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Navigation infrastructure of the Northern Sea Route

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Abstract

The reduction of sea ice area in the Arctic has increased the availability of the Russian Arctic seas for navigation by vessels of relatively low ice class. The signing of the Act on the Northern Sea Route (NSR) by the President of the Russian Federation has created the possibility for ships from countries other than Russia to use the NSR. However, the NSR is very poorly recognized in terms of navigation by countries other than Russia. The author of the paper analyzed the NSR navigation infrastructure components in terms of the reliability of the information provided by the main producers of nautical publications for initial voyage planning. For the purpose of this analysis an indicator of the quality of the navigation infrastructure was developed.

The value of this indicator, obtained on the basis of the above analysis, is low. Navigators that collect information during the initial stage of voyage planning may be misled if they use nautical publications originating from only one global producer of charts and publications. If the navigators act in accordance with good seamanship and familiarize themselves with information from two or three global producers of nautical publications, they may be disoriented due to the receipt of divergent information. It seems that before the voyage begins and preferably before planning a trip, the master or owner of the vessel intending to carry out a voyage by the NSR should first use the most current local knowledge in the possession of the Northern Sea Route Administration. This is also where information can be found as to where to obtain the most current and reliable information for initial voyage planning.

Abbreviations

DGPS – Differential Global Positioning System;
GLONASS – GLObal NAvigation Satellite System, (ГЛОНАСС, Глобальная навигационная спутниковая система);
GPS – Global Positioning System;
GUNiO – Head Department of Navigation and Oceanography (Главное управление навигации и океанографии);
IMO – International Maritime Organisation;
INSROP – International Northern Sea Route Program
LORAN – LOng RAnge Navigation;
MCA – Maritime and Coastal Agency;
NGIA – National Geospatial-Intelligence Agency;
NSR – Northern Sea Route;
PRIP – Coastal warning broadcasts for waters of the Russian Federation;
RSDN – LOng RAnge Navigation (РСДН – Радиосвязь дальней навигации);
UKHO – United Kingdom Hydrographic Office;
UNiO – Department of Navigation and Oceanography (Управление навигации и океанографии).

Introduction

There was a rapid acceleration in the reduction of the sea ice surface in the Arctic at the turn of XX and XXI century. The greatest changes have occurred on the Siberian Continental Shelf and the smallest changes were observed in the area of northern Greenland. These changes affect the potential development of shipping by vessels of relatively low ice classes (and with low construction costs) in the above mentioned areas.

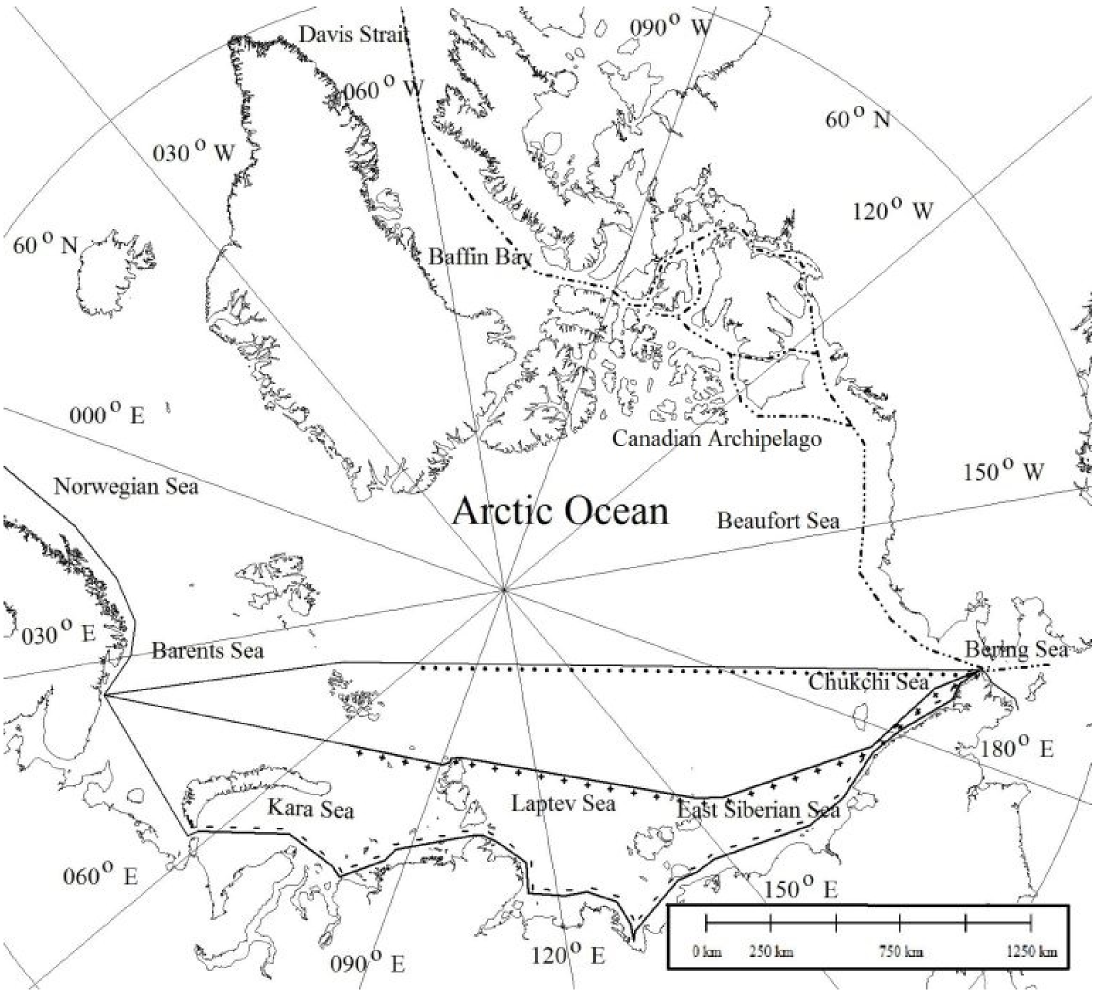

Figure 1. Trade routes in the Arctic Ocean: ------- Northeast Passage, - · · Northwest Passage, · · · trans-arctic NSR route, + + + deep-water NSR route, - - - coastal NSR route (made by author following: Peresypkin & Yakovlev, 2008; Kraska & Levie, 2010; AMSA, 2009)

Trade routes in the region of the Arctic Ocean are traditionally divided into those leading from the Atlantic Ocean to the west (the Northwest Passage) and to the east (the Northeast Passage (NEP)). They are presented in Figure 1. The most favorable route for the European Union countries, leading to the Far East, is the NEP. The NEP runs along the European and Asian coasts of Russia and continues through the Bering Strait to the Pacific. The NEP consists of two parts. The western part of the NEP is the Barents Sea lying off the coast of Europe, which has long been largely free of ice. This allows for continuity of navigation through most of the year on this sea. East of the Barents Sea is located a NEP segment where difficult, and extremely difficult, ice conditions occur throughout most of the year. This segment of the NEP is named the Northern Sea Route (NSR).

The reduction of the sea ice area in the Arctic has increased the availability of the Russian Arctic seas for navigation by vessels of relatively low ice class (which are cheaper in terms of the construction and operating costs) and for navigation without the assistance of icebreakers. This reduction has also resulted in extending the navigation season (currently from the third week of July till the third week of October). Previously, during the years 1993–1999, the International Northern Sea Route Program (INSROP), in which Russia, Norway and Japan participated, have investigated the possibility of using the NSR as an alternative shipping route to routes leading through the Suez Canal and the Panama Canal. This route, according to Laulajainen (Laulajainen, 2009), can move up to 20–35% of the global carriage of containers, if the NSR maintains ice conditions similar to those of 2007.

On 28 July 2012 the President of the Russian Federation signed the Act on the NSR (Federal Law No. 132-FZ). This Act created the possibility for vessels not flying the Russian flag to use the NSR and has become a milestone for accelerating the use of the NSR. In such a situation, the NSR is a potentially important route for international shipping. However, due to the previous unavailability of the

NSR and its poor hydrographic recognition and acceptance as internal waters, first by the Soviet Union and later Russia, the NSR is very poorly recognized in terms of navigation by navigators from countries other than Russia.

This extremely important knowledge for guiding vessels on the NSR is not yet reflected in literature. There are few papers on aspects of cargo vessel navigation and traffic on the NSR. Except for one contemporary work (Marchenko, 2012), the remaining few studies, articles and notes, most often come from 50–70 years of the twentieth century, when ice conditions and climate conditions in these areas did not resemble those currently occurring (i.e. there were much more difficult ice conditions), nor were the vessels technically similar to modern vessels (e.g. general cargo steam vessels with a 45-man crew). The usefulness of this small number of old literature sources is now negligible. In addition, most of these publications are practically unavailable outside Russia. Several studies published later dealt only with one aspect of the operation of vessels on the NSR, which is sailing in sea ice (Ryvlin & Chejsin, 1980; Arikajnen & Tsubakov, 1987; Arikajnen, 1990; Mironov, 2010) or discussed in very general terms the possibility of using the whole NSR for shipping (Kitagawa, 2001) or as a portion of Arctic shipping (AMSA, 2009). Some of these works are technical reports prepared by specialized research institutes for the US Army (Mulherinh, Sodhi & Smallidge, 1994; Sodhi, 1995; Mulherin, 1996, Mulherin et al., 1996) or for the European Union (Ragner, 2000; Moe & Jensen, 2010). Issues related to knowledge available on charts and nautical publications have already been described by the author (Pastusiak, 2015). Due to the shortage of information related to the actual condition of navigational infrastructure on the NSR, the author decided to analyze the matter. Based on the analysis of currently available nautical charts and publications provided by the main official suppliers, several surprising facts were revealed. It has been observed, for example, that the provision of navigation aids for a ship's voyage through the NSR was not satisfactory, especially in the eastern part of the NSR (Pastusiak, 2015). So the proposed thesis – that the navigation infrastructure of the NSR is much more expensive than the production of nautical publications – may be all the more unsatisfactory. The objectives of the work were assumed thus:

1. Determining the actual state of the existing navigational aids;
2. Determining what exists; if it is operating reliably or not;
3. The cross-checking of information received from several independent global providers of nautical publications and the Russian Federation as a coastal state of the NSR;
4. Using information available in the Russian language that is difficult to access for users outside of the Russian Federation;
5. Developing a quality indicator for the independent assessment of data.

It is therefore assumed that it will be possible to achieve the main goal of the work – to evaluate the current state of navigational infrastructure and its reliability and to identify sensitive areas of the navigational infrastructure of the NSR that requires special attention.

Research method

Due to the sparse and rather old literature on navigation infrastructure on the NSR it was decided to analyze the information in official nautical publications. Publications of global producers of nautical charts and publications UKHO and NGIA (US), as well as the producer of nautical charts and publications in Russia (as the coastal state of the NSR) were used for the purpose of comparison. The author made every effort to ensure literature on the subject of the work was complete and fully up-to-date. For this purpose, not only were Russian nautical publications used but also information contained in the Russian Notices to Mariners. These are not available on the world market for two reasons. They are not widely available for sale and marketing information on popular search sources, such as the Google search engine, is practically non-existent. Some Russian-language websites, including the governmental Ministry of Defense of the Russian Federation site, related to the topic of shipping in the Arctic or on the NSR have a complete set of information only in the Russian language. The English version of the websites are very poor in content, or even point to the need to establish direct contact with the website owner. Hence, the persons concerned do not know that such literature exists or where it can be acquired. The second problem is the Russian language of publication. In a world heavily dominated by the English language, knowledge of Russian is virtually reduced to countries where the language is or was mandatory, or where it was a national language. In the countries of Eastern Europe, where the older generation of inhabitants was taught Russian in schools, the number of people with knowledge of this language diminished rapidly over time. In a world dominated recently by the UKHO as a global provider of paper charts and nautical publications hardly anyone points out that there is another global official provider of nautical information for the Russian Arctic region – the United States of America (USA). All these sources were examined.

Navigation infrastructure was divided into the following groups: beacons, leading beacons and leading lights, buoys and floating stakes, passive radar reflectors and radar transponders (Racon type), non-directional radio beacons (RC type) and coast radio stations providing signals for taking bearing on request, land-based radio navigation systems, as well as GPS and GLONASS satellite systems, including DGPS stations.

The quality classification method was used for the assessment of navigation infrastructure. This method is commonly used. The author has already applied it in his earlier works. As a result, it can be assumed that the method is proven and enables identification of areas of knowledge, information or practical application of reduced quality that need improvement or at least require increased vigilance to avoid threats. Each group of infrastructure was described by the quality scale in a range between 0 and 1. The quality classification method is commonly used for comparative assessment of phenomena or objects with distinct, incomparable quality characteristics (Kolman, 1994). The above-mentioned quality scales include the assumptions of e-Navigation (IMO, 2008) and the ISM Code (MCA, 2009). This method has been used by the author to assess the quality of assurance of adequate equipment onboard vessels that are making surveys in uncharted areas (Pastusiak, 2012). These quality scales represent the distinctness and clarity (confidence) of information that serve navigators in the process of voyage planning during the initial collection of information, to identify sources of possible determination of a vessel's position. They refer to the Zones of Confidence index, which reflects the credibility of navigational information shown on nautical charts. The pattern originally presented by Eastwood (Eastwood, 2014) for assessing the quality of data on the concentration and type of ice in NetCDF file type was used to determine the quality scale. The following values corresponding to the quality assessment were accepted: 0 – erroneous or not confirmed by any global data provider, 0.25 – unreliable (confirmation unsatisfactory), 0.50 – acceptable (confirmed by one of three global data providers), 0.75 – good (confirmed by 2 of three global data providers), 1.00 – excellent (confirmed by every data source). The coverage of the NSR region by the element of infrastructure was also taken into consideration. It was represented by factor F as a fraction of the basis equal to 7. The numerator is the number of seas covered by that element of the navigation infrastructure. Each group of navigation infrastructure components is described using the credibility of prevalence on the NSR in reality. The confirmation of occurrence is notification of the occurrence of a particular group of infrastructure on NSR in publications of each individual global provider of nautical charts and publications. The quality of the navigation infrastructure has been described generally by Eq. (1).

$$Q_T = \frac{Q_1F_1 + Q_2F_2 + Q_3F_3 + Q_4F_4 + Q_5F_5 + Q_6F_6 + Q_7F_7}{7} \tag{1}$$

where:

- Q_T – quality indicator of total infrastructure on NSR;
- Q_1 – quality indicator related to beacons and leading beacons;
- Q_2 – quality indicator related to buoys and floating withes/stakes;
- Q_3 – quality indicator related to radar reflectors and Racons;
- Q_4 – quality indicator related to radio beacons RC type and providing service on request;
- Q_5 – quality indicator related to land radio navigation systems;
- Q_6 – quality indicator related to GPS and GLONASS satellite navigation systems;
- Q_7 – quality indicator related to DGPS stations;
- F_i – factor of coverage of NSR region by the element i of navigation infrastructure.

Such an indicator of the quality of information on the navigation infrastructure on the NSR shows the credibility of various sources of information, unofficial and official, which will meet the navigator in the process of initial voyage planning. The higher the rate of total quality indicator Q_T, the more consistent the information is. The lower the overall rate, the more likely it is that the navigator will not find confirmation of information contained in one source, in other sources, or that it will be found in reality.

Analysis of information on the navigation infrastructure on NSR

Beacons, leading beacons and leading lights

All aids to navigation used for the NSR are included on nautical charts and described in sailing directions designed for route planning on the NSR

(GUNiO, 1996). This publication is currently out of print and the UNiO does not plan to resume production (Pastusiak, 2015). Sailing directions do not contain detailed information on aids to navigation. This creates problems for ships intending to use the NSR to become adequately prepared for the voyage.

Coastal permanent aids to navigation on the NSR operate automatically, but mostly only work during the navigational season. Dates of inclusion and exclusion are determined administratively (UNiO, 2008) and together with all other changes are advised by the Notices to Mariners and the Navigation Warnings (PRIP) disseminated by radio. These devices cannot be relied upon to operate properly and regularly during the period of their operation. Most beacons and leading marks on the NSR are daymarks only. Their appearance is often very similar, making it difficult to identify. The colors of the beacons seem to be close to the color of the surrounding snow, making it difficult for detection.

Leading lights are usually near major ports such as Igarka, Dudinka, Dikson, Tiksi, Pevek and areas of heavy traffic like the rivers Yenisey, Chatanga, Anabar, Kolyma, and Yana. Generally they are not in the northernmost regions of narrow passages. According to the Russian nautical publication updated to 5 February 2011 (UNiO, 2008) the distribution of existing lighting aids to navigation is as follows: Yugorskiy Shar – 19, Kara Gate Strait – 5, Matoczkin Shar Strait – 2 (on eastern coast), on the north of Novaya Zemlya – 1, Vilkitsky Strait – 9 (including 8 on the continental coast), Shokalsky Strait – none, Laptev Strait – 4, Sannikov Strait – 1, on the north of the New Siberian Islands – none, De Longe Strait – 4 (including 3 on the continental coast), Bering Strait – 5. The largest number of lighting aids to navigation in the narrow passages are located on the continental coast. The number of these aids decreases with distance from the mainland coast. The reasons for this distribution are twofold. Firstly – aids to navigation located on the mainland side are much more easily accessible for servicing. Secondly – the largest demand for lighting aids to navigation exist on this route, which is often preferred by ships for navigation on the NSR. This is a coastal route, on which there is generally no summer sea ice or a polynya is permanently reproduced in the same place, or there are areas free of sea ice. Most of the lighting aids to navigation are located just in the areas of these polynyas. Notices to Mariners for Russian nautical publication (UNiO, 2008 with corrections until NTM 30 dated 25 July 2015) notify a significant number of devices that are destroyed, abolished or working only in the navigation season from mid-August to early November. Some information is published with a delay of up to a few years. Occasional information applies to devices operating all year round. For such information on aids to navigation the quality indicator Q_1 equal to 0.50 was adopted.

Buoys and floating stakes

Buoys have only limited application on the NSR due to the short period of the navigation season, in which the waters are free of sea ice. In the summer navigation season along the NSR up to one thousand floating stakes are sometimes positioned. Like leading marks, buoys and floating stakes whose circulation has run out are also described in sailing directions designed for route planning on the NSR (GUNiO, 1996). This can cause problems for navigators who want to be properly prepared for the voyage. Navigation buoys operate automatically. They are exhibited during navigation periods and more specifically from the moment when the sea is completely free of ice until the first sea ice forms. The Russian nautical publication (UNiO, 2008) does not contain information regarding the floating stakes. This suggests unreliability of the position of buoys and floating stakes exhibited during the navigation season. It must be remembered that in the NSR waters after the disappearance of the ice sheet, ice that has drifted from the north can reappear. The occurrence of such drifting ice can lead to offsets of floating buoys and stakes. This is the reason why UNiO stipulates that the buoys are not objects serving to determine the position of the vessel. Dates of placing buoys and their removal from the designated working positions are determined administratively (UNiO, 2008). These dates and any other changes observed in the location of buoys and floating stakes are advised in the Notices to Mariners and the Navigation Warnings (PRIP) disseminated by radio. However, due to uncommon navigational aid inspections carried out by the Russian Maritime Administration, it is not certain that in the period of their use, these devices will operate properly and regularly. For such information on aids to navigation the quality indicator Q_2 equal to 0.25 was adopted.

Passive radar reflectors and radar transponders (Racon type)

The arctic coasts of Russia are relatively low and flat, causing problems for radar detection. In 2000, thirty radar devices of the Racon type and 700 passive radar reflectors were installed along the

NSR in particularly dangerous locations (Ragner, 2000; Kitagawa, 2001). They were mostly related to existing lighting aids and to navigation daymarks. According to Russian nautical publications, radar transponder devices of the Racon type were placed mostly in estuaries, which operate all year round. As of 30 April 2011 (GUNiO, 2006) radar transponder devices were present on the Barents Sea (3 units – which were all out of use in 2010), the Kara Sea (12 units), the East Siberian Sea (3 units) and the Chukchi Sea (2 units). They are located among others in the Kara Gate (1 unit), the Vilkitsky Strait (2 units) and near the De Longe Strait (2 units). Up until July 2015 another 4 devices were excluded from the operation. There are no radar devices of the Racon type on the Laptev Sea or the New Siberian Islands. Information on these devices presented in the nautical publications issued by other providers is highly diversified. Radio navigational publications (NGIA, 2005, 2014a) issued by the US National Geospatial Intelligence Agency do not contain information about radar devices of the Racon type across the whole NSR between the meridians 83 °E and 169 °E. In turn, the British Admiralty List of Radio Signals in volume 282/2 (UKHO, 2010) contains information about four such devices working in this area. In the current issue of the Admiralty List of Radio Signals in volume 282/2 (UKHO, 2014/2015) 7 devices are listed in the Barents Sea, 10 in the Kara Sea, 4 in the East Siberian Sea and 1 in the Chukchi Sea. These discrepancies of data across different sources of information suggest, according to nautical publications (NGIA, 2010; UKHO, 2011; NGIA, 2015a), doubtful credibility regarding the operation of radio-navigational devices between meridian 90 °E and the Bering Strait. In the latest publication NGIA (NGIA, 2014b) the credibility of the operation of the radio aids to navigation from the eastern border of Novaya Zemlya to the Bering Strait is questioned. In addition, the publication NGIA (NGIA, 2015b) cautions that information about changes to aids to navigation and information relevant to the safety of navigation for the region of Russia may be out of date due to insufficient information. For such information on aids to navigation the quality indicator Q_3 equal to 0.25 was adopted.

Non-directional radio beacons type RC and coast radio stations providing signals on request

In 2000, 47 beacons with a range of 100–150 NM were placed along the NSR (Ragner, 2000). Another beacon of a range of 300 nautical miles was planned. According to the Russian nautical publication (GUNiO, 2006), as of 30 April 2011, marine radio beacons for taking bearings existed only on the Barents Sea. These were 15 radio beacons of the type RC (of which 7 were excluded from use in 2004 and one in 2008) and one radio station was working on request. There is no information about other devices. Because the Barents Sea does not officially enter into the area of the NSR, it can be concluded from the above that along the NSR are no operating RC type radio beacons or any radio stations transmitting signals for taking bearings on request. A similar conclusion can be made on the basis of analysis of the publication "Radio navigational aids" (NGIA, 2005, 2014a) issued by the US National Geospatial Intelligence Agency. There is a lack of radio beacons for taking bearings along the NSR east of the meridian 37 ° E according to the information contained in this publication. The Admiralty List of Radio Signals (UKHO, 2014/2015) does not contain information on beacons in the Arctic region of Russia. However, the NGIA publication (NGIA, 2015a) mentions the existing radio beacons and indicates that they were not included in the publication because of insufficient reliable information. For such information on aids to navigation the quality indicator Q_4 equal to 0.25 was adopted.

Land-based radio navigation systems

In 2000, the existing land-based radio navigation system along the NSR was described (Ragner, 2000). It was the equivalent of the western long-range radio navigation system named LORAN-C. The name RSDN was used in Russia for this system. There are five types of RSDN system – 3, 4, 5, 10 and 20. According to the Russian nautical publication (GUNiO, 2006, as of 30 April 2011), there were two chains of ground system RSDN-5 in the NSR area covering the entire Kara Sea and western part of the Laptev Sea, which is the area of responsibility of the western branch of the Marine Operations Headquarters. The position accuracy of the system in the Kara Gate Strait is 200 meters, north of Novaya Zemlya it is 250–300 meters and it is 200–250 meters at the Severnaya Zemlya straits. There is no coverage by terrestrial radio navigation systems in the eastern part of the Laptev Sea, the East Siberian Sea or the Chukchi Sea, being in the competence of the eastern branch of the Marine Operations Headquarters. Unofficially the intention was announced to construct a more modern version of RSDN called "Scorpion" in Russia (http://masterok.livejournal.com/1232841.html, attempt 19/07/2015). RSDN is currently the only system that could replace the satellite GPS/ GLONASS system failure in the event of damage to satellite systems as a result of an act of terrorism or in the event of war.

The Admiralty List of Radio Signals (UKHO, 2014/2015) does not contain information about the existence of the LORAN-C station (RSDN) in the NSR area. The “Radio navigational aids” (NGIA, 2005, 2014a) issued by the US National Geospatial Intelligence Agency does not contain information on land-based navigation systems along the NSR either. For such information on aids to navigation the quality indicator Q_5 equal to 0.25 was adopted.

GPS and GLONASS systems including DGPS stations

According to Ragner (Ragner, 2000), GPS and GLONASS satellite positioning systems could be used along the NSR to ensure the accuracy of position in the range of up to 100 meters with a probability of 95%. From 1 May 2000, the position accuracy should be 10–20 meters. However, the accuracy of position may be dependent on local conditions and interference. It has been found that devices of the electronic active VHF/UHF marine television antennas are interfering with, and causing operational degradation, in the performance of GPS receivers. This interference may be realized as a display of inaccurate position information or a complete loss of GPS receiver acquisition and tracking ability. Such interference may occur up to 610 meters away from such active antennas (NGIA, 2005). Ragner’s report (Ragner, 2000) also showed four DGPS stations already in operation in 2000. They were to give enhanced position accuracy within 10 meters with a probability of 95% in most parts of the Kara Sea, the Kara Gate Strait, the Vilkitsky Strait and the river Yenisey, even further behind the port of Igarka.

The actual Russian nautical publication (GUNiO, 2006) together with the amendments, only contain information their DGPS stations for GPS / GLONASS receivers for the Barents Sea and the Kara Sea – at the stage of design, testing or operation, and several DGPS stations in the Bering Sea. There is no information on planning a DGPS station for the rest of the NSR. The DGPS station range is 200–250 NM. The official US nautical publication (NGIA, 2005; 2014a) does not provide any information about DGPS stations on the NSR or in its vicinity. The Admiralty List of Radio Signals (UKHO, 2014/2015) does not mention a DGPS station in the NSR area either. For such information on aids to navigation the quality indicator Q_6 equal to 1.00 was adopted. In the case of DGPS stations, the quality indicator Q_7 equal to 0.25 was adopted.

Results

The results of the assessment of particular groups of navigation infrastructure on the NSR made in *Analysis of information...* are collected in Table 1. The occurrence of individual elements of the navigation infrastructure is presented as a relative value factor. The maximum value of occurrence for a particular sea is equal to 1.0 (100%). In the case that the navigation infrastructure group does not cover the whole sea, the value of factor is reduced proportionally to the area coverage. Average value of coverage of the NSR by particular navigation infrastructure group F_i is presented separately in Table 1. Only one quality indicator Q_i described in the *Analysis of information...* was distinguished for the whole group due to the small amount of, and mostly ambiguous, information available. Inserting data from Table 1 to the Eq. (1) the value of the quality indicator of the total infrastructure on the NSR Q_T equal 0.28 was obtained. This is a low value as a result of two factors. On one hand the unofficial publications mention many navigational systems, some of which have been withdrawn from service because they consist of old technology. They are obsolete in some regions of the NSR and are decreasing the value of the coverage factor F_i. On the other hand, there is

Table 1. The relative area coverage factor of individual elements of the navigation infrastructure at the various seas of the Russian Arctic, coverage factor F_i and quality indicator Q_i

Navigation infrastructure group	Relative coverage area factor for the particular sea by the group						Average F_i	Q_i
	Barents Sea	Kara Sea	Laptev Sea	East Siberian Sea	Chukchi Sea	Bering Sea		
Beacons and leading beacons	1.00	1.00	0.50	0.50	0.75	1.00	0.68	0.50
Buoys and floating stakes	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50
Radar reflectors and Racons	1.00	0.75	0.00	0.50	0.50	1.00	0.63	0.25
Radio beacons RC type and on request	1.00	0.00	0.00	0.00	0.00	0.00	0.17	0.25
Land radio systems	1.00	1.00	0.50	0.00	0.00	0.00	0.42	0.25
GPS / GLONASS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DGPS	1.00	1.00	1.00	1.00	0.00	1.00	0.83	0.25

a considerable disparity between the information coming from different sources about the real state of the navigation infrastructure. This also results in a reduction of the quality indicator Q_i of the navigation infrastructure group.

Conclusions

The analysis of the available information allows the author to conclude that the radio navigational system for direction finding on the NSR does not exist in practice. The operation of this system is not being maintained. Still-functioning devices are systematically dismissed from operation. It seems that this is due to the widespread use of satellite systems with relatively high accuracy, even in the absence of DGPS reference stations. The analysis found no coverage of terrestrial radio navigation systems in the eastern part of the Laptev Sea, the Chukchi Sea or the East Siberian Sea. The land-based radio navigation system RSDN of Russian origin is not of significant importance for ships other than Russian (which are currently in operation and already have installed this system). So there is no system for determining position that could replace the satellite systems GPS / GLONASS or verify obtained using them entry. As no guides for planning routes on the NSR are available, this makes it difficult to obtain information on floating stakes in advance.

Currently, the existing number of Racon type radar devices and their location does not provide coverage of the busiest passages and straits on the NSR. There are no Racon type radar devices on the Laptev Sea or the New Siberian Islands. Some of these devices have even been deactivated from operation in the last few years. Nautical publications warn of the dubious credibility of functioning radio beacons and radio navigational aids between the meridian 90 °E and the Bering Strait. This area covers almost the entire NSR route except the regions of the Kara Sea which are intensively used by companies extracting gas and oil. Only the main and widest NSR straits are provided with satisfactory navigation infrastructure. This suggests underinvestment and a large backlog of investment in Russia. This is noticeable primarily in the area of responsibility for the eastern branch of the Marine Operations Headquarters that consists of the Laptev Sea, the East Siberian Sea and the Chukchi Sea.

The analysis of the navigation infrastructure available on the NSR, as well as the nautical publications and the navigational warnings available for the NSR, show that knowledge of the Russian language is required in order to use the most accurate data, the recommended nautical charts and publications and also to understand the Russian Notices to Mariners and the Russian Coastal Warnings that are in the Russian language. This places crews who do not have a comprehensive understanding of the Russian language in a worse competitive position in the global labor market. In order to know the current state of terrestrial aids to navigation on the NSR it is absolutely necessary to have ongoing access to the Russian Notices to Mariners and Navigational Warnings. It appears that safe shipping in this area is impossible without this knowledge.

The value of the navigation infrastructure quality indicator obtained on the basis of the above analysis is very low. Navigators who gather information at the initial stage of voyage planning may be misled when using nautical publications coming from only one global producer of charts and publications. If the navigator acts prudently, as required by normal good seamanship, and familiarizes themselves with information from two or three global producers of nautical charts and publications, the divergent information is likely to leave them disoriented. It seems that before the voyage begins, and preferably before planning a voyage, the master or owner of the vessel intending to carry out a voyage on the NSR should first access the most current local knowledge from the branch of the Northern Sea Route Marine Operations Headquarters. Information relating to where the most current and reliable information for initial voyage planning is to be found, should also be obtained here.

The above analysis is a research study and is designed for those concerned with issues of navigation on the NSR. The references used were classified as official nautical publications, approved by the institutions responsible for the safety of navigation. This applies both to those familiar with this subject and those trying to become acquainted with this subject. For people familiar with the subject, many things may seem logical and self-explanatory. For those who are not familiar with the subject, numerous doubts, uncertainties or incorrect conclusions are likely to be raised. The author therefore presented the content of the work so that it meets the needs of both groups concerned. The official nautical publications from the NSR coastal state are practically inaccessible to researchers, the maritime community, national and international shipping companies and decision-makers who are considering the possibility or economic efficiency of launching new shipping lines, who are unfamiliar with the Russian language. Therefore, this work introduces professionals to the issue of acquiring this information from the coastal state of the NSR. It should be noted that the currently unavailable GUNiO publication (GUNiO, 1996) was only released in two languages – Russian and English. Those interested may be surprised that all currently available GUNiO / UNiO publications are issued only in the Russian language.

The work also indicates the most important sources of information and points out deficiencies of navigation infrastructure and discrepancies in the relevant information provided by the main providers of nautical publications. In this way, decision-makers, politicians, practitioners and planners gain the ability to not only read the information on the NSR from a single source, but can also assess the reliability, completeness and uncertainties associated with the use of these sources of information when making key decisions with a long-range economic timeframe. The practical results of this work also indicate the institutions from which planners should seek official information and what one should pay attention to when preparing a set of questions for clarification.

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