2 emissions anywhere in the Arctic based on 2004 estimates (Arctic Council, 2009). An analysis of air emissions based on vessel data from 2012-2013 echoed this for other pollutants as well (Det Norske Veritas, 2013). Figure 5-5 shows portion of emissions by vessel type for the Bering Sea based on a study conducted by DNV for the Arctic Council (2013). The study used AIS data from August 2012-August 2013. Estimated air emissions reflect a combination of vessel type and size, fuel type, quantity of fuel consumed, and distance traveled/time spent in the area.

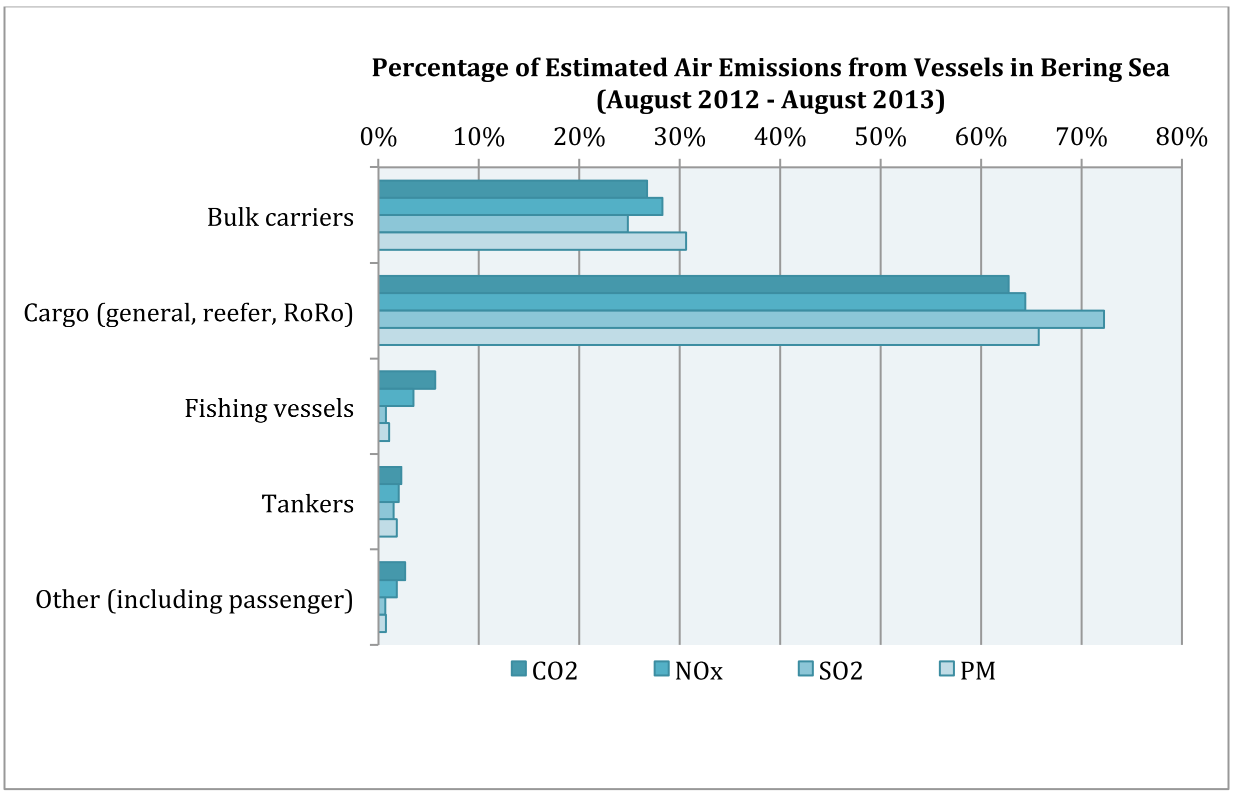


Figure 5-5 Estimated air emissions in the Bering Sea based on 2012-2013 AIS data (DNV, 2013)

6 Analysis of Bering Strait Vessel Traffic

To better characterize the risks posed by vessel traffic in the area, we need to understand the types of vessels currently transiting the area. For this study, Nuka Research analyzed Bering Strait vessel tracks based on Automatic Identification System (AIS) data from 2013-2015 as an indication of activity throughout the Bering Sea. The dataset developed is restricted to an area (Figure 6-1) encompassing the Bering Strait. This area serves as a natural focal point for ships that transit the sea and the data provides vessel type, size, estimated petroleum on board (fuel or cargo), flag state, and route details.

6.1 Data Inputs and Processing

Two sources of AIS data were used to identify vessels operating in the Bering Strait: the Marine Exchange of Alaska (MXAK) provided shore-based AIS data for the years 2013-2015, and the Norwegian Coastal Administration (NCA) provided[19] satellite-based data for the years 2013-2014. The spatial extent of the two datasets overlapped but were not exactly the same, as shown in Figure 6-1. NCA data covered a larger area extending south and west of the area covered by MXAK, but was not available for all three years. Data from 2013 and 2014 are 100% compatible but the data from 2015 covers only a subset of the area (shown in orange in the map below). Because of this, data cannot be compared between the 2013/14 years with 2015 to observe temporal trends. Three years is also too short a time period to reliably illustrate trends, as activity fluctuates based on markets, ice conditions, and industrial activity in the immediate area or Arctic.

Figure 6-1 Boundaries used for vessel traffic data. The yellow outline shows area covered by the NCA data, while the orange outline shows area covered by the MXAK data.

[19] *Data were provided via Ocean Conservancy.*

Automated Identification System (AIS) Data

AIS receivers compile the signals transmitted from the vessel to a receiver, communicating information about the vessel and its position. A simple algorithm can be used to develop a map-based vessel track for each vessel based on its position signals. AIS data compiled over time illustrate general vessel movements in the area.

The International Convention for the Safety of Life at Sea (Regulation 19, Chapter V) requires AIS to be fitted on board the following types of vessels – though some vessels choose to use AIS voluntarily:

- Vessels of 300 gross tons or more
- All tank ships
- Self-propelled vessels of 65 feet or more
- Vessels engaged in commercial service or international voyages
- Most towing vessels
- Dredges
- Certain classes of passenger vessels.

AIS records have some limitations. With an emphasis on immediate safety, AIS broadcasts are required to transmit the vessel's identity, type, location, course, speed, and status. Other information may be included as well, though information may be missing or incorrect. General gaps in AIS datasets include:

- Some data are missing or incorrect. Because some data must be entered manually (and is not required), AIS data often has significant gaps and errors, primarily misidentification or incorrect classification of vessels.
- Barges are not required to have AIS, so AIS data cannot be used to characterize barge traffic. While the tugs that tow the barges have AIS receivers, the AIS data does not indicate whether a tug has a barge in tow, or what type of barge if there is one.
- Government and military vessels are not required to have their AIS transmitting at all times. These vessels have AIS transponders but are not required to use them, so AIS data for these vessel types are typically incomplete.
- Smaller vessels are not required to use AIS. Some small vessels voluntarily have AIS but it is not required by the IMO, they are generally under-represented in AIS data.
- AIS data may vary over time due to changes in satellite coverage or the addition or upgrade of land-based AIS stations.
- The strength and reception of an AIS signal varies from ship to ship depending on equipment and antenna location.
- The strength and reception of AIS signal is affected by atmospheric conditions and is not consistent through time.

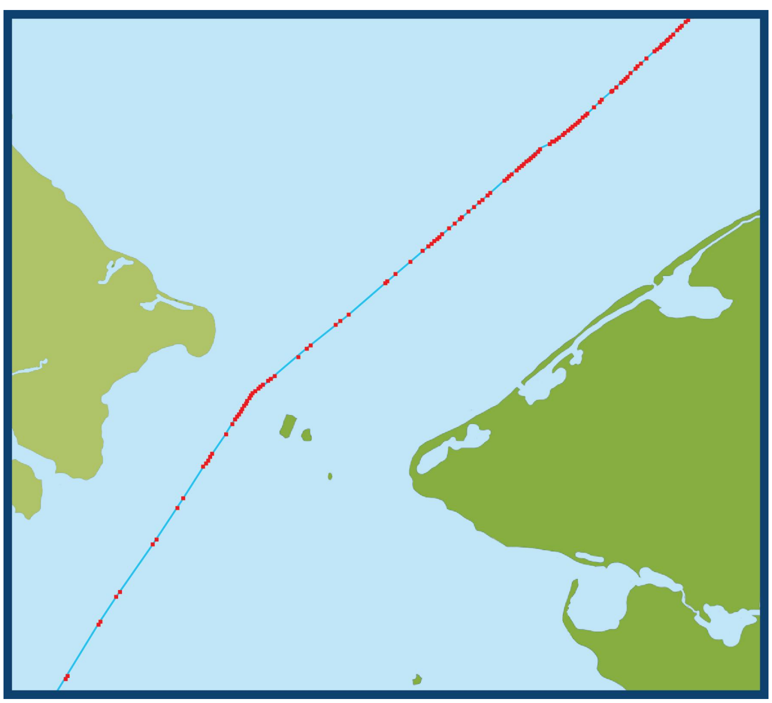
Despite these limitations, AIS provides the most comprehensive source of data for vessel traffic in a given area, as long as either satellite or shore-based receivers are functioning.

6.1.1 VESSEL TRACK DATA

When an AIS signal is transmitted from the vessel to a receiver, a data point is logged identifying the position of the vessel. When the next signal is transmitted and received a track of the vessel's movement can be extrapolated. It is possible for the AIS transmission interval to relay information every second. This can rapidly increase the number of data points associated with a track.[20]

The initial dataset combined the MXAK and NCA data into a single dataset with more than 53 million individual points. This was too large to easily manipulate using conventional analytical tools. A method was established to decrease the number of data points associated with each vessel track while retaining the information needed for analysis. Each AIS vessel track was ordered chronologically and processed using an algorithm that eliminated points that were outside the boundary of the study, were three minutes apart or less (for the same vessel), or were 0.02 nm apart or less (again, for the same vessel).

Data were also excluded if they had fewer than five points recorded over the three-year period. Data were thus pared into a manageable size (approximately one million points) while still retaining information regarding vessel movement. With the vessel tracks compressed, the information was identified based on each individual vessel and its track data. Tracks were assigned a zone (U.S. or Russian) depending on whether they primarily traveled in that zone or called at a port there. For Cargo:Bulk, Cargo:Other, and Tankers), tracks were also assigned one of three activities based on their zone. For the Russian zone, these activities were: (1) supporting commercial fishing activities, (2) calling at a port in the study area, or (3) transiting through Russian waters in the study area. For the U.S. zone, activities were: (1) calling or lightering at a U.S. port other than Red Dog mine, (2) calling or lightering at Red Dog mine, and (3) transiting through U.S. waters in the study area.



Each track was saved as a .kml file and presented in Google Earth. The file can be used to visually assess the location, route, and vessel identification information associated with each track. Tracks of a similar characteristic, such as vessel type, can be grouped and displayed together.

Figure 6-2 shows the results of a single track associated with a vessel transit.

Figure 6-2 Example of a vessel track (light blue line) based on the AIS location points (red dots) that resulted from the data processing described in

[20] *Note that a vessel "track" in this usage is not the same as the transits of the Bering Strait that have been reported in other studies. Here a track may refer to a voyage or portion of a voyage that does not go through the Strait at all.*

this section

The amount of time a vessel spends in an area is another important factor when representing the hazard or risk exposure. The distance traveled provides a similar indication, though does not include time spent anchored or at a dock. Based on the AIS data, two metrics were applied to track data related to these aspects of hazard exposure:

- **Total operating days:** The total number of days the vessel was observed in the study area, regardless of how time was distributed throughout the three years in the dataset.
- **Total operating nautical miles**: The total length of the tracks of the vessel observed in the study area, in nautical miles (1.15 miles).

If a vessel has a higher proportion of operating days than it does nautical miles, it spends less time moving or moves more slowly than other vessels.

6.1.2 VESSELS AND VESSEL CHARACTERISTICS

Vessels associated with each track were identified based on their Maritime Mobile Service Identity (MMSI) number.[21] Several sources were then used to obtain vessel characteristics when they were not already included within the AIS data:

- Data transmitted as part of the AIS signal
- Marine Exchange of Alaska (data purchased)
- Marinetraffic.com (data purchased)
- Data previously compiled for study of vessel activity on the west coast of Canada (Nuka Research and Planning Group, 2013)
- Online database research: www.vesseltracker.com, www.shipspotting.com, and wireless2.fcc.gov, U.S. Coast Guard's Vessel Response Plan database

Where information from different sources conflicted, Nuka Research chose a value based on the preponderance of evidence and best professional judgment. Table 6-1 lists and defines the primary variables associated with each vessel.

[21] Vessel names were also identified, but these are subject to change, and also subject to typos or variations in spelling and spacing in AIS data. Vessels may also have the same or similar names.

Table 6-1 Vessel characteristics included in dataset

VARIABLE	CHARACTERISTIC AND UNITS	SOURCE
MMSI	MMSI from AIS data associated with a track	Source data
IMO Number	International Maritime Organization registration number	Source data
Name	Vessel name	Source data
Flag State	Country where vessel is registered	Source data/research
Vessel Type	Vessel type assigned for this study: • Barge – barges carrying AIS transmitters • Cargo:Bulk – vessels carrying cargo in bulk • Cargo:Other – other cargo vessels including: general cargo, refrigerated cargo, offshore supply vessels, and landing craft • Fishing Vessels – used for fishing as well as sometimes research or other tasks (only those with AIS transmitters are included; many in this category are not required to have them) • Government – military, Coast Guard, search and rescue • Passenger – Cruise ships • Tanker – oil tankers and chemical product tankers • Tug – towing vessels, either traditional tug boats or anchor handling vessels • Other – pleasure craft, non-government research vessels, drill ships, LNG carriers, non-government ice breakers • Unknown – vessels for which type could not be identified	Source data/research
Length	Overall length in meters	Source data/research
Breadth	Maximum width in meters	Source data/research
Draft	Maximum draft in meters	Source data/research
Gross Tonnage	Volume of all internal spaces of the ship	Source data/research
Deadweight Tonnage	Weight of cargo, fuel, consumable stores, hull, machinery and equipment	Source data/research
Draft Type	Vessel draft type assigned for this study: • Shallow – maximum draft less than 2 meters • Light – maximum draft greater than or equal 2 meters and less than 8 meters • Deep – maximum draft equal to or greater than 8 meters	Assigned based on source data/research
Non-persistent Fuel Capacity	Estimated maximum volume of non-persistent fuel carried onboard in barrels	Source data/research/algorithm
Persistent Fuel Capacity	Estimated maximum volume of persistent fuel carried onboard in barrels	Source data/research/algorithm
Tanker Cargo Capacity	Estimated maximum volume of liquid cargo carried onboard in barrels, for tankers only	Source data/research/algorithm
Fuel Type	Classification of fuel type used by vessel[22]	Source data/research

[22] *Most vessels that use persistent fuel also carry some non-persistent fuel. If a vessel was estimated to carry any persistent fuel it was classified as persistent, but the volume of non-persistent oil was also estimated in the data associated with this vessel.*

In total, 633 unique vessels were contained in the AIS data. Table 6-2 lists the number of vessels by type and draft in the dataset developed. In the table below, vessels identified in the brown shaded areas are excluded because of incomplete data. Shallow draft vessels do not provide an accurate representation of the category and are excluded from the remainder of the analysis. These vessels, along with barges, are not required to have AIS transmitters and there is no way to know the proportion carrying AIS transmitters voluntarily.[23] Vessels characterized as "unknown" could not be identified by type. The tracks of the remaining 532 vessels were included in the analysis.

Table 6-2 Unique vessels by type and draft contained in 2013-2015 dataset for Bering Strait region

TYPE	DRAFT				TOTAL
	Deep Draft	Light Draft	Shallow Draft	Unknown	
Barge		7			7
Cargo:Bulk	71	3			74
Cargo:Other	33	73	1		107
Fishing	2	149	2	17	170
Government	2	19	16	2	39
Passenger	1	12		1	14
Tanker	43	13			56
Tug		67	7	3	77
Other	13	31	27	3	74
Unknown		12		3	15
Total	165	386	53	29	633

6.1.3 PETROLEUM TYPE AND CAPACITY

A wide range of substances fall under the broad category of "petroleum," varying in their composition and the potential impacts associated if they spill.[24] We categorized petroleum that vessels carry as fuel or cargo as being either non-persistent or persistent, according to the following definitions:

Non-persistent oil

A refined petroleum product (Type 1 or 2) that will evaporate rapidly, e.g., diesel, marine diesel, marine gas oil, home heating oil, jet fuel, or naphtha.

Persistent oil

A refined petroleum product that does not readily evaporate. This includes Type 3 and 4 oils such as heavy fuel oil (HFO), intermediate fuel oil (IFO), bunker oil, Number 6 fuel oil, or residual oil.[25]

[23] *Shallow draft vessels usually carry less fuel than deep draft vessels and thus represent a less significant oil spill exposure, though they may still cause other impacts.*
[24] *These variations also affect whether and how one can respond – or plan to respond – to a spill.*
[25] *Crude oil is also persistent, but there is no indication that crude oil was transported through this area during the study years. This could change in the future.*

Information about the quantity and type of petroleum a vessel carries as fuel or cargo is not available from a single, reliable source. Information was obtained for some vessels from the data sources referenced; otherwise, estimates were developed based on vessel type and size using the assumptions in Table 6-3.

We have less confidence in the assumptions made regarding the type of oil used or transported by vessels operating in Russian waters than on the U.S. side. Limited information was available on Russian vessels and oil cargoes. Interviews with Russian experts were outside the scope of this study. Our analysis generally assumed that the larger cargo vessels (Cargo:Other > 5,000 DWT) use persistent oil, while smaller Cargo:Other vessels use non-persistent oil. It could be the case that we underestimated the volume of persistent oil on board vessels, if it is either delivered as cargo to Russian communities and/or used as fuel by smaller Cargo:Other vessels operating there.

Table 6-3 Sources and assumptions applied to estimate petroleum type and volume on board (fuel and cargo)

<table>
<tr><th>Vessel Type</th><th>Assumptions Related to Fuel/Cargo Type</th><th>Assumptions Related to Fuel/Cargo Capacity</th></tr>
<tr><td>Cargo: Bulk</td><td>Fuel: Primarily persistent, but also carry some non-persistent</td><td rowspan="5">Fuel capacity based on known sources, or estimated using linear regression of fuel capacity vs. GT or DWT from known sources (depending on information available for each vessel).</td></tr>
<tr><td>Cargo: Other</td><td>Fuel: Smaller than 5,000 DWT = non-persistent fuel; larger than 5,000 DWT = a combination of persistent and non-persistent fuel</td></tr>
<tr><td>Fishing</td><td>Fuel: Non-persistent fuel</td></tr>
<tr><td>Gov’t</td><td>Fuel: Non-persistent (except one vessel)</td></tr>
<tr><td>Passenger</td><td>Fuel: Non-persistent[26]</td></tr>
<tr><td>Tanker</td><td>Fuel: Smaller than 10,000 DWT = non-persistent; larger than 10,000 DWT = persistent (unless known data indicate otherwise) but also carrying some non-persistent fuel
Cargo: Non-persistent</td><td>Cargo and capacity taken from known sources or estimated via linear regression of known sources against DWT.</td></tr>
<tr><td>Tug</td><td>Fuel: Non-persistent</td><td rowspan="2">Fuel capacity based on known sources or estimated via linear regression of known sources vs. GT or DWT.</td></tr>
<tr><td>Other</td><td>Fuel: Non-persistent, except when known data indicate otherwise</td></tr>
</table>

[26] The passenger vessels/cruise ships included in the dataset were relatively small, with none more than 150 m long. The 2016 voyage of the Crystal Serenity drew attention as an indication of the potential for larger cruise ship activity through the Bering Strait and along the Northwest Passage. This vessel, by comparison, is 250 m according to marinetraffic.com.

6.1.4 OIL EXPOSURE AND WEIGHTED OIL EXPOSURE

To associate an indication of oil spill hazard with each track, estimates of oil exposure and a weighted oil exposure were calculated. Oil exposure accounts for both how much oil is on board a vessel and how much time it spends moving through the area, and relies on some general assumptions. It is calculated as the amount of oil carried (bbl) multiplied by the duration of the track (days). The quantity of oil on board will vary by vessel, the nature of the voyage (e.g., making an oil delivery vs. returning from that delivery with empty cargo tanks), or timing during a voyage. While fuel capacity and cargo *capacity* remain the same, the actual volume of fuel on board changes as it is used up. Likewise, cargo volume changes if it is offloaded during the voyage. For the purpose of estimating oil exposure, fuel tanks are assumed to be 70%[27] full and the liquid cargo tanks in tankers to be 50% full. An oil exposure estimate was calculated for each track and each oil type as follows:

Persistent Oil Exposure = 70% of Persistent Fuel Capacity (bbl) x Track duration (days)

Non-persistent Oil Exposure = (70% of Non-persistent Fuel Capacity (bbl) + 50% of Tanker Cargo Capacity[28] (bbl)) x Track duration (days)

Persistent oil and non-persistent oil have different impacts on the environment when spilled, and those impacts last for different lengths of time. Although persistent oil may have a lower initial toxicity than non-persistent oil, it remains in the environment longer and thus has the potential to impact biological receptors over a longer time than non-persistent oil. To account for this, we applied a factor of 1.64 to Persistent Oil Exposure to develop a *Weighted* Oil Exposure for each vessel track:

Weighted Oil Exposure = (Persistent Oil Exposure x 1.64) + Non-persistent Oil Exposure

The value 1.64 is based on a 2014 risk assessment conducted for marine areas around Alaska. In that study, the authors considered 4 oil types: crude oil, heavy oils, light oils, and distillates[29] and assigned a value to represent each oil type's relative potential for the kinds of impacts described in Section 5.1.1 (Reich et al., 2014). With no crude oil and minimal distillates on vessels identified in our dataset, our "persistent" and "non-persistent" oil types correspond to the "heavy" and "light" oils, respectively, in the other study. The value 1.64 that we apply comes from the weighting of these two types as applied in the 2014 study. The referenced study was used because it is recent and presented all assumptions clearly in a publicly available report focused on Alaska waters. Other values could be used. The intent of weighting is essentially to acknowledge the potential difference in impact: the effect of any actual spill will depend on the substance spilled, location, season, and other conditions.

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[27] Different values are can be used for the assumed fuel volume. We chose to use 70% because this value was used in the Aleutian Islands Risk Assessment vessel traffic study (DNV & ERM-West, Inc., 2010).

[28] For vessels other than tankers, Tanker Cargo Capacity = zero.

[29] Examples of distillates are kerosene and gasoline.

This Weighted Oil Exposure is a measure of the potential oil volume and hazard associated with each vessel track. It should be noted that there are other factors associated with the risk of an incident and resulting oil spill that are not consider as part of this weighted oil exposure, such as:

- Vessel design, construction, age, and maintenance;
- Safety practices of operating company and crew;
- Other vessel traffic in the vicinity; and
- Waterway conditions (weather, depth, channel constriction, bottom type, ice).

The Weighted Oil Exposure also does not incorporate other potential vessel hazard exposures, such as noise, waste, or air emissions.

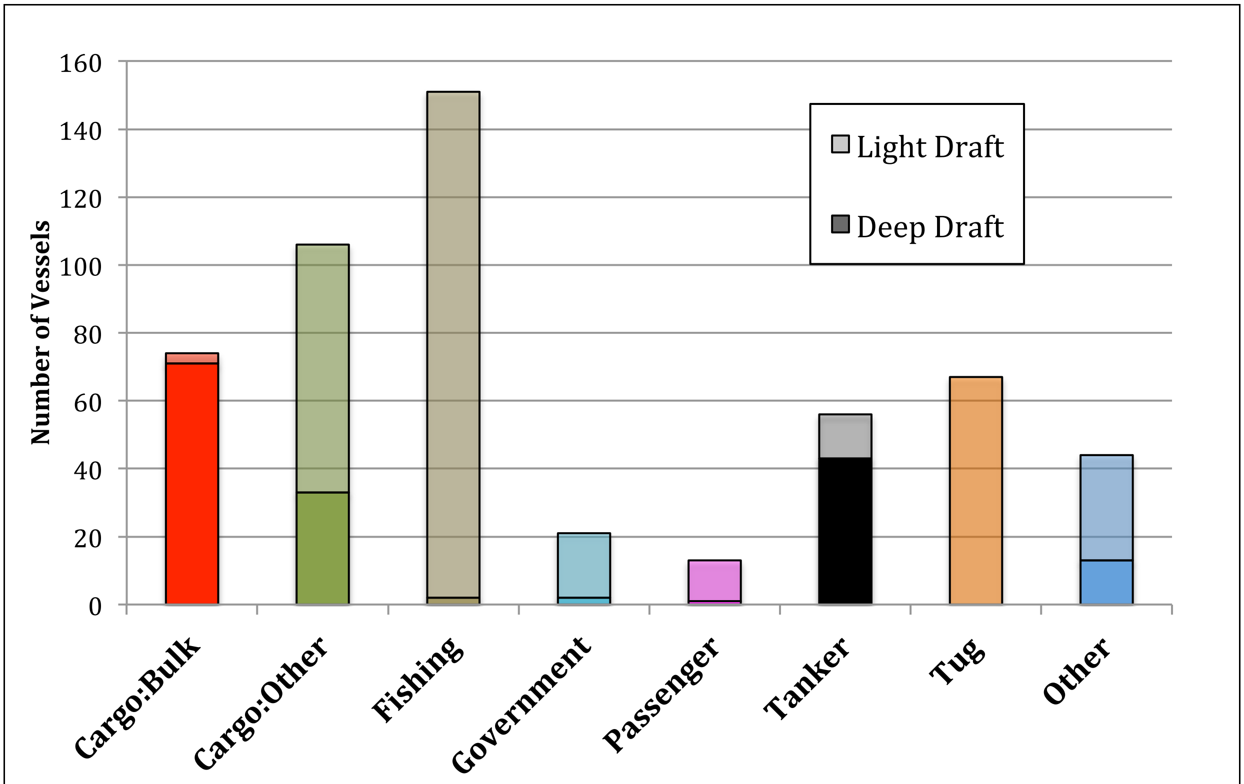
6.2 Results of Bering Strait Vessel Traffic Analysis

The study area for this vessel traffic analysis includes both U.S. and Russian waters. We first summarize the type and size of vessels moving within the region, then consider some of the differences in activity between the U.S. and Russian sides.

6.2.1 OVERALL RESULTS: VESSEL TYPE, SIZE, AND VARIATIONS BY MONTH

The final dataset contained 532 unique vessels equipped with AIS that operated in the study area between 2013-2015.[30] Figure 6-3 shows the number of individual vessel types identified in the dataset by draft category. There are more Fishing Vessels and Cargo:Other vessels than any other vessel type, but most deep draft vessels are Cargo:Bulk and Tankers.

[30] Not including vessels excluded according to the criteria described above (shallow draft, unknown type, etc.).



	# of Vessels							
Draft	**Cargo: Bulk**	**Cargo: Other**	**Fishing**	**Gov't**	**Passenger**	**Tanker**	**Tug**	**Other**
Light	3	73	149	19	12	13	67	31
Deep	71	33	2	2	1	43		13
Total	**74**	**106**	**151**	**21**	**13**	**56**	**67**	**44**

Figure 6-3 Number of individual vessels identified in final dataset by type and draft. For this and subsequent figures, darker shading is used for deep draft vessels and lighter shading of the same color for light draft.

Draft is just one indication of vessel size. Deadweight tonnage[31] is another common measure. Draft and draft and tonnage may correlate within individual vessel types, but cannot be generalized across vessel types. Figure 6-4 contains a quartile plot[32] of deadweight tonnage for each vessel type. This figure shows that the largest vessels in the dataset (by deadweight tonnage) are Cargo:Bulk and Tankers. Looking back to the previous figure, we also see that these vessel types are predominately deep draft.

[31] Weight of cargo, fuel, consumable stores, hull, machinery and equipment

[32] Also called a box and whisker plot, a quartile plot divides the data distribution into quarters. The bottom of the whisker (vertical line) is set at the minimum value and the top indicates the maximum value. The bottom of the box represents the 25th percentile of the data, meaning that 25% of the values in the data are less than this number. The line in the middle of the box is the 50th percentile and the top of the box is the 75th percentile.

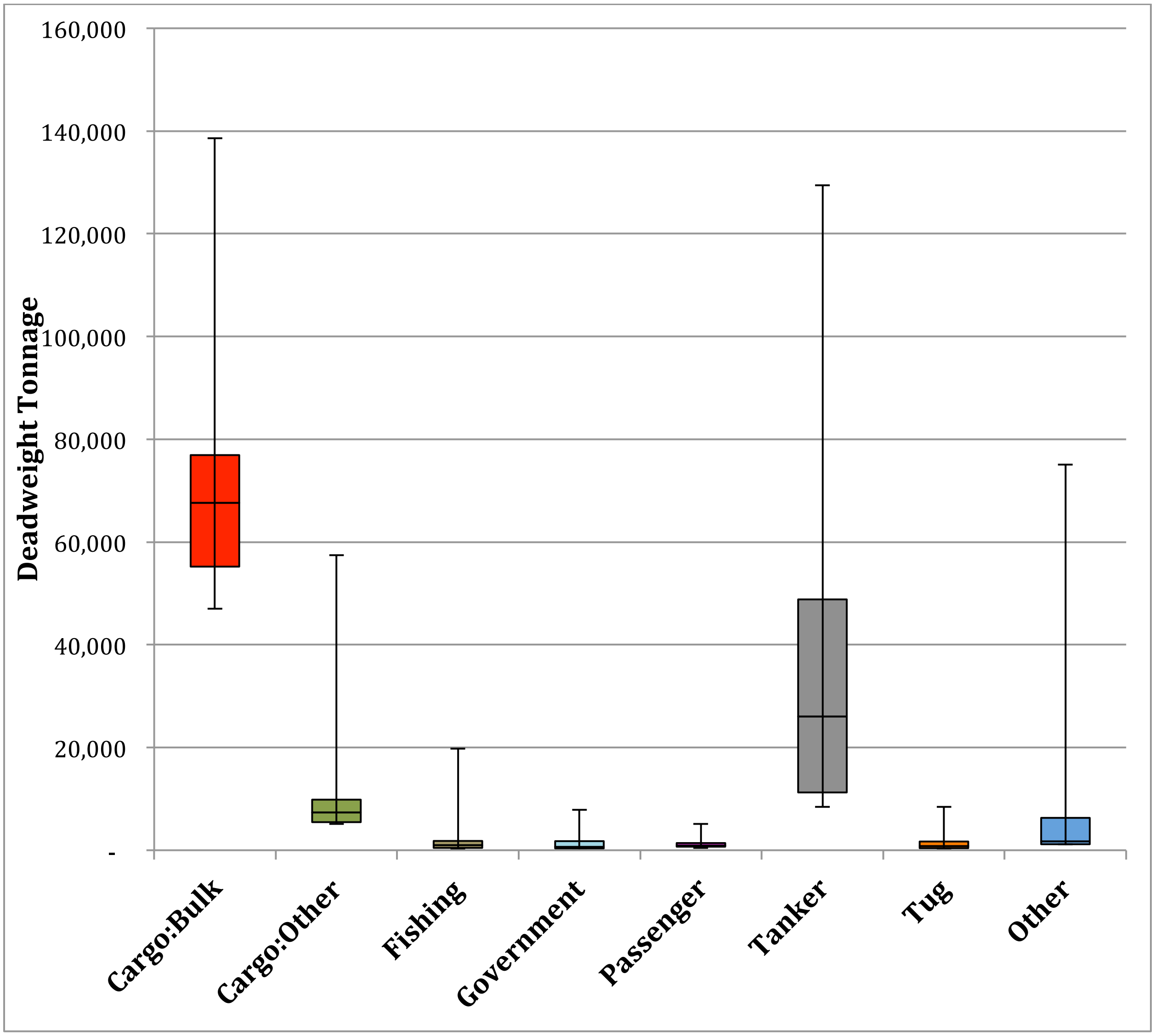


Figure 6-4 Quartile plots of deadweight tonnage (one measure of vessel size) by vessel type

The seasonal variation in vessel activity is also apparent across the study area. Figure 6-5 shows vessel tracks by month for the study area, with 2013-2015 tracks combined. Vessel traffic is highly season-dependent and limited by the presence of sea ice, primarily concentrated in the months of June through October (data from 2013-2015). Activity seen in the winter months is primarily by Russian fishing and government vessels south of the usual sea ice extent. A small cargo ship and Russian icebreaker moved through the area in April 2015. (Because the figure includes data from three years, the vessels shown were not necessarily present in the same month and same year; the maps illustrate general monthly variations.)

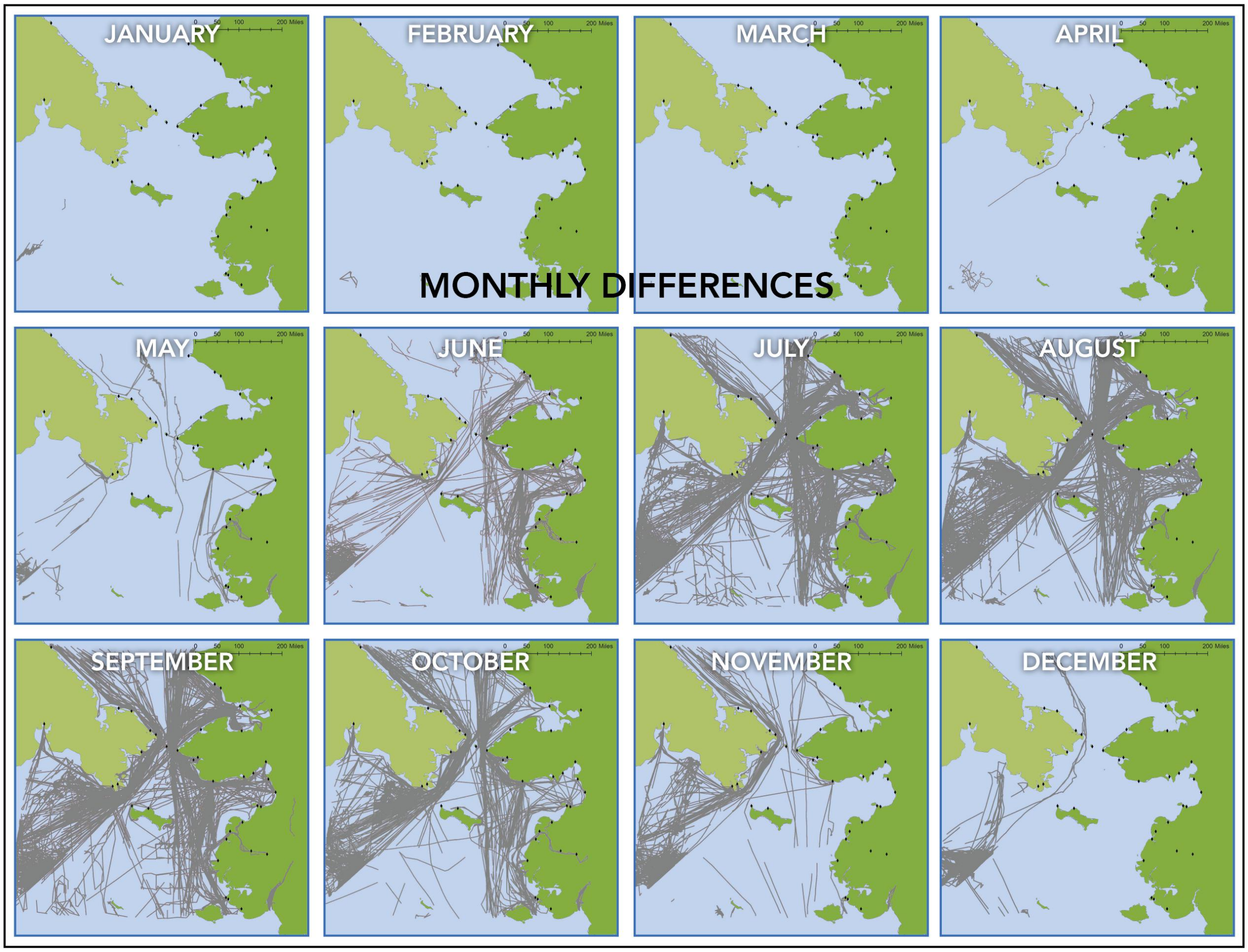


Figure 6-5 Vessel tracks by month, with tracks from 2013-2015 combined

Vessels of different types follow different routes. Figure 6-6 presents the tracks recorded for each vessel type in the dataset. The figure shows all tracks for the three years studied. Cargo:Bulk activity in the region is dominated by calls at the Red Dog mine on the U.S. side and transits through on the Russian side. Fishing activity is more prominent on the Russian side.

Figure 6-6 Vessel tracks by type

6.2.2 COMPARISON OF U.S. AND RUSSIAN ZONES: VESSEL TYPE, SIZE, FLAG, AND OPERATING DAYS

By sorting vessels according to which country's waters they spent most of their time in, we can see the similarities and differences in general vessel activity within the region. Vessels were assigned to the U.S. or Russian "zone" for the purpose of this analysis based on whether they called at a port in the U.S. or Russia, or primarily spent time (based on what is visible in this dataset) in either country's waters. This section compares vessels assigned to each zone based on vessel types, sizes, flag, and operating days.

Vessels typically travel primarily within one zone. The most prominent exception to this is vessels traveling from the Red Dog mine in Alaska. These vessels cross through Russian waters en route to or from ports in East Asia.

6.2.2.1 Vessel type

Some of the differences in vessel traffic in the two countries are evident by looking at vessel type (see Figure 6-7). Among deep draft vessels, the U.S. zone had more bulk carriers, though most of these leave the U.S. and go through Russian waters to Asia. The Russian zone had more tankers overall (including both transits and local deliveries). Among the light draft vessels, the Russian zone had far more Fishing Vessels while the U.S. zone had more Tugs (due to barge use) and Government vessels.[33] Passenger vessels were distributed between the zones more evenly than any other vessel type.

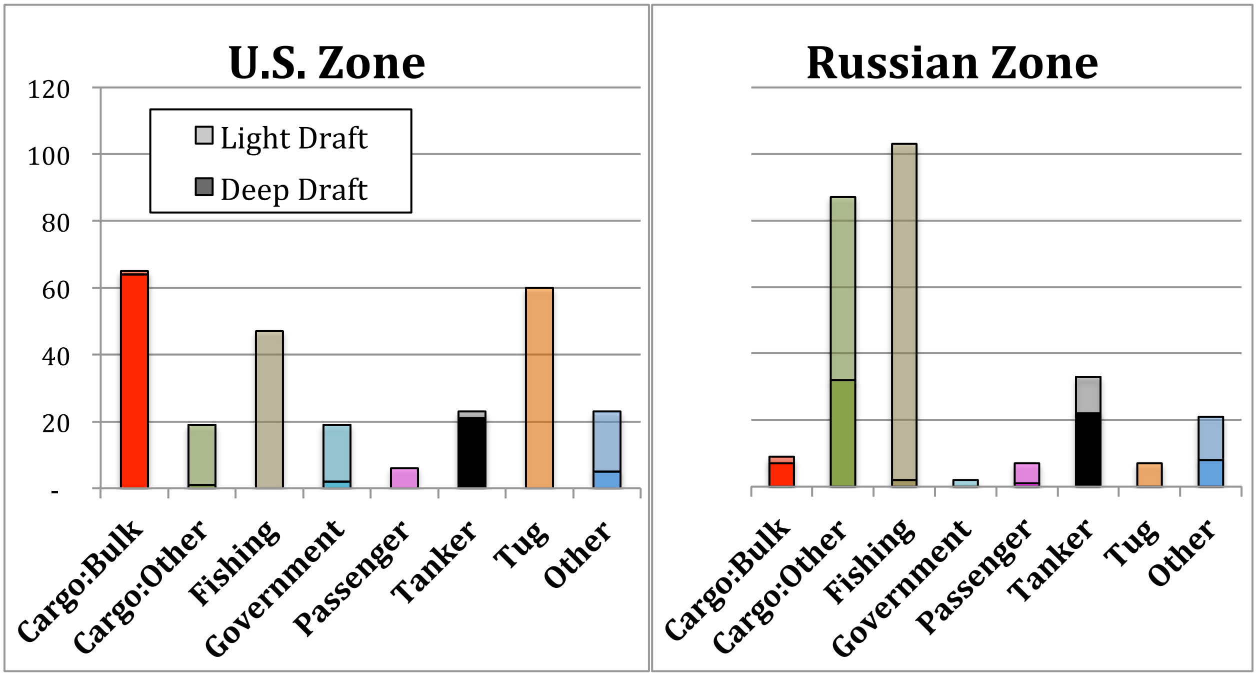


Figure 6-7 Unique vessels operating in the U.S. and Russian zones by type and draft

6.2.2.2 Operating days and distance traveled

The amount of time a vessel spends in the area may inform understanding of its potential impacts (both potential oil spills and other impacts). Distance traveled represents another way to consider exposure. The 532 vessels spent a total of 18,321 days in the study area during the three-year period analyzed. They traveled just over 1.2 million nautical miles in that time. Figure 6-8 compares the percentage of operating days for each vessel type to the portion of total distance traveled for each vessel type. Tugs and Fishing Vessels spend a slightly larger portion of time in the area relative to their share of nautical miles traveled, while Cargo:Bulk and Cargo:Other have slightly larger portions of distance covered than they do operating days.

[33] *Fishing vessels are assumed to be engaged in activities besides fishing in the study area.*

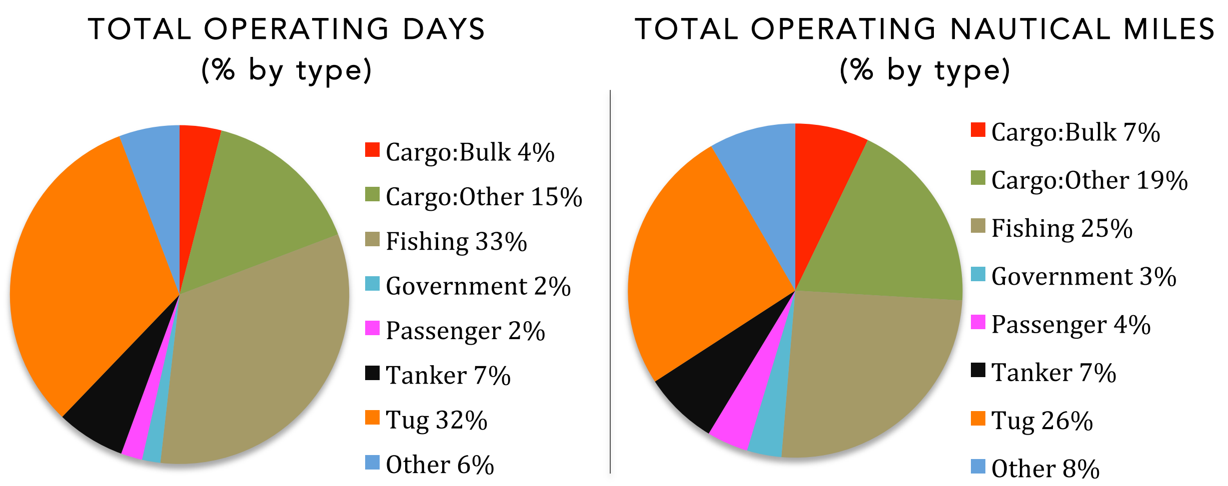


Figure 6-8 Comparison of total operating days and total operating nautical miles by vessel type (whole region)

Figure 6-9 focuses on operating days, comparing these between the U.S. and Russian zones for each vessel type. Tugs (U.S.) and Fishing Vessels (Russia) stand out with the most operating days.

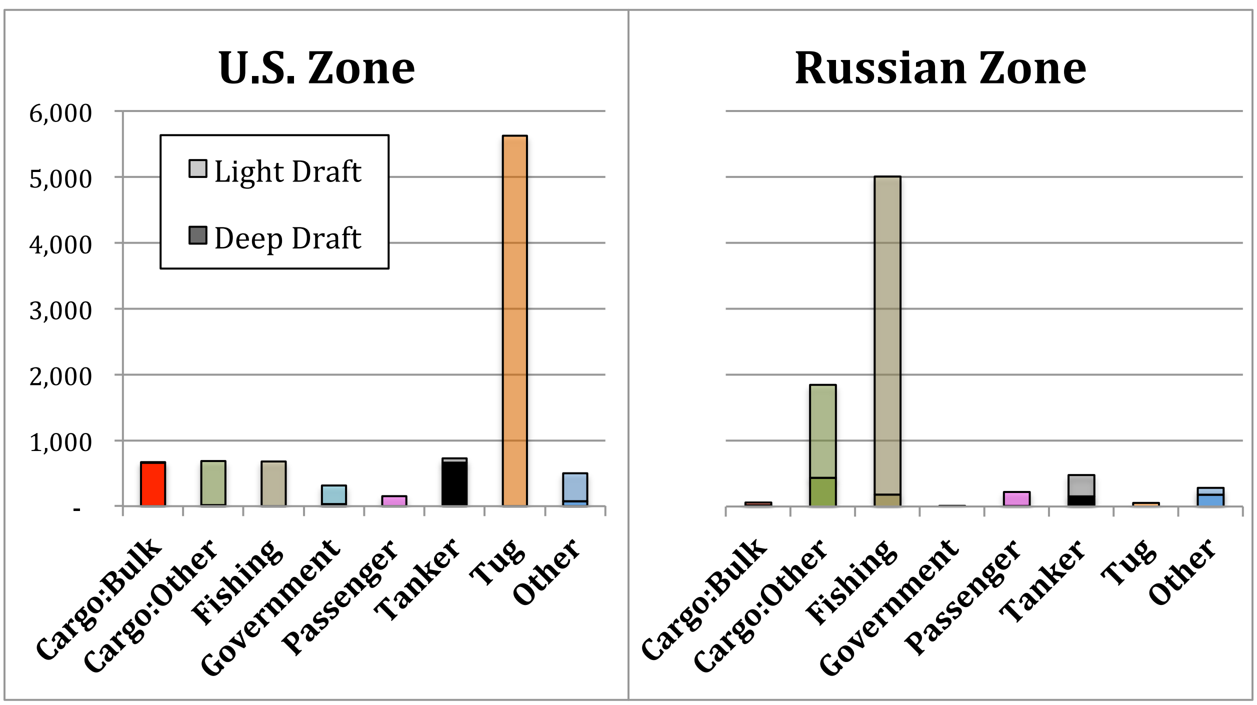


Figure 6-9 Comparison of operating days by vessel type (and draft) in the U.S. and Russian zones

6.2.2.3 Flag state

All vessels are registered in a country and fly that country's flag. The "flag states" of vessels in the region are almost evenly divided among the U.S., Russia, and a third group of 34 other countries. Table 6-4 shows the flag states for vessels assigned to each zone. Not surprisingly, most vessels in the U.S. zone are U.S.-flagged vessels, and likewise in the Russian zone. Most of the vessels from flag states other than the U.S. or Russia were assigned to the U.S. zone.

On the U.S. side, foreign-flagged tankers regularly deliver oil to communities and the Red Dog mine, and foreign-flagged bulk carriers export material from Red Dog mine.

Table 6-4 Flag states of vessels assigned to the U.S. and Russian zones

U.S. ZONE VESSELS		RUSSIAN ZONE VESSELS	
Flag State	***# of Vessels***	***Flag State***	***# of Vessels***
USA	203	Russia	226
Marshall Islands	21	Liberia	7
Panama	20	Panama	7
Singapore	13	Netherlands	6
Canada	10	Korea	5
Hong Kong	10		
Liberia	8		
Malta	6		
Japan	5		

Countries with fewer than 5 flagged-vessels in dataset (both zones):

Antigua Barbuda	Cayman Islands	Finland	Netherlands	St Kitts Nevis
Australia	China	Greece	Norway	Sweden
Bahamas	Croatia	Hong Kong	Philippines	Switzerland
Belgium	Curacao	Isle of Man (UK)	Poland	United Kingdom
Belize	Cyprus	Japan	Portugal	Wallis Futuna Is
Bermuda	Denmark	Malta	Sierra Leone	
Cambodia	Dominica	Marshall Islands	South Korea	

6.2.3 VESSEL ACTIVITY BY ZONE

This section summarizes vessel activity associated with each zone (U.S. or Russian), considering some broad categories of activities to complement the information provided in the previous section on vessel type, size, and operations. We focus particularly on the three categories of vessels that tend to be the largest and have the greatest volume of oil on board as fuel and/or cargo: Cargo:Bulk, Cargo:Other, and Tankers. For the U.S. zone, we also discuss two unique and related aspects of vessel activity: the delivery of petroleum to ports in the study area and barge activity.

6.2.3.1 U.S. Zone

Tugs dominate the overall number of vessels and operating days associated with the U.S. zone. Fishing Vessels, Cargo:Bulk, Cargo:Other, and Tankers follow with fairly similar numbers of operating days. Fishing vessel activity is also prominent, though less so than it would be farther south in the Bering Sea. This is due in part to two factors: the area is covered with sea ice for more of the year than in Russian waters (where there is more fishing activity within our study area) and a prohibition on bottom trawling on the U.S. side of the northern Bering Sea (NPFMC, 2011). In addition, relatively few fishing vessels travel north of the Bering Strait, where most commercial fishing is currently prohibited on the U.S. side (NPFMC, 2009).

Cargo:Bulk, Cargo:Other, and Tanker tracks were assigned an activity based on whether they appeared to be serving the Red Dog mine,[34] calling on another U.S. port in the study area, or transiting through the area without calling on a port. Of these three ship types, the highest number (840) of operating days were associated with Cargo:Other vessels calling at U.S. ports (besides Red Dog); Cargo:Bulk vessels serving Red Dog followed with 668 associated operating days, and Tankers calling at U.S. ports came third with 641 operating days.

Most of the operating hours by deep draft vessels on the U.S. side were spent by Cargo:Other and Tankers serving ports in the area.

Red Dog mine accounts for 92% of operating days spent by Cargo:Bulk ships in the study area for the three years studied. During the study period, there were 65 individual bulk carriers calling at Red Dog. More than half of these vessels only visited the area one or two times in the three years. All were foreign-flagged (and delivering to non-U.S. ports). This pattern is typical of spot charter use, where shippers are paid to move materials from one port to another at a bulk rate. Tanker traffic associated with fuel deliveries to Red Dog was much less pronounced, and only five individual tankers – all foreign-flagged – made 12 port calls at Red Dog in the study period. The tugs engaged in moving barges to and from the offshore bulk carriers and tankers are typically U.S. flagged and regular operators in the area. Sixteen U.S.-flagged tugs served the Red Dog port area during the study period.

Vessels transiting the U.S. zone had relatively few operating days with 112 for Cargo:Bulk, Cargo:Other, and Tankers. Almost all of these were by Cargo:Other.

Table 6-5 Operating days associated with Cargo:Bulk, Cargo:Other, and Tanker activities assigned to the U.S. zone

ACTIVITY	CARGO:BULK	CARGO:OTHER	TANKERS	TOTAL
Serving Red Dog mine	668	6	76	**750**
Calling at U.S. port*	--	840	641	**1481**
Transiting	3	100	9	**112**
Total	671	946	726	**2,343**

*Refers to U.S. ports except for Red Dog. For Tankers, this primarily refers to Tankers that stay offshore and lighter – or transfer – oil to barges for delivery to communities. This is discussed further in the next section.

[34] Because Red Dog mine is north of the Bering Strait, vessels delivering fuel or remove ore pass through the Bering Strait and sea. After community supply, it is the primary reason deep draft vessels operate in the region today.

6.2.3.1.1 Petroleum delivery to U.S. ports in study area

Fuel oil is carried into the region for community use is non-persistent. It is moved cargo on tankers or large tank barges. Within the area studied, these vessels are only able to dock and offload in Nome. In order to serve other communities, tankers or large barges must offload, or "lighter," oil to smaller barges. Vessel tracks from 2013, 2014, and 2015 indicate that the delivery of oil to Western Alaska communities through lightering at sea from tankers to smaller barges is common.[35] Nome is also a regional hub: product stored in there is then delivered to neighboring communities. In the study period, we observed three tanker calls at the Port of Nome and ten tankers lightering offshore. Tankers engaged in lightering may spend days or even weeks in one place as tugs/barges shuttle to and from making delivers. Figure 6-10 shows an example of this practice, with a tanker moving to different locations both north and south of the Bering Strait. The tug (with AIS) is moving between the tanker and ports, towing a barge that does not have AIS.

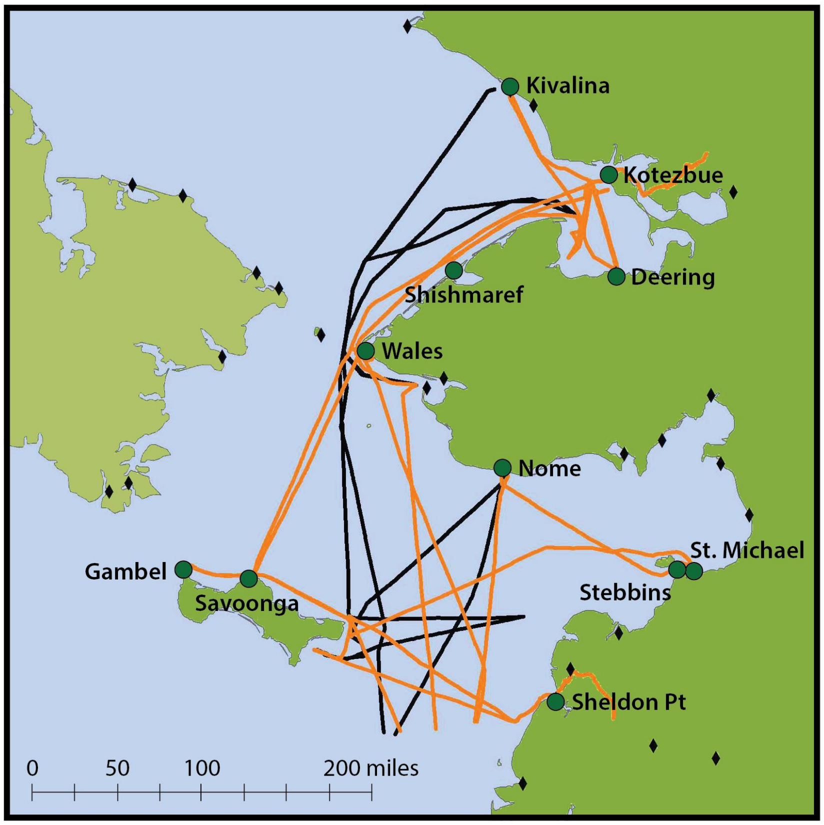


Figure 6-10 Tracks associated with a tanker Maersk Belfast *(black) lightering at different points to the tug Cavek (orange) in 2015*

AIS data also indicate that tankers arriving in Western Alaska to lighter fuel oil anchor at distances greater than three miles offshore, outside state waters. Figure 6-11 shows the apparent locations where tankers have lightered to tank barges based on examining tracks of tankers and tugs during the months of June through October during the three years in the study. (As noted, most barges do not have AIS and thus we are unable to see their tracks.)

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[35] Use of tankers for western Alaska resupply has become common since the 2012 emergency fuel delivery by the Russian tanker Renda and U.S. icebreaker Healy (Joy Baker, personal communication).

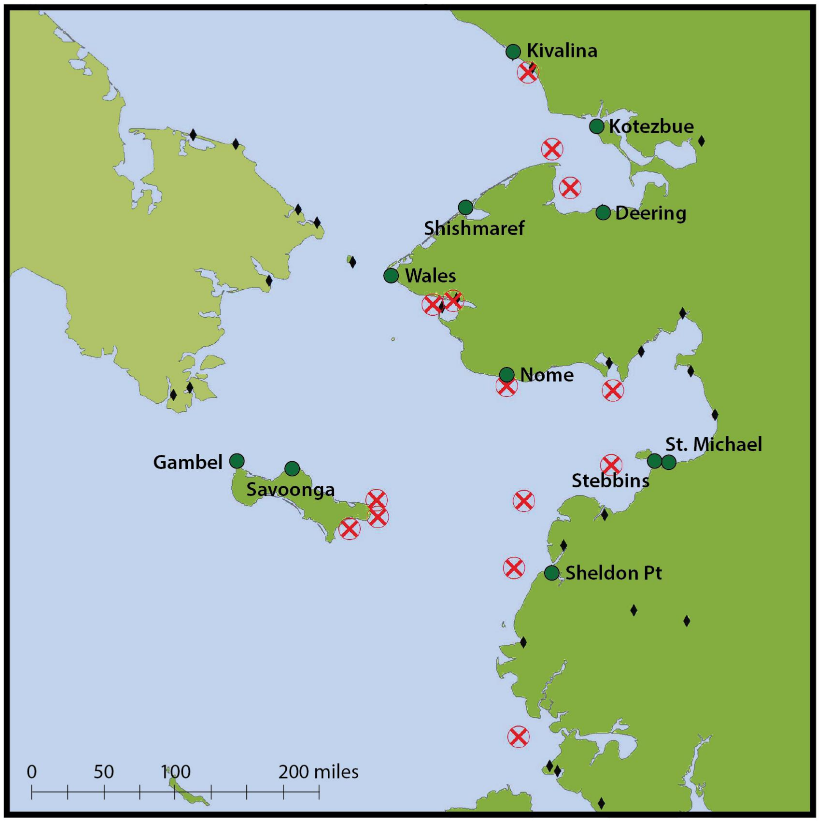

Figure 6-11 Locations in study area where lightering from tankers to barges may have occurred based on vessel tracks observed, 2013-2015

6.2.3.1.2 Barge activity

In western Alaska, barges provide a vital service delivering fuel and other goods to coastal communities along the relatively shallow coast and up rivers where beach landings are sometimes required. Barges are also used to transport resources out of the area, and serve industrial activities in the region.

All barges are maneuvered by tugs. Some barges are towed, while others have an "articulated" connection point where the tug moving the barge fits into a notch in the stern of the barge in what is known as "push" formation. Even though tugs are included in the AIS dataset, there is no indication as to how a barge is attached (articulated or with a tow line), what the barges' cargo may be, or whether the tug is accompanied by a barge at all on that voyage (barges themselves are not required to carry AIS devices and thus are generally missing from the AIS data collected for this study). Therefore, we cannot apply the same approach to determine barge operating days, operating nautical miles, or oil exposure that we use for other vessel types.[36]

[36] This information could be obtained through additional research and calculations based on discussions with tug and barge operators in the region.

Nuka Research was able to identify 23 tank barges that operate in Western Alaska through online research and interviews with operators.[37] Although not required, 7 of these barges were outfitted voluntarily with AIS transmitters and identified in the AIS data used for this study. Four of these barges were utilized by the 2015 oil exploration project by Shell and three are cargo barges used to carry cargo to Western Alaska communities. Figure 6-12 shows these barge tracks. The yellow tracks are barges tracks associated with Shell's oil exploration in 2015 and the green tracks were associated with cargo barges. This shows the level of activity that can result from a single project, and the way that this type of activity can create anomalies in the data: this activity was seen in 2015 only due to offshore exploration in the U.S. Arctic.

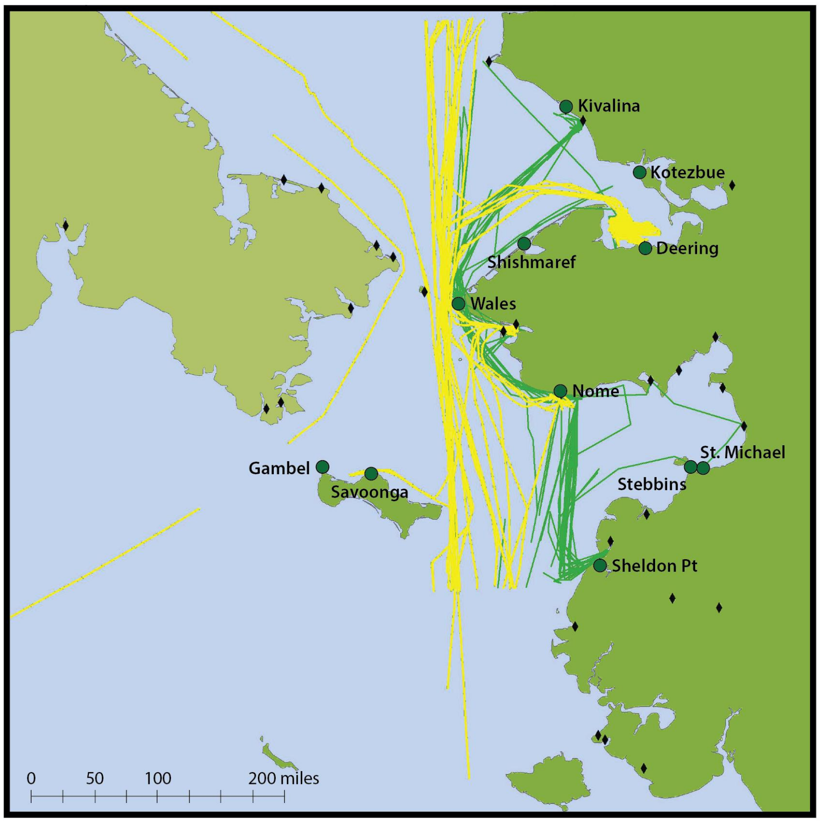

Figure 6-12 Barge tracks observed in 2013-2015 AIS dataset used for study. Yellow tracks are all associated with Shell's Arctic activity in 2015. Green tracks are associated with cargo barges. Tracks are from the 7 barges which used AIS voluntarily and do not include all barges in the region.

In another project, Nuka Research used 2014 AIS data to observe transits through the Bering Strait. Tug operators were contacted based on these observations to estimate how many of the recorded tug movements were associated with barges and whether they were carrying petroleum or other cargo. Based on this information, 54 barges transited the Strait that year, 18 of them with fuel as cargo. These represented about two-thirds of all tug *transits* across the

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[37] Barge operating companies report that there were at least 36 individual barges working either "seasonally" or "year-round" from Cook Inlet to the Beaufort Sea based in 2014, with an additional, unreported number in the area either "infrequently" or "rarely" (Alaska Petroleum Distributors and Transporters, 2015).

Bering Strait in 2014.[38] This information is provided as one indication of how often tugs may be operating with a barge attached as opposed to without, though it does not indicate barge cargo (petroleum or otherwise.

6.2.3.2 Russia

Fishing Vessels dominate the overall number of vessels and operating days associated with the Russian zone, operating mostly south and west of the Bering Strait. Very few Russian fishing vessels operate north of the Bering Strait on the Russian side.

As was done for the U.S. zone Cargo:Bulk, Cargo:Other and Tanker tracks were assigned an activity. For the Russian zone, activities were based on whether vessel tracks appeared to be associated with supporting Russian fisheries,[39] calling on a Russian port, or passing through Russian waters in the study area.[40] Among the three vessel types for which activities were assigned, most operating days within the Russian zone were associated with vessels that called at Russian ports within the region, primarily by Cargo:Other ships (1,433 operating days), followed by Tankers (326 operating days) then Cargo:Bulk (31 operating days). See Table 6-6.

Table 6-6 Operating days associated with Cargo:Bulk, Cargo:Other, and Tanker activities assigned to the Russian zone

ACTIVITY	CARGO:BULK	CARGO:OTHER	TANKERS	TOTAL
Russian fisheries	--	143	16	**159**
Calling on Russian port	31	1,433	326	**1,790**
Transiting	29	270	135	**434**
Total	60	1,846	477	**2,383**

Vessels transiting through the area had the second largest number of operating days for the Russian zone. Transiting vessels are of interest because those traveling fully or partially along the Northern Sea Route in the Arctic represent potential for long-term growth as that shipping route develops over time (see Section 7.1). For 2013-2015, however, there were far fewer operating days spent by vessels passing through than those calling at ports within the study area. Transiting vessels are primarily Cargo:Other (with 270 operating days), followed by Tankers and Cargo:Bulk.

Finally, while Fishing Vessels themselves dominate operating days for the Russian zone overall, there were 143 operating days associated with Cargo:Other vessels engaged in commercial fishing-related activity (trampers taking the catch from the fishing grounds) and 16 operating day for Tankers similarly engaged.

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[38] Personal communication with Crowley Marine, Foss Maritime, Dunlap Towing, and Western Towboat, October 2015.

[39] Note that this does not include fishing vessels, just cargo vessels serving the fishery.

[40] These transits may have called at a port elsewhere in the Bering Sea, or in Russia outside the study area, but we do not know this from the dataset.

6.2.4 HAZARD EXPOSURE

This section discusses some of the elements from the data that can be used to illustrate hazard exposure, with a focus on potential oil spills. For this section, the region as a whole is considered. Vessels assigned to the U.S. zone, or operating only in U.S. waters, can expose sensitive resources on the other side of the border to potential hazards – and vice versa. Most carry oil as fuel, while tankers and tank barges may also care it as cargo.

6.2.4.1 Oil Type and Capacity

The estimated amount and type of oil carried for a vessel to use as fuel varies considerably. Figure 6-13 shows quartile plots of estimates of non-persistent and persistent fuel oil capacities for each vessel type. While more vessels use non-persistent fuel than persistent, the volumes carried by vessels using persistent fuel tend to be larger. Most vessels carry less than 5,000 bbl of non-persistent oil as fuel (the notable exception being the 35,714 bbl capacity of the USCG icebreaker *Polar Star*). Cargo:Bulk, Cargo:Other, and Tankers are the predominant carriers of persistent fuel.[41]

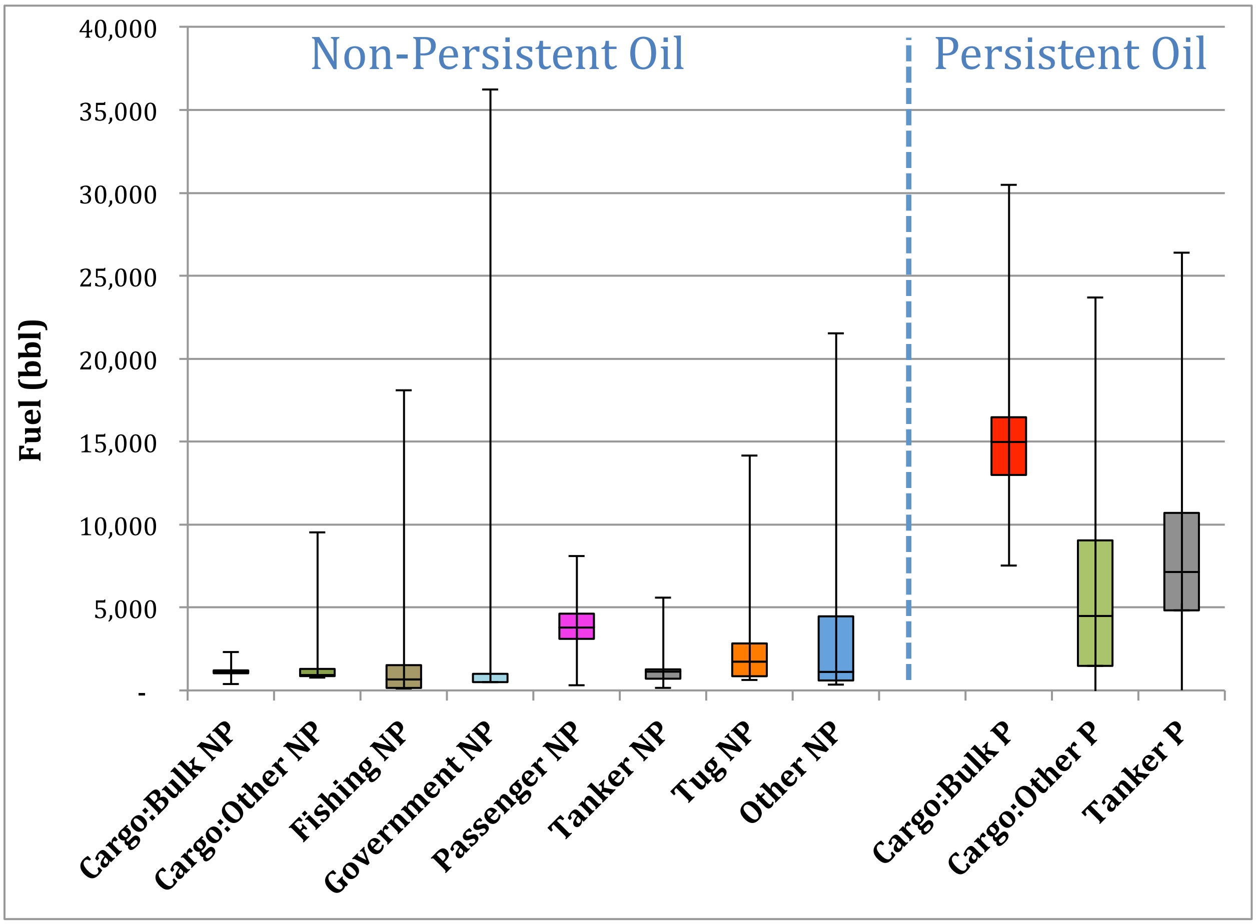
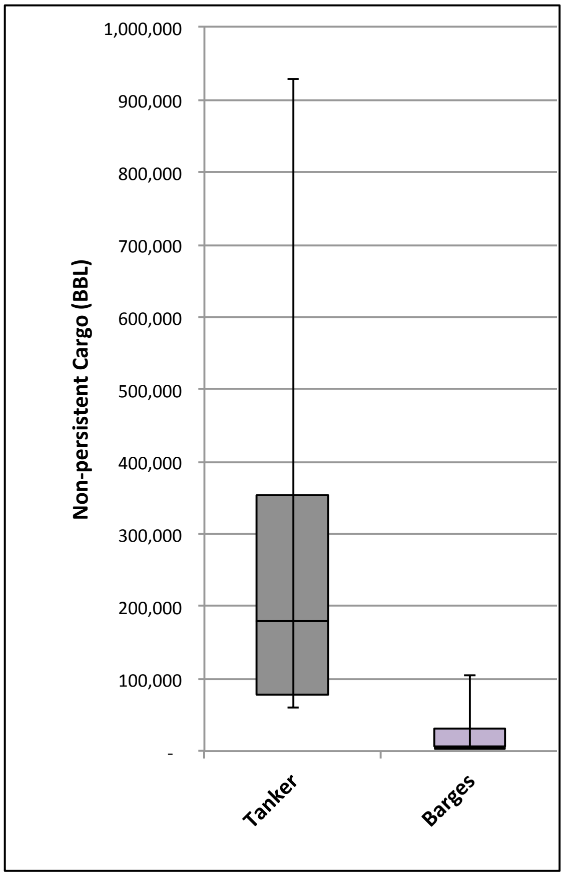


*Figure 6-13 Quartile plots for estimated **fuel** capacity of non-persistent and persistent oil by vessel type*

[41] *A single vessel in each of the Government and Other types also carried persistent fuel.*



Tankers and tank barges may carry oil as cargo as well as the oil they carry for their own fuel. Figure 6-14 presents the quartile plot for the estimated cargo capacity of Tankers and tank barges operating in the study area.[42] Estimated tanker cargo capacities range from 18,913 to 848,846 bbl, while Barge capacities range from 814 bbl to 100,000 bbl. While barges are generally smaller than tankers, the largest barge cargo volume is bigger than the smallest tanker cargo volume in the dataset.

*Figure 6-14 Quartile plot for non-persistent **cargo** capacities estimated for Tankers and Barges*

The majority of vessels in the Bering Strait region on the U.S. side only have non-persistent oil on board. No persistent oil is carried as cargo in the dataset; the only persistent oil in the U.S. zone is that used as fuel on ships (Cargo:Bulk and larger Cargo:Other and Tankers; see Figure 6-13).[43] Vessels in the Russian zone may be more likely to carry persistent fuel, though uncertainty regarding fuel type has been noted previously.

6.2.4.2 Oil Exposure and Weighted Oil Exposure

Using the formulas previously described, we estimated the raw and weighted oil exposure for the vessel tracks observed in the study. These metrics consider the estimated amount of oil onboard and the duration of time that the vessel was observed within the study area. Figure 6-15 presents the oil exposure for persistent and non-persistent oil for each vessel type. Tankers account for 90% of the non-persistent oil exposure for all vessels as a result of their cargo capacities, since "exposure" combines oil carried as fuel and oil cargo. Persistent oil is fairly evenly split between Cargo:Bulk (38% of persistent oil exposure) and Cargo:Other (36% of persistent oil exposure) vessels, since many of them use persistent oil as fuel. The other larger ship type – Tankers – accounts for 25% of persistent oil exposure based on the fuel they use.

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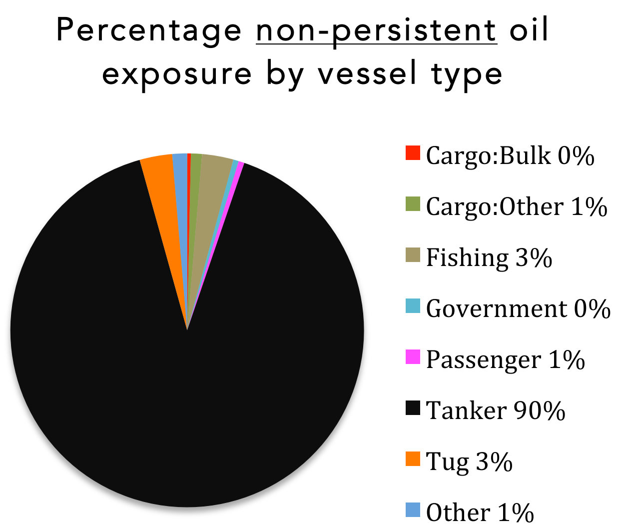
[42] Barge volumes based on company websites and interviews.

[43] Crude oil is another type of persistent oil. Though not currently carried through the Bering Strait (during the years studied), it could potentially be transported in this area from Arctic oil production areas in the future. Some crude oil moves through the Aleutian Islands in the southern Bering Sea, but this is outside the area for which we analyzed AIS data.



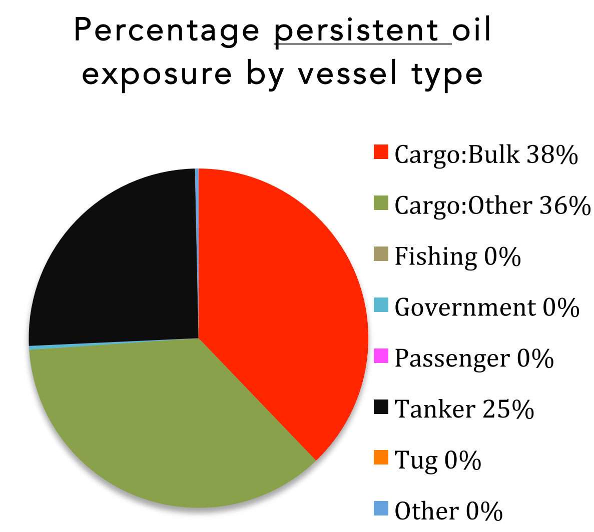


Figure 6-15 Oil exposure for persistent and non-persistent oil based on all tracks observed in the study[44]

Weighted oil exposure is calculated for each vessel type, with exposure of persistent oil 1.64 times greater than non-persistent oil, as discussed in Section 0. Tankers dominate this weighted oil exposure with 80% of the total. Cargo:Bulk and Cargo:Other each represent 6% and 7% respectively of the total. All other vessel types combined represent only 6% of the total weighted oil exposure. See Figure 6-16.

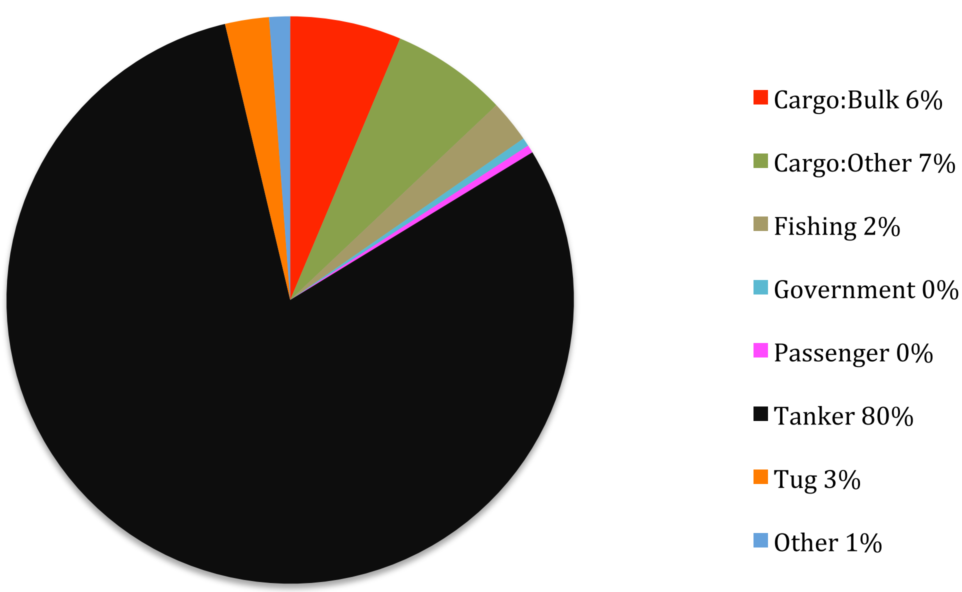


Figure 6-16 Percentage of **weighted oil exposure** *for each vessel type (includes both oil used as fuel and oil carried as cargo)*

[44] While we obtained information about barge cargo capacities for oil, without AIS information to develop operating days we did not calculate oil exposure for barges.

Finally, we can also consider *weighted* oil exposure based on the activity with which the vessel is associated, as shown in Figure 6-17. More weighted oil exposure is associated with U.S. zone vessels than Russian zone vessels. On the U.S. side, *tankers* calling at U.S. ports (other than Red Dog) represent 46% of overall weighted oil exposure. This is followed by 19% of weighted oil exposure associated with *tankers and bulk carriers* calling at Red Dog mine (12% of which is accounted for by tankers delivering fuel, though more calls are made there by bulk carriers). In the Russian zone, 11% of overall weighted oil exposure came from vessels transiting the region (the total for transiting vessels was 13% when U.S. transits were added). Cargo:Other vessels calling at Russian ports in the study area were associated with 6% of weighted oil exposure, and Tankers calling there with 5%. All other vessel activity, including all vessel types as well as Cargo:Other calls to U.S. ports, accounted for 10% of weighted oil exposure.

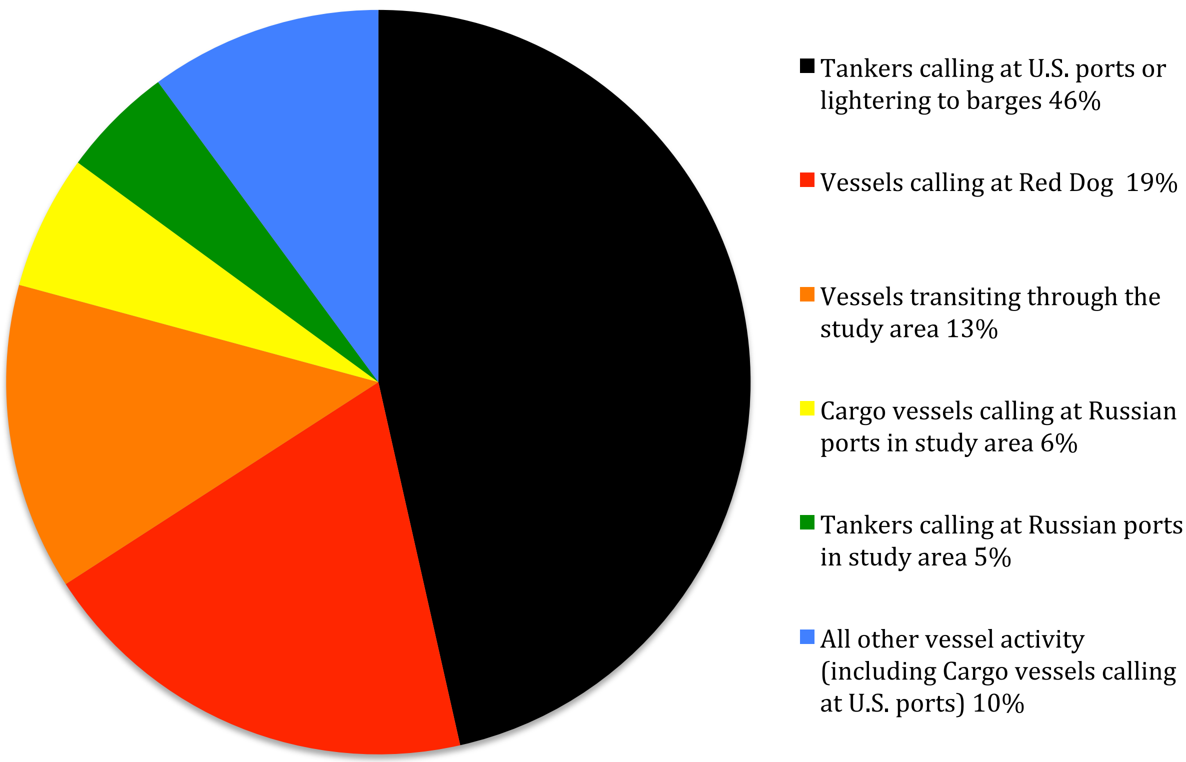


Figure 6-17 Percentage of overall ***weighted oil exposure*** *attributed to activities. Note that the 46% of Tankers calling at U.S. ports (or lightering) does not include those serving Red Dog mine.*

7 Future Vessel Traffic in the Bering Sea

Vessel traffic in the northern Bering Sea and Bering Strait area is expected to continue to increase in the future (Arctic Council, 2009). Predictions of the extent and type of activity that will increase in a given year or timeframe are, however, are uncertain. This section discusses some of the drivers for this activity, though it does not seek to forecast growth, which, in the near term, is highly susceptible to global markets; where, when, and how quickly sea ice retreat actually occurs; international affairs; investment in both onshore and offshore resource extraction in the Arctic; and the development of infrastructure to support increased activity.

7.1 Sea routes

Two shipping routes through the Arctic Ocean are poised to experience increased traffic as sea ice retreat makes them more accessible to vessels seeking shorter routes between East Asia or North America on the Pacific side and northern Europe, Canada, or the U.S on the Atlantic side. The routes are commonly referred to as the Northern Sea Route (NSR), along Russia's Arctic coast, and the Northwest Passage (NWP), following Canada's Arctic coast. In the future, a Central Arctic Ocean route across the pole may also be possible. Whichever Arctic route a vessel takes, they will be required to travel through the study area since the Bering Strait is the only marine passage between the Arctic Ocean and the North Pacific. Simplified versions of these three routes are shown in Figure 7-1.

Figure 7-1 Emerging Arctic shipping routes (based on Arctic Council, 2009). The NSR is one portion of the longer Northeast Passage, but is the focus here because of our attention to the eastern portion and the Bering Strait and Sea.

The primary driver for an increase in commercial shipping along these routes is to save time and costs, though avoiding potential political unrest or pirates via the Suez Canal route must be considered, too (Masters, 2013). Traffic via the NSR is expected to increase first, as the sea ice continues to retreat from the Russian coast sooner than the island-packed Canadian coast. The NSR is also the shortest route between Northern Europe and Asia (Smith & Stephenson, 2013).

Figure 7-2 shows the difference in miles from Hamburg, Germany to Hong Kong, China and Vancouver, Canada by using the NSR as compared to traditional routes. In particular, the NSR provides a shorter route for China to deliver goods to European markets and for Russia to export its significant resources of minerals and petroleum (Tekes, 2013).

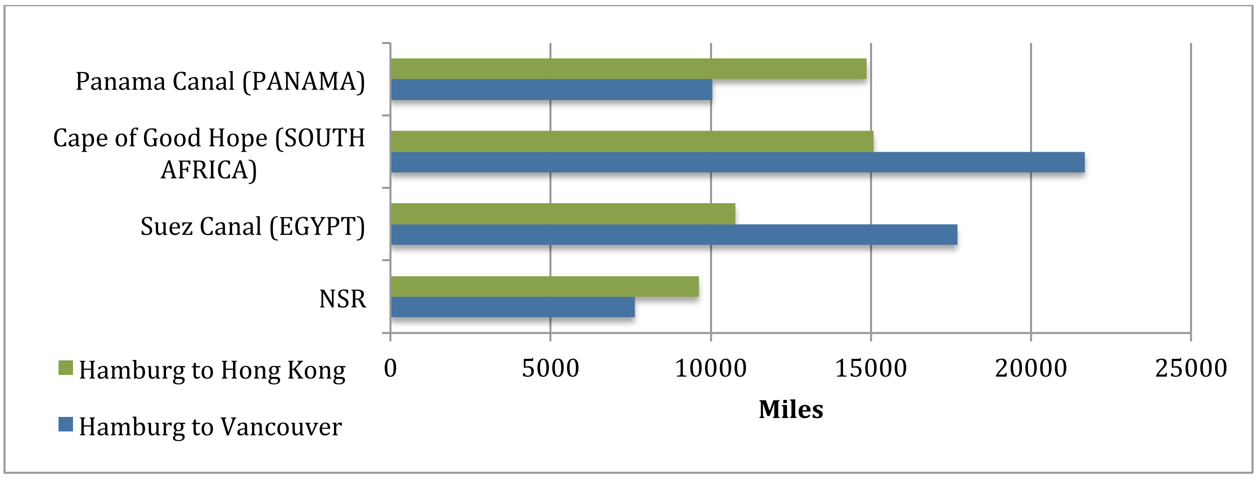


Figure 7-2 Comparison of distance traveled by vessels on routes from Hamburg, Germany to Hong Kong, China and Vancouver, Canada (Ragner, 2000)

Russia oversees shipping on most of this route through the Northern Sea Route Administration (NSRA), which manages the waterway by maintaining aids to navigation, supporting search and rescue operations, and by issuing permits for vessels to use the route. Vessels must be suited to ice conditions and may be required to be escorted by an ice-breaker (NSRA, 2016).

According to information provided by the NSRA, there were 229 NSR transits from 2011-2015, or about 45 per year on average, though the numbers fluctuated across years. Tankers made roughly half of the transits, and various cargo vessels (not including bulk carriers) made approximately one-quarter of them. Many of these voyages do not reflect the longer-range vision of the route being used for the exchange of goods and materials between Europe and Asia, but rather its use to and from Russian Arctic ports (NSRA, 2016). When we compared the AIS data analyzed for this study to the Northern Sea Route Administration's reported transits for the same time period, we found that some vessels travel through the Bering Strait to points north in Russia, but without counting as NSR voyages by the Russian government. So NSRA-reported voyages represent some, but not all, vessels moving through the Bering Strait area on the Russian side.

The Northwest Passage routes, which primarily extend along Canada's Arctic Coast, currently see a different mix of vessel types and fewer transits overall than the NSR, though the number of transits has been increasing over time. The first and only cargo bulker to make the trip did so in 2013 (the *Nordic Orion*), and both tankers and other cargo ships have represented a small percentage of activity along portions of the route. In 2009-2013, more than half the transits were made by vessels categorized as Other, including icebreakers, private adventurers/pleasure craft, and escort vessels (Northwest Territories, 2015). Although there are proposals and plans to develop ports and other infrastructure in both Canada and the U.S. (Tekes, 2013), the NWP's lack of infrastructure and other logistical challenges mean it is unlikely to become a common shipping route in the near future (Vard Marine, Inc., 2016).

7.2 Resource extraction

The extraction of natural resources in the Arctic also has the potential to increase traffic through the Bering Sea. This is essentially a subset of the commercial shipping context discussed above, though can also include vessel activity associated with supply or construction, pollution response, and offshore drilling rigs, for example, depending on the type of activity. With the extraction of mineral resources and oil and gas development both expected to expand in the Arctic, related shipping is expected to increase as well.

The Arctic Council (2009) predicted that bulk carriers are likely to see the greatest growth among ship types overall in the Arctic, and those traveling to east Asian markets from Arctic (or European) countries will increasingly pass through the Bering Strait (as will any transporting materials from the Arctic to East Asia or western North America). As with the Red Dog zinc and lead mine in Alaska, mining operations also require fuel deliveries by tanker or tank barge. This potential for growth is associated not only with trans-Arctic shipments but also with the export of materials from Canadian and Russian resource development projects (in particular).

The scale and speed with which this type of activity increases (or decreases) will depend on market forces, regulatory climates, international cooperation or dispute, and other drivers (Arctic Council, 2009). However, the scale of resources likely to be available in the circumpolar Arctic region indicate that in the long-term, vessel activity associated with exploration, development, production, and extraction of massive petroleum reserves and mineral resources (Bird et al., 2008) are expected to grow.

7.3 Tourism

Marine tourism on cruise ships of various sizes is on the rise globally and in the Arctic generally. In its 2009 study of shipping in the Arctic, the Arctic Council anticipates the growth of vessel-based tourism in the Arctic and highlights some of the potential challenges. These include conducting search and rescue operations or providing large-scale emergency medical services in remote areas should they be needed. Cruise ships – as well as smaller tour vessels whether or not they are associated with a large cruise ship – are also likely to travel in areas frequented by wildlife such as the ice edge or haulout areas (Arctic Council, 2009). As with all other vessel types, cruise ships accessing the Arctic Ocean -- whether traveling east to Russia or west through Canada -- will use the Bering Strait to or from East Asia or western North American ports. Their growth will likely increase traffic in the area.

The *Crystal Serenity* luxury cruise voyage in 2016 was the first voyage by a large cruise ship along the NWP, traveling from Seward, AK to New York City, NY including a stop in Nome, AK. Interest was strong enough that a 2017 voyage was planned even before the 2016 trip had sailed (Paris, 2016). This ship has a fuel capacity of more than 20,600 bbl,[45] which is more than twice the volume of any of the passenger vessels in the 2013-2015 dataset described in Section 6. This fuel volume is also larger than most, though not all, of the Cargo:Bulk and Tankers in the AIS data studied.

7.4 Community supply

The waters of the Bering Sea provide a critical pathway for the delivery of fuel and other supplies to Bering Sea communities that are not otherwise connected to the continental road network. The Arctic Marine Shipping Assessment found that community supply activity, primarily by tug/barge combinations in the Bering Sea region, is likely to grow as populations increase in the Arctic (Arctic Council, 2009). The Alaska Petroleum Distributors and Transporters has reported that fuel deliveries by barge have remained stable since the early to mid 1990s (Alaska Petroleum Distributors and Transporters, 2015).[46] As noted in the previous section, vessels serving Alaskan communities currently have the most operating days of the vessels in the dataset for the northern Bering Sea and Bering Strait area.

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[45] According to the "worst case discharge" in the federally required vessel response plan.

[46] Through a partnership with the Denali Commission, the U.S. Army Corps of Engineers has been working to support barge deliveries by installing mooring points in the Yukon-Kuskokwim delta region, where barge operators have reported challenges with shoreline erosion on inland waterways (Budnik, 2013).

8 Existing Mitigation Measures

This section focuses on existing mitigation measures related to reducing the likelihood or consequences of a vessel accident. (The consequence of focus is oil outflow, but preventing injury or loss of life should be the priority.) We review current risk mitigation measures related to spill prevention (preventing an accident, or the release of oil should an accident occur) and spill response (including planning and resources in place) on the U.S. side of the Bering Sea.

8.1 Regulatory Context

A vessel's *location* will determine whether it is in state waters, U.S. territorial waters, the U.S. Exclusive Economic Zone (EEZ), international, or Russian waters. On the U.S. side, *state waters* extend three nautical miles from shore under the U.S. Submerged Lands Act of 1953 (43 USC §1312). Within state waters, vessels are subject to both U.S. law and State of Alaska law, unless in innocent or transit passage (see below). The United Nations Convention on the Law of the Sea (UNCLOS)[47] defines a country's territorial waters, which extend to 12 nautical miles from the low-water line (UNCLOS Section 2) and its Exclusive Economic Zone (EEZ), which extends another 200 nautical miles beyond territorial waters (UNCLOS Article 57).

The IMO establishes and oversees maritime activities globally. U.S. Coast Guard regulations set the mandates for U.S.-flagged vessels under these conventions. The Coast Guard also implements inspections of other countries' vessels calling at U.S. ports under Port State Control to monitor and enforce compliance. Both the U.S. Coast Guard and State of Alaska implement and enforce oil spill prevention and response planning regulations for vessels covered by their laws and subject to their jurisdiction. With the notable exceptions discussed in the next section, vessels operating in the U.S. EEZ or with a U.S. flag are generally subject to federal regulations, and those operating in state waters to Alaska's regulations. (Many small vessel classes are not covered by the regulations discussed in this section.)

8.1.1 INNOCENT PASSAGE

Some vessels will not be subject to U.S. or Alaska regulations if they do not enter U.S. territorial waters or are in innocent passage. At the same time that UNCLOS established a country's

[47] The U.S. became a signatory to the Convention on the Law of the Sea in 1994, though President Ronald Reagan had already declared that the U.S. would abide by the Convention as customary law in 1983 (TRB, 2008). However, the U.S. has never actually ratified the treaty with the two-thirds vote in the U.S. Senate that is required by the U.S. Constitution.

marine boundaries, it also ensured that vessels would be able to continue to move through the world's oceans by defining the concepts of *innocent passage* and *transit passage*.[48]

Vessels in innocent passage[49] are passing through the territorial waters of a country other than their flag state without calling at a port or anchoring on that voyage. A vessel in innocent passage is still subject to general international requirements through the laws of its own flag state. While the U.S. is allowed by international law to apply rules to vessels in innocent passage for "the preservation of the environment…and the prevention, reduction and control of pollution" (per Article 21 of UNCLOS), U.S. regulations explicitly exclude "foreign flag vessels in innocent passage" from the federal requirements related to oil spill response planning requirements [33 CFR 155.1015(c)(7) and 33 CFR 155.5015(d)].

The State of Alaska mimics the concept of innocent passage when determining whether vessels passing through state waters are subject to state regulations. Vessels that pass through state waters but are _not_ coming from or going to a port in the State of Alaska are thus not subject to state-level laws and regulations (regardless of their flag state).[50]

This is primarily an issue in the Aleutian Islands, where half the transits of Unimak Pass in the Aleutian Islands were in innocent passage in 2012 (Nuka Research and Planning Group, 2014). It may become a greater concern in the Bering Sea if international transits through U.S. waters of the Bering Strait increase in the future.

8.1.2 SPILL PREVENTION

The IMO has several conventions that establish minimum requirements for vessel construction, operations, and general safety. Many of these can be broadly considered to relate to oil spill prevention because they are designed to prevent accidents (or prohibit the intentional release of some polluting substances). Conventions typically apply to certain classes of vessels regardless of where they operate, and so are not particular to the Bering Sea and not described in detail here. These conventions include:

- International Convention on the Safety of Life at Sea (SOLAS)
- International Convention on the Prevention of Pollution from Ships (MARPOL)
- International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW)

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[48] Article 19 of UNCLOS prohibits activities such as spying, engaging in any military activities, willful pollution, etc.

[49] Transit passage is functionally the same as innocent passage, but applies when a vessel is using a strait that has been historically used for international navigation, such as Unimak Pass in the Aleutian Islands or the Bering Strait.

[50] AS 46.04.055 includes this exemption for non-tank vessels. For tank vessels, the state interprets the pre-emption clause in regulations at 18 AAC 75.007(c) as excluding tank vessels because it makes clear that state authority, in this case, is pre-empted by federal jurisdiction.

The International Code for Ships Operating in Polar Waters (Polar Code), adopted in two parts in 2014 and 2015[51], adds new safety and environmental protection provisions to both SOLAS (Part I) and MARPOL (Part II) that will apply to vessels operating Arctic and Antarctic waters. It also includes recommended practices (IMO, 2016b). Though specific to polar waters, the Polar Code is similar to the other Conventions noted in that it relates safety for the vessel and crew – in this case in extreme cold and ice environments – and the intentional release of pollution (waste).

The northern portion of the Bering Sea is within the waters designated as "Arctic" for the purposes of the Polar Code (60 degrees N; see Figure 8-1). Vessels subject to provisions of the Polar Code that are included in SOLAS and MARPOL will be required to comply when in this area. This does not include vessels transiting typical routes through the Aleutian Island chain but would capture vessels traveling through the Bering Strait. The U.S. Coast Guard will be responsible for ensuring that U.S-flagged vessels comply, and can also inspect other countries' vessels if they call at U.S. ports. Vessel compliance for foreign-flagged vessels that do *not* stop in U.S. ports will rely on the flag state to ensure compliance, or another country inspecting the vessel through its own Port State Control.

Figure 8-1 The IMO's Polar Code applies to waters north of 60N in the Bering Sea

[51] *The Polar Code follows on the IMO's voluntary Guidelines for Ships Operating in Polar Waters from 2009.*

IMO-approved routing measures have been developed for the Aleutian Islands region, though not farther north. Though technically voluntary, these measures set the expectation that vessels transiting the region will stay at least 50 nm offshore except when using one of three approved passes. The U.S. Coast Guard issued these in a guidance to local mariners and they are included on nautical charts of the area (Nuka Research and Planning Group & Pearson Consulting, 2016).

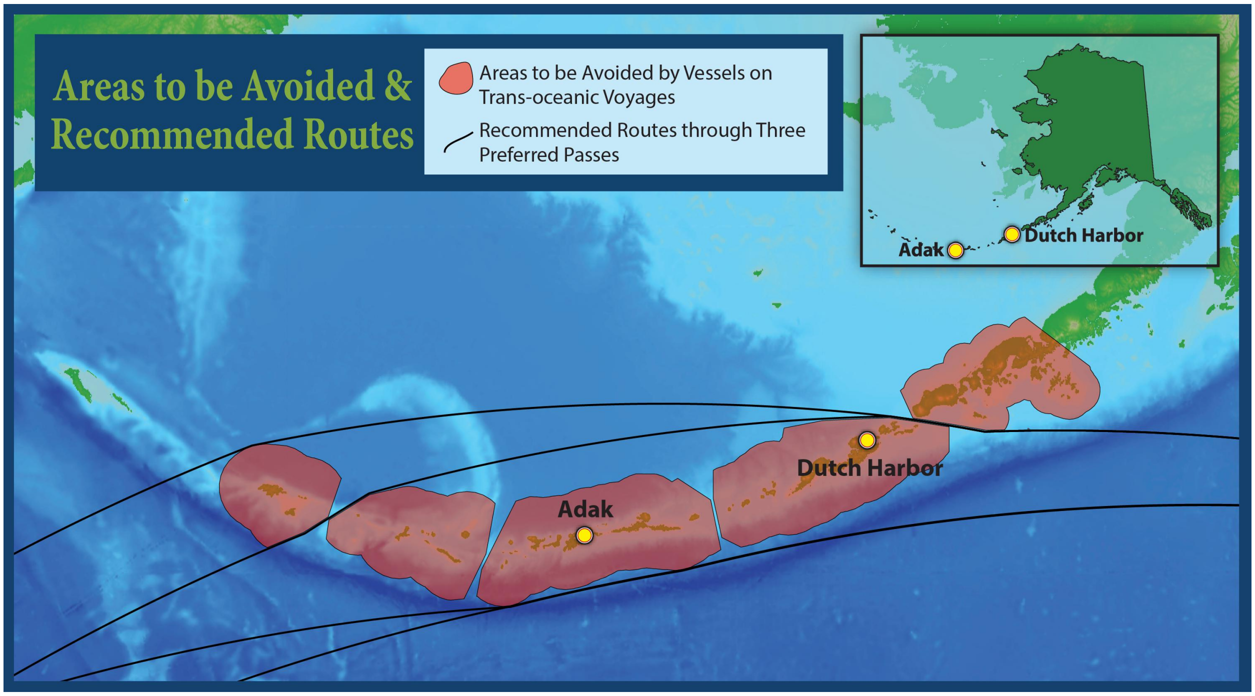

Figure 8-2 Recommendatory areas to be avoided established around Aleutian Islands through the IMO

As part of a Port Access Route Study,[52] the U.S. Coast Guard has proposed potential routes for vessels traveling U.S. waters through the Bering Sea to and from the Bering Strait. These routes have been released for public comment, but are not final as of October 2016 (Abel, 2014).

Figure 8-3 Proposed vessel routes through Bering Sea and Bering Strait as of November 2016

[52] *The U.S. Coast Guard conducts Port-Access Route Studies prior to establishing routing or other measures to direct vessel traffic. The process includes examining all uses of a waterway and considering potential risk reduction measures to improve safety and/or measures to increase the efficiency of shipping operations (U.S. Coast Guard, 2016b).*

8.1.3 SPILL RESPONSE

This section provides a general overview of the international conventions and U.S. laws or regulations that govern oil spill response planning in the Bering Sea.

8.1.3.1 International

International law does not drive the placement of oil spill response resources or dictate specific planning requirements to countries.[53] However, there are some agreements in place that set baseline expectations regarding how countries will coordinate in the event of an imminent or actual oil spill.

The eight countries of the Arctic Council established an Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic in 2013. This agreement is similar to an existing global International Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC). It primarily focuses on coordination among countries and mutual assistance and does not include equipment or planning in either country. There are no provisions specific to the Bering Sea, as the agreement is Arctic-wide (and the OPRC is global), but the expectation is established to the effect that the U.S. and Russia - and other parties - will:

- Pre-position spill response equipment
- Exercise and train personnel
- Develop oil spill response plans and communications capabilities for spill response
- Establish a spill response management system
- Notify other countries who may be affected by a spill, if one occurs
- Conduct monitoring activities to detect and track oil spills
- Assist each other during a spill response
- Facilitate the movement of spill response assets through, or to and from, its waters
- Follow defined reimbursement procedures
- Conduct joint exercises and joint reviews of actual responses
- Share information to improve oil spill preparedness and response.

To the extent that a spill in Russian waters could impact the U.S. side, the Arctic Council, the OPRC, and a 1989 bi-lateral agreement between the U.S. and Union of Soviet Socialist Republics (now Russia) all establish the expectation that information and, potentially, resources should be shared to facilitate prompt action and mitigate impacts to the environment (Agreement between U.S. and U.S.S.R, 1989; Arctic Council, 2013; IMO, 1995).

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[53] MARPOL does require that oil tankers greater than 150 GT and other vessels greater than 400 GT carry Shipboard Oil Pollution Emergency Plans (SOPEP) approved by their flag country. These plans must, at minimum, describe notification procedures, actions to be taken by the crew, and the person onboard who will coordinate with the relevant authorities in the event of a spill. They are not location-specific, nor do they include any requirements for response resources. (MARPOL Annex 1, Ch. 5, Reg. 37)

8.1.3.1.1 U.S. Federal

The U.S. Coast Guard implements and enforces federal laws and regulations related to emergency towing, salvage, and spill response in the U.S. EEZ. Regulations under the Oil Pollution Act of 1990 require vessel operators to submit plans describing how they will meet requirements for the quantity and type of oil spill response resources for each Captain of the Port (COTP) zone through which the vessel will travel. These regulations do not apply to vessels in innocent passage.

The U.S. Coast Guard divides U.S. waters into COTP zones for the oversight of navigational safety, security, and environmental protection. There are three COTP zones in Alaska. The Bering Sea is included in the largest of these: the Western Alaska COTP zone, which extends from Seward on the Kenai Peninsula to the Canadian border in the Beaufort Sea, and out to the limit of the EEZ. Anchorage is the port city (see Figure 8-4).

U.S. oil spill contingency planning regulations apply to most non-tank vessels greater than 400 GT [33 CFR Part 155.1015(a)(4)] and all ships or barges that carry oil as their primary cargo [33 CFR 155.1050(a)]. The quantity and type of oil carried and where the vessel travels (in the nearshore or offshore areas, for example) are used to determine the quantity and type of resources that must be available within set timeframes. How quickly the requisite response resources should be able to be on-scene are somewhat location-specific, and will vary depending on the COTP zone (33 CFR Part 155). Some resources, such as emergency towing and some salvage-related equipment, are only required to be available within a certain time if the vessel is within 50 miles of the COTP city (Anchorage). For example, regulations require that a rescue tug be available to be able to control the ship in 40-knot winds should a loss of steering or power occur, but this requirement only applies within 50 miles of Anchorage (33 CFR 155.4010 – 4055). Similarly, regulations specify some salvage services and equipment that must be available within set times, but while the services and resources must be identified in the plan, there is no time requirement outside 50 miles from Anchorage (33 CFR 155.4040(d)(6).

For oil spill response planning purposes, Alaska is also divided into 10 subareas, each with its own plan developed and maintained jointly by state and federal agencies. The Bering Sea is divided among 4 subareas. Subarea Contingency Plans fall under the umbrella Alaska Federal/State Preparedness Plan for Response to Oil & Hazardous Substance Discharges/Releases (Unified Plan, which serves as both the Area Response Plan and Regional Contingency Plan), which, in turn comes under the National Oil and Hazardous Substance Pollution Contingency Plan. A request for comments on a suggested revision to these subareas was issued in September 2016 (ADEC, 2016). Figure 8-4 shows both COTP zones and subareas as they are currently configured.

Figure 8-4 Alaska is divided into Captain of the Port zones, for the purposes of U.S. Coast Guard oversight, and subareas used by both federal and state agencies for oil spill response planning

8.1.3.1.2 Alternative Planning Criteria

A vessel operator may propose to the U.S. Coast Guard an alternative to the regulatory requirements discussed above if the operator "believes that national planning criteria…are inappropriate to the vessel for the areas in which it is intended to operate." This option exists both for tank vessels (33 CFR 155.1065(f)) and non-tank vessels (33 CFR 155.5067). At the Coast Guard's discretion, such alternative planning criteria (APC) may be used for remote areas, or places where there is no OSRO capable of meeting the regulatory requirements. Operators – or organizations acting on their behalf – must submit an application for an APC that describes the alternative proposed and explains how it will mitigate risks associated with vessel traffic in the area[54] (USCG, 1997). The U.S. Coast Guard sought public comments on potential revisions to APC requirements with a September 2016 deadline (81 FR 33665).

8.1.3.2 State of Alaska

State of Alaska oil spill response planning regulations apply to vessel owners or operators of both tank and non-tank vessels operating in state waters and traveling to/from a port in Alaska, though the requirements differ for tank and non-tank vessels (AS 46.04.030 and AS 46.04.55).

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[54] *Operators must identify the specific geographic areas they will travel (within the COTP zone) and keep to these areas, but the proposal should address the whole COTP zone.*

The Alaska Department of Environmental Conservation reviews and, as appropriate, approves plans according to the state regulations.[55]

Central to the planning requirements is a response planning standard (RPS), which is based on the cargo volume, type of cargo, and vessel type, as shown in Table 8-1. Note that there are currently relatively few crude oil tankers transiting the Bering Sea and all of these are in transit through the Aleutian Islands (DNV & ERM-West, Inc., 2010). None were identified in the AIS data analyzed for this study.[56] The regulations do allow for partial reductions in the response planning standard for vessels carrying crude oil if the meet certain additional requirements [18 AAC 75.438(d)].

In addition to the RPS, regulations require the plan to, "demonstrate the general procedures to clean up a discharge of any size, including the greatest possible discharge that could occur," typically done through a narrative scenario. [18 AAC 75.430(a)]

Table 8-1 Response planning standards in Alaska regulations

Vessel in Alaska state waters	Response Planning Standard applicable to spills to open water	Regulatory citation
Crude oil tanker or tank barge *Crude oil is not currently being moved to or from an Alaskan port in the Bering Sea region, so this more aggressive planning standard (in terms of recovery volume) does not apply.*	Must have resources in region to contain/control *and clean* up spill in 72 hours, *plus* be able to deploy enough resources from either in or out of the region within 72 hours to contain/control and cleanup 60% of total tank volume Planning volume = 300,000 bbl if cargo is greater than 500,000 bbl, or 50,000 bbl otherwise	18 AAC 75.438
***Non*-crude oil tanker or tank barge** *Applies to tankers and tank barges operating in Bering Sea if they enter state waters. Those that stay outside state waters and lighter to barges are not subject to this requirement.*	Must have resources in region to contain/control spill in 48 hours and clean up in shortest possible time Planning volume = 15% of total cargo capacity	18 AAC 75.440
Non-tank vessels *Applies regardless of fuel type if vessels are in state waters; similar to the tankers, it does not apply to vessels that stay offshore such as bulk carriers at Red Dog mine.*	Must have resources in region or capable of arriving within 24 hours to contain/control spill in 48 hours Planning volume = 15% maximum oil (fuel) capacity	18 AAC 75.441

[55] 18 AAC 75.400 – 420 and 18 AAC 75.425 – 496, as applicable

[56] The vessels entering state waters in the Bering Sea are primarily carrying non-crude oil or are not tankers or tank barges. Also note that Alaska's regulations focus only on cargo volume for the tankers, not total fuel capacity.

8.2 Implementation of current mitigation measures

The State of Alaska has conducted additional planning at the programmatic level, with the following measures developed for the Bering Sea as well as other areas of the state:

- **Geographic Response Strategies (GRS)** identify sensitive coastal areas and suggest booming and other spill response strategies based on input from local communities and responders. Dozens have been developed in the Bering Sea region. These are referenced in the subarea plans.
- **Potential Places of Refuge (PPOR)** suggest areas that may be suitable for a disabled vessel to find protected anchoring or mooring to implement repairs. While actual direction given to a vessel captain will depend on a wide range of circumstances at the time, PPOR are intended to provide information to decision makers to help them to secure a stricken vessel while avoiding the most sensitive resources. These are referenced in the subarea plans.
- **Emergency Towing Services (ETS)** are packages of towing equipment that can be deployed to a vessel that has lost power or propulsion. The equipment can be deployed to a drifting ship from either a helicopter or another vessel, and allows a rescue vessel to establish a tow with a disabled ship Effective use of the equipment requires a capable tow vessel (and a suitable helicopter if one will be used to deploy the equipment to the ship). These are stationed in Nome near the Bering Strait, and, Cold Bay, Unalaska, and Adak in the Aleutian Islands.
- **Trailers stocked with spill response resources.** The state maintains equipment stockpiles with spill response equipment that can be accessed by community-based responders. Resources vary depending on the area, but generally include some boom, sorbet materials, safety equipment and gear, and possibly skimming equipment. These are located in several places throughout the Bering Sea region (ADEC, 2015).

Except for the two ADEC programs that put the ETS and response equipment containers in place, it is really vessel operator compliance with the federal and state[57] oil spill response regulations described above that drives the procurement and placement of response equipment and the number and location of trained responders and other support resources (such as vessels, barges, etc.). Operators typically comply with both state and federal requirements by participating with a response organization that maintains the resources on behalf of a group for one or more COTP zones (USCG, 2016b) or subareas.

Alaska Chadux, initially established by companies operating barges in the region, is the primary response organization in the Bering Sea region. Because of its initial focus on serving a

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[57] *State of Alaska regulations apply only to vessels in state waters, and are much more stringent for those tankers or barges that carry crude oil. As would be expected, there is no indication in the Aleutian Islands Risk Assessment or the data analyzed for this project (Section 3) that crude oil is moving through state waters in the Bering Sea in recent years. The most stringent regulations, therefore, are the federal requirements for tankers, which apply to vessels outside state waters (anywhere in the U.S. EEZ), and these are currently implemented through the alternative approaches as described in this section.*

barge industry that is strictly moving non-persistent petroleum, until recently Alaska Chadux focused entirely on nearshore and inland response-related equipment and services[58] (Alaska Chadux, 2016). Response organizations also serve vessel operators' required to comply with state regulations.

In the Bering Sea, spill response resources are actually determined not by compliance with the regulatory requirements as written, but by the alternative compliance described above. There are currently six U.S Coast Guard-approved "APCs" (commonly used to refer to "alternative planning criteria") in Alaska, all of which cover some or all of the Bering Sea. These are summarized in Table 8-2 (as of April 14, 2016). APCs may be implemented by OSROs or may be other entities that contract OSROs to provide equipment, personnel, and vessels. APCs are designed for different categories of vessels, including barges, tankers, and non-tank vessels.[59]

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[58] This includes booming to contain oil around a stricken vessel or to protect sensitive areas and skimming capability.

[59] "Non-tank" vessels are ships that use petroleum for propulsion but do not carry oil as cargo, such as bulk carriers, other cargo ships, and passenger/cruise ships. While tankers have been subject to federal response planning requirements for decades, the regulations for non-tank vessels only took effect as of January 2014 (78 FR 60100).

Table 8-2 U.S. Coast Guard-approved APCs for regulated vessels operating in the Bering Sea (USCG, 2016c). Resources listed are based on those located in the Bering Sea only; all entities also have plans to "cascade" additional resources as needed from elsewhere in Alaska and the Lower 48.

APC Name	Covered vessel type	Coverage area	Elements included in APC (only resources based in Bering Sea are included)[60]
Alaska Petroleum Distributors & Transporters APC	Tank barges	All of Alaska	Alaska Chadux response resources (and barges commit to reserving space onboard for emergency lightering) (Alaska Petroleum Distributors and Transporters, 2015)
Alaska Maritime Prevention and Response Network's "Alaska APC for Tank Vessels"	Tank vessels	Western Alaska COTP Zone	Offshore routing through the Aleutians, real-time AIS monitoring, Alaska Chadux response resources. Includes procedures specific to tankers that transfer fuel to barges offshore Bering Sea communities. (Alaska Maritime Prevention & Response Network, 2016)
Alternative Planning Criteria for Cruise Ships Operating in Northwest Gulf of Alaska	Cruise ships	Western Alaska & PWS COTP Zones	Only applies to cruise ships traveling to or from Seward or Prince William Sound (D. Eley, personal communication, September 11, 2016)
Alaska Maritime Prevention and Response Network's "Alaska APC for Non-Tank Vessels"	Non-tank vessels	Western Alaska & Prince William Sound COTP Zones	Offshore routing through the Aleutians, real-time AIS monitoring, facilitate identification of rescue vessels, organize vessels of opportunity, Alaska Chadux response resources. (Alaska Maritime Prevention & Response Network, 2013)
Alaska Response Company's "Pathway to Protection"	Non-tank vessels	Great Circle Route (Aleutian Islands, Bristol Bay, and Kodiak subareas)	Emphasizes infrastructure and support services in the region, such as on-land storage capacity, air strips, warehouse space, housing, on-land storage, and small vessels; landing craft operating in area seasonally; response resources in Adak (Alaska Response Company, LLC, 2016)
National Response Corporation/ Resolve's "1-Call Alaska"	Non-tank vessels	Great Circle Route (Aleutian Islands, Bristol Bay, and Kodiak subareas)	Offshore routing measures; real-time vessel monitoring; Dutch Harbor resources: rescue tug and salvage vessel, marine firefighting package, lightering pumps, storage barge, on-land storage, and response resources. (1-Call Alaska, 2015)

[60] All entities also have plans to cascade resources of varying types from locations in Alaska and elsewhere.

Figure 8-5 shows the response assets that are currently located in the U.S. side of the Bering Sea. As shown, assets are owned by ADEC or private entities that either are APCs or, as is the case with Alaska Chadux, an OSRO serving an APC. The spill response equipment caches designated vary in their inventories but are primarily designed for the nearshore, shoreline, or inland (or on land) response, with some recent open-water-capable additions in the Aleutian Islands.

Figure 8-5 Response resources located around the U.S. Bering Sea. Assets are primarily designed for response to small spills in the nearshore, shoreline, or inland areas. Additional assets would be mobilized from other parts of Alaska and the Lower 48 as needed and weather permitting. Map developed based on information from APCs shown in table above. Information is subject to change.

Two of the APCs in Table 8-2 apply to the tankers lightering to barges for petroleum delivery in the Bering Strait area that has become common practice in recent years. Tankers bringing oil into the region are covered under one APC (Alaska Maritime Prevention & Response Network, 2016), and the barges that deliver the oil operate under a second APC (Alaska Petroleum Distributors and Transporters, 2015). The tankers must stay at least 12 nm offshore except when traveling closer to shore to lightering areas.[61] When approaching less than 12 nm offshore, the tanker must wait until the port can ensure that a towing vessel is available to provide immediate assistance if needed.[62] The tanker operator must provide a lightering plan to the U.S. Coast Guard that includes identifying a vessel with some response equipment. That equipment includes pumps and hoses to offload the largest cargo tank, containment boom, skimming capacity,[63] and storage space available in the barge (Alaska Maritime Prevention & Response Network, 2016).

There are no set timelines for how quickly the tug or vessel with response resources needs to be able to be on-scene. It also is not clear whether or not the towing vessel required when the tanker travels inside 12 nm offshore could be one of the vessels towing a barge engaged in the lightering operation. A U.S. Coast Guard guidance document states that a "suitable towing vessel" is one that is used for mooring in the port, or, if no mooring-assist tug exists in the port, no towing vessel is required ("Western Alaska Tanker APC's FAQ Sheet," 2012). Thus it is unclear that towing vessels would be required at many of the places where tankers lighter to barges, or whether any of the towing vessels used for mooring assistance would be capable of securing a tow and controlling the vessel in inclement weather.

Because they stay outside state waters (3 nm offshore), the tankers also are not subject to state planning requirements. The response equipment and timing requirements would not be as aggressive for these tankers with non-crude cargo as they are for tankers carrying crude oil (see Table 8-1), but if state requirements were in effect for these vessels they would be subject to financial responsibility and other contingency planning requirements.

8.2.1 SUMMARY OF CURRENT MITIGATION MEASURES

Figure 8-6 below summarizes the how the current mitigation measures established through international, federal, or State of Alaska requirements may prevent or mitigate the impacts of a spill or vessel casualty using the accident chain introduced in Section 2. The figure does not include pending or proposed measures, such as the routing measures proposed through the PARS.

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[61] *Tankers traveling through the Aleutian Islands must stay 75 nm offshore (farther than the IMO requirement of 50 nm) except when using an approved pass or calling at a port (Alaska Maritime Prevention & Response Network, 2016).*

[62] *An escort vessel is required if the tanker will go inside 3 miles (and the tanker must have tow gear at the ready).*

[63] *Skimming capacity specified is sufficient to pump a maximum of 1250 bbl/day.*

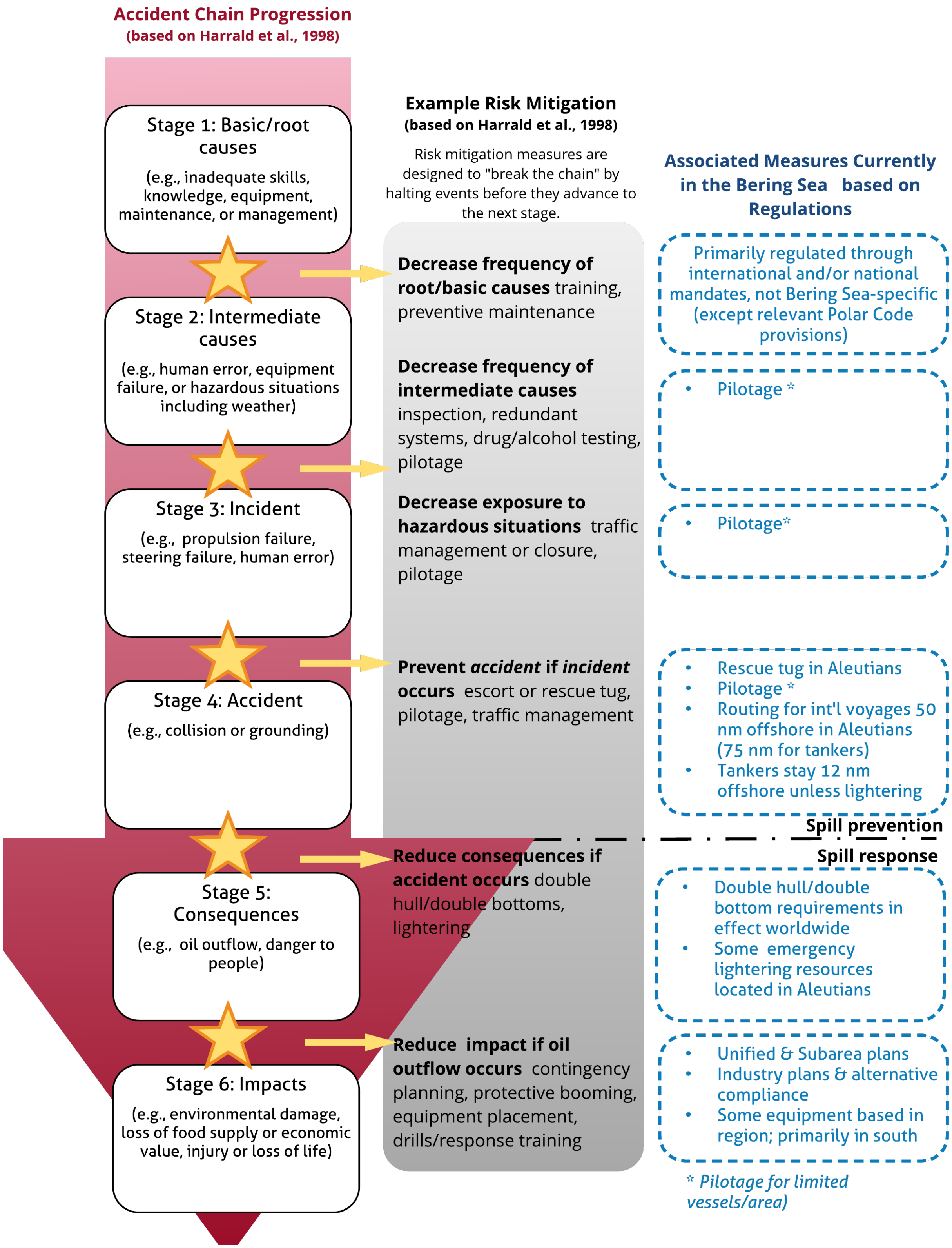

Figure 8-6 Summary of current mitigation measures based on accident chain framework

9 Discussion

This section discusses the potential for impacts to subsistence use and commercial fisheries from shipping in the Bering Sea, as well as findings and recommendations from this study.

9.1 Potential for Impacts to Subsistence and Commercial Fisheries

This study characterized three years of vessel traffic in the northern Bering Sea and Bering Strait. That analysis identified vessels of the general type and size that have been known elsewhere to strike marine mammals, disturb or endanger marine mammals with engine and hull noise, and release pollutants to the water and air. Any vessel with oil onboard may suffer a casualty that results in a potential or actual oil spill. We do not quantify the likelihood of any of these hazards impacting the species and habitat on which both subsistence-based communities and commercial fisheries depend. However, we do observe that the impacts are possible and the likelihood can be expected to increase as shipping increases through the area.

A range of potential consequences from shipping-related hazards is possible. The consequences associated with a hazard such as underwater noise may be that species people rely on (including commercially-fished species, though this study did not explore the literature related to vessel noise and fish) suffer health effects that reduce their population or modify their behavior in such a way that harvest is reduced or impossible. The impact of marine mammal strikes, on the other hand, is likely limited to the subsistence-based communities that depend heavily on walrus and other marine mammals. Without more data we cannot know if there may be a population-level effect on marine mammals from vessel strikes, such effects are not necessarily a prerequisite to risk mitigation. As acknowledged in the introduction regarding risk perception, it is also important to acknowledge that an effect does not necessarily need to be at the population level to be very severe to a person, family, or community.

Finally, the contamination of food from vessel waste or oil spills is of concern whether fish, mammals, or birds are being consumed locally or a commercially-caught species is consumed thousands of miles away. In both cases, there is the potential for impacts based even just on the *perception* of contamination, whether that means people avoiding an area or particular species for subsistence uses, or a reduced market for a commercially-caught species. A spill of thousands of gallons of persistent oil represents the other end of a hypothetical range of contamination impacts. Depending on location and season, the concentration of many Arctic species means that such an event could threaten the food security of dozens of communities already experiencing the effects of climate change, and that this may be a multi-year effect. It could also close commercial fisheries in the affected area, or, again, reduce the demand for a particular species caught in the general area or in Alaska overall due to consumer perceptions even if no effect is identified.

9.2 Findings and Recommendations

This section summarizes findings and discusses how these might inform consideration of future oil spill risk mitigation options, both for current vessel traffic and potential future growth.

In the southern Bering Sea, most oil exposure is associated with vessels transiting through the area, while in the northern Bering Sea, most oil exposure today is associated with calls to ports (or lightering) in the region. There is a baseline level of vessel activity throughout the Bering Sea that is related entirely to serving Bering Sea communities and in-region economic activities (such as fisheries and mining). This activity is heavily dependent on tug/barge combinations but also includes small tankers and cargo vessels. This activity represents most of the oil exposure in the north, since Bering Strait transits, though growing, still are still relatively few in number when compared to the thousands of transits each year along the North Pacific Great Circle route through the Aleutian Islands. In contrast, the risk of oil spills and other vessel traffic impacts in the southern Bering Sea is primarily due to vessels passing through the area, as this type of use overshadows the local service-oriented traffic with respect to number and size of vessels and associated oil exposure.

The Aleutian Islands Risk Assessment includes detailed recommendations for an oil spill prevention and response system that would mitigate some of the risks in the southern Bering Sea. While the risk assessment was conducted with extensive supporting technical analysis and input from diverse stakeholders who reached near-consensus on most issues, a number of recommendations have yet to be implemented. Areas to be avoided have been implemented through the IMO and some spill response and salvage resources have been added, there are still improvements needed to implement and sustain the AIRA recommendations as described at the end of that project (Nuka Research and Planning Group & Pearson Consulting, 2016).

Tankers serving U.S. ports and bulk carriers and tankers serving Red Dog mine constitute approximately 65% of weighted oil exposure for the Bering Strait area. Building off the finding that oil exposure in the Bering Strait area is currently driven by activities in the region, we can look more closely at the basis for this exposure. Tankers delivering fuel to U.S. communities represented the most of the weighted oil exposure in the Bering Strait region (46%). Vessels serving Red Dog mine represent the second greatest weighted oil exposure (19%). In both cases, this exposure refers only to the volume of oil on the vessels (both as fuel and, for the tankers, also oil cargo) and the time they spend in the area; it does not further incorporate potential exposure from the transfer of oil to barges and the operation of those barges. Currently, much of this exposure comes from persistent heavy fuel oil used as fuel, though the cargo contents of the tankers is entirely non-persistent fuel for delivery to communities or Red Dog mine. A persistent spill would be expected to last longer in the area and thus potentially spread its impacts across seasons or years, but a non-persistent spill could potentially have a devastating impact if it occurred during a time or in a place where species were highly concentrated and/or at a particularly sensitive part of the lifecycle (this will vary depending on species).[64]

These vessels are not in innocent passage because they are not simply passing through U.S. waters but are instead making deliveries (or, for the bulk carriers, picking up mined material). The vessels are therefore subject to U.S. regulations, and currently operate under an APC as discussed previously. The costs of any mitigation measures should be well understood and the potential for increasing already high fuel costs to communities weighed carefully. Because they stay outside state waters, the vessels also are not subject to Alaska's contingency planning requirements. Although they are not as aggressive for non-tank vessels or tank vessels carrying non-persistent cargo as they are for tank vessels carrying crude oil,[65] state plans do require operators to describe how they would respond to a scenario and incorporate an opportunity for public review that is missing from the federal process.

The following items related to mitigating current risks associated with serving Bering Sea/Bering Strait area ports/lightering could be further explored:

- Determine whether lightering procedures and spill prevention practices associated with these vessels align with national and international best practices or if any improvements in procedures could be made.
- Understand possible outcomes if a tanker or bulk carrier loses its mooring or anchorage three miles off shore (the typical lightering distance, just outside state waters), including how long it may take to drift ashore and feasibility of achieving a self-arrest and/or emergency tow (and the availability and capability of potential emergency tow vessels at different locations used for lightering).
- Conduct a tabletop or possible field exercise to test preparedness for an incident related to a tanker that is set adrift or loses steering/propulsion while approaching a lightering location. Such a scenario should consider the location and capability of tugs/barges and whether these may be away from the tanker making deliveries when an incident occurs. The potential for such an incident could be considered both off Nome and off another community with a lower level of vessel activity and infrastructure for support. It may also consider the role community-based first responders could play in deploying protective booming of sensitive areas, or expose gaps in local preparedness.
- Assess the capacity to respond to a spill from a tanker or bulk carrier in the nearshore area, including consideration of the potential spill trajectory and weathering (which

[64] HFO used as vessel fuel is the only persistent oil moving on vessels on the U.S. side currently. If vessels change the type of fuel they use in the future, due to IMO requirements or any other reason, then the weighting of oil exposure calculated would change (if they changed to a non-persistent fuel type such as marine diesel). This should inform response planning, as the oils will behave differently. However, currently the greatest weighted oil exposure in the region studied comes from tankers and is driven by their sheer volume – since they are all only carrying non-persistent oil even today.

[65] Both HFO and crude oil are considered persistent, but state regulations are based on tank vs. non-tank vessels and whether a tank vessel carries crude or non-crude oil, as discussed previously.

could include both persistent and non-persistent oils), available spill response resources, including storage, and the location and time required to mobilize and deploy those resources. Although only federal spill response regulations (implemented through APCs) apply since ships are not entering state waters, this exploration could be an opportunity to engage state and community input and expertise.

- Consider stakeholder input to designate areas where lightering should - or should not - be conducted. This could either be done based on identifying the safest options that avoid sensitive resources (which could perhaps build off of the work already done to identify potential places of refuge for the area), or by designating the most sensitive/least safe places as areas where lightering should be avoided. These could be developed with input from the subsistence community and commercial fishing industry.

Bulk carriers and other ships transiting the Bering Strait represent the most likely area of growth in oil spill exposure in the near future. Assuming that the "baseline" traffic that exists to serve communities in the region grows slowly with community demand, the far greater potential for an *increase* in vessel activity in the region over time will be associated with shipping through the Bering Strait. Growth in the near-term is most likely to be bulk carriers serving resource extraction projects in Russia and possibly Canada. (As noted, tankers also serve mining projects.) Currently, the bulk carriers and tankers serving mining projects, as well as larger general cargo vessels, use heavy fuel oils for their propulsion and so represent a persistent oil spill exposure in the Bering Sea.

Anticipating an increase in Arctic shipping activity, the U.S. Committee on the Marine Transportation System (CMTS) has identified risk mitigation measures for the U.S. Arctic related to both information and response infrastructure. Many of these build on recommendations from the Arctic Marine Shipping Assessment and other Arctic policy documents (U.S Committee on the Marine Transportation System, 2013) based on a widespread recognition of this potential increase in shipping activity. The recommendations all support safe navigation in the U.S. Arctic, and thus apply to the Bering Strait/Bering Sea region. These include improved sea ice and marine weather forecasts, improved charts for navigation, two-way communications with vessels both to enhance their situational awareness (weather, small boat/subsistence activities nearby, marine mammals, etc.) and to allow for prompt response to emergencies, expanded AIS coverage, overall improved oil spill response for in the Arctic context, improved search and rescue capabilities, and improved icebreaking vessel capacity (U.S Committee on the Marine Transportation System, 2013). The emphasis has been on measures intended to disrupt the accident chain early in the process: providing accurate information to mariners (improved charts), or even real-time information (via AIS) to help improve knowledge, as well as avoiding hazards (via routing).

Options for potential consideration in the Bering Sea related to transiting vessels may include the following, many of which are in progress or active consideration already.

- ***Reducing exposure to hazards via routing measures, potentially including areas to be avoided.*** The U.S. Coast Guard is already considering vessel traffic routes through the Bering Sea and Bering Strait (see Figure 8-3). Establishing such measures not only in U.S. law but also at the IMO (similar to the measures established in the Aleutian Islands) would encompass international vessel traffic regardless of flag state or voyage, if such an agreement could be achieved at the international level. Complementary areas to be avoided could be established to guide ships deviating from the routes – for example, to serve local ports or lighter oil to barges – about sensitive or potentially hazardous areas to avoid. These could be developed in conjunction with consideration of areas where lightering activities are not recommended.

- *Preventing an <u>incident</u> from becoming an <u>accident</u>* through *rigorous planning for disabled vessels.* Building on some of the suggestions related to tankers/bulk carriers already operating in the area, attention is warranted to what would happen if a ship transiting the Bering Strait lost steering/propulsion. This can be considered as both understanding what is most likely to happen to the vessel (direction/speed of drift depending on wind conditions, vessel type/size, and other factors) and the means in place – or needed – to respond, such as: how would the problem be detected (perhaps depending on whether the vessel is actively engaged with the APC for the area, or in innocent passage or in Russian waters); maintaining a high degree of readiness to deploy the ETS in Nome; the likely ability of a vessel to stop its own drift using its anchor; potential places of refuge in the area and any additional infrastructure needs; the time it would likely take for a rescue tug to reach a vessel and take it under control; and the capabilities that such a rescue vessel would need in order to be successful. A dedicated – or partially dedicated – rescue tug was recommended for the Aleutian Islands after considering many of these same factors (and weighing the high level of ship traffic through the area), but the answers may be different farther north. The seasonality of ship activity should also be considered.
- *Preparing to reduce consequences of an oil spill, particularly for a vessel in innocent passage.* While keeping focus on the methods of preventing hazardous situations and oil spills, it is also always prudent to plan and equip for an oil spill. Scenarios and exercises assessing options for spill response, particularly for a vessel in innocent passage, would help to identify gaps that may become more critical in future if the quantity of such traffic grows. This could parallel an assessment of spill response capacity and options for a ship calling/lightering at or near a U.S. port today. Any consideration of spill response planning should consider what the role of local first responders or vessels of opportunity might be, and how their preparation to play such roles safely and effectively will be ensured.
- *Advance recommendations from the 2014 workshop on community spill response in the region.* Incorporating not only local response capacity but local input into response planning is critical, especially in a region with deep troves of local and traditional knowledge and a direct dependence on local resources for both subsistence and commercial purposes. We identify the proceedings from a 2014 workshop by the Wildlife Conservation Society as a source of detailed recommendations to both of these points (WCS, 2014).

Arctic shipping has received a great deal of attention in the U.S. and other Arctic nations. The opportunity exists to pursue near-term measures to mitigate current risks while exploring and developing measures for a future of increased shipping. Collaborative efforts such as the Artic Waterways Safety Committee (in the U.S. portion of the northern Bering Sea) and the Arctic Council internationally, provide forums through which to develop solutions with the broadest possible input from the diverse groups who value, or depend on, the Bering Sea.

Even without an accident, vessels can impact Bering Sea resources. Vessel types known to harm marine mammals (vessel strikes, underwater noise) and release air pollution and waste are already transiting the Bering Sea. As these impacts affect wildlife and their habitat, they also affect the people who depend on Bering Sea animals and plants for subsistence or commercial fishing. Measures such as tightening requirements for vessel waste management in the Arctic via the Polar Code or other agreements (perhaps necessitating additional infrastructure), communicating with vessels about the presence of marine mammals or hunters, avoiding the most sensitive areas (whether seasonally or always), or speed restrictions are among those being explored (Huntington et al., 2015). The potential for unintended impacts, such as the relationship between sound exposure and vessel speed, must be weighed carefully.

There is extensive local knowledge available about the Bering Sea ecosystem that can inform the development of mitigating measures and response planning. The experiences of those who are on the waters and shores of the Bering Sea regularly should be amplified to inform the development of mitigation measures. Although broad stakeholder engagement such as was conducted for the Aleutian Islands Risk Assessment was not part of the scope for this study, as part of the process of developing this report we benefitted from input from Kawerak, Inc. Valuable local knowledge can be translated into the risk mitigation and oil spill response planning contexts, including identifying trends and types of shipping impacts to subsistence use and the environment, potential changes in spill risks based on local activities, and informing response scenarios. In the event of a spill, local knowledge of ocean currents and wildlife activities could play an important role in informing the responder decisions. Identifying the types of information available and the keepers of that information up front should be part of spill response planning for the area, and may be able to be enhanced.

10 Conclusion

This study considered the potential for vessel traffic in the Bering Sea to negatively impact the environment of the Bering Sea and those who depend on it for their well-being and livelihoods. The Bering Strait represents a chokepoint between the Arctic and Pacific Oceans, and is expected to see increasing vessel traffic as Arctic sea ice retreats and both trans-Arctic shipping and the extraction of resources from Arctic countries grows. At the same time, the Bering Sea is recognized as one of the world's most productive ecosystems, and the expansion of shipping activity is occurring in a place where people and wildlife are already experiencing the effects of climate change. Layered on this changing and complex ecosystem are international, federal, and state laws, policies, and practices, and complex relationships between the US and Russia.

To try to understand this system from the perspective of vessel traffic risks, we summarized literature describing the potential impacts from normal vessel operations, including noise, air emissions, marine mammal strikes, and vessel waste generation and management. We also considered how the potential for oil spills of different types and the pathways through which oil in the marine environment impacts different species. A quantitative analysis of the likelihood of any particular impacts (or the quantified consequences) was not conducted, but summary information provided and sources identified for future analyses.

In order to better characterize the type of vessel activity in the Bering Sea north of the Aleutian Islands' Great Circle Route traffic, we analyzed vessel types and movements based on AIS data from 2013-2015 for the Bering Strait region. While the number of vessels in this area is currently about one-tenth that seen in the southern Bering Sea, hundreds of vessels still ply these relatively pristine waters. Considering the quantity of oil on-board vessels in this area as fuel or cargo, oil exposure today is based largely on the delivery of fuel to U.S. communities and vessels calling at Red Dog mine. Similar vessels are active in Russian waters as well.

Efforts to mitigate risk should be developed with the best possible information available about actual shipping activities, combined with input from technical experts and local stakeholders. The Arctic Waterways Safety Committee, Subarea Committee(s), and Arctic Council can serve as forums for engaging diverse inputs, with contributions from ad-hoc collaborative efforts especially helpful to foster a shared understanding of hazards and potential consequences, generate ideas for risk mitigation, and explore options outside formal channels when appropriate. Relationships across the Strait between U.S. and Russian communities have already been activated to facilitate the collection of information about vessel activities and impacts, as well as response to emergencies. Collaborations also provide the opportunity to weigh potential unintended consequences, including weighting the costs to different groups.

The Bering Sea has long been important to the people who live and work there, and is becoming even more important as an international shipping route. Efforts to mitigate today's risks can only help to mitigate the risks of tomorrow as well, even as long-term planning is underway for a future of many more shipping transits.

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