

Adherence to Bering Strait Vessel Routing Measures in 2019

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Executive Summary

This white paper presents the results of a study of vessel movements in the Bering Sea and Bering Strait region from June to October 2019. The purpose of the study was to understand the extent to which vessels adhered to new International Maritime Organization (IMO) routing measures there.

In the context of increasing ship traffic in the Arctic, the IMO adopted routing measures including recommended routes, precautionary areas, and areas to be avoided (ATBAs) in the Bering Strait and Bering Sea region. The measures are all voluntary, as is common for such measures globally, and were not intended to significantly alter vessel activity in the area or disrupt local trade or services. The first goal of the proposed recommended routes and precautionary areas was to “organize the streams of ships passing the Bering Strait and along United States and Russian coasts in the Bering Sea” (USCG, 2017b). This reflected the overall purpose of the routes and context in the region regarding the current and growing potential for transiting traffic to and from the Arctic.

This analysis used Automatic Identification System (AIS) data transmitted by vessels according to international requirements. Vessels carrying AIS transmitters send regular signals regarding their location and heading, with some limited vessel characteristics. Additional research was conducted regarding vessel particulars where needed, and the data signals compiled to portray vessel tracks. These tracks were used to make maps and examine vessel movements, individually or grouped by type.

This paper provides a first review of the extent to which vessels adhered to the measures in 2019, the first shipping season after the measures took effect. It found that transiting ships were generally adhering to the routing measures as a whole. This included bulk carriers, LNG/LPG tankers, and some other cargo and tanker traffic that appeared to be moving through the study area rather than trading there. In cases in which cargo vessels and tankers were going off the recommended two-way routes or into an ATBA, many times it appears likely based on general knowledge of vessel activity in the region that they were calling at a port or “lightering” (transferring) fuel to barges. On the other hand, passenger vessels, tugs, and fishing vessels—all of which were engaged in local trade or activities—generally did not follow the IMO routing measures and would not necessarily be expected to do so.

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1 Introduction

The IMO adopted voluntary vessel routing measures for the Bering Sea and Bering Strait region that went into effect in December 2018. This paper discusses the extent to which vessels adhered to the recommended routes and areas to be avoided from June to October 2019, the first shipping season after the measures took effect. This paper is not a comprehensive analysis of vessel traffic in the area but is intended to be a first review of how vessels observed the new measures.

2 Background

It is widely recognized that shipping activity is increasing in the Arctic as sea ice retreats, allowing for increases in vessel traffic associated with tourism, cargo, and resource extraction activities generally (Arctic Council, 2009; USCG, 2016a; CMTS, 2019). This includes the Bering Sea and Bering Strait areas (CMTS, 2019). Vessel traffic in the Bering Sea/Strait is associated with transits to and from the Arctic as well as mining, fishing, and serving communities on both the U.S. and Russian sides within the region (Fletcher and Robertson, 2016).

2.1 IMO Routing Measures

The IMO is a United Nations agency made up of member states (countries). Among many other functions, the IMO adopts international routing measures for certain vessels. These measures are adopted under the International Convention for the Safety of Life at Sea (SOLAS) (IMO, 2020).

IMO-approved vessel routing measures may include traffic separation schemes, two-way routes, recommended tracks, ATBAs, inshore traffic zones, roundabouts, precautionary areas, deep-water routes, and archipelagic sea lanes, depending on the location and risk. Although routing measures may be mandatory or voluntary, most are voluntary (IMO, 2019).

Three types of voluntary routing measures are in place in the Bering Strait for ships of 400 gross tons (GT) and larger (these are discussed further in Section 2.2):

- **Two-way route:** A route within defined limits inside which two-way traffic is established, aimed at providing safe passage of ships through waters where navigation is difficult or dangerous.
- **Precautionary area:** An area within defined limits where ships must take particular caution. The direction of traffic flow is sometimes recommended, though this is not the case in the Bering Sea/Strait.
- **Area to be avoided:** An area that all or some ships are encouraged to avoid because it is particularly hazardous for navigation or it is particularly important to avoid casualties there (IMO, 2019).

“The purpose of ships’ routeing [sic] is to improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited. ... Ships’ routeing [sic] may also be used for the purpose of preventing or reducing the risk of pollution or other damage to the marine environment caused by ships colliding or grounding or anchoring in or near environmentally sensitive areas.”

—General Provision on Ships’ Routeing (IMO, 2019)

When a member state proposes routing measures to the IMO, it must explain the purpose of the measure, justify the need (based on the potential for impacts from international shipping, sensitivity, or past incidents), and describe the extent to which the measure would affect current vessel traffic. Information on charting and navigational safety is also required. Proposed routes “should follow as closely as possible the existing patterns of traffic flow in the areas as determined by traffic surveys” (IMO, 2019). Thus, it is not expected that implementing a routing measure would significantly change traffic patterns in an area because the measures themselves are designed to minimize disruption to traffic flows.

Once a routing measure is in place, countries should “promulgate all information necessary for the safe and effective use of adopted ships’ routeing [sic] systems” (IMO, 2019). Information on the measures is published in the IMO’s guide titled Ships’ Routeing and must be included on international charts. A country may monitor adherence to the measures it has proposed, though no method is prescribed for how to do this. Flag states are also urged to ensure that vessels registered to them comply with the measures. In short, countries “shall do everything in their power to secure the appropriate use of ships’ routeing [sic] systems ...” (SOLAS Regulation V/10(6) in IMO, 2019).

As of June 2019, the IMO had approved 51 sets of recommended (voluntary) routes or precautionary areas and 70 sets of ATBAs¹ at 56 general locations around the world (IMO, 2019). Measures are introduced for a variety of reasons related to safety or environmental protection. Safety considerations may relate to traffic volume or hazardous areas for navigation (shallow waters or shoaling, for example), but there are also ATBAs around key navigational aids or known ammunition dumps. Routing measures are often applied within the same geographic area, as done in the Bering Strait. Voluntary routes can be implemented in conjunction with mandatory routes, though this is most common for traffic separation schemes in busy port areas (IMO, 2019).

2.2 Bering Strait Routing Measures

In May 2018, the IMO’s Maritime Safety Committee adopted recommended routing measures for the Bering Sea and Bering Strait. These measures, which are recommended for vessels of

400 GT and larger, took effect in December 2018. They include six recommended two-way routes, six precautionary areas, and three recommended ATBAs, as shown in Figure 2.2-1 (IMO, 2019).²

The purpose of the proposed routing measures, as described in the joint U.S.-Russia application submitted to the IMO, is to:

1. Organize the streams of ships passing the Bering Strait and along United States and Russian coasts in the Bering Sea.
2. Reduce the risk of collision and provide adequate sea room for ships executing collision avoidance measures.
3. Provide ships with the maximum amount of flexibility in avoiding ice when present.
4. Focus limited survey resources in areas of greatest concentration of shipping.
5. Help ships avoid numerous shoals, reefs, and islands that lie close outside the two-way routes, particularly where the area has not been surveyed thoroughly.
6. Enable better monitoring of a ship's transit through the region and allow more time for intervention in case a ship suffers a breakdown of its propulsion machinery.
7. Allow ships to follow well-defined routes, thereby enhancing the safety and efficiency of navigation.
8. Prevent and reduce the risk of pollution or other damage to the marine environment, including national and international habitat and recognized species.
9. Avoid key areas for fishing activities and for local indigenous communities' subsistence activities (USCG, 2017a).

In addition to the routing measures adopted by the IMO, the U.S. Coast Guard recommended two alternatives: (1) a larger ATBA around St. Lawrence Island and (2) an ATBA in the middle of the Bering Strait itself. The first of these was proposed to the IMO (USCG, 2017b) but not adopted. The second was not put forward in the IMO application but was a recommendation resulting from the Coast Guard's Port Access Route Study for the Bering Strait (USCG, 2016a). Figure 2.2-1 includes these proposed but not adopted areas, along with those that took effect in December 2018.

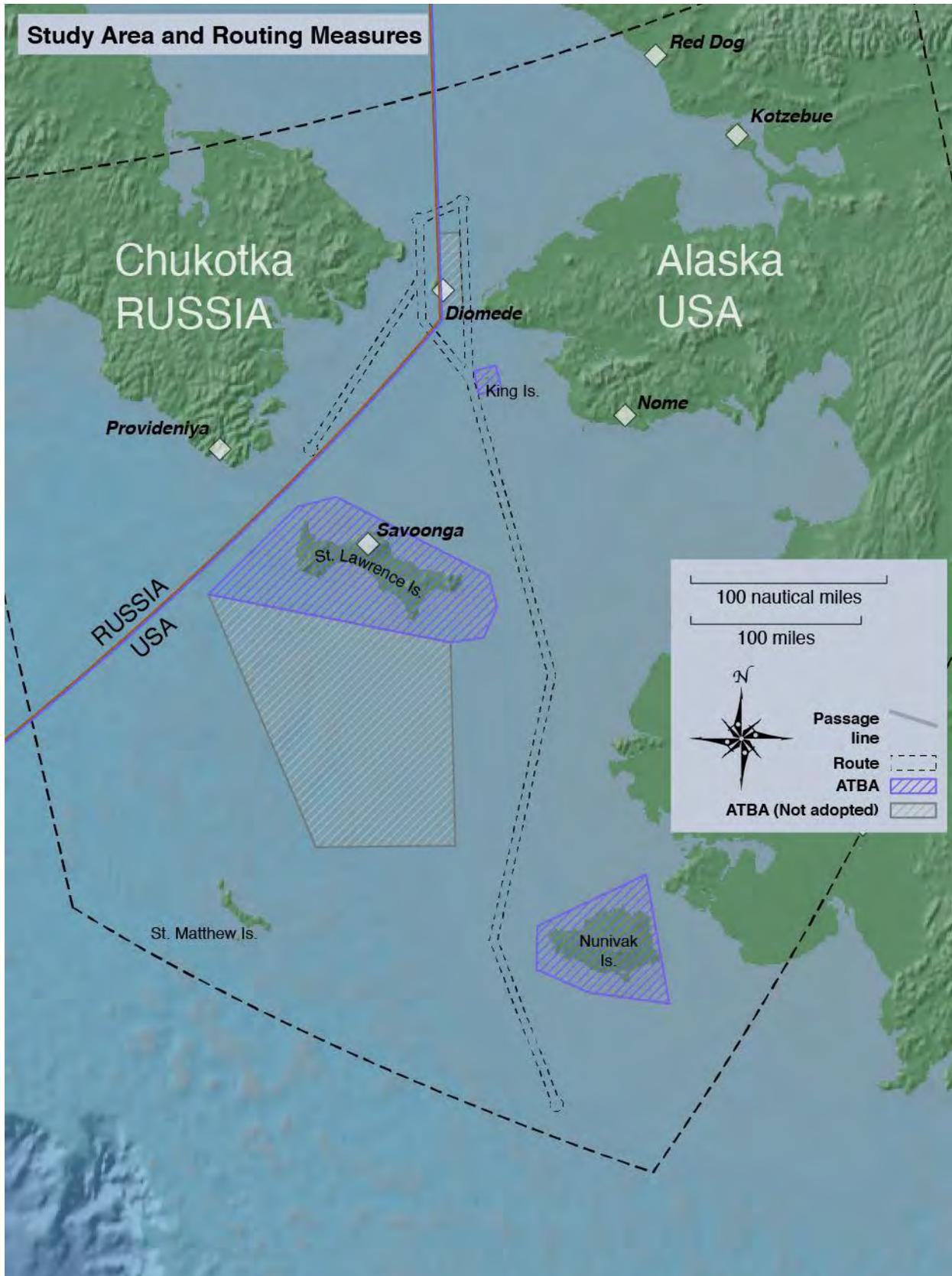


Figure 2.2-1 Bering Strait routing measures, both adopted and proposed, as of December 2018.

3 Methodology

Vessels use AIS to transmit information about their location and vessel characteristics and receive the same information transmitted from vessels near them. SOLAS requires AIS to be fitted on board the following types of vessels:

- Vessels of 300 GT or more *on international voyages*³
- Cargo ships of 500 GT or more, *regardless of destination*
- Passenger ships, *regardless of size*

SOLAS also specifies the fields that vessels are required to transmit: ship identity number, location, vessel type, course (direction), speed, and navigational status. There are other fields that can be transmitted voluntarily (Chapter V, Regulation 19). AIS signals are received by other ships in the area using AIS, thus serving the primary safety purpose of informing ships within a certain area of a vessel's location, status, and intended movements. When AIS signals received by a shore station or satellite are compiled, data can be used to understand vessel movements in a particular area, as was done in this study. Although the AIS requirements have been in force since 2004,⁴ receivers have become more widespread since that time, increasing the viability of using AIS data to research or characterize vessel traffic.

This study used AIS data to answer the following research questions:

1. To what extent were vessels *adhering* to the IMO routing measures in the first year of implementation (2019)? What vessel types were *not* adhering to the measures, and why may this have been the case?
2. To what extent were vessels transiting the *proposed*, though not adopted, ATBA in the Bering Strait and south of St. Lawrence Island?

3.1 Data Analysis

Nuka Research procured data for June to October 2019 from the Marine Exchange of Alaska from the Bering Strait and northern Bering Sea, including signals received both from shore stations and from exactEarth satellites. Although the sea ice regime in the region is changing rapidly, the data were intended to include the months with the most vessel activity (CMTS, 2019). Since the routing measures took effect in December 2018, the 2019 shipping season was the first after the measures were implemented. The results of this study focus on 2019 data, in some cases comparing those with data from earlier years (particularly 2017) to understand whether there have been changes in vessel movements that may be attributed to the routes and ATBAs.

Pew provided Nuka Research with the raw AIS data for June to October 2014-17 as well. These data were available from an earlier project and provided an opportunity to consider whether vessel tracks that appeared to adhere with the voluntary routing measures likely represented a change in vessel movements when compared qualitatively with tracks from a period before the measures had been adopted. These earlier data were also procured from the Marine Exchange of Alaska; however, these data were from shore-based AIS receivers only. This reduced coverage in the southwestern portion of the study area in particular.⁵ Although this difference in data sources made it impossible to quantitatively compare traffic across years, it was possible to establish tracks based on the AIS signals. For vessel types that we observed had an apparent

high rate of adherence to the routes in 2019, we reviewed the data from 2017 to see if this likely reflected intentional adherence to the routes, or if this was where the vessels traveled anyway.⁶

AIS data include many vessel types. For the purpose of this study, we used the types listed in Table 3.1-1.

Table 3.1-1 Vessel Types Applied in Analysis

Vessel Types and Subtypes	Description
Fishing	Includes processors (not active in the study area but present in the AIS data purchased) as well as fishing vessels. Fishing vessels may also be used for research, so there is some overlap with the vessel type and its function at any particular time, which is not a problem for this study because we are not examining fishing activity specifically.
Tugs	Tugs maneuver vessels in ports and deliver barges carrying fuel and goods throughout the area, including up rivers.
Passenger	Passenger vessels in this region are all cruise ships of various sizes that take paying passengers on overnight voyages.
Cargo vessels	Bulk carriers transport commodities in bulk—in this case, primarily mining-related.
- Bulk carriers - Other cargo	Other cargo captures a range of vessels, including general cargo, refrigerated cargo, roll on/roll off vessels, offshore supply vessels, landing craft, and a few container ships.
Tankers	Oil tankers carry crude or refined oil as fuel; in this region, the delivery of heating fuel and other refined products is the primary activity.
- Oil tankers - LNG/LPG	LNG/LPG tankers carry liquid natural gas.
Other vessels	Other vessels include research vessels, government vessels, and vessels for which a subtype could be identified that did not fit one of the other categories. In the 2019 data, these were all government research vessels.

AIS data were processed using a custom code to establish vessel tracks (connecting consecutive signals from a vessel) and a database of vessel attributes. These were described, along with some of AIS' limitations, in Appendix A.

3.2 Analyzing Adherence to Routing Measures

There is no mandated method for coastal states to assess adherence to voluntary routing measures, and examples of published assessments of adherence are rare. Two relevant examples of assessment of adherence to an ATBA were examined: the Olympic Peninsula in Washington and the Roseway Basin off the coast of Nova Scotia.⁷ This section briefly describes these approaches and then the approach used in this study.

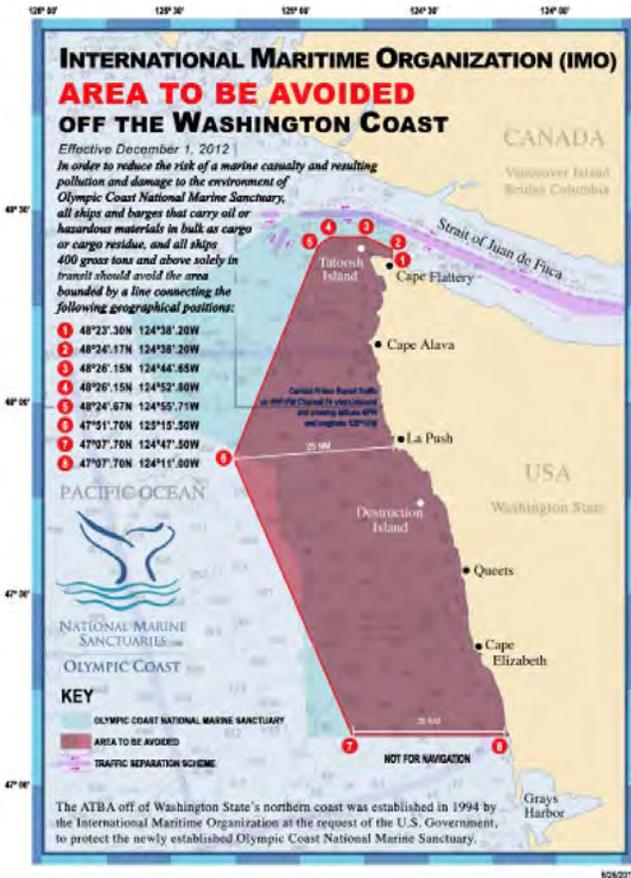


Figure 3.2-1 Informational flyer for IMO ATBA off Washington coast, from Olympic Coast National Marine Sanctuary website (NOAA, 2015).

3.2.1 Evaluating Adherence to Other ATBAs

An IMO-adopted ATBA recommends that vessels of 400 GT or larger avoid much of the Olympic Coast National Marine Sanctuary in Washington when transiting the area (IMO, 2019). (See Figure 3.2-1.) The National Oceanic and Atmospheric Administration (NOAA), which manages the sanctuary, monitors adherence with the ATBA annually based on AIS data processed into tracks by NOAA and complemented by vessel attribute information from third parties (most commonly the IHS Maritime World Register of Ships). NOAA reports the total number of vessel tracks within an “area of interest” (larger than the sanctuary and

ATBA) and those that enter the ATBA. This ATBA is explicitly for vessels “solely in transit.” The sanctuary reports make clear that vessels identified as entering the ATBA may be doing so for legitimate reasons. Overall, NOAA estimates that approximately 95 percent of vessels complied with the ATBA in 2018. They do not attempt to quantify whether a vessel is in the region for legitimate purposes (such as fishing), is unaware of the ATBA, or is knowingly entering the ATBA. Vessel compliance by type is presented annually on the sanctuary’s website (NOAA, 2018).

On the other side of the continent, an IMO-adopted ATBA took effect in 2008 off the coast of Nova Scotia, Canada. This is a seasonal ATBA intended to protect endangered whales. It applies to transiting vessels of 300 GT or larger (IMO, 2019). A 2009 study quantified adherence with the ATBA using AIS data for the purpose of assessing whether the measure was effective in protecting the whales. Similar to the Olympic Coast, a study area was defined around the ATBA. Vessel tracks were assembled based on AIS data and counted as “avoiding” or “not avoiding” based on whether the track entered the ATBA. If the vessel did *not* enter the ATBA, it was considered to be “avoiding” if the most direct route for the vessel would have entered the ATBA but the recorded vessel track did not. (This was substantiated by comparing the tracks of individual vessels before and after ATBA implementation to see if there was a difference.) If it was not clear whether the vessel was avoiding the ATBA or just on its preferred route anyway, it was identified as such. This allowed the calculation of a percentage of adherence and an estimated uncertainty. This approach—combined with an analysis of vessel speeds—was then used to predict the number of lethal whale strikes avoided as a result of the ATBA (Vanderlaan and Taggart, 2009).

3.2.2 Approach Used for Bering Strait Analysis

The two examples presented above both apply to studying a single ATBA only. The first provides a count of vessels that enter the ATBA from among those that enter a larger area of interest, resulting in a percentage of compliance estimated by vessel type but not depicting actual routes. The second provides a more statistical approach, which is necessary for the authors' efforts to quantify the effectiveness of the measure to reduce whale deaths. Both approaches are well suited to their purposes for those other ATBA studies, but neither was appropriate for the purpose of this analysis.

In the Bering Strait, the measures include three ATBAs, a set of recommended routes, and six precautionary areas. (This analysis did not address the precautionary areas because it is not possible from the AIS data to determine whether a vessel operator was "taking precaution.") To examine adherence with the combination of three ATBAs and routes in the Bering Strait and meet the purpose of the project within time and scope constraints,⁸ we reviewed maps of the vessel tracks by type (in Google Earth) to answer the research questions. Depending on the activity observed, we then examined specific locations or movements that indicated adherence or deviation from the routes. More attention to specific areas or activities was given to the larger vessels, such as tankers and bulk carriers, for which we also considered vessel tracks from 2017 AIS data to understand whether apparent adherence to the recommended routes was likely because of the routes taking effect, or whether the vessels were using them anyway. (As noted above, IMO routing measures are not intended to significantly alter vessel traffic patterns in a given area.)

Although the AIS data cannot tell us what a vessel is actually doing at any given moment, in cases in which a vessel track goes to a port, we assume that it is for a port call and consider it a legitimate deviation from the routes—and a very necessary one: For example, the busiest U.S. port in the study area, Nome, is not on a recommended route at all. Communities in the area, including inland villages along rivers, depend on deliveries via vessel. It is not expected that vessels serving communities in this region (including lightering tankers) would stay on the routes, nor were the routes intended to impede community deliveries. In other cases, a vessel may be deviating from a route, or entering an ATBA, for weather avoidance or other safety purposes not evident from the AIS data. For example, sometimes a vessel follows a route, then seems to veer off it briefly—whether this was in error or done to avoid another vessel or for some other reason is unknown. We were unable to determine from the AIS data what the safest or best course of action was for a vessel at a given time.⁹

For the approved ATBAs, especially St. Lawrence and Nunivak islands, tanker activity warranted additional attention, because these vessels do enter ATBAs to engage in lightering of fuel to barges for local delivery. For tankers, we calculated the total number of days (total number of hours based on the AIS data divided by 24) spent by tankers in June to October 2019 around the region, including in the areas that are now ATBAs, because what could count as just one or a few vessel "entries" to the area may actually represent days or weeks spent by a tanker there.

In answering the research question regarding the extent to which vessels entered the two ATBAs that were considered but not adopted (in the Bering Strait and the extended area off St. Lawrence Island), we counted the number of vessels and tracks by type that entered those areas.

The approach taken was deemed suitable to the purpose of this first examination of vessel adherence of the IMO measures in the region. In many cases, simple counts would not provide a clear picture of adherence (e.g., whether a vessel was entering an ATBA for a port call or just passing through, or if a vessel deviated from a route only briefly but otherwise followed it throughout). However, a more quantitative approach would have been required to compare adherence over time (as done in Washington).

4 Results

The purpose of this analysis was to gain a first look at whether vessels are adhering to the IMO routing measures in the Bering Strait and Bering Sea that took effect in December 2018 (Section 4.1) and to understand the extent to which vessels are using the areas that were considered as possible ATBAs but not adopted at the IMO (Section 4.2).

First, for context, Figure 4-1 shows tracks associated with all vessels included in the study. This includes vessels less than 400 GT but excludes those using AIS B or no AIS at all, or vessels for which gross tonnage could not be determined (as discussed in Appendix A).

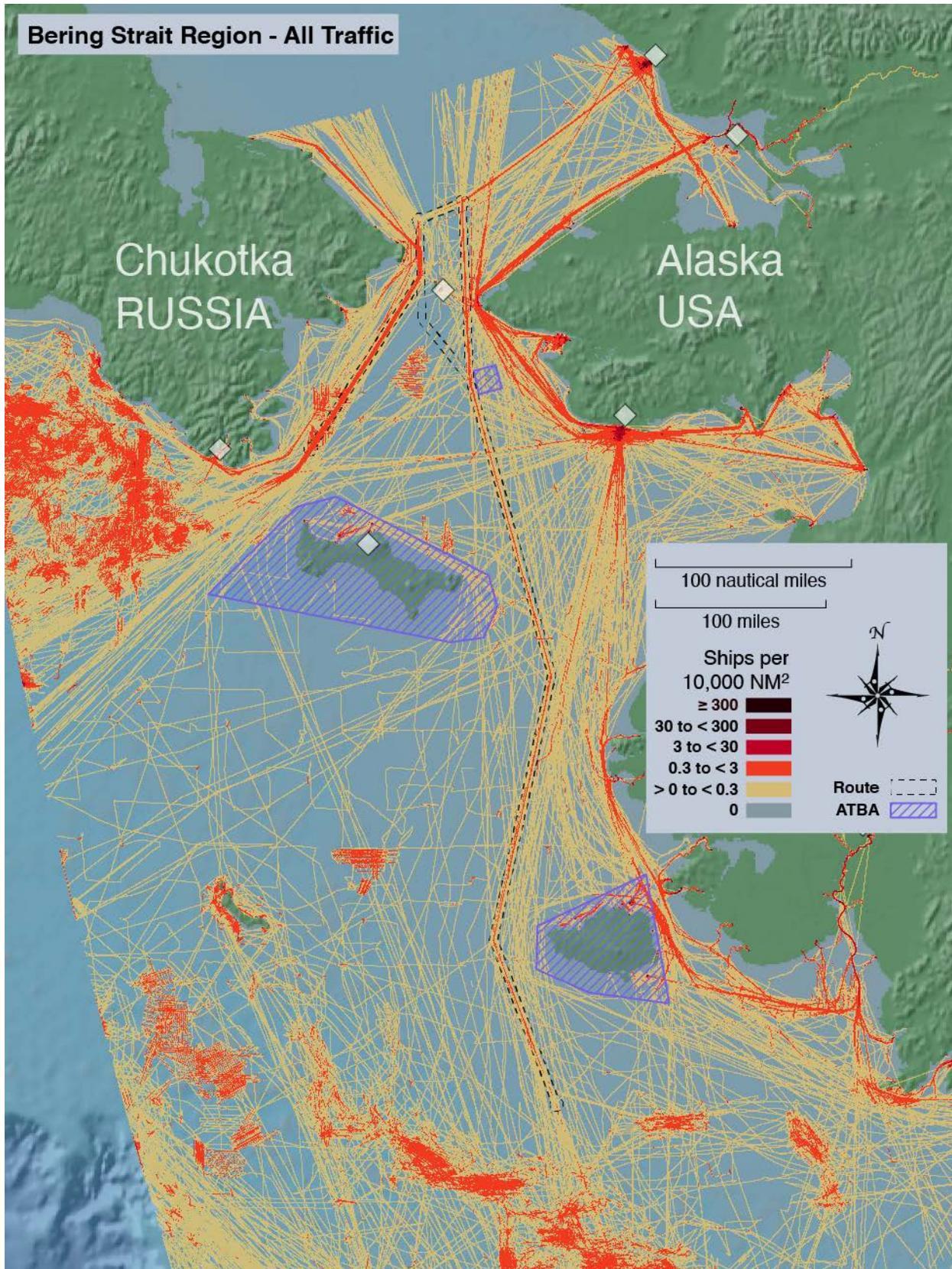


Figure 4-1 Map showing activity of all vessels included in the study, June to October 2019.

4.1 Overview of Adherence to Routes by Vessel Type

This section describes the overall adherence to the routes by vessel type. Maps by vessel type include all vessels included in the study that were 400 GT or larger. All vessel types in the categories applied for this study were considered, though the authors recognize that the routing measures are not intended to affect local trade or fishing, thus we would not expect to see changes in movements of fishing vessels, tugs, or passenger vessels. (Cargo vessels and tankers vary in their trades and are discussed in the relevant subsections.)

4.1.1 Fishing Vessels

Vessels identified as fishing vessels or processors are primarily in the region fishing, though they do sometimes transit the area and are also sometimes used to support marine research.

As shown in Figure 4.1-1, the tracks of fishing vessels 400 GT or larger do not follow the routes or the ATBAs. This is to be expected, as the SOLAS measures under IMO are not intended to direct fishing activity. (Note also that only fishing vessels broadcasting AIS are visible on this map, and then only those of 400 GT or larger. Vessels operating solely with a proprietary Vessel Management System are not represented.)

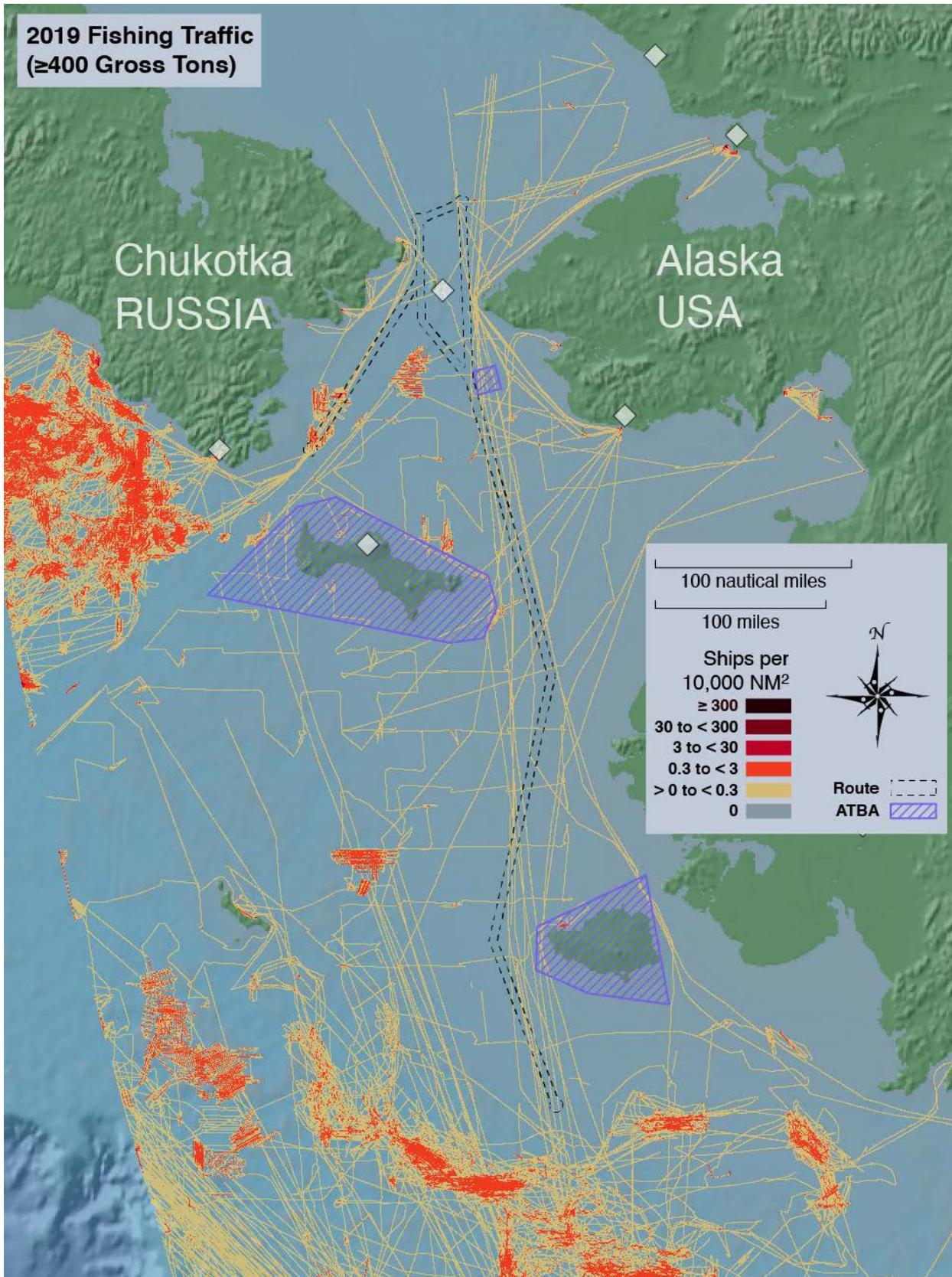


Figure 4.1-1 Density of fishing vessel tracks of 400 GT or larger, June to October 2019.

4.1.2 Tugs

Tug activity in the study area was primarily on the U.S. side, where tug/barge services provided the majority of goods and fuel to support both commercial and residential activities there (Fletcher and Robertson, 2016). Similar to fishing vessels, tugs' trade brought them into ATBAs to call at ports or maneuver barges alongside lightering tankers, and their voyages by necessity took them off recommended routes. There were also cases observed when a vessel appeared to be transiting the area with the routes but did not adhere to the routes. See Figure 4.1-2 for the movements of all tugs 400 GT and larger in the study area from June to October 2019. Figure 4.1-3 shows an example of tug movements simply to portray tug activity relative to the routes.

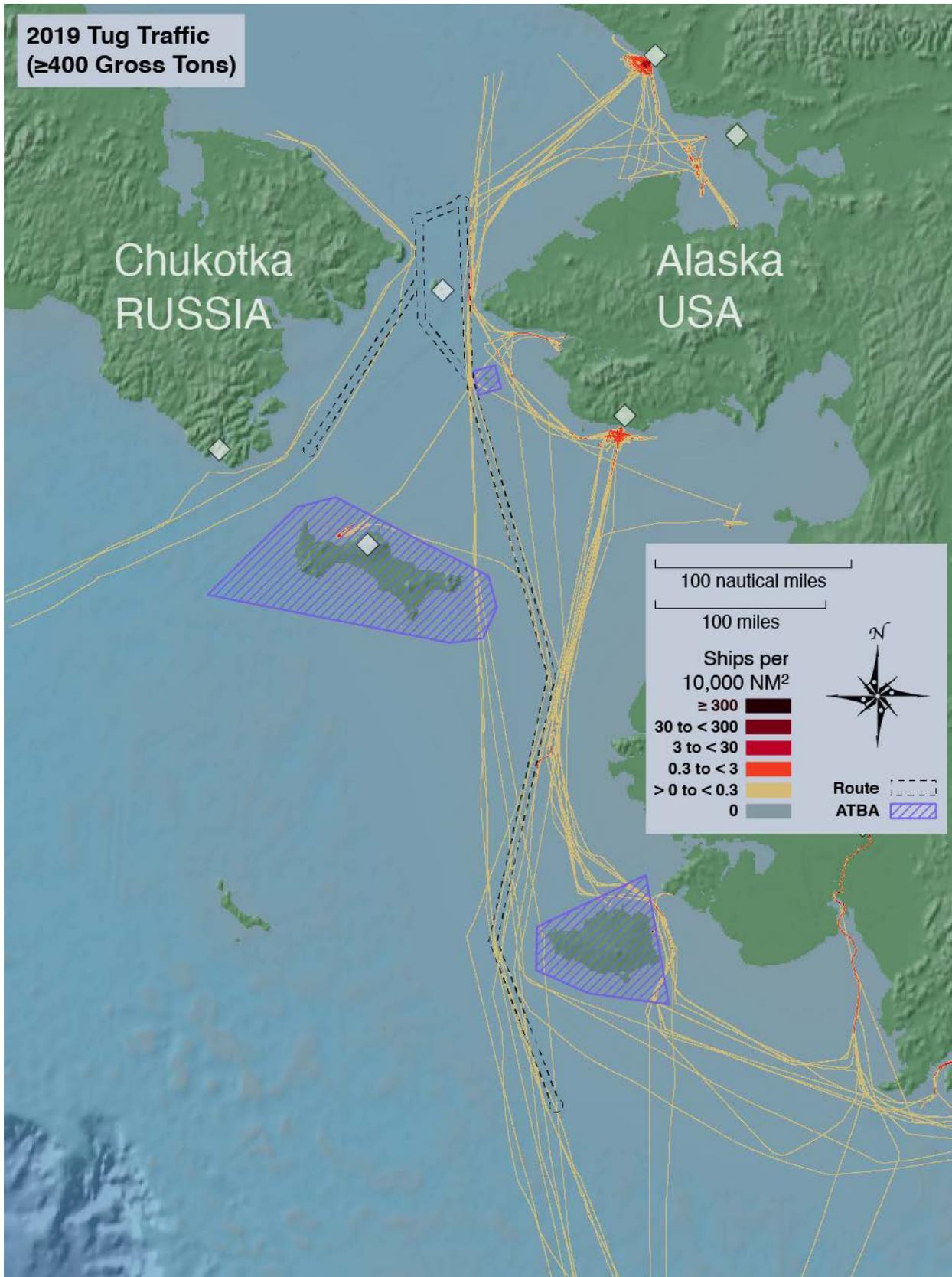


Figure 4.1-2 Density of tug tracks (400 GT or larger), June to October 2019.

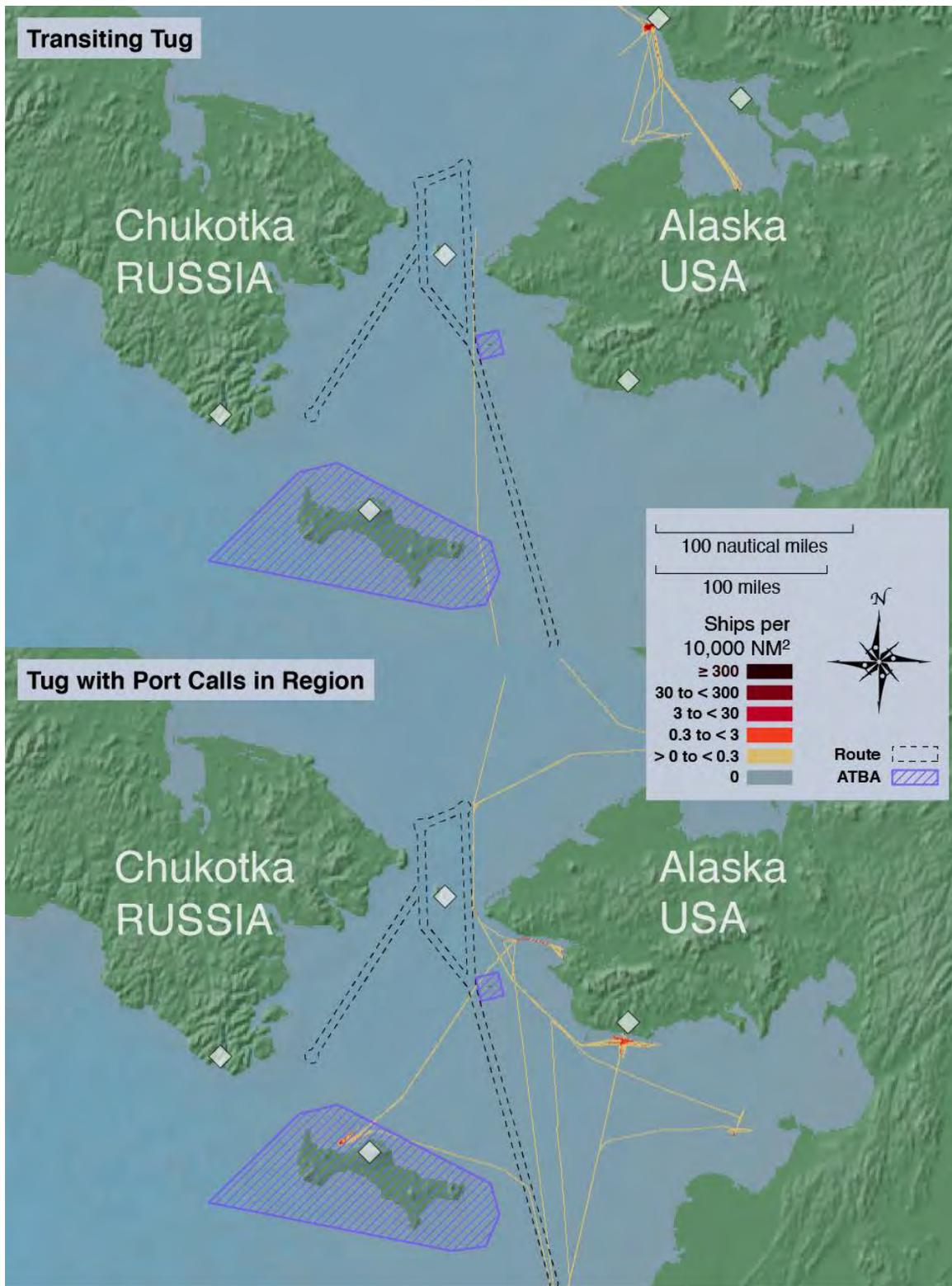


Figure 4.1-3 Example of 2019 tracks from single tug that appeared to be attending to lightering tankers and making deliveries to ports throughout the region (bottom) and track from another tug in 2019 that appeared to be transiting the area with routes to conduct business farther north in Kotzebue Sound (top); both tugs were > 400 GT.

4.1.3 Passenger Vessels

The passenger vessels in the area are cruise ships of various sizes. (Those subject to the routing measures ranged up to 55,575 GT in 2019.) Arctic cruises are becoming increasingly popular, with vessels calling at ports in the study area in both the U.S. and Russia. Most passenger vessels in the data are more than 400 GT, with tracks in 2019 shown in Figure 4.1-4.

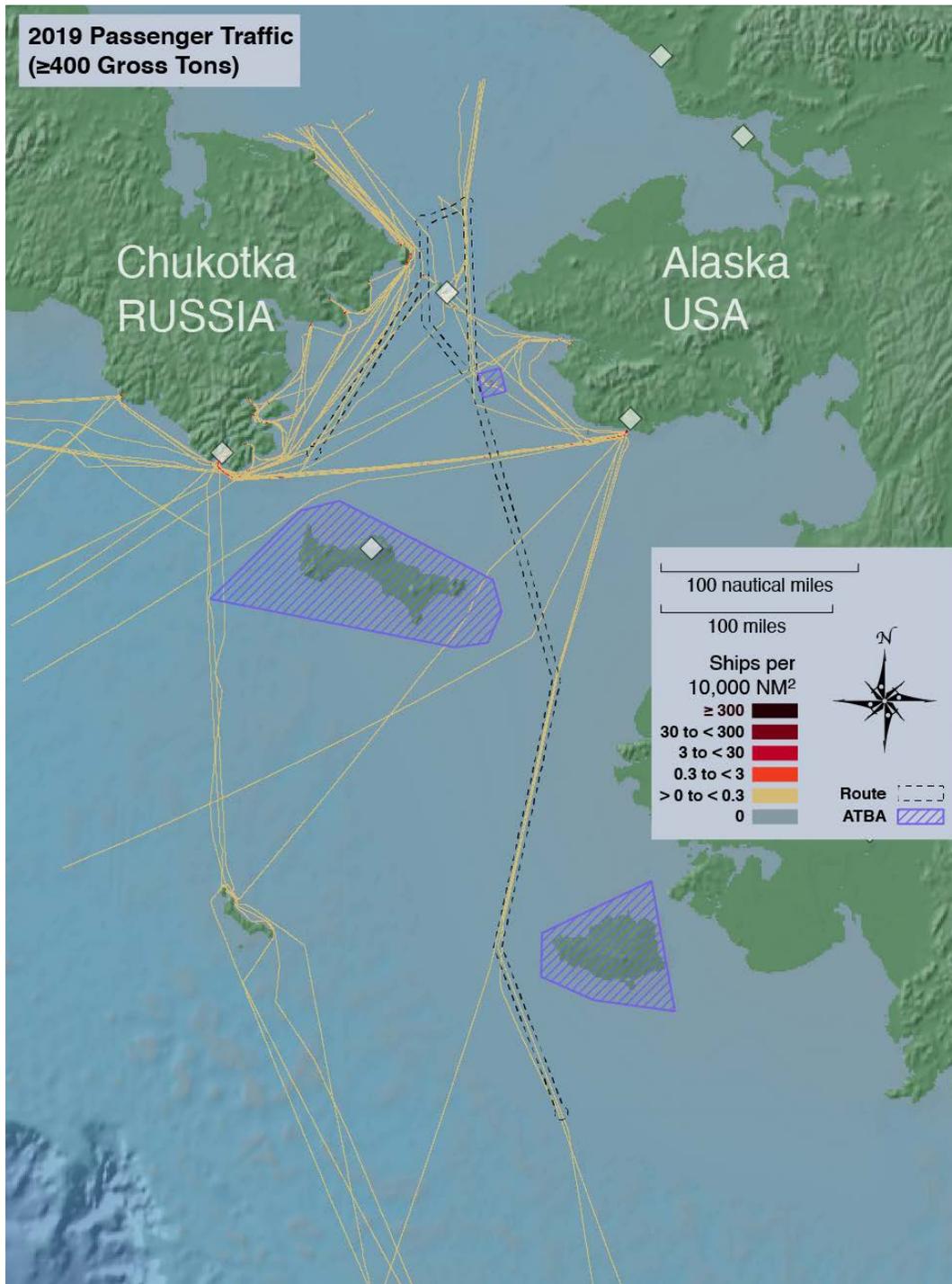


Figure 4.1-4 Density of passenger vessel tracks (400 GT or larger), June to October 2019.

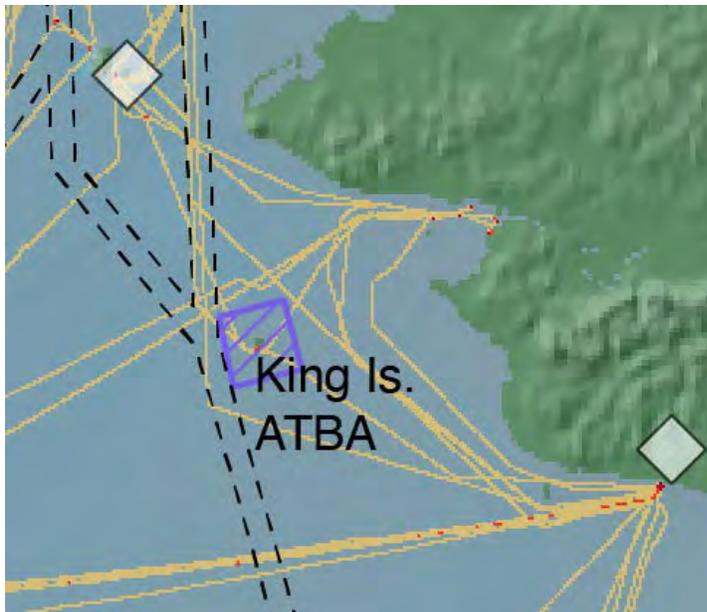


Figure 4.1-5 Passenger vessel tracks of 400 GT or larger entering or near King Island ATBA, June to October 2019.

Similar to both tugs and fishing vessels, passenger vessels were conducting their “trade” in the region—in this case, providing passengers with sightseeing and other experiences. Some passenger vessels traveling between the Aleutians and Nome follow part of the recommended route until leaving it to go to Nome; though there was also a vessel in 2019 that passed through the ATBA around St. Lawrence Island roughly 6 nautical miles (NM) offshore. The latter vessel was one of two that went into the King Island ATBA, though in this case apparently en route to the island. The two vessels in Figure 4.1-5 traveled within approximately 0.6 NM of the island.



Figure 4.1-6 Passenger vessel tracks of 400 GT or larger off Russian coast in June to October 2019.

Looking west at the same latitude as King Island, it is apparent that some passenger vessels transiting the coast between Provideniya and the Bering Strait were stopping at ports along the way, while others were passing between Provideniya and the Diomed Islands or points north of the strait. None of these tracks followed the southwestern leg of the recommended route, but some went close to it. However, the same vessels that seemed to use part of the route in this area also did not use the route at all on other trips, so it is difficult to discern whether this was an effort to adhere to the recommended route. See Figure 4.1-6.

4.1.4 *Cargo Vessels*

Cargo ships active in the study area in 2019 were serving ports in the region or transiting through. Cargo vessels were divided into two subtypes: bulk carriers (mining-related in this region) and other cargo vessels (ranging from small landing craft to container ships). As noted previously, tug/barge deliveries were prominent on the U.S. side, while other cargo vessels are more common on the Russian side. Cargo vessels of 400 GT or larger generally stayed out of the ATBAs in 2019 (with the exception of one general cargo vessel that made two tracks through the southeastern corner of the St. Lawrence Island ATBA).

Figure 4.1-7 shows all cargo tracks of vessels 400 GT or larger. Most of the tracks in Figure 4.1-7 are from other cargo vessels. (Bulk carrier tracks are in Figure 4.1-8.) Port calls in the region are evident from the vessel routes. There are also areas where other cargo vessels appeared to travel nearer to shore than the routes. Looking at the Seward Peninsula of Alaska, for example, there are several tracks that run closer to Seward Peninsula than the recommended route. These tracks are associated with two small landing craft (each larger than 400 GT but smaller than 500 GT). Tracks that are closer than the Chukotka Peninsula on the Russian side than the recommended route there are also largely associated with port calls in the area.

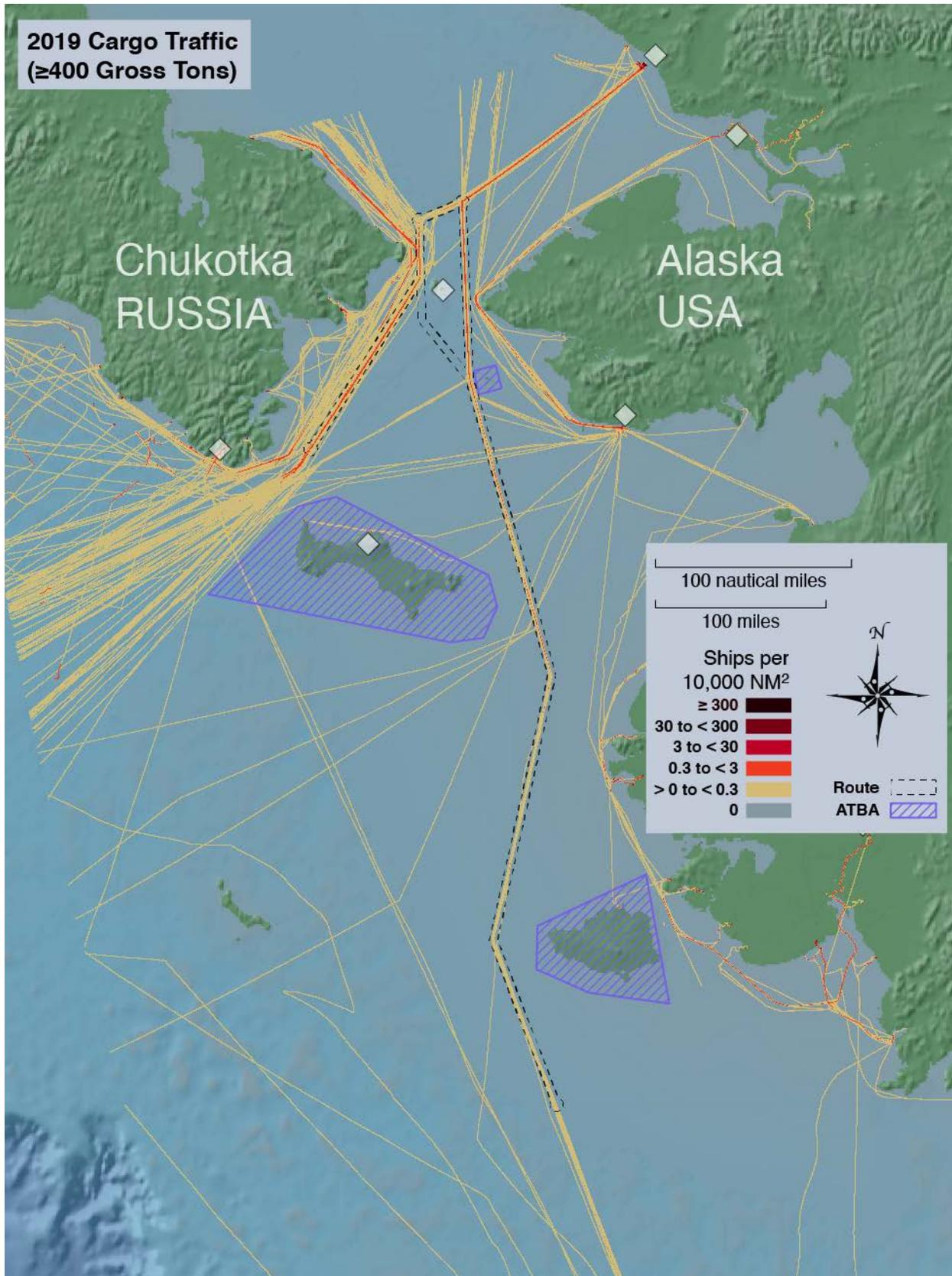


Figure 4.1-7 Cargo vessel tracks of 400 GT or larger, June to October 2019.

Most of the bulk carriers in the study area in 2019 traveled between the Red Dog mine and East Asian ports. As shown in Figure 4.1-8, these vessels followed the recommended routes almost entirely. One bulk carrier track was notable for cutting across the routes north of the Bering Strait, though this same vessel also used the entire eastern route on another leg of its voyage. Six bulk carriers also made a total of eight tracks that cut between the eastern and western routes south of the Bering Strait.

In order to see if this observed high level of adherence to the routes represented a change from previous years, we compared the density plots of bulk carrier movements for 2019 with those from the 2017 data. (Figure 4.1-8.) This indicated some key shifts in bulk carrier movements, most notably through the Bering Strait itself, where vessels used to go much closer to the Diomedes Islands before the routes were implemented.

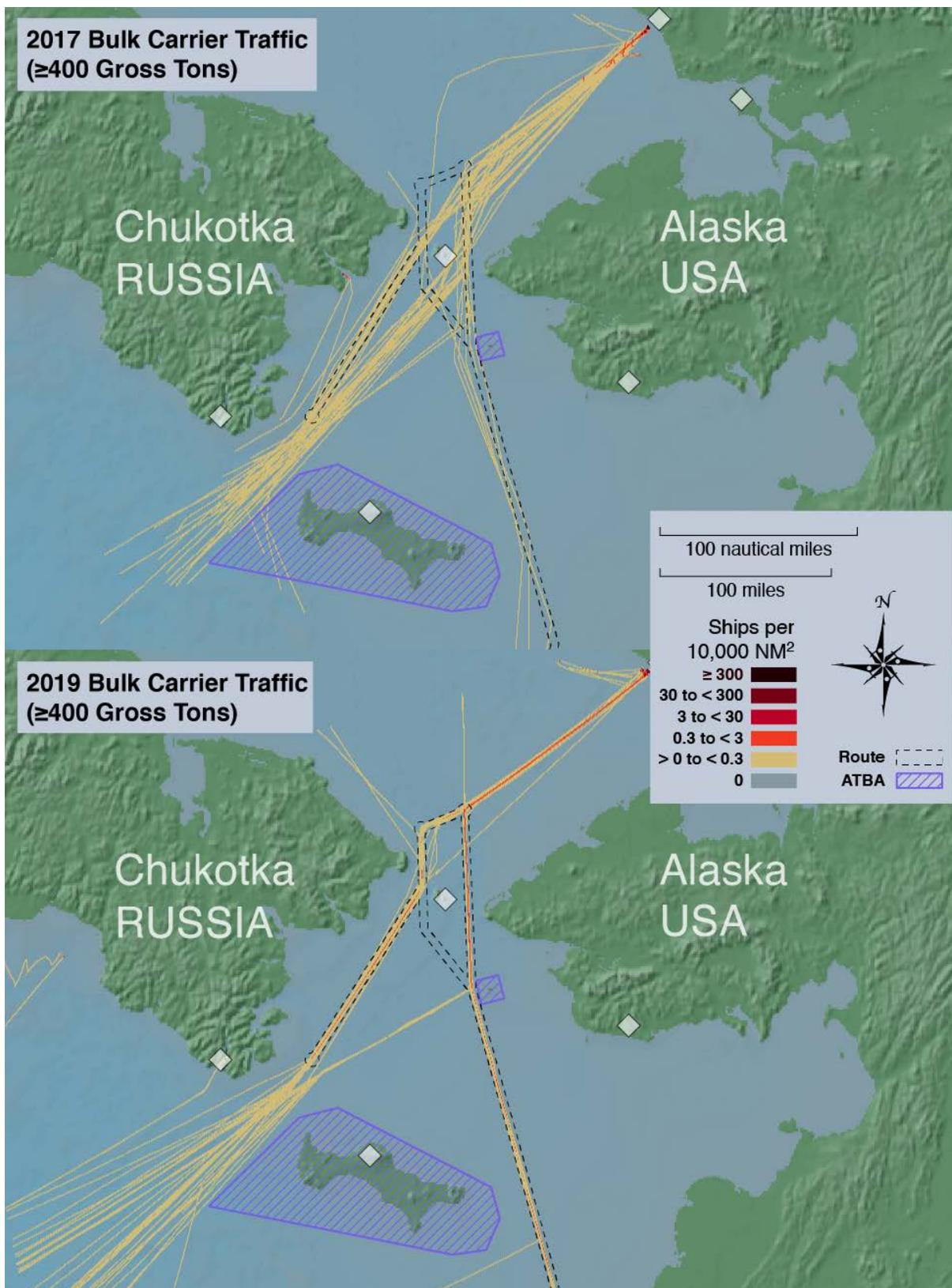


Figure 4.1-8 Density of bulk carrier tracks (400 GT or larger), June to October 2017 (top) and June to October 2019 (bottom).

4.1.5 Tankers

Tankers include both oil tankers and, on the Russian side only, LNG/LPG tankers. Tanker tracks overall in 2019 are shown in Figure 4.1-9. This figure also overlays a grid with the estimated number of days spent by tankers in each 50-NM² grid cell.

Tankers on the U.S. side were primarily oil tankers delivering fuel to communities and commercial or industrial operations. They largely used the routes when transiting but spent significant time away from the routes (and in ATBAs) to conduct port calls and lighter to barges. For example, Nome is a popular hub both for lightering tankers and for smaller tankers that enter the port. Tankers traveling between Nome and the Aleutian Islands did consolidate into the recommended route as compared with 2017 tanker tracks, whether entering it directly from the southern end or joining it from the west. (There are several tanker tracks visible in Figure 4.1-9 that appeared to stay just east of the recommended route; these were all from the same vessel.)

The practice of lightering fuel to barges for distribution around the region has become increasingly common since 2012 (Fletcher and Robertson, 2019). Tanker activity within ATBAs or nearshore in other areas was most likely related to lightering, as vessels sought shelter and access to delivery destinations. Traveling to preferred lightering areas brought tankers into ATBAs around St. Lawrence and Nunivak islands as well as locations in Kotzebue Sound and around Norton Sound. As shown in Figure 4.1-9, tankers spent time in fairly concentrated areas. At the same time, oil tankers also used the routes when transiting to a large extent in both the U.S. and Russia. The figure presents tanker days spent in each area to illustrate this activity, because looking at tracks alone does not portray this.

Transiting tankers through the Bering Strait on the U.S. side largely followed the recommended routes: Both tankers going to Red Dog and those continuing north out of the study area tended to stay on the routes until the northeastern terminus. Of those going into Kotzebue Sound, two different vessels made three tracks showing that they used the recommended route to the northeastern terminus, while one other vessel made three tracks that used the route through the strait but not all the way to the terminus. (This was the same vessel that was just east of the route farther south. It did use the route through the strait and to the northeastern terminus when traveling north into the Chukchi Sea.)

In Russian waters, transiting oil tankers also appear to be largely following the western recommended route through the Bering Strait and south almost to St. Lawrence Island. Similar to the U.S. side, some transiting tankers use the route through the Bering Strait but leave (or join) it south of the northwestern terminus. These vessels do not appear from the track data to be going to a nearby port.

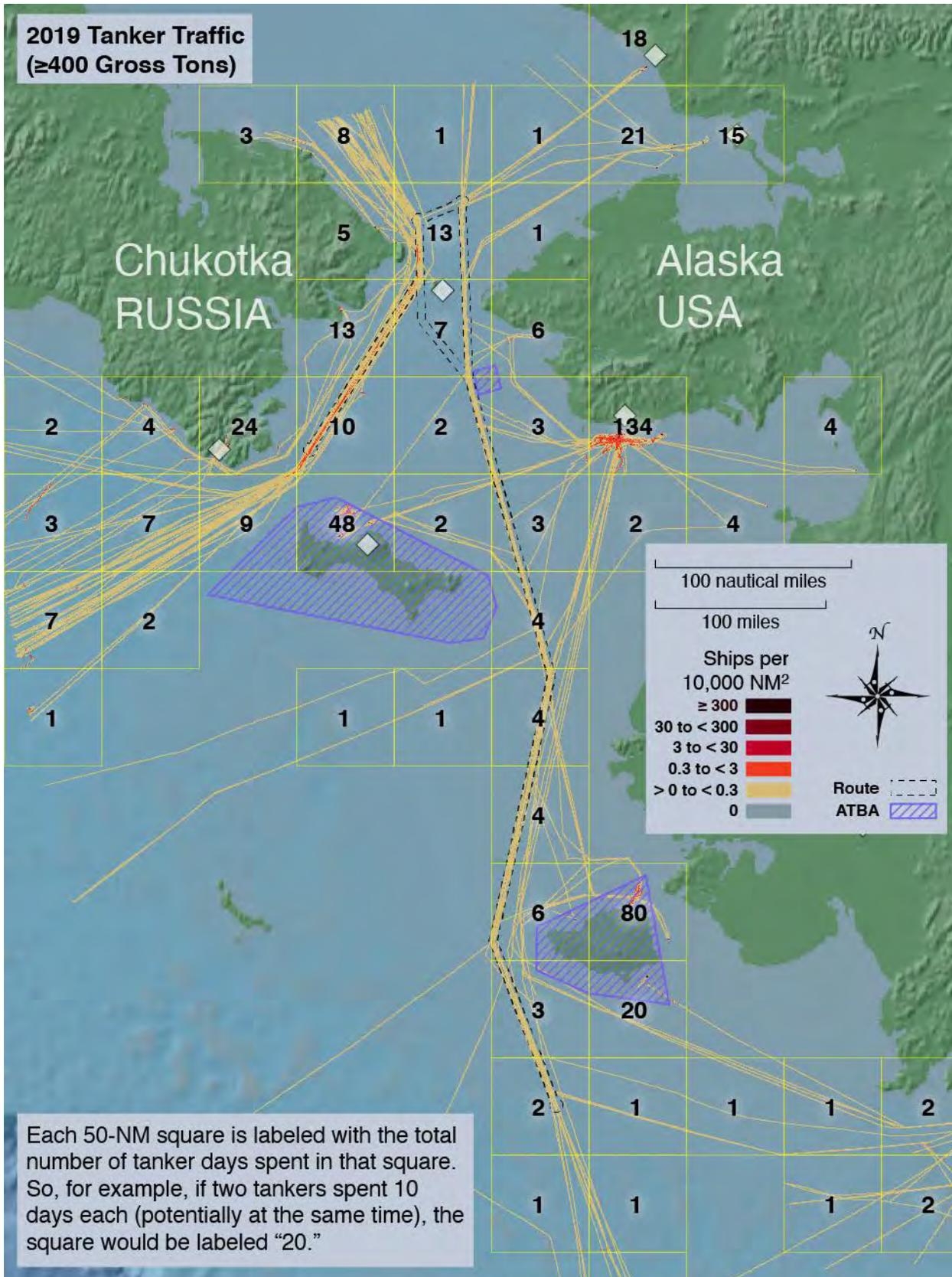


Figure 4.1-9 Density of tanker tracks (400 GT or larger), June to October 2019.

There are also LNG/LPG tankers on the Russian side, many of which are likely associated with the reported increase in shipments from the Yamal LNG facility in Russia (Schuler, 2019). LNG/LPG tankers traveling to and from the Russian Arctic largely follow the recommended routes. Of the 12 LNG/LPG tankers identified in the 2019 dataset, seven of them used the full length of the eastern route on all their voyages. Of the other five, one used the routes almost entirely except for a deviation to the east, one mostly followed the route except right at the strait, and three deviated from the northern end of the route past the Bering Strait (with some slight deviations in the south as well). See Figure 4.1-10.



Figure 4.1-10 Density of LNG/LPG tanker tracks near Chukotka Peninsula, June to October 2019.

4.1.6 Other Vessels

There were just seven “other” vessels 400 GT or larger identified as operating in the northern Bering Sea in 2019. These were icebreakers, research vessels, and other government vessels flagged to the U.S., Russia, Canada, China, Japan, and South Korea. The two Russian-flagged vessels followed the western recommended route while going through the area. The U.S. and Canadian vessels both followed the routes and also went off them seemingly as their missions required, similar to commercial vessels that called at local ports. The other vessels did not appear to follow the routes at all as they passed through the region. See Figure 4.1-11.

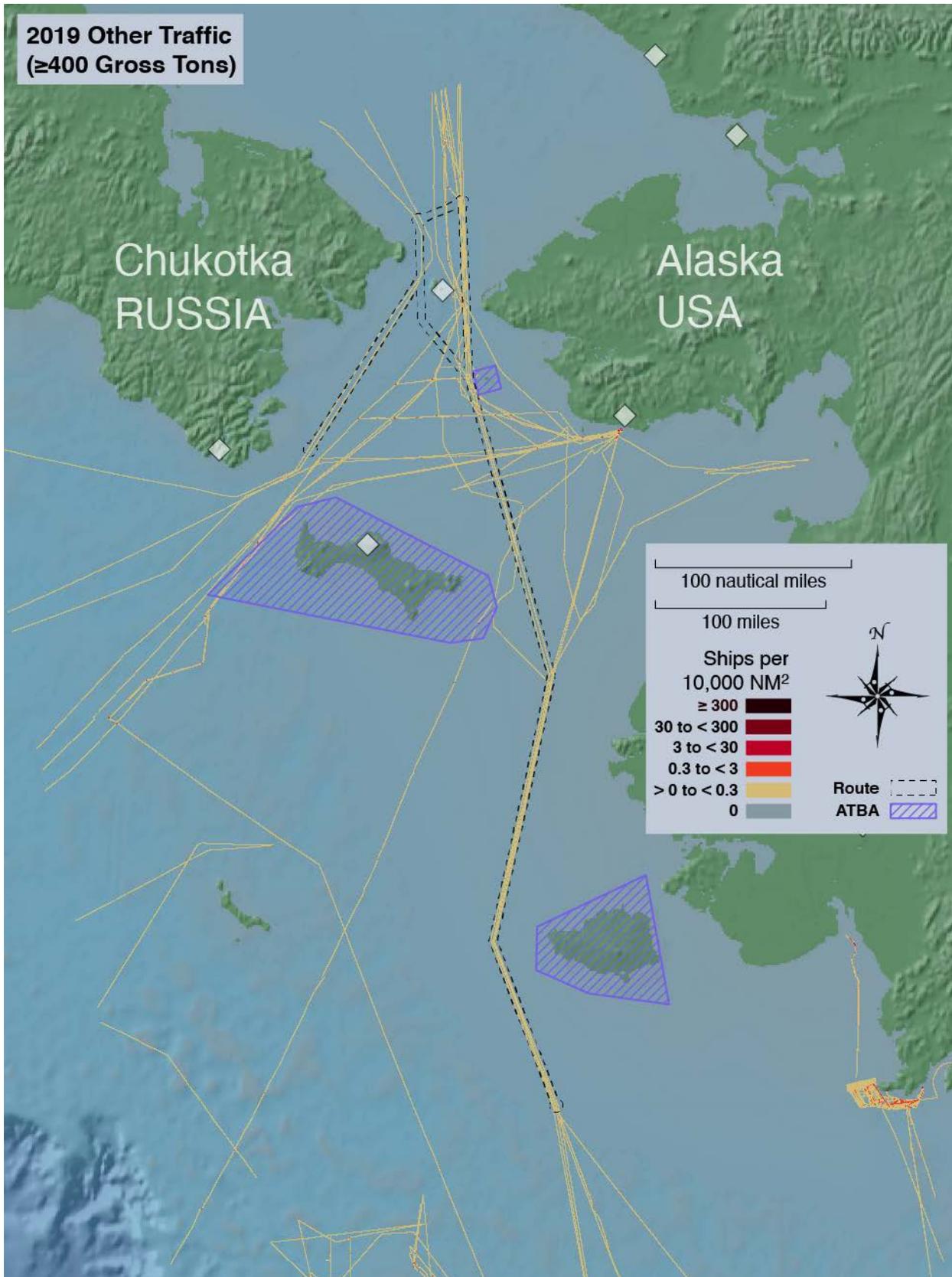


Figure 4.1-11 Density of other traffic tracks of 400 GT or larger, June to October 2019.

4.2 Vessel Movements in Proposed ATBAs

Two areas to be avoided were considered but not adopted: one in the Bering Strait and another that would extend the St. Lawrence Island ATBA farther south.

Figure 4.2-1 shows all included vessel tracks that entered the not-adopted Bering Strait ATBA. Ten vessels of 400 GT or larger (those that presumably would be included in a routing measure) included one bulk carrier, four cruise ships, one Canadian fishing vessel, and four other vessels.¹⁰ There were no tankers or tugs (over 400 GT) identified in the data that entered the proposed but not adopted Bering Strait ATBA in 2019. Many of the vessels that entered this area were smaller than 400 GT, meaning that they would not be captured by an ATBA for vessels of 400 GT or above. (Many of these are calling at the Diomedede Islands anyway and would be expected to continue their routes as depicted here.)

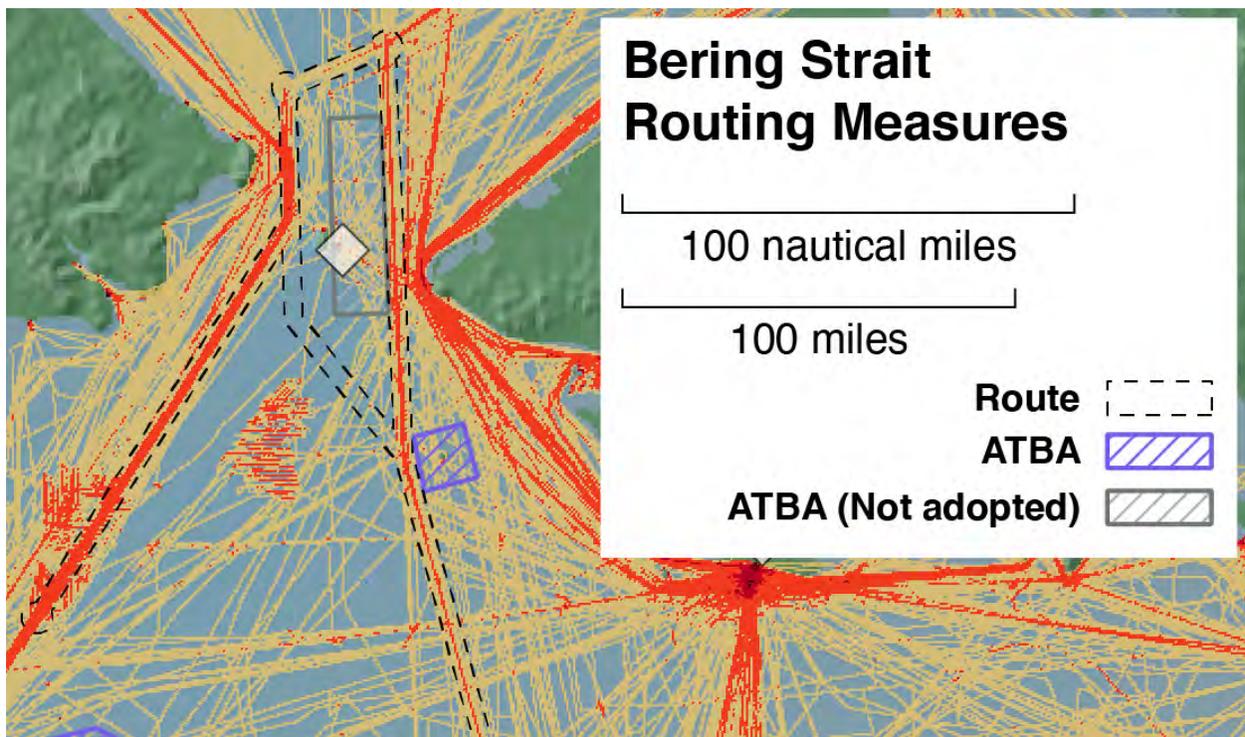


Figure 4.2-1 Density of vessel tracks in the Bering Strait in June to October 2019 (including for ships smaller than 400 GT) and the proposed but not adopted Bering Strait ATBA.

In 2019, some 18 vessels of 400 GT or larger entered the area south of St. Lawrence Island that had been considered as an ATBA. This included two tankers, three cruise ships, one bulk carrier, and four each of other cargo vessels, fishing vessels, and other vessels. No tugs of 400 GT or larger entered the area of the proposed but not adopted portion of the ATBA. Several of the voyages across this area were by vessels that did use the southwestern recommended route but joined (or left) it north of its southern terminus. See Figure 4.2-2.

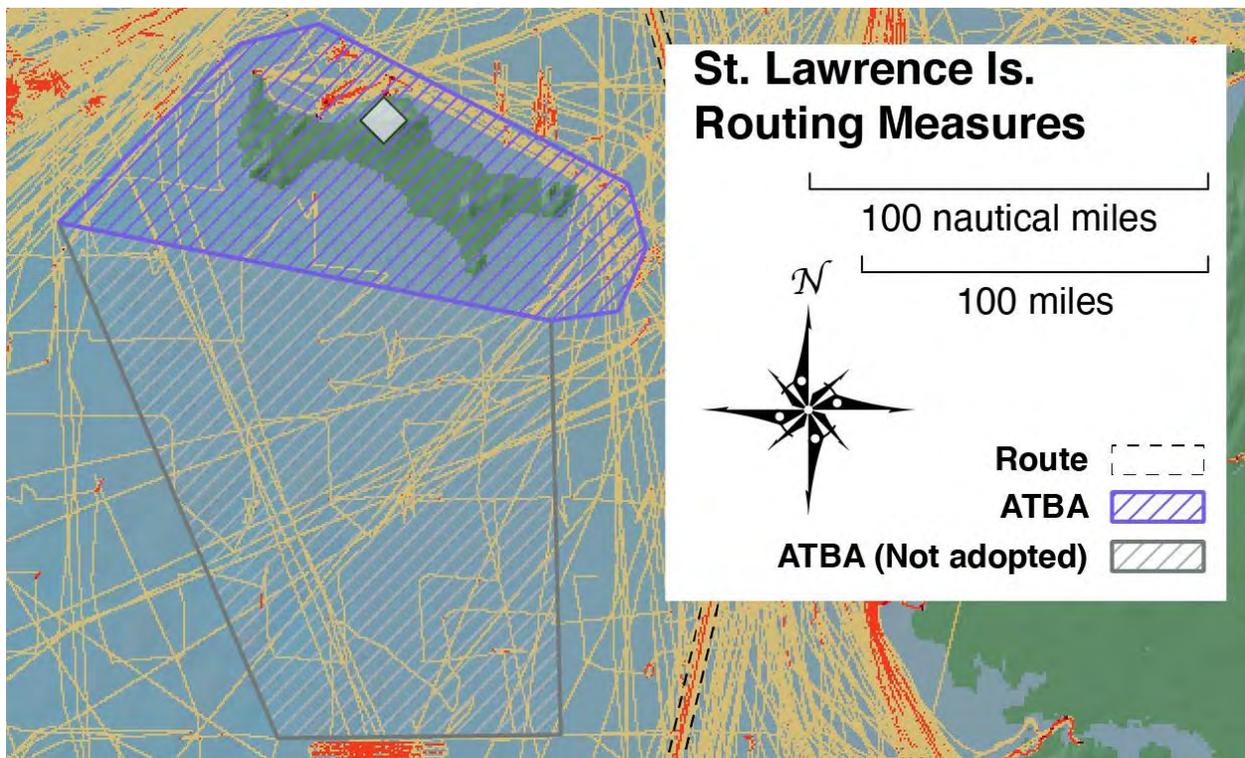


Figure 4.2-2 Tracks of vessels south of St. Lawrence Island in June to October 2019 (all vessels of 400 GT or larger), including the proposed but not adopted larger St. Lawrence Island ATBA.

5 Findings and Discussion

The findings below are based on this initial review of June to October 2019 AIS data for the Bering Strait region. The authors add related recommendations and commentary as well.

- Bulk carriers were largely following the recommended routes when traveling through the region. There are some places where bulk carrier transits cut a corner or cut across between routes (south of the Bering Strait). *Further outreach to the Red Dog chartering company could be conducted to learn whether bulk carriers that leave the routes do so because of weather or for another reason, because most appear to follow them the majority of the time.*
- Tankers transiting the region generally followed the routes, though there were some transits in Russian waters that stayed inshore and other deviations that could be explored with operators.
- Tankers operating throughout the U.S. waters to ports or for lightering operations did not follow the routes as a whole, nor would they be expected to because they were trading in the area. (They did follow the routes through the Bering Strait itself.) Overall, to the extent that these vessels represent a risk in the region, that will be better addressed through other measures because they need to go off the recommended routes (and do go into ATBAs) as part of normal operations. *Tankers on the U.S. side work with the*

same spill response planning organization and are already in communication on lightering issues via the Arctic and Western Alaska Area Committee; either of these could be a forum for exploring any recommendations or opportunities regarding further outreach to chartered vessel operators regarding use of the routes when feasible and reasonable given movements around the area.

- Passenger vessels of 400 GT or larger were not using the routes and did enter the King Island and St. Lawrence Island ATBAs. These vessels appear not to have changed their voyages, and port calls and sightseeing are part of their normal operations. As with the lightering tankers or cargo vessels calling at ports, concerns about risks posed by cruise ships are better addressed via other measures.
- Tugs and fishing vessels have not modified their routes to adhere to the IMO measures, nor would they be expected to. These measures are not intended to impede fishing activity or trade in the region, which fully capture these two vessel types.

6 Conclusion

This paper was intended to provide an initial review of the extent to which vessels are adhering to new IMO-approved routing measures in the Bering Strait and northern Bering Sea region. The first goal of the proposed recommended routes and precautionary areas was to “organize the streams of ships passing the Bering Strait and along United States and Russian coasts in the Bering Sea” (USCG, 2017b). This reflected the overall purpose of the routes and context in the region regarding the current and growing potential for transiting traffic to and from the Arctic.

It appeared from this first review of 2019 vessel traffic that transiting ships were generally adhering to the routes and ATBAs as a whole (with some deviations). This included bulk carriers, LNG tankers, and some other cargo vessels and tankers that appear to be moving through the study area rather than trading there. In cases in which cargo vessels and tankers were going off the recommended two-way routes or into an ATBA, many times it appeared likely based on general knowledge of vessel activity in the region that they were calling at a port or lightering fuel to barges. On the other hand, passenger vessels, tugs, and fishing vessels, all of which are engaged in local trade or activities, generally did not follow the IMO routing measures and would not necessarily be expected to do so.

The results of this initial review of AIS data would be informed and no doubt enhanced by input from vessel operators or charterers in both the U.S. and Russia. The authors hope that this analysis will contribute to a shared understanding among all parties regarding the effectiveness of the routing measures in place today and inform future efforts to protect the Bering Sea for the sake of the people who depend on it.

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Appendix A—Data Sources, Processing, and Limitations

This appendix describes the method used to compile and process the AIS data used for this study.

Identifying Vessel Tracks

Raw AIS data were provided as a comma separated values (CSV) file of individual AIS transmissions for a particular area and time period. The vessel track database was built by connecting sequential AIS points for each individual vessel. First, vessels were excluded if any of the following applied:

1. Vessel did not enter the study area. Because the original data had been acquired by Pew for another study (The Pew Charitable Trusts, 2018), it included a wider geographic area than necessary for this study. (For ships that were included, we did not discard data outside the study area because it was helpful to use all available data to better understand their movements.)
2. Only one or two AIS data points were included from a vessel. For this study, we needed to know where a vessel went, not just whether it was in the region at all. Because a route cannot be determined from so few points, these vessels were excluded.
3. Vessel sent Class B AIS signals. Because Class B signals are weaker and are used by an unknown share of vessels that use AIS voluntarily (also by smaller vessels than those required to use AIS), Class B AIS data were removed.
4. Insufficient data were obtained. For this study, we primarily needed to know vessel type and size (whether 400 GT or larger). There were some vessels for which we were unable to obtain sufficient information, most commonly regarding vessel size.

Figure A-1 presents all data received, the location of signals where the vessel was excluded for being “too short” (having fewer than three data points in the dataset), vessels excluded because we were unable to determine gross tonnage, and vessels transmitting Class B AIS signals. (In most study outputs, only vessels of 400 GT or larger are presented, per the wording of the IMO routing measure.) The data here were presented on a 5-NM grid to better show the density of data that were removed, in comparison to what was kept.

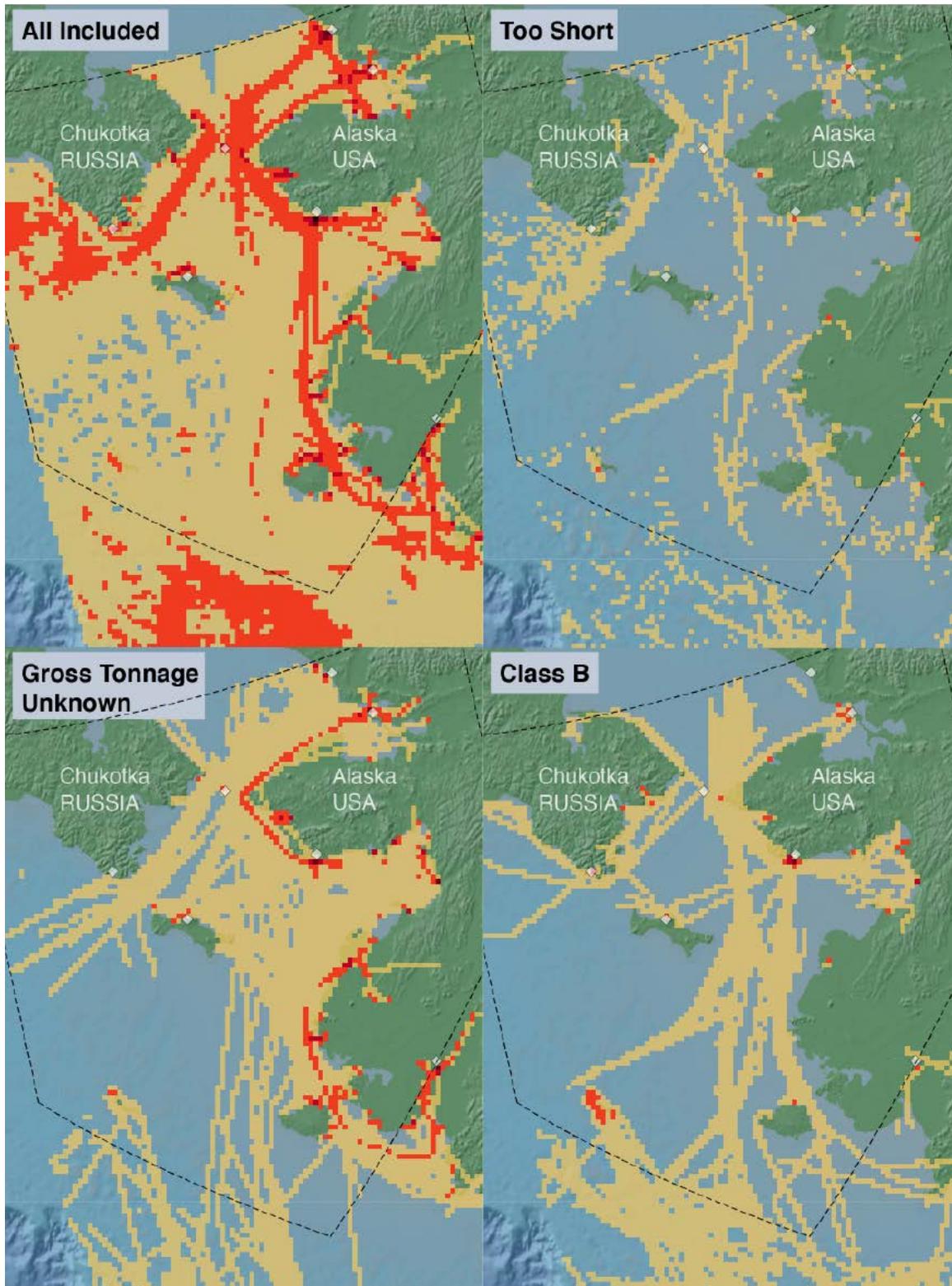


Figure A-1 Density plots showing AIS points for all vessels included in the study, as well as those associated with tracks eliminated because they were too short, associated with a vessel of unknown gross tonnage, or Class B AIS signals (June to October 2019); density legend is the same as maps in Section 4 of this white paper.

Remaining data points were grouped by vessel and ordered chronologically. One or more tracks was then built for each vessel using the following method:

1. The first and last points were always kept.
2. Beginning with the first point chronologically, each succeeding point was compared with the previous point. The successive point was excluded if it was less than three minutes since or closer than 0.2 NM to the previous point. However, if the points were less than 0.2 NM but greater than 12 hours apart, the successive point was kept. Because AIS signals can be sent every few seconds, this step significantly reduced the number of data points while retaining information about where a vessel travels (to the extent that it is complete within the data). An additional test was used to remove track points that appeared to be erroneous. This test involved predicting successive points going both forward and backward in time: If a point was more than 20 NM from where it would be expected to be given both preceding and subsequent transmissions from the same ship, that point was removed. This represents a small portion—much less than 1 percent—of the data that might otherwise have been kept.
3. Tracks were constructed from the remaining set of points for each vessel. Segments between points that were more than 150 NM, or one day, apart were removed, as simple linear interpolation between these points was questionable. The 150-NM cutoff is an arbitrary cutoff, developed by experimenting to see what effect different cutoffs had on the data.
4. Each track was identified with a specific vessel based on that vessel's Maritime Mobile Service Identity (MMSI) number and then associated with vessel-specific attributes based on the same number. (See Section 3.1.2.)

Identifying Vessel Attributes

Vessel tracks depict vessel movements, but often it is necessary to know more than a vessel's location. Though some attributes were included with the AIS data, desired information is often missing, and there may be errors. Each AIS signal sends a vessel identification, or MMSI, number. The MMSI numbers were used to identify the vessel associated with a track and to assign other vessel attributes to that track as needed for the study. In this study, the key attributes of interest were:

- **Vessel type:** AIS data can include more than two dozen different vessel types, so for simplicity all vessels were assigned one of the types in Table 3.1-1. Where type was missing from AIS data, it was filled in as possible from other sources. Results were then described in terms of the vessel types. Cargo vessels and tankers were further broken down into subtypes to facilitate exploration of some of the differences in operations among vessel types.
- **Size:** Vessels may be commonly measured according to length, draft, gross tonnage, or deadweight tonnage. Because the IMO routing measures target vessels based on gross tonnage of 400 or more, gross tonnage was the metric relevant to this study.
- **Flag state:** The IMO measures are applicable regardless of flag state, but we were interested in whether there were any observations that could be made of vessel

adherence based on flag state. Flag states, along with the coastal states (the U.S. and Russia, in this case) are also responsible for overseeing vessel adherence to IMO measures, although, as discussed, the measures are all voluntary and there are no prescribed methods for oversight.

From the AIS data, Nuka Research identified a total of 1,176 vessels in 2019. However, this number was reduced to 780 in the study area (of these, 110 vessels transmitted Class B AIS signals and were excluded from the analysis).¹¹ Many vessels were still missing one or more of the necessary fields for this analysis. As a first step, Nuka Research added information from its growing database of vessel information compiled from past studies (Fletcher and Robertson, 2016 among them). Next, data on 463 vessels were purchased from MarineTraffic.com. Desired data fields that were still missing were filled to the extent possible by researching MarineTraffic.com (searches of individual vessels sometimes yielded information that had not been provided in the batch data purchase) and online databases from the U.S. government¹² and other sources. After integrating this information, the gaps identified in Table A-1 remained.

While vessel type and subtype were fairly well resolved, gaps in gross tonnage were the most difficult to fill. Vessels were excluded if gross tonnage was unavailable after the steps described above were completed. Although estimating tonnage is suitable to answer questions related to overall oil exposure in the region, estimating gross tonnage and potentially including a vessel that is actually less than 400 GT was not appropriate for this analysis. Further, the larger vessels consistently have more complete information in AIS as well as databases such as MarineTraffic.com, so the authors are confident that the larger vessels—which carry more fuel oil or cargo—are adequately captured and the vessels for which gross tonnage could not be obtained are much more likely to be less than or close to the 400 GT cutoff. (This also means vessels are more likely engaged in local operations that take them off the recommended routes and/or into ATBAs anyway in order to engage in their particular trade, whether that is fishing or transporting cargo.)

Table A-1 Vessel Types Applied in Analysis

Field Missing	Missing From AIS and Nuka Data	Still Missing After MarineTraffic.com Data Purchase	Number Excluded Due to Insufficient Information
Type	446	14	14 (gross tonnage also missing for all but two of these)
Flag state	463	12	12 (none of these had gross tonnage either)
Gross tonnage	451	83	45 excluded, mostly fishing vessels and tugs (vessel info for 38 cargo vessels and tankers was researched and remained in the analysis)

Limitations

AIS signals are received by other ships in the area using AIS, thus serving the primary safety purpose of informing ships within a certain area of a vessel's location, status, and intended movements. When AIS signals received by a shore station or satellite are compiled, data can be used to understand vessel movements in a particular area, as is done in this study. Although the

AIS requirements have been in force since 2004,¹³ receivers have become more widespread since that time, increasing the viability of using AIS data to research or characterize vessel traffic.

At the same time, AIS records have some limitations. Information regarding vessel particulars may be missing or incorrect. AIS data can also have gaps if there are gaps between signals that obscure a vessel's actual course through the water. Gaps between signals occur because a vessel stops sending signals or a receiver does not pick them up as a result of atmospheric conditions, an outage, or gaps in satellite coverage. (Fishing vessels operating with a proprietary Vessel Management System are not included unless also broadcasting AIS signals.)

This study seeks to generally assess the extent to which vessels are following IMO-recommended routes and ATBAs in the Bering Strait and Bering Sea. With recognition of the inherent limitations, AIS data are suitable to this purpose because the use of both satellite and shore station data provide geographic coverage of the area of interest, and the vessels for which the routes are recommended are required to use AIS. Because we are interested in vessel routes, or tracks, underway, other data sources—such as cruise schedules or port calls—would not provide the information needed to answer the research questions.

Endnotes

¹ Some measures for a given area include one or more routes and/or one or more individual ATBAs. For example, the Bering Strait routing measure includes three ATBAs, and the Aleutian Islands ATBA measure includes five. The numbers above are simply intended to indicate that the measures in the Bering Strait are not unique. All of the ATBA measures are voluntary except one in New Zealand (IMO, 2019; p. III/16).

² The process the U.S. Coast Guard used to develop its recommended approach to routing measures is described in the Port Access Route Study for the region (USCG, 2016a).

³ This does not include barges, just self-propelled vessels (33 CFR 164.46).

⁴ Per SOLAS and, in the U.S., regulations at 33 CFR 164.46.

⁵ See Marine Exchange of Alaska website, <https://www.mxak.org/services/mda/tracking>, for more information, including a map of locations of shore-based AIS receivers. These are located on the Alaska mainland around the Bering Sea as well as St. Lawrence Island and the Pribilof Islands.

⁶ Data from 2014 to 2016 were processed but did not inform the analysis; therefore, they are not presented in the results.

⁷ At the time this white paper was developed, another forthcoming study of adherence to routing measures in the Aleutian Islands was underway but not yet available.

⁸ A draft report was required in mid-December 2019; all AIS data were not available until after the end of October in order to align 2019 data with the previous datasets for 2014-17.

⁹ Operator interviews would be highly informative regarding times when route deviations may be necessary for safe navigation or other factors affecting vessel movements, but they were not included in the scope of the study.

¹⁰ The research vessels were from China, Japan, and Canada.

¹¹ Vessels required to use AIS generally must use Class A transmitters, which send a stronger and more frequent signal than the Class B transmitters that are primarily used by vessels using AIS voluntarily (USCG, 2016b).

¹² The U.S. Coast Guard's Vessel Response Plan database allows searches by MMSI or vessel name and provides information on vessel type and size for vessels required by U.S. regulations to submit a Vessel Response Plan.

¹³ Per SOLAS and, in the U.S., regulations at 33 CFR 164.46.