IMPACT OF THE GLOBAL WARMING ON SHIP NAVIGATION IN POLAR AREA

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ABSTRACT

Generally, navigating in polar areas has always been one of the most dangerous voyages. The main reason for the increased risk derives from ice, but also from the other unfavorable navigation conditions that occurs in the high northern and southern latitudes, for example: very low temperatures, ice-covered coastlines, sparse population, inability to escape from danger, difficult communication and positioning etc. So far, maritime traffic in area of high latitudes has been relatively small, and the main reason for this can be found in the absence of major ports in this region, and in the inability to use certain routes because of ice. However, significant changes are happening in the last few years, and those changes have announced a brand new role of polar areas in terms of new main routes for merchant ships, especially in Arctic area. These changes have occurred as a result of the increasing exploitation of mineral resources in the polar areas, the exploiting of fish stocks, development of tourism, military and political objectives, etc., including the development of modern technologies that enables us to use, and the people that are living and working in extreme polar conditions. All this is further encouraged by global warming and consequent melting of ice. Precisely, the melting of ice has opened the possibility of using new routes for ships, which today represents completely new challenges for the global shipping industry. This article handles the basic geographical and climatological characteristics of polar areas, maritime transport, and the impact of global warming on the possibility of opening new routes, including existing and upcoming changes in legal regulations for maritime navigation in this area. Special emphasis will be given to the new demands which are being placed in front of crew that are sailing in area of high latitudes.

KEY WORDS
polar areas, global warming, a new route for ships, crew training.

1. INTRODUCTION

Borders defined by IMO (International Maritime

the southern coast from Jan Mayen towards the island of Bjørnøya, Svalbard all the way to Kanin Nos, and from Kanin Nos it follows the north coast

° 00,0' N, λ = 056 ° 37,1 'W) to P5 (φ = 058 ° 00,0' N ; λ = 042° 00,0 'W). (Figure 1)
The Antarctic waters are the waters south of 60° 00,0´S. (Figure 2)

Waters covered with ice are the polar waters where ice conditions represent a threat to the ships.

Figure 1. Borders on Arctic defined by IMO [40.]

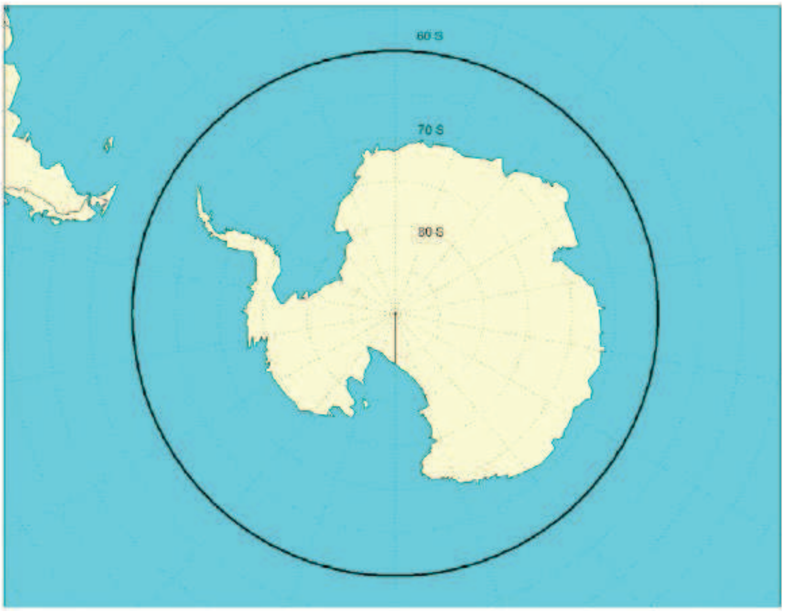

Figure 2. Borders on Antarctic defined by IMO [40.]

2. NAVIGATION PROBLEMS IN THE HIGH LATITUDES

The navigation in the polar areas can be difficult due to the lack of the vast number of the navigation devices. Natural land marks may not be shown on the map, or it could be difficult to identify it. Also the occurrence of certain changes in land can be changed under ice conditions. When snow covers the coast and extends for miles towards the sea, even the shore is hard to spot.

Ships navigating in the areas of the Arctic and the Antarctic are exposed to many risks and perils. Cold temperatures in these areas can reduce the effectiveness or even cause the interruption of function of some components on the board. Search and Rescue (SAR) operations or oil pollution operation can be very complicated and expensive due to the harsh conditions and the distance of the area. Navigation in these areas is a real challenge to mariners due to bad weather conditions, the relative reliability of navigational charts for the polar region, the interference of communication systems and the impact of harsh conditions on other navigational aids.

Not many geodetic measurements have been made in these areas and so the nautical charts for polar region are less reliable compared to the charts for other regions. Since not many depth measurements were made in this area, ships that enter the port often send boats ahead to check the depth of the water in front of them. However, the reliability of nautical charts in the Polar Regions improves constantly as new information becomes available.

Sky waves of Loran C are available throughout the Arctic, and ground waves only in some parts of Arctic. Ground waves and sky waves are not available in Antarctica. [35] Radar is useful, but the interpretation of range in Polar Regions is important for reliable results. Radio direction finder is useful only when radio signals are available. The use of electronics in the Polar Regions is further limited by magnetic storms, which are particularly severe in the auroral zones. [35]

There are difficulties in determining dead reckoning position in Polar Regions because the reliability of dead reckoning position depends on the availability of the precise measurements of direction and distance, or speed and time measurements. The direction is measured by compass. The magnetic compass becomes unreliable near the Earth's magnetic pole, and the gyro compass when seeking north becomes unstable near the Earth's poles. One of solutions may be the use of directional gyro (and inertial systems) which maintains its own axis in a certain direction, but must be returned at regular intervals, because of the gyroscopic drift.

In Polar Regions celestial navigation may be of great importance, and sometimes the only way to determine the position, or establish reference direction. When navigating at lower latitudes, navigators generally avoid observing bodies near the horizon because of the uncertainty of refractive correction. However, although the refractive refraction is uncertain, navigators often have no choice. Near the equinox the Sun may be the only body available in a few weeks, and it remains close to the horizon.During the polar summer the Sun is often the only celestial body that is available. In situations when only one celestial body is available, that body is observed in intervals.

Measuring distance or speed in the polar region does not represent a problem for airplanes, but it does for ships. When ships navigate in ice-covered waters, the sensor can be negatively affected or damaged by ice.

Determination of dead reckoning position for ships that navigate in ice-covered waters is problematic, not because of difficulties in measuring the course and speed, but of the fact that none of these two elements can not be constant for a long time.

During the developing of passage plan for Polar Regions, special attention should be paid to environmental protection, limited resources, and navigation information.

Passage plan should include the following factors:

- safe areas,
- no-go areas,
- overview of maritime corridors and contingency plans for the regions far from SAR areas,
- situations when it is not safe to enter the areas covered with ice or icebergs,
- safety distance from icebergs, and
- safety speed in those areas.

Country	Oil (bbs)	% World	Gas (tem)	% World
United States	30,9	2,2	7,7	4,1
Canada	32,1	2,3	1,7	0,9
Russia	77,4	5,6	44,8	23,9
Norway	6,7	0,5	2,0	1,1
Arctic states total	147,1	10,6	56,2	30,0
World total	1383,2	100,0	187,1	100,0

Table 1. World reserves of oil and gas in 2010

3. DEVELOPMENT OF MARITIME INDUSTRY IN POLAR REGIONS

According to the research, the Arctic can contain up to 20% of world's undiscovered resources of carbohydrate.[7] Of all the resources, it is believed that 84% are to be found in off-shore waters, i.e. in the waters where water depth is lower than 500m. Although these resources have not been discovered yet, they incite significant industrial activities in the Arctic region. Other industrial sectors also see diverse possibilities in this region, for example: excavation of rare minerals from the ground, fish abundance and the growth of tourism.
Exploitation operations of oil and gas in the Arctic are more demanding than in the North Sea, because of the harder working conditions in the Arctic. Extremely low temperatures and long periods of darkness create extremely difficult working conditions for the staff. However, such harsh conditions can affect the characteristics of materials and equipment performance and functionality. The harsh conditions may reduce the functionality and availability of safety barrier if not operated correctly.
Increase of activities in various industries in the Polar Regions is expected in next few years. International cooperation in such areas would lead to greater productivity and also reduce the possibility of maritime accidents, increase the efficiency of search and rescue operations, etc. In long term, further editing regulations, technologies and standards adapted to hard conditions of Arctic are way forward to achieve an acceptable level of risk for working on the Arctic. [33]
The number of seismic drilling operations in the Arctic is increasing each year. The future projects are based on the exportation of natural gas and minerals from the ice covered parts in the Arctic where the high technology ships are being used. After 40 years of negotiations, in 2010. Norway and Russia have agreed on Barents Sea border, which have opened up large areas for new seismic studies and the potential discovery of new oil and gas fields.
Areas of Antarctica and Arctic are not yet fully explored and additional data on resources, ice and weather conditions in this area are needed. Advanced studies and researches as well as systematic data collection will be of utmost importance for the prediction and risk management in the Arctic. Also according to the instructions of IMO Polar Code, companies are required to prepare their ships and to invest in education and training of staff in these areas.

4. GLOBAL WARMING AND CLIMATE CHANGES

4.1. Arctic

One of the world's leading ice specialists predicted the final collapse of Arctic sea ice in summer within five to ten years. What experts call a "global catastrophe" takes place in the far northern areas of high latitudes. Marine area each year freezes and melts at the lowest extent ever recorded.
Global warming is the result. Researches have shown that during the winter period the growth of ice decreases every year and during the summer months there is an increase in ice melting. In the summer months in 2011 the sea temperature in the Arctic was 7°C, which is too high for this area.
Given the above situation, urgent measures are needed to reduce global warming. However, on the other hand, the continuous increase of temperature in these areas causes ice melting and makes possible the opening of new geo traffic routes that will contribute to increase of marine traffic i.e., the

transport of goods in these areas. In this way new areas would be created where seismic explorations would be performed, and new sources of gas and oil would be discovered.

The satellite pictures of the Arctic from 2012, that were taken by National Aeronautics and Space Administration (NASA) Earth Observatory shows that the ice surface has reached its lowest level. Ice measurements in the Arctic have begun in 1979, and according to the recent results the amount of ice in the Arctic is 50% below average. On the photos taken by NASA we can see the amount of ice on 13/9/84 compared to amount of ice on the 14/9/12. (Figure 3)

According to data from The National Snow and Ice Data Center (NSIDC) in Boulder, Colorado, Arctic sea ice fell to its lowest level of 3.4 million square kilometers (1.32 million square miles) in 2012. This value is the lowest since satellites began to provide data in 1979. Average minimum ice extent for the period 1979 to 2000 was 6.7 million square kilometers (2.59 million square miles). [11]

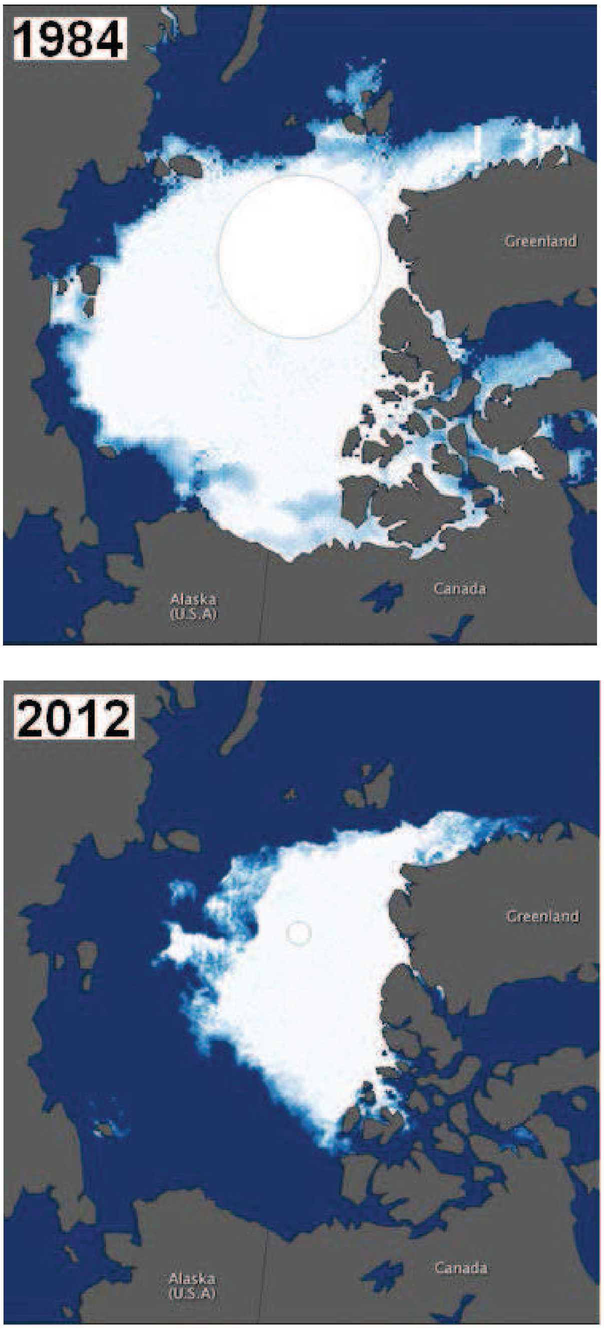

Figure 3. Satellite images of the Arctic ice from NASA Earth Observatory [11.]

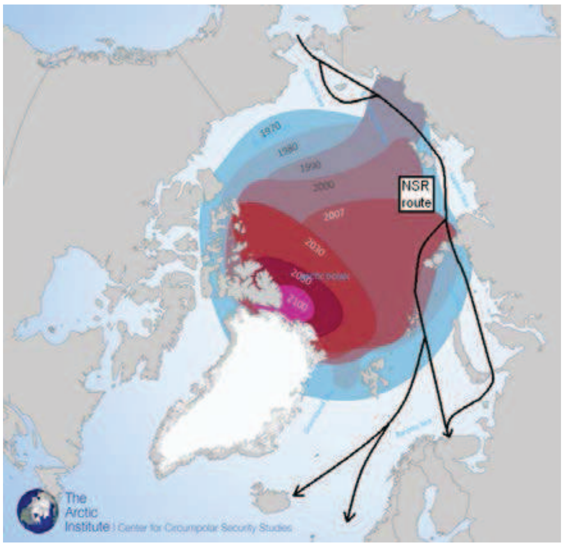

Figure 4. Further decline of ice in the eastern Arctic will reflect positively on the NSR route [15.]

A new study by the National Aeronautics and Space Administration (NASA) shows that the old thicker ice is disappearing faster than the newly created thinner ice. Furthermore, the distribution of the remaining summer ice will not be uniform across the Arctic Ocean. Studies show that the sea ice will continue to accumulate, mostly along the northern part of the Canadian Archipelago and Greenland, while the central and eastern part of the Arctic will be impacted as a significant decrease in ice. This case Northern Sea Route (NSR) route will last 141 days, from early July to mid-November. (Figure 4).

As regards to maritime transport, the global warming will have the most impact on the Arctic. According to the Climate Impact Assessment (ACIA) reducing the level of ice in the Arctic is very likely, and thus the increase of sea transport in these areas and the approaching of new sources for industry to exploit natural resources.

Intra-Arctic1 and trans-Arctic2 shipping may provide alternative solutions to new and shorter shipping routes versus using much longer routes for transportation, such as through the Panama and Suez Canal or the Arctic routes which are partly on land and partly by sea. (Figure 5)

It should be borne in mind that although in the future the summer will be without sea ice, the sea ice will continue to be present in the Arctic Ocean in lesser extent, but various other factors can affect the aggravation of navigation in these area.

Figure 5. The ratio of the length of navigable waterways between the Northern Sea Passage (NSR) and the Southern Sea Passage (SSR) [41.]

It can be expected that in the near future the high hydrocarbon prices will lead to a greater use of shorter trans-Arctic routes, and thus the increase of vessel traffic in these areas. It is also expected the increase of exploration and exploitation of hydrocarbon resources in the Arctic, that will contribute to increase of maritime transport in the Arctic marine area. A key role will have risk-assessments of classification societies and marine insurance industry for the economic viability of all sectors of shipping in Arctic Sea.

4.2. Antarctic

The concentration of sea ice in the Antarctic 2008 was 4.4% higher than in 1979 when satellite measurements began at the poles. In November 2008 the sea ice surface was 16.6 million square miles, and in November 1979 it was 15.9 million

[1] Intra-Arctic is navigation between two places in the Arctic Ocean, for example between Dudinka and Murmansk.

[2] Trans-Arctic shipping is navigation between the ports in the Pacific and the Atlantic Ocean that goes via the Arctic Ocean, for example between ports in Japan and ports in Germany, via Northeast Passage.

square miles. Sea ice concentration shows an equal increase of 11.2 million square kilometers in 1979, to 11.7 million square kilometers in 2008. [7] Apparently the southern hemisphere is not suffering from global warming. Satellite measurements show an increase of sea ice in Antarctic (Figure 6).

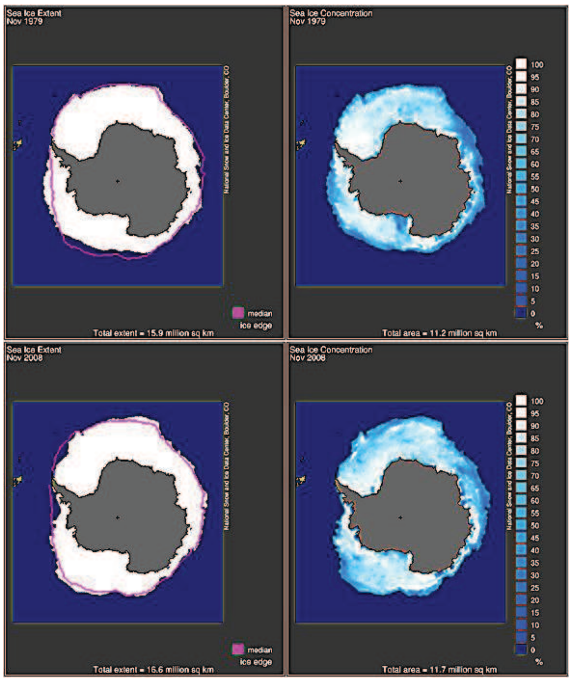

Figure 6. The concentration of ice in Antarctica through periodic measurements by satellite[14.]

According to National Oceanic and Atmospheric Administration (NOAA) GISS data winter temperatures in Antarctica have dropped by 1° F compared to 1957, where the coldest year was in 2004. [14] Anomalies of sea ice from 1979 to 2012 in the Arctic and Antarctic are shown in Figure 7. It can be seen that the sea ice from 1979 to 2012 has greatly reduced, while in Antarctica experienced a slight increase. Thick lines indicate 12-month running means, and thin lines ne monthly anomalies. [14]

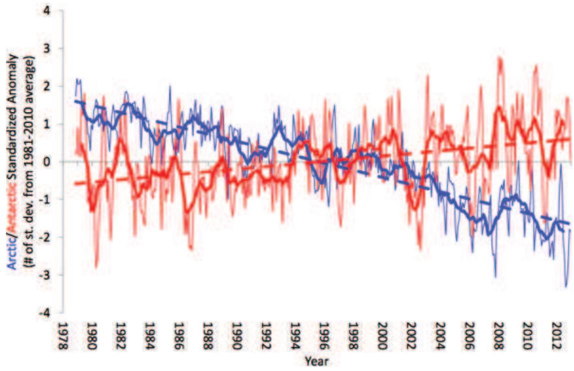

Figure 7. Arctic and Antarctic Sea Ice Extent Anomalies, 1979-2012;

Antarctica is also warming up, but not as fast as the rest of the world since it is colder. Also there is a difference of ozone loss in the stratosphere over Antarctica, which results in colder stratosphere. [30]
The amount of ice on the Arctic is decreasing, while on the Antarctic is increasing. The reason lies in fact that the North Pole consists of ocean, so that ice on the Arctic moves beyond the usual areas, that's why the consequences of warming atmosphere and ocean can be seen on the Arctic. Antarctica is a continent that is isolated from the rest of the world and has its own climate system. Winds in Antarctica blow in a clockwise direction but in a way that they make some kind of protective layer surrounding the land. For this reason the Antarctica is also warming up, but not as fast as the North Pole. [30]

5. TYPES OF MERCHANT SHIPS OPERATING IN POLAR REGIONS

Tankers have a very important role in the transport of crude oil and other forms of liquid cargo in areas such as the Arctic, Russia and several European parts in which is difficult to navigate during the winter period, where the water surfaces are covered with thick layers of ice. All ships that pass through those areas requiring assistance from icebreakers which are going forward and breaking thick layers of ice. This type of assistance from icebreakers requires additional costs for the company because they have to pay for such services.

For this reason it is important to mention DAS (Double acting ship) and DAT (Double acting tankers) ships that companies are using to reduce their costs, while navigating in polar areas. These are types of ships that are specially designed for sailing in the waters covered by thin ice. However, they can change direction and continue to drive astern in heavy ice conditions.

These vessels can operate in areas covered by ice without icebreaker assistance, and also have better performance in open water than ice breakers. Therefore, these ships were constructed to break the ice with the stern, and to navigate in open waters with bow. (Figure 8)

In order to avoid additional expenses and to enable ships to navigate in the waters that are covered by thick ice like in Russia, Canada or north Europe, without the assistance of icebreaker, the DAS and DAT ships are being used. DAT tanker can break and navigate in thick ice even without the help of ice breakers. The first such DAT tanker "Tempera" was delivered to shipping company in 2002. [38]

Double acting tanker navigates in the forward direction as any other ship. However, when it comes to breaking the ice, the ship is moving astern. The aft part of the hull structure is composed of special reinforced double skin with a fatigue life of around 40 years. [38]

Figure 8. The aft part of the hull structure in double acting ships is composed of special reinforced with a double skin which breaks the ice when moving astern [37.]

With these ships, conventional rudder and propeller were replaced with Azipod system that can achieve speeds above 15 knots. Azipod system consists of a high-power electric motor and a fixed pitch propeller that can rotate 360 degrees. Also on these ships a bow thrusters are added to provide excellent maneuverability in narrow channels and harbors. This design allows the DAT to reach speeds of more than 2 knots over the ice sheets thicker than 1mm when they drive astern. Propulsion on these ships is being used to generate streams of water between the hull and ice that lubricates the contact surface and reduces friction hull. [37]

Double acting ships are able to direct the propeller water flow to crush the ice and push it away. In this way, double acting ships navigate through the sea surface covered by ice without icebreaker assistance. [37]

In this kind of ships all bunker tanks are made of double hull because the main parts of stern are in contact with ice. The coffer dam and pump room are also protected by a double hull. [37]

6. EXISTING MARITIME TRAFFIC AND ITS ANALYSIS

Northeast Passage (NEP): connects the Atlantic Ocean and the Pacific Ocean in the north coast of Eurasia, from Murmansk to the Bering Strait. Northern Sea Route (NSR): NSR is known by its Russian name. The difference between NEP and NSR is that NEP includes NSR including Barents Sea. (Figure 9) According to the data from 2011, during the summer months in the Northeast Passage (NEP) more than 835000 t of cargo was transported (Table 2). That number can only increase over the next few years, taking into account the annual decline of ice in the Arctic. The North West Passage (NWP) was the first without ice in 2007. If the global warming effects continue, the Transpolar Sea Route (TSR) could also be opened for the merchant ships in the upcoming decades. The development of the offshore industry in the Arctic will contribute to the improvement of the economic activities and the integration of the Arctic economy into the global trade. With global warming, the Trans-Arctic routes could provide new and additional capacity for the growing marine traffic in years to come.

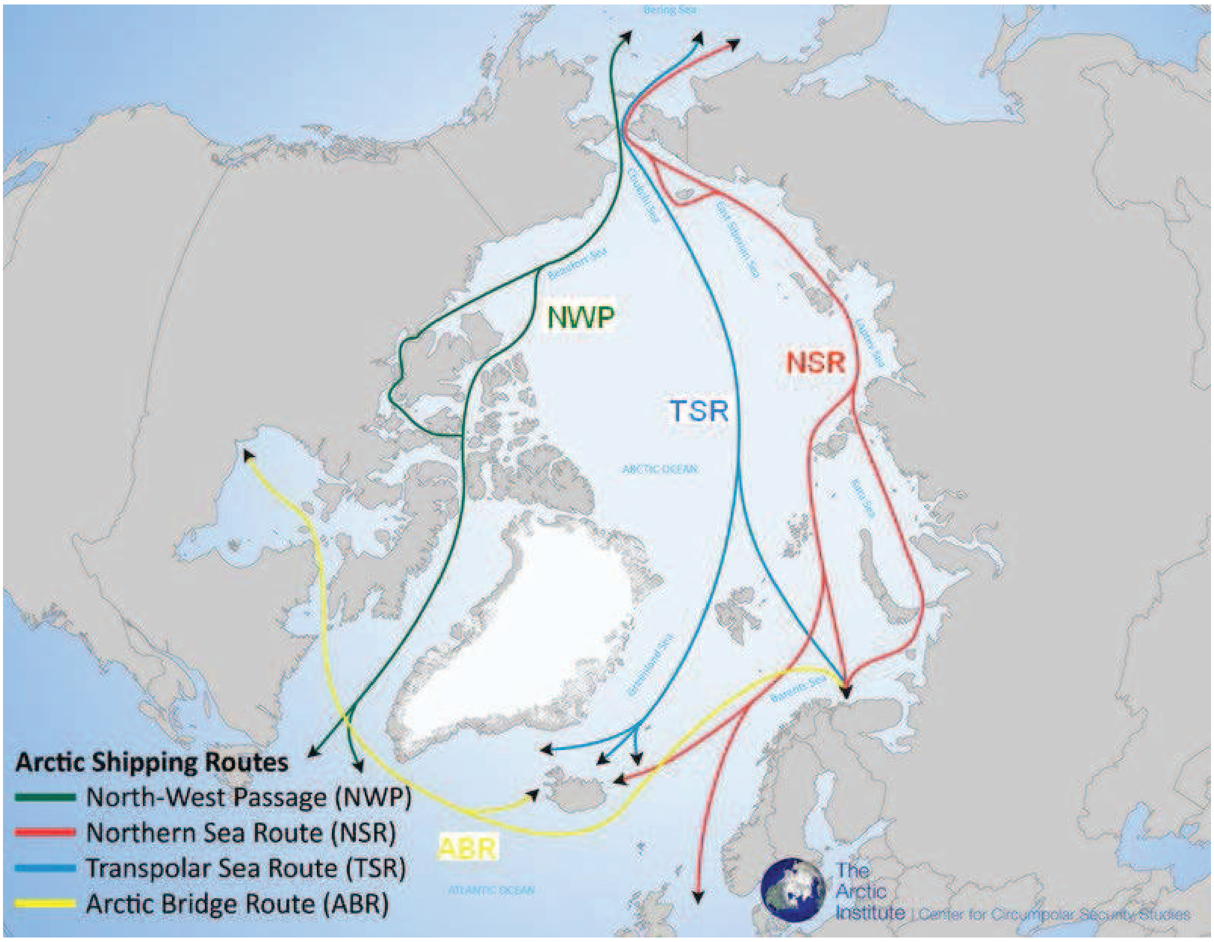

Figure 9. Arctic Shipping Routes [15.]

The main barriers for navigation in polar areas are floating ice and icebergs, especially during the warmer season when the ice begins to melt. Navigating through the Arctic the ships will save on distance, time and fuel. The energetic efficiency would improve while navigating from one port to another.

Savings on the way through the Arctic waterways is up to 40% compared to traditional routes, for example through the Suez Canal. Also smaller distance provides better efficiency in transport, so that the ship made multiple trips from one port to another which eventually resulted in higher profits for the shipping company.

Volume of transit cargoes transported on the Northeast Passage in 2011		
Cargo	Volume ton	Voyages
Gas condensate	600607	9
Kerosene	64500	1
Disel fuel	21409	5
Iron ore concentrate	109950	3
Fish	27535	4
General cargo	10930	4
Total	834931	26

Table 2. Volume of transit cargoes through Northeast Passage in 2011

Also the decrease of speed through shorter way will translate into a reduction of fuel consumption, i.e. energy efficiency would increase, and thus reduce of CO2 into the atmosphere.
However, the main problem in safety of navigation in the Arctic will remain in lack of reliable weather forecasts, icebergs (especially at the beginning of the warmer season when the ice begins to melt), and weather conditions. Ship operations in this area depend on three key factors: predictability, accuracy and economy. The lack of schedule reliability and highly variable transit routes along the Arctic, are major barriers to the development of shipping in the Arctic. Navigable waterways in the Arctic are the subject of restrictions and limitations on draft and traffic direction.

For example, ships from the Northern Sea Route (NSR) have to pass through many shallow and tight straits in Kara and Laptev Sea. Navigation through NSR begins at the port Murmansk in the south of the Barents' sea, and it proceeds through the Yugorsky Strait (Width: from 1.6 n.m. to 5 n.m.) or Kara Strait (width of the canal: 30 n.m.) until the Kara Sea. After the Kara Sea there is the canal Vilk'itskii Strait (canal's length: 60 n.m.; depth: from 12 to 30 m). After entering the Laptev Sea, the ships need to navigate through Dmitry Laptev Strait (Cnals' length: 63 n.m.; canal's width: 30 n.m.; width: from 10 to 14m) or through Sannikov Strait (canal's width: 30 n.m., depth from 10 to 20 m) to enter East Siberian Sea. [3] (Figure 10).

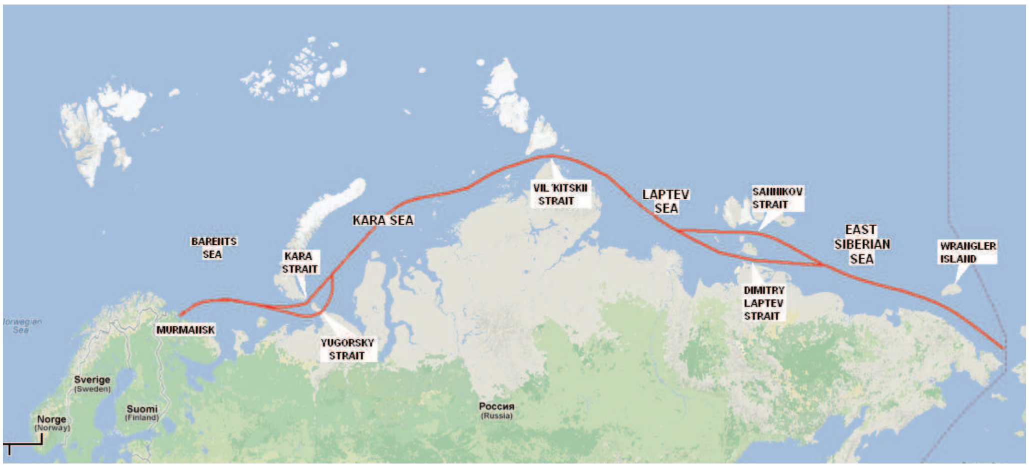

Figure 10. Ships in Northen Sea Route (NSR) must pass through a series of narrow passages and shallow straits

The Northern Sea Route is mostly free of ice. Russians have recognized this advantage and send many ships through that route, including the largest tanker ever went through that route.

Shipping in the Arctic is becoming a reality and all Arctic nations must be ready to take advantage that opportunity.

On the other hand, there is the Northwest Passage (NWP) for the ships, but the biggest problem of this passage is the disputable sovereignty over waters which might complicate the future of ships traffic in this passage. The Canadian government considers that this passage is a part of Canadian internal waters, while the USA and many other European countries claim that this passage is an international strait or a transit passage that enables free and easy maritime navigation. [39]

Until 2009, the Arctic ice prevented regular passage of ships most time of the year. However, the situation has changed with the effect of global warming. It must be mentioned that out of three sea routes, Northwest Passage (NWP), North Sea Route (NSR), Transpolar Sea Route (TSR), the Northwest Passage (NWP) was the first one to lose ice and to become available for the ships in 2007.

The Northwest Passage (NWP) is considered to be a passage that connects islands and Canada, rather than a real navigating path. From the historical point of view the Northwest Passage is better known as Strait of Anian, and which is the Spanish name for the passage that was believed to connect the Pacific and the North Atlantic in the 16th century, and was the famous trading route. This passage allows navigation from the North Atlantic Ocean, through the David Strait between Canada and Greenland continuing through the Arctic Archipelago to Beaufort Sea. Passage continues through the Chukchi Sea and the Bering Strait into the Pacific Ocean. There are always new potential routes for ships because of numerous islands in Arctic Archipelago. However, in some straits is better to navigate than in others due to the formation of land under water.

Arctic marine shipping mostly consists of waters within the Arctic, which dominated the summer from the Canadian Arctic side and from the east and west coast of Greenland. Year-round Arctic sea transport in the Russian Arctic is maintained between port Dudinka on the Yenisey River and Murmansk from 1978 to 1979. Since 2000, there have been only a small number of trans-Arctic voyages in the summer months for scientific research, and cruiser tourism across the Northwest Passage (NWR).

Not so long ago, there was an increase of explorations done by the ship in the Northwest Passage and Beaufort Sea, because of the consequences of climate change in the Arctic marine ecosystem. Since the 1980s travelling through this passage has become an annual event. Canadian Coast Guard icebreakers that operate in the Beaufort Sea on an annual basis since 2002 are providing assistance in navigation and assistance in carrying out researches. Since 1980s, tugboats, supply ships and tourist ships have used Northwest Passage. The commercial use of these ships, as well as the cruising tourism in the Arctic is increasing each year. [31]

Based on the latest research, the number of ships that pass through the Northwest Passage has increased from 4 to 20 per year in the period of 2009-2011. The ships that navigate in NWP are mainly coastguard icebreakers, investigation ships, tourist ships, tugboats and supply vessels. Other ships that navigate through this passage are oil tankers, seismic vessels, and cable vessels and buoy tenders. (Figure 11)

When looking from the late 1980s, most of the increase in the ships transit was due to increased activity of tug-supply vessels involved in the oil and gas industry in the Beaufort Sea. Their growth over the last ten years, we can see in Figure 11. When navigating through Northwest Passage, the vast majority of ships usually begin their journey through Beufort Admundsen Gulf (northwestern territory of Canada). It should be noted that only 11% of ships transit entering or leaving the Beaufort Sea are passing around Banks Island when navigating Northwest Passage route. Statistics of the annual number and types of ships passing through the Northwest Passage can be seen in Figure 11.

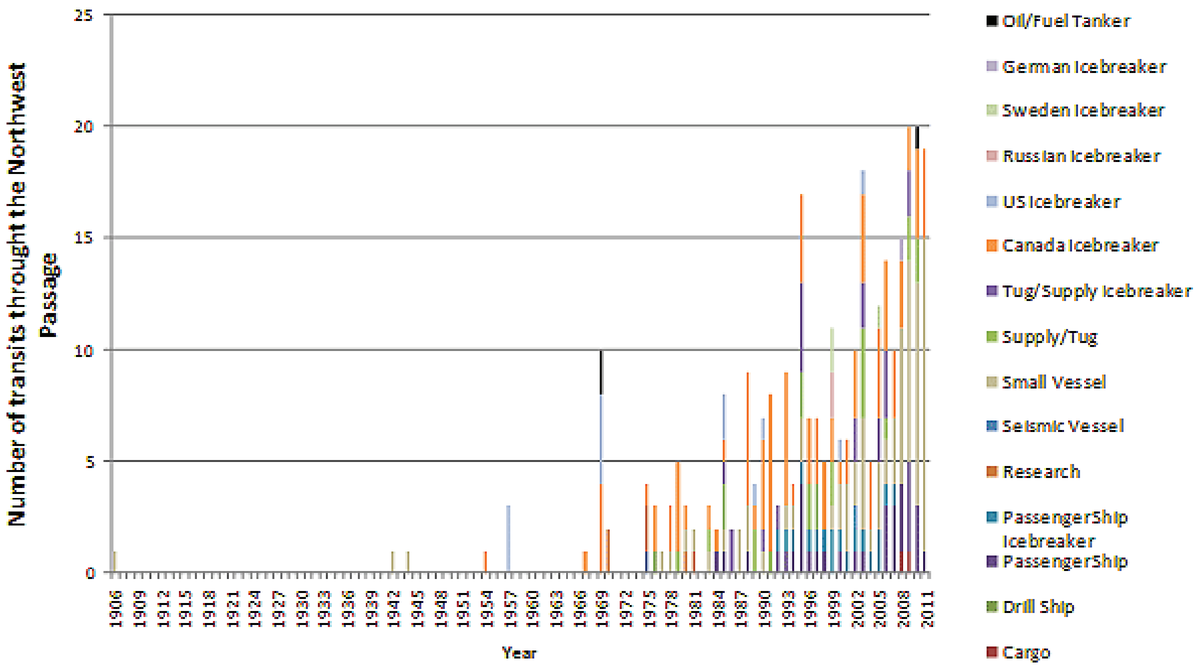

Figure 11. Annual statistics of type and number of ships passing through the Northwest Passage (NWP)

It should be mentioned that the amount of ice melting in the last few decades in the Arctic has fallen notably. According to the predictions, ice melting in the Arctic will continue and this will turn the Arctic waters into navigation passages. When the amounts of ice reduce in thw Arctic, further increasing of maritime transportation can be expected. When this will happen is still uncertain, and it depends on further climate change. However, given the economic challenges of the region, in the future the Arctic shipping will be profitable only for a limited number of operators.

7. MARITIME LEGISLATION

Present activities that are organized by IMO related to the navigation in Polar Regions can be found in "International Code of Safety for Ships Operating in Polar Waters".
Requirements contained in the IMO Conventions and in related codes, guidelines and recommendations are introduced and briefly explained in:
SOLAS (International Convention on the Safety of Life at Sea), safety requirements – relate to all ships that are part of "Convention operating in Polar waters". Chapter number V is especially important because it addresses safety requirements of navigation. Regulation V/5 : Meteorological services and warnings ; Regulation V/6: Ice Patrol Service ; Regulations V/31 and V/32: Danger messages
MARPOL (International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978). It covers necessary environmental protection for Antarctic and Arctic. They belong to special protected areas (Special Areas). Additional MARPOL measures can be found in Chapter 9, Annex I, and they refer to ˝Carriage of heavy grade oils in the Antarctic area˝ that entered into force in August 2011.
STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978) requirements. Adopted guidelines and recommendations for training and competency of officers and crew members on ships in the Polar Regions. Current recommendations and guidelines are important for the officers and crew members on board so they would have the necessary experience in the polar region. These are also the measures where the masters and officers who operate in the

polar region had the necessary training and experience.

UNICLOS (United Nations Convention on the Law of the Sea) – a legal framework for rights and responsibilities of the nations in their use of the world's oceans. The convention entered into force in 1994, and 162 countries have signed it so far. It is a legal framework that regulates rights and responsibilities of the countries that use the sea.

Torremolinos Protocol of 1993 to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (Terremolinos Protocol). Regulation III/8 is especially important – Ice accretion – Icing allowances for stability calculations, ship designed to minimize ice accretion, means for removing ice.

8. CONCLUSION

Ships navigating in the Polar Regions may be exposed to numerous risks and dangerous. Such areas have not been fully explored and additional data on resources, ice and weather conditions needs to be made. Advanced studies and researches in polar areas will be of vital importance for the safety of navigation.

If there is a rise in temperature at the poles, global warming will mostly affect the Arctic where the new routes for ships will be created as alternative to longer routes, such as those that pass through the Panama and Suez Canal. The increase of maritime traffic in these areas will lead to increased exploration and exploitation of hydrocarbon reserves in the Arctic. The main barriers to navigation in Polar Regions may be the lack of reliable weather forecasts, floating ice and icebergs, especially during the warm season when the ice begins to melt. Navigating through the Arctic the ships will shorten their route, save on time and fuel. The energetic efficiency would improve while navigating from one port to another.

After several years of research it was discovered that in the past few decades, sea ice melting in the Arctic was in significant decline, so that over the last few years the maritime traffic has increased through NWP and NEP.

According to the further predictions, if melting of ice in the Arctic continues, the water in that area will transform into true navigational waterways. When this scenario could be expected is still uncertain and depends on further climate change. If the predictions of global warming come true and the amount of ice in the Arctic reduces, it could be expected that new areas for seismic exploration and extraction of oil and gas from new sources will be discovered. On the other hand it will also be possible to open the new geo traffic navigational routes for ships that will contribute to increase marine traffic in these areas.

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BIOGRAPHIES

Stipe Galić was born 25.04.1981 in Split, Croatia. Elementary School "Josip Pupačić" completed in 1995 in Omiš. Electro technical secondary school "Jure Kaštelan" finished in 1999 in Omiš. In year 2006 was graduated on Faculty of Maritime Studies of Split, field: Nautical studies, in duration of four years. From 2007 to 2010 he was working on merchant vessels. At end of 2010 he was working as a collaborator for the Faculty of Maritime Studies of Split. In early 2011 he laid a distinctive program and gained the title: Magister engineer. At end of 2011 he is employed as an assistant at the Faculty of Maritime Studies, and was subsequently enrolled in post-graduate studies "Technological Systems in Traffic and Transport" on Faculty of Transport and Traffic Sciences in Zagreb.

Dr.sc. Zvonimir Lušić was born on 06.12.1971 in Trogir, Croatia. Elementary school in Rogoznica completed in 1986. Maritime and military secondary school finished in Split in 1990. Higher Maritime School in Split finished in 1993 and in

1997 was graduated on Faculty of Maritime Studies of Split, field: Nautical studies, in duration of four years. From 1996 to 2002 he was working as an officer on merchant ships, and from 2003 to 2005 he was working as a crew agent for Hanseatic Shipping Company from Cyprus. From 2002 to 2005 he was working as a subcontractor for faculty of Maritime Studies of Split, and since 2005 he is working as a permanent employee in the workplace as lecturer in the navigation group of subjects. Master's degree finished in 2006, and doctoral studies completed in 2010 on the Faculty of Maritime Studies of Rijeka, field: technical sciences, the field of traffic technology and transport, maritime and river transport.

Danijel Pusić was born 16.06.70 in Split, Croatia. He finished elementary and secondary nautical school in Split. From 1991 to 1996 he was working as an officer on merchant ships. Since 1997 he is employed in the Hydrographic Institute of the Republic Croatia as a nautical system support adviser. In academic year 2006/2007 graduated at the Faculty of Maritime Studies in Split, field: Nautical studies in duration of three years. In academic year 2008/2009 graduated at the Faculty of Maritime Studies in Split, field: Nautical studies in duration of two years and gained the title: Magister engineer. Since January 2010 he is hired part time as an assistant lecture at the Faculty of Maritime Studies. He is a member of the Croatian Chamber of traffic engineering technology - class maritime transportation and traffic engineers in the Inland Waterway.