

A Justification of Proposals to Improve Shipping in the Bering Strait

Alexander A. Lentarev*

ABSTRACT

This paper presents the geographical features of the Bering Strait, the existing hydro meteorological and navigational conditions, the state of shipping and environmental aspects. Estimates of the probability of navigation accidents and possible oil spills are given. The systems for ensuring the safety of navigation, in particular, the ship's routing system, the ship's reporting system, the global maritime distress and safety system, as well as possible instruments for regulating navigation in this strait are presented. Based on the analysis performed and taking into account the expected explosive growth in the volume of freight traffic, proposals were developed for improving the organization of the regulation of shipping in the Bering Strait.

Keywords: Bering Strait, shipping, vessels, marine safety system, marine environment

* Department of Navigation, Marine State University named after adm. G. I. Nevelskoy, Vladivostok, Russia, lentarev@msun.ru

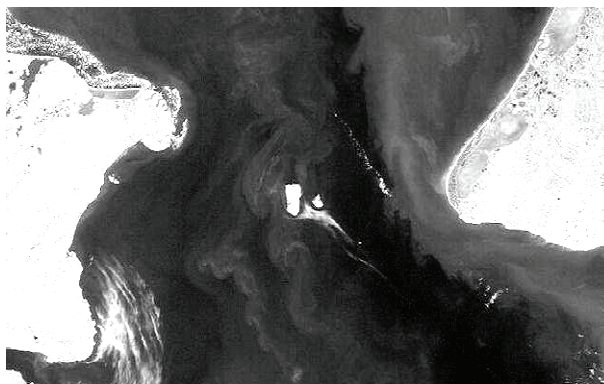
1. Introduction

Recently, the Arctic states, the media, various public organizations are paying great attention to the Arctic Ocean. The strategic importance of the Arctic is defined by three components: firstly, this region has huge reserves of natural resources, especially hydrocarbon raw materials. Secondly, there are several sea transport corridors leading from the Pacific Ocean to the Atlantic Ocean in this region. Thirdly, the Arctic is considered as a significant factor of geopolitical influence. In this sense, the Bering Strait is particularly important, as the only route leading from the Pacific Ocean to the Arctic Ocean and further to the Atlantic through the Northern Sea Route (NSR) or North-West Passage (NWP). From this point of view, this paper examines the geographical features of the location of the Bering Strait, hydro meteorological and navigational navigation conditions. The current state of shipping and the navigation systems operating in the strait are discussed. On the basis of the analysis done, taking into account the prospects for the development of Arctic cargo transportation, it is shown that the shipping organization system that currently exists should be improved in order to ensure an adequate level of navigation safety and protection of the unique biosphere in this strait.

2. Geographical features

The Bering Strait is located in the northern part of the eastern hemisphere and, on the one hand, connects the Bering Sea and the Chukchi Sea, and, on the other hand, it separates Russia and the United States (Fig. 1). The borders of the Bering Strait run along the coastal line of the Chukotka Peninsula (from the west) and the Seward Peninsula (from the east). From the north and south, the Bering Strait is limited by straight lines connecting, respectively, Unikyn Cape (Chukotka Peninsula) and the southern entrance Cape of Shishmarev bay (Seward Peninsula) and Novosyltsev Cape (Chukotka Peninsula) and York Cape (Seward Peninsula) (see below, Fig. 2).

Figure 1. The Bering Strait (satellite image)



Source: <http://komanda-k.ru>, access date 22 August 2018

The distance in the narrowest part of the strait between Cape Dezhnev in Chukotka and Cape Prince of Wales in Alaska is 47 nautical miles (86 km). Approximately in the middle between these capes are the islands of Ratmanov and Kruzenshtern, which are called the Islands of Diomede. The border between Russia and the United States lies in the middle between these islands. Thus, the island of Ratmanova refers to Russia, and the island of Kruzenshtern refers to the United States. The distance between them is 2.3 miles (4.2 km). On the island of Ratmanov there is a Russian border post, and on the island of Kruzenshtern, in addition to the American military, there are also local residents. The island of Kruzenshtern is connected by regular flights with the city of Nome. Between the islands of Ratmanov and Kruzenshtern there is also a date change line.

In fact, the Bering Strait is a combination of three straits: 1) between Cape Dezhnev and Ratmanov Island; 2) between the islands of Ratmanov and Kruzenshtern and 3) between the island of Kruzenshtern and Cape Prince of Wales. The width of the first and third straits is about 22.5 miles, and the smallest depth is 36 m.

Directly within the borders of the Bering Strait, seaports that could take transport vessels (excluding port points) are absent both on the Russian and American coasts. On the coast of Russia, the ports of Providenie and Egvekinot are closest to the Bering Strait, and on the coast of US - Dutch Harbor on the Aleutian Islands.

Thus, the Bering Strait, by virtue of its geographical location, is extremely important because it is the only shipping route that provides communication between the Arctic and Pacific oceans. All ships following the Northern Sea Route (NSR) or the Northwest Passage (NWP) inevitably pass through the Bering Strait. In the future, the importance of the Bering Strait and attention to it from the leading maritime powers will only increase.

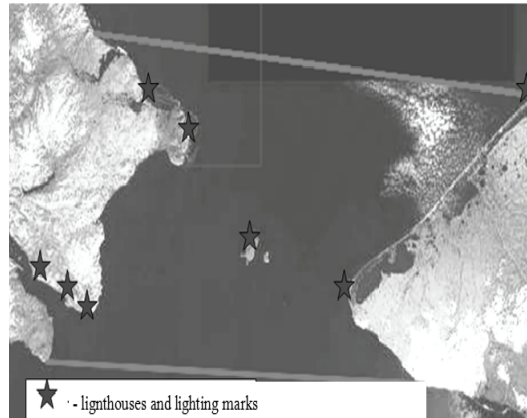
3. Hydro meteorological and navigation conditions

In the Bering Sea, including the Bering Strait, many hydro meteorological and other factors, especially storms, fogs, lowered temperatures, limited visibility, ice conditions and ship icing, have a significant negative impact on the safety of navigation. These and other factors important for navigation in a given area are determined by the following characteristics (NP 23, 2013):

- storm winds with a speed of up to 40 m/s can be observed up to 65 days in a year, they are especially frequent from November to March. In winter, northern storm winds prevail, in summer - southerly winds. From June to August, the frequency of storm winds is sharply reduced and usually does not exceed 2-3%. With storm winds, wave heights can reach 12 m;
- fogs are most frequent from May to August (on average 10-25 days per month), but in winter fogs are quite rare (1-3 days per month). Due to fogs and low clouds, limited visibility is observed 20-30% of the time in summer. In summer, the number of cloudy days can reach 25-28 per month, in winter - 11-18;
- in the period from late August-early September to mid-June, negative temperatures are observed in the strait, in winter, the air temperature in the strait

- can reach -25°C . The highest temperature ($8-11^{\circ}\text{C}$) is observed in July. Relative humidity is quite high and can reach 90%;
- precipitation, often in the form of snow, is observed up to 240 days a year. The number of days with blizzard is up to 100 per year;
 - ice is observed in the strait up to 9 months a year. In some winters, the thickness of ice can reach 6 m, and some ice floes can occur even in summer;

Figure 2. Coastal AtoNs in Bering Strait



Source: NP 85, 2008

- icing is often observed from October to May (repeatability - up to 35%), occurs at negative air temperatures and strong winds (Fig. 3).

Most often icing occurs with northeastern and northwesterly winds blowing at a speed of 1–20 m/s and a wave height of 3–6 m. Icing can also be observed when supercooled precipitation falls, when a ship passes through supercooled fog and during sea soaring.

In addition to the heavy hydro meteorological conditions, the navigation situation in the Bering Strait is characterized by a number of specific features that impede the navigation of ships. One of them is related to the distance from traditional sea routes, ports and supply bases, search and rescue centers and ports of refuge. Due to frequent reduced visibility, astronomical observational capabilities are limited. Visual and radar observations are further hampered by a monotonous coastal landscape, a rare number of perceptible navigational landmarks. The situation is aggravated by a small amount of aids of navigation supporting (AtoN). Thus, according to navigational publications (NP 85, 2008), the entire coastline of the strait is equipped with only 8 lighthouses and light beacons (Fig. 2). Radar beacon-responders are absent at all.

From the point of view of currents, depths, tides, navigation does not cause any particular problems.

The entire strait is in the zone of sufficiently reliable operation of the global navigation satellite systems (GNSS) GPS Navstar and GLONASS. In addition, the entire strait is covered by the radio navigation field formed by the Russian ground-based

radio navigation system "Chaika" and the similar American system Loran-C, which, however, has been removed from navigation use in recent years. The differential GPS (DGPS) stations, ensuring the accuracy of ship's fixing of 2-5 m, are currently absent in this region. However, the plans for the development of the NSR include the installation of two DGPS stations at Cape Dezhnev and at the Providenie port, which will cover almost the entire Bering Strait. This will provide an increase in the accuracy of ship's fixing several times (from 50-100 m to 2-5 m).

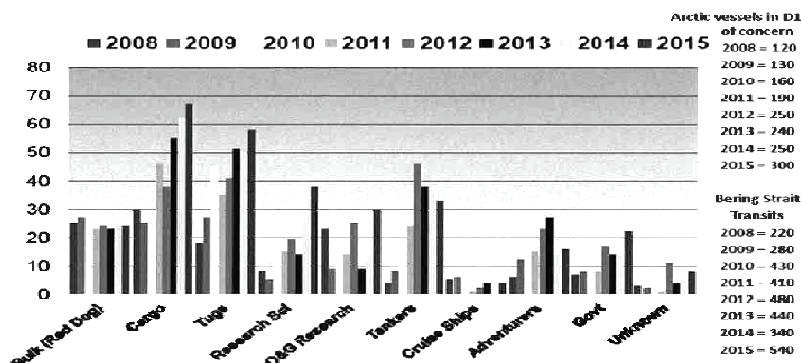
Thus, the hydro meteorological situation in the Bering Strait is quite complicated, especially in the autumn-winter period. The greatest problems are associated with reduced visibility, frequent storms and ice conditions. Navigation conditions of navigation are complicated by the difficulties traditional for high northern latitudes: problems with astronomical, visual and radar observations, an insufficient number of coastal AtoNs, remoteness from ordinary sea routes, supply bases and search and rescue centers.

4. Shipping situation

The total traffic of vessels in the Bering Strait is formed on the basis of the following components: a) transit transport vessels going by NSR in both directions; b) transit transport vessels going by the NWP in both directions; c) vessels carrying out the northern delivery of cargo from the seaports of the continental parts of Russia and the United States; d) fishing vessels; e) passenger and cruise ships; f) local vessels.

According to the analysis (Fletcher and Robertson, 2016), the Bering Strait passed in both directions: in 2009 - 239 vessels; in 2010 - 222 vessels; in 2011 - 222 vessels; in 2012 - 314 vessels; in 2013 - 349 ships. Some other data are presented in another paper (Preliminary Findings. Port Access Route Study: In the Chukchi Sea, Bering Strait, and Bering Sea 2016), which are shown in Fig. 3 (bottom right). However, these are numbers of the same order.

Figure 3. Distribution of total ship traffic by types of ships for the period 2008-2015.

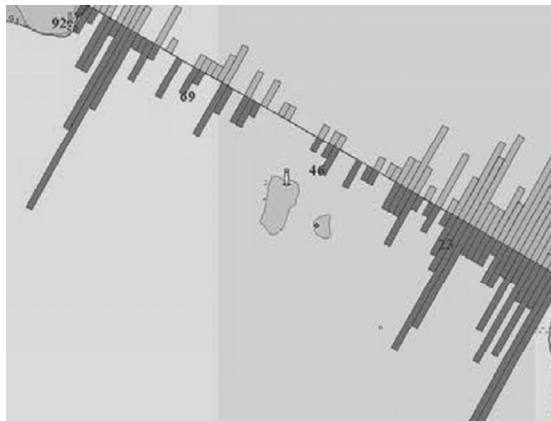


Source: Preliminary Findings. Port Access Route Study: In the Chukchi Sea, Bering Strait, and Bering Sea (2016)

The distribution of the trajectories of transit vessels across the width in the narrowest part of the Bering Strait according to the data of the automated identification system (AIS) for 2013 is shown in Fig. 4. As can be seen, the highest traffic density is observed along both sides of the strait, and the traffic flows that follow in the southern and northern directions are approximately equal.

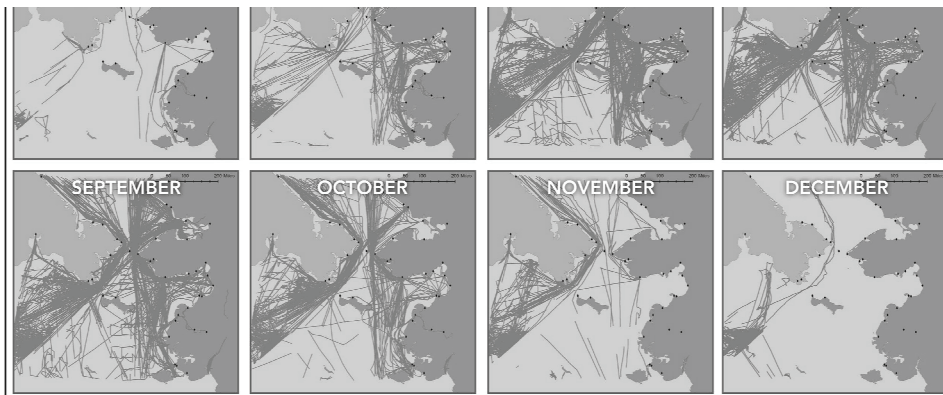
Distribution of total ship traffic in the Bering Strait by type of vessels for the period from 2008 to 2012 is shown in Fig. 3. Most part of the traffic was formed by tankers, cargo ships, tugs and bulk carriers. The distribution of the trajectories of the movement of various types of vessels for the period 2013-2015 is shown in Fig. 4. These data explain the large number of tugboat movements shown in Fig. 3: the overwhelming part of them is located in the waters adjacent to American territory.

Figure 4. Ship traffic distribution across the width of the Bering Strait (2013)



Source: Northern Economics, Inc. Feasibility Analysis: Port Clarence Support Base, 2014

Figure 5. Traffic density in the Bering Strait by months according to AIS data for 2013-2015

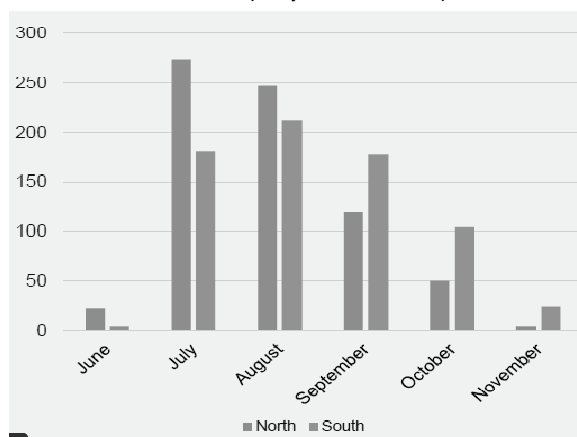


Source: Fletcher and Robertson 2016

The density of transit traffic in the strait depending on the time of year (month) is presented in Fig. 5. Data obtained from the reports of the AIS in the period 2013-2015. The greatest movement of vessels is observed in the period from July to October, while from January to March, the AIS system did not record transit vessels. This tendency is confirmed by the data presented in Fig. 6 (Northern Economics, Inc. Feasibility Analysis: Port Clarence Support Base, 2014). And in the summer (June-August) the number of ships following in the north direction exceeds the number of ships going to the south.

The situation observed in the Bering Strait during 2017 can be assessed using information from <https://www.marinetraffic.com> presented in Fig. 7. As in Fig. 5, the maximum traffic density is observed along the coasts of Alaska and Chukotka in the area of the Cape Dezhnev and the Cape Prince of Wales: in these areas it reaches approximately 20 ships per 0.4 square kilometers per year. Attention should be paid to the complete absence of transit vessels to the south of Ratmanov Island, and just three ships passed to the south of Kruzenshtern Island during the year.

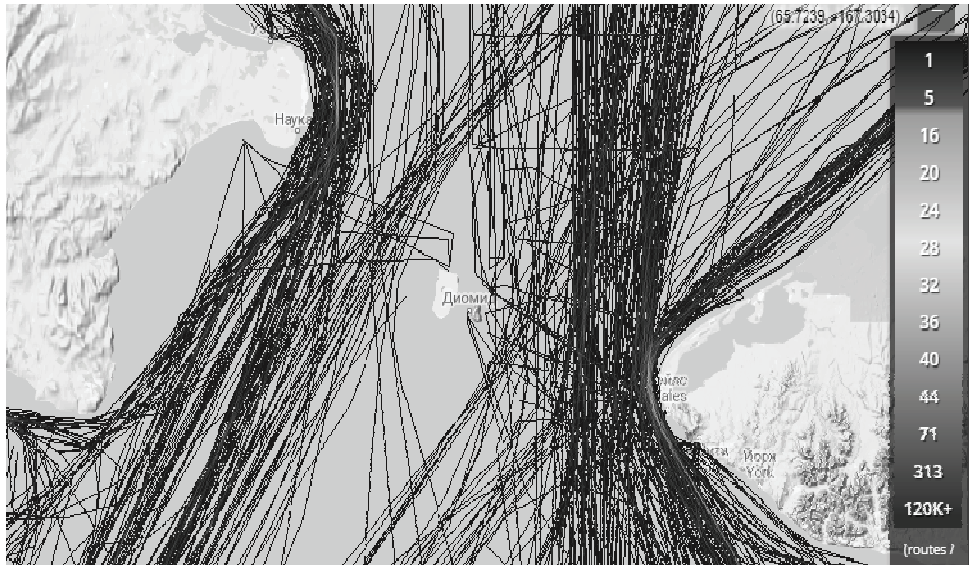
Figure 6. Distribution number of ships by months in the period from 2009 to 2013



Source: Northern Economics, Inc. Feasibility Analysis: Port Clarence Support Base, 2014

In general, in comparison with other areas of the oceans, the shipping situation in the Bering Strait is quite calm. However, the volume of freight traffic through the Bering Strait will increase dramatically in the near future: for example, according to the US Coast Guard, if in 2012 about 3 million tons of cargos were transported through the strait, that in 2020 the cargo traffic could increase to 50 million tons. (<https://seagrant.uaf.edu/events/2013/bering-strait-maritime>). Taking into account this factor, the general development of the Arctic region and the transformation of the Arctic by 2050 into the main center of offshore hydrocarbon production, an inevitable sharp increase in ship traffic in the Bering Strait and complications in the shipping situation should be expected.

Figure 7. Distribution of routes total flow of ships in the Bering Strait in 2017



Source: <https://www.marinetraffic.com>, access date 22 August 2018

5. Navigation accidents and oil spills

In the absence of offshore oil production in the Bering Strait at present, the main sources of oil products spills are ships in the strait that may be involved in a navigation accident. One of the largest was the oil spill in October 1997, when the tanker “Castrol” ran aground near the port of Nome, and more than 50 million gallons of engine oil spilled into the sea. More than 500 thousand birds, a large number of fish and seals suffered (<https://www.theonion.com>). The threat of oil pollution in the strait remains a permanent factor, and the source of pollution is not always known: there are regular reports of seabirds and mammals polluted with oil of unknown origin in this region.

Pollution by oil and petroleum products transported as cargo, occurs as a result of a navigation accident of transit tankers and tankers engaged in the northern delivery and local transportation. Vessels of all other types can be a source of contamination with marine fuel, lubricating oils, etc.

A large number of models have been developed for evaluating probability of navigation accidents, for example, the most well-known IWRAP program (IALA Waterway Risk Assessment Program - IAMA program for risk assessment on waterways), which is widely used to develop shipping control measures.

Approximately the probability of a major navigation accident can be estimated as follows. According to WWF data, the number of accidents with severe consequences for 10 years from 2005 to 2015 was from 0.028% to 0.04% of the total composition of the ships of the world fleet (<https://wwf.ru/upload/iblock/324/nir>). Consequently,

the probability of a major accident for each vessel over a period of 25 years of operation will be approximately 0.1%. For difficult conditions of navigation in the Bering Strait, this estimate can be increased by about 5 times. However, not every navigation accident is accompanied by an oil spill. Estimates of the probability of the occurrence of such a situation are different: it is quite acceptable to recognize the results presented in Journal of Navigation (Quon and Bushell 1994). Based on the analysis of statistical data in this work, it was shown that 15% of navigational accidents with tankers and barges carrying oil and oil products lead to real oil spills (cargo spills). Non-cargo oil spills (spills of ship fuel, oils, etc.) occur in 3-5% of navigation accidents with vessels that are not tankers and barges carrying oil.

For the northern part of the Bering Sea, a detailed analysis of the likelihood of various oil spill scenarios was made by Risk Informatics Company (<https://wwf.ru/upload/iblock/be7/otchetmodelrazl.pdf>). From the results of calculations it follows that the risk of exceeding the spill volumes of 500 tons may occur with a frequency of about 1.0×10^{-3} 1 / year, and the spill volume of 1500 tons is with a frequency of 2.3×10^{-4} 1/year.

As for oil spills in the Bering Strait, it should be noted that in the event of a real spill, only the crew of the emergency vessel can take response measures at the first stage, since coastal spill response resources are far enough away. For example, if the spill occurs in the area of Cape Dezhnev, then the nearest coastal resources are at port of Anadyr (260 miles, approximately 20 hours for a rescue vessel), the port of Pevek (560 miles, more than one and a half days of travel) and in the port of Petropavlovsk-Kamchatsky (1300 miles, more than three days of travel).

Fast assistance from the US Coast Guard is also unlikely, since its main forces and assets are based south of the Ale Islands in more than 800 miles.

Thus, the level of navigation accidents and accordingly the risks from oil spills with the existing density of ship density in the Bering Strait cannot be considered critical. However, given the sharp increase in shipping volume in this region, one should expect an even sharper (accident rate depends in quadratic degree on the intensity of traffic) increase in risk from oil and oil products spills, which indicates the need for early development to reduce potential risks, including the creation of local centers for the elimination of emergency oil spills.

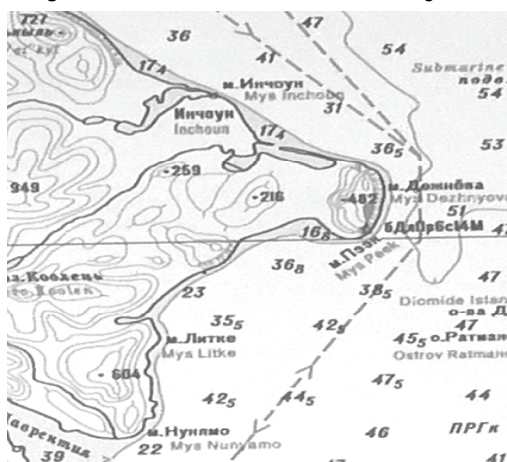
6. Maritime safety systems

Bering Strait falls within the area of three maritime safety systems (MSS) namely Ship's routing (SR), Ship's reporting system (SRS) and Global maritime distress and safety system (GMDSS). In reality, the coverage areas of different MSS may overlap partially or even completely. In this case situations arise when the vessel, following in any area, may be simultaneously in the zones of operation of several MSS.

Of all the possible elements of the SR system, at present, only recommended routes are operating in the Bering Strait, the directions of which are $215^\circ - 35^\circ$ (in the Pacific part of the strait) and $0^\circ - 180^\circ$, $136^\circ - 316^\circ$ and $147^\circ - 327^\circ$

° (that part of the strait, which is located in the Arctic Ocean) (Ship's Routing, 015). On the maritime navigation chart these routes are indicated by dotted lines with red or orange arrows (Fig. 8).

Figure 8. Recommended routes in the Bering Strait



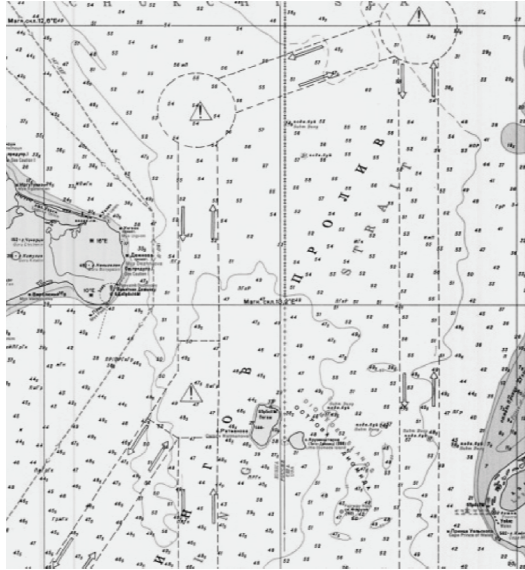
Source: marine chart No 60092

However, from 1 December 2018, the situation with regard to the SR system in the Bering Strait changes significantly. This is due to the fact that the IMO Committee for Maritime Safety (MSC) at its 99th session in November 2017 approved a joint Russian-American proposal to establish a new traffic scheme in the Bering Sea. The scheme proposed by Russia and the United States implies the establishment of six 4 miles wide, two-way recommended routes in the Bering Strait and on the approaches from the Russian and American sides, as well as the six precautionary area (PA), crossing or changing their direction (four two-way routes and three PA are directly in the Bering Strait) (Routeing Measures and Mandatory Ship Reporting Systems, 2017) (Fig. 9).

The paths of vessels are paralleled through the Russian and American parts of the Bering Strait, which will allow ship owners to choose the most convenient route for the passage, taking into account weather and ice conditions in the area, as well as the location of the ship's destination. The tracks are located at the maximum distance from the coast, and the depths along the entire length are more than sufficient for the safe passage of large-tonnage vessels. These routes are recommended for vessels with a gross tonnage of 400 tons and more.

In addition, off the west coast of the Bering Strait, in the territorial waters of Russia, there are two "marine mammal habitat areas", representing 12-mile zones around the Capes of Dezhnev and Inchoun. These areas are not included in the SR system, since they were introduced on the basis of Russian legislation. In these areas it is forbidden to stay ships, to give beeps and signals, to fly on aircraft below 4000 m, shooting, catch fish and other marine mammals and plants, and visit rookeries.

Figure 9. Two-way routes and precautionary areas in the Bering Strait



Source: Routing Measures and Mandatory Ship Reporting Systems, 2017

As for such a MSS as the SRS, the Bering Strait (as indeed any part of the World Ocean) falls within the global SRS AMVER (Automated Mutual – Assistance Vessel Rescue System). The Operation Center of AMVER is managed by the US Coast Guard. With the help of special messages reception/transmission, the Operations Center ensures constant monitoring of the movements of the vessels registered in the system, as well as coordination of search and rescue operations, if necessary. Participation in AMVER is voluntary and free of charge.

Figure 10. Base AIS stations of MXAK company in Alaska



Source: http://www.mxak.org/vtrack/vtrack_intro.html

In the framework of the global maritime distress and safety system (GMDSS), the Bering Strait belongs to the sea area A3, the peculiarity of which is that ships operating in this area must have additional radio equipment onboard, the list of which is defined by "General requirements for ship borne radio equipments forming part of the global maritime distress and safety system and for electronic navigational aids, which were approved by IMO Resolution No. A.694 (17) on 6 November 1991. In accordance with the IMO work plan on GMDSS modernization this system is supposed to be supplemented with base stations of AIS, including the use of AIS for monitoring ships and using new types of messages [11]. In the Bering Strait, the AIS base station of the Marine Exchange of Alaska Company (MXAK) currently operates on a commercial basis (Fig. 10) (<http://www.mxak.org/>).

Thus, of all currently existing MSS in the Bering Strait, the SR system functions in the form of such elements as recommended routes, as well as four two-way routes and three PA (from 1 December 1 2018). Bering Strait is included in the marine area A3 of the GMDSS, there is one AIS base station in this strait. In this area also works global AMVER. In addition, in the northwestern part of the strait there are two habitats of marine mammals, the navigation of vessels in which is prohibited.

7. Environmental aspects

The peculiarity of the geographical location of the Bering Strait at the junction of two continents and two oceans determined the uniqueness of this area from an environmental point of view. The shores, islands and sea waters of this strait are characterized by the highest in the Arctic level of diversity and productivity of various species of birds, animals and fish. The strait is a critical area that provides habitat, reproduction, feeding and migration of many species of marine mammals, including large, walrus, ringed seals, beluga whales, and gray and bowhead whales which migrate twice a year through Chukchi and Bering seas. For a considerable part of the year, a huge number of seabirds inhabit the strait area, which nest and feed here, including such species as least and crested auklets, thick-billed murres, kittiwakes, thin-billed petrels, white and pink seagulls and at least thirty more numerous species of seabirds, sea ducks, geese and loons.. Here are the largest colonies of seabirds in the Arctic (up to 20 million).

The strait is the most important migration corridor and crossroads of birds, sea and land animals from various regions of the planet, which are part of the faunas of many countries. As a whole, the territory of Eastern Chukotka and the adjacent waters, including the Bering Strait, played an extremely important role in the formation and development of the biota of the Arctic and subarctic regions. The greatest number of marine animals in the strait is observed in the periods of formation and destruction of the ice cover.

In order to preserve the historical and cultural heritage, biological diversity, as well as improve the living conditions of the population living in these areas, preserve and develop the unique Bering Sea hunting culture of the indigenous population

(Chukchi and Eskimos), protect the biological diversity of rare and typical representatives flora and fauna, ensuring the natural state of the fragile Chukchi landscapes in this region, on January 27, 1993, the Beringia National Park was established with a total area of 3053.3 thousand hectares. This park received the status of a specially protected natural area (SPPA) of federal significance in 2013 in accordance with Russia government decree of January 17, 2013 No. 3 “On the establishment of the Beringia National Park in the Providensky, Chukotka and Iultinsky municipal districts Chukotka Autonomous Okrug”. The marine water area of the park makes up almost 20% of its total area (Fig. 11).

In accordance with the Federal Law of 14.03.1995 No. 33-FL “On specially protected natural area”, protected zones with a restricted nature management regime should be created in areas of land and water space adjacent to the SPPA. Within such protected zones, economic and other activities that negatively affect natural objects and SPPA complexes are prohibited.

The special ecological situation in the Bering Strait is also recognized internationally. For example, in November 2010, the International Union for Conservation of Nature (IUCN) and Natural Resources Defense Council (NRDC) held a seminar in which many experts from the USA, Canada and Russia took part. The workshop identified in the Bering Strait four so-called “super-EBSAs” (an environmentally and biologically area) based on criteria developed under the auspices of the Convention on Biological Diversity (CBD). The workshop identified the Bering Strait as the Arctic region, characterized by the highest productivity and diversity of marine nature. This region is a critical habitat for walruses, seals, fish, several species of whales, as well as a huge number of birds. It preserves the ancient history of human civilizations and the enduring cultural heritage that is of great importance for humanity in general and for local indigenous peoples in particular.

Figure 11. The approximate sea border of the park "Beringia" (red line)



Source: <https://wwf.ru/upload/iblock/>

In the Bering Strait, the greatest environmental risks are associated with shipping activities. These risks mainly are connected with possible spills of oil and oil products during ship navigation accidents (collisions and grounding). The extremely negative impact of such spills on the marine fauna and flora is widely known. However, even in normal operation, vessels in the strait have a negative impact on the environment in the form of the following factors: a) unauthorized or emergency discharge into the water of ship waste, oily and waste water, garbage; b) replacement of ship's ballast, when sea water is used as ballast; c) emissions of pollutants from ship engines; d) noise pollution from the work of ship propellers, engines and other devices, as well as noise resulting from the exploration and production of marine resources and from the work of naval hydroacoustic stations; e) unloading of cargo on the shore that is not equipped for such activity; f) use of fishing equipment that is harmful to the environment, as well as excessive by-catch.

Although all these factors are regulated by the relevant international regulatory documents, their negative impact on the environment cannot be completely excluded. Minimizing the negative impact of shipping-related factors is possible with the help of certain measures, some of which are presented in the next section.

8. Possible shipping regulatory tools

The main measures for the regulation of shipping by establishing a certain navigation regime in specific areas of the World Ocean are implemented within the framework of the IMO on the basis of the regulatory documents adopted by this organization. The most frequently used tools for this are the SR elements, which is mentioned in section 5.

In general, the purpose of the SR system is to increase the safety of navigation in areas where ship flows converge and in areas with high traffic intensity or where freedom of movement of ships is restricted by limited maritime space, obstacles, limited depths or adverse weather conditions. Depending on the specific factors, the negative impact of which must be neutralized, the establishment of the SR elements is carried out in order to accomplish one or more of the following tasks: a) separation of the ship's counter flows in such a way as to reduce the likelihood of collisions; b) reducing the risk of collision of vessels proceeding in established traffic lanes with vessels following courses crossing such lanes; c) simplify the organization of traffic in areas of convergence of ship flows; d) the organization of safe movement of vessels in areas of intensive research or development in the open sea; e) organizing the flow of vessels in or around areas where navigation of all vessels or certain classes of vessels is dangerous or non-desirable; f) reducing the risk of ship's grounding by establishing the special organization of the movement of ships in areas in which the depth is unreliable or close to the draft of the vessel; g) organization of vessel traffic at a sufficient distance from fishing areas or through fishing areas (Ship's Routing, 2015).

With regard to the Bering Strait, all these tasks should be considered relevant,

with the exception of the task of organizing the safe movement of ships in areas of intensive research or development on the high seas.

In addition to the elements mentioned in section 6 (two-way and recommended routes and PA), the SR system also includes traffic separation schemes (TTS), inshore traffic zones (ITZ), areas to be avoided (ATBA), which, in principle, can be used to regulate shipping in the Bering Strait.

However, the problem lies in the fact that, from a legal point of view, recommendations on navigation of vessels, established in various elements of an SR system, have the lowest priority among other regulatory requirements, in particular, the requirements of the International Regulations for Preventing Collisions at Sea in 1972 (COLREGS-72). For example, a ship following its own lane in the TTS is obliged to “make way” for the ship, observed on the right and following the crossing course just as in the open sea. Although the second ship violates Rule 10 of the COLREGS-72 wherein.

To solve environmental problems an effective measure is the introduction of mandatory SRS (see section 6), as well as vessel traffic service (VTS), which have precisely defined areas of operation.

All the above tools (SR, SRS and VTS) have the main purpose of ensuring the safety of navigation and, achieving this goal, they also solve environmental problems.

However IMO has a tool that is used to solve just environmental problems: the establishment of “Particularly Sensitive Sea Areas” (PSSA). A PSSA is “an area that requires special protection through actions by the IMO because of its importance to recognized environmental, socio-economic or scientific features, if due to such features it may be vulnerable to damage caused by international shipping.” (IMO Resolution A.982 (24)). Such areas are established by IMO on the basis of Resolution A.982 (24) “Revised guidelines for the definition and designation of particularly vulnerable marine areas” adopted on 1 December 2005.

Another tool for solving environmental problems is the establishment of a special area (SA), which is defined as “a sea area in which, for confirmed technical reasons related to its oceanographic and ecological conditions, as well as the specifics of shipping, it is necessary to adopt special obligatory methods of preventing pollution of the sea by oil, harmful liquid substances, wastewater or garbage, depending on the circumstances” (IMO Resolution A.1087 (28)). The SAs are established in accordance with the provisions of IMO Resolution A.1087 (28) “Guidelines for the Designation of Special Areas 2013 under the MARPOL Convention”, adopted on 4 December 2013.

It should be noted that both the PSSA and the SA are provided with a higher level of protection than other areas of the oceans, including increased legal liability of vessels that are allowed to sail in such areas. This status has the marine space, occupying 3.2% of the oceans (<http://www.zaosi.com>). At present IMO has begun to explore the possibility of creating another SA in the Mediterranean Sea, where it will control emissions of sulfur generated during the burning of marine fuel (Sea Trade Maritime News, 2018).

9. Suggestions for improving shipping regulation

On the basis of the above analysis of the situation in the Bering Strait, as well as taking into account the prospects for the development of this region, it is possible to formulate the following proposals for regulating navigation as the main source of environmental threats.

1. Adapting of the existing recommended routes and the two-way routes introduced from 1 December 2018 because the existing recommended routes and the newly introduced two-way route in the south-western part of the strait are essentially duplicative of each other (see Fig. 9), which inevitably introduces an element of uncertainty and confusion when choosing a transit route. Solution of the problem: the cancellation of the recommended route $215^{\circ} - 35^{\circ}$ and the corresponding adjustment of the other recommended routes.
2. The establishment of the ITZ between the two-way routes and the coast of Chukotka and Alaska, which is the logical conclusion of the movement pattern in case of the adoption of the above proposal (proposal 1). Under the existing traffic pattern, the establishment of an ITZ along the Russian coast of the strait is impossible, since the recommended routes do not have an exactly defined width.
3. The introduction of the status of ATBA around the islands of Ratmanov and Dezhnev, which will lead to streamlining the movement of local navigation vessels (transit vessels near these islands are practically not observed (see Fig. 7).
4. Considering the introduction of PSSA and/or SA status in coastal areas of the strait (or even throughout the strait) with increased environmental vulnerability.
5. Development and implementation of the mandatory regional SRS (named, for example, BERINGREP) in the northern part of the Bering Sea (by analogy with the existing SRS REEFREP in the Great Barrier Reef). The operational center of such SRS could be the nearest AIS base station in Alaska.
6. Installation of AIS base stations on the Russian coast of the Bering Strait (or in the northern part of the Bering Sea) and coordination of their work with AIS stations on the coast of American Alaska.
7. Organization of work on the justification and design of regional VTS: in the short term, as the intensity of traffic in the strait increases, such a VTS will be extremely necessary, since, as practice shows, automated VTS is the most effective means of organizing and controlling the movement of vessels.
8. Organization of studies on the need to introduce temporary (seasonal) navigation measures in the strait (for example, speed limits) associated with periods of maximum concentration of marine mammals and their type of life activity.
9. Strengthening rescue preparedness during the navigation period, for example, by sending to the area the grouping of forces and means for oil spill prevention and response.

Solving traditional navigation support issues, which for the Bering Strait are of increased importance, for example, expanding coastal AtoN, improving the quality of cartographic support, and improving the work of forecast services will also contribute to improving the safety of navigation in this region.

It seems expedient to study the question of introducing an ice patrol in this area (by analogy with the northwestern Atlantic), which operates in accordance with rule 6 of chapter 5 of the Annex to SOLAS-74.

Finally, the preliminary training of ship crews will also contribute to reducing environmental risks. The Bering Strait is within the scope of the Polar Code, so the commanding staff of all vessels operating in the area must receive appropriate training. The program of such training can include a section related to environmental risks. It is also possible to organize such training in a separate program.

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