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Ice formation on a vessel

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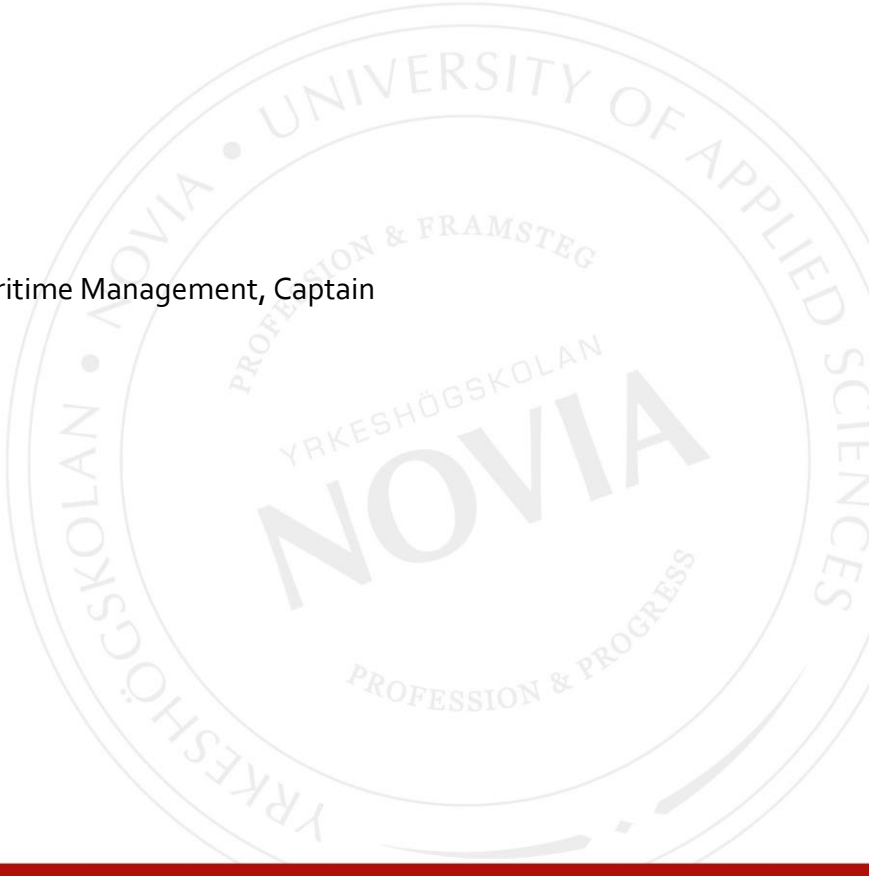

BACHELOR'S THESIS

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Abstract

Northern Europe in winter can present certain problems for sailors who are accustomed to navigating southern waters. Snow storms, frozen bays, drifting ice, low temperatures, etc. For the navigator, these and some other winter weather conditions can cause problems in the fast and safe operation of the boat.

My aim is to answer the question What methods are used to prevent and fight ice formation on a vessel. To clarify the specifics of working with an ice-covered deck, I conducted research work by studying various web-sites and conducting a survey to people who have extensive experience in working at sea and also my personal experience. The people I interviewed are highly qualified crew members. They have lived and worked most of their lives in this region and you can rely on their experience. In addition, different web-sites I use are time-tested and they describe in great detail the weather and ice conditions of the Baltic Sea.

At the end of my thesis, I was able to answer to my research questions that can help the navigator enter cold waters. I was able to cover most of the topics and describe different methods for preventing and fighting ice formation on a vessel.

Language: English Key words: Ice, Navigation, Safety, North Europe, Baltic

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1 Introduction

1.1 Aim, research questions and delimitation

Significant ice formation on a ship or offshore facility can be devastating. A large accumulation of ice on the deck of a ship can lead to a colossal change in the stability of the ship and soon overturn it. You should always take into account unpredictable situations that will require a quick response and a good knowledge of the ship and maritime region.

My main goal is to find out all possible ways to deal with ice, if it happened so that icing could not be avoided and part of the vessel was covered with a thick layer of ice. Before starting my work, I needed to identify for myself the main research questions and methods of collecting information that will help to reveal in detail the topic of my thesis. The main research questions for me is What methods are used to prevent and fight ice formation on a vessel. In order to answer this and other questions, I worked with various Internet sources that are time-tested and reflect the real experience of the authors of article.

My thesis focuses primarily on trying to answer my research question exclusively by deck workers. I did not give access to my questionnaire to students and other people who have little experience at sea. It is also my goal to explore different ways of dealing with ice on board, but not the process of ice formation itself.

1.2 Introduction

Since in cold seasons, water droplets with a temperature of about zero, gradually cool the surface of the ship and after that the deck, superstructure and all upper structures become iced. In this case, there is a danger to both the vessel and the crew of the vessel. (Alekseev, 1960)

The vessel's buoyancy margin drops sharply and a negative effect on stability will appear. As a consequence of the colossal amount of ice on the deck, the vessel may take an unacceptable draft, heel or excessive trim to any extremity. To avoid the above problems, de-icing should be started as soon as possible to save the vessel. (Alekseev, 1960)

Ice can form in several ways. The first is when the spray of water freezes from bottom to top on the surface of the vessel. Ice build-up begins on the deck, superstructures, and then on the upper deckhouses. In such cases, with a headwind, the ice can increase in thickness

at a speed of 35 - 40 mm per hour, which can lead to a heel on the windy side. (Alekseev, 1960)

In the second case, ice begins to form as a result of cold rain hitting the cooled surface of the upper structures of the vessel. Since most of the ice forms on the superstructures of the vessel, the effect of ice on the stability of the vessel will be greater than when ice forms on the side of the vessel. Also, such ice formations can injure the crew of the vessel, because when the vessel vibrates, icicles and pieces of ice can fall on someone. It should be understood that ice formed from top to bottom can also damage the antennas and equipment of the vessel, therefore this is the second reason why such ice formation is dangerous. (Alekseev, 1960)

2 Main part

2.1 Meteorological characteristics

The maritime climate in temperate latitudes is characterized by high humidity, frequent precipitation, and cloudiness. Temperature in temperate latitudes varies slightly throughout the year. The climate in the open sea and the Gulf of Riga is milder than in the Gulf of Finland. The climate in the Gulf of Finland is influenced by the continent, in winter in this region it is cloudy, frequent precipitation, sometimes there are severe frosts, but short-term. wind in winter from s, sw and w, often stormy wind. (Meteorological characteristic, n.d.)

In the eastern part of the sea and in the bays, the wind speed is higher than near the coast, and the average monthly wind speed in autumn and winter is 5 - 8 m / s. Usually the direction of the winds at this time of the year is from SW, S and W, but sometimes from SE. In the region of the Gulf of Finland, short-term storms often occur in autumn and spring, their duration is from one to three days. Storm winds depend on cyclones, when a cyclone passes north of the Gulf of Finland, winds come from S and SW, subsequently the wind direction changes to W and NW. If the cyclone passes south of the Gulf of Finland, then the direction of the storm winds is from NE and E. (Meteorological characteristic, n.d.)

Rarely, there are clear and sunny days over the eastern part of the sea and bays, only 10 - 20%. Very cloudy in autumn and winter. At the same time of the year, there are often long rains in this area, from October to February 15-30%, on average 130-200 rainy days a year. (Meteorological characteristic, n.d.)

The average monthly temperature in winter ranges from -1 to -8 in the Gulf of Finland and from +1 to -3° in the eastern part of the sea. On the coldest days, the air temperature drops to -36 °, -42 ° in the bays and to -23 °, -34 ° in the eastern part of the sea. On rare days of thaw, the temperature rises, respectively, to 6 ° and 10-12 °. During the year in the open sea, the relative humidity varies from 80 to 90%. (Meteorological characteristic, n.d.)

2.2 Hydrological characteristics

The bay and coast along the east coast is mostly ice-covered from December to March, so the water temperature is at its lowest. The average monthly water temperature at this time of the year is from 0 ° to 6 °. (Hydrological characteristics, n.d.)

When the ice melts. then the bay warms up slowly, in May the water temperature on the surface in the open sea is about 7°, and off the coast 8° - 9°. In autumn, the water temperature begins to decrease slowly and by the beginning of winter (average monthly) the temperature in the bay drops to 2 - 4°, in the east 3 - 6°. (Hydrological characteristics, n.d.)

The salinity of the Gulf of Finland is low, in the east the water from the Neva River significantly freshens the sea and the salinity on the surface is about 1 - 3 ‰. In the west, the salinity of the Gulf of Finland increases to 5 - 6 ‰. The salinity of the surface water layer in the Bay of Gdansk is 7 ‰. When the ice melts in spring and continental streams of water flow from the coast, the salinity decreases slightly. In spring and summer, the density of water decreases slightly, in winter the density increases slightly. The density of the water in the Gulf of Finland is uneven, from 1.001 - 1.002 in the eastern part to 1.003 - 1.004 in the western part. The density of sea water in the east is from 1.003 to 1.006. (Hydrological characteristics, n.d.)

3 Onega

Figure 1 The Russian-flagged fishing trawler Onega (Sander696, 2020)

On 28 December 2020, the fishing vessel Onega sank in the Barents Sea, killing 17 crew members. As it soon became known, this tragedy is the result of a combination of several circumstances. As a result of the investigation, the commission found that the vessel sank due to the vessel's icing, which contributed to a decrease in initial stability. (DW, 2020)

It was concluded that the ship's master made an unjustified risk when he has decided to haul a line in difficult hydrometeorological conditions. Also, unprofessional actions of the ship's master and the chief officer, consisting in the lack of proper control over the stability and the late announcement of an alarm to abandon the ship. (DW, 2020)

This case shows how important it is to analyze the weather conditions before going to sea. Ice formation on a vessel can lead to dire consequences, so the crew members needed to take their responsibilities more seriously to avoid losing the vessel and their colleagues.

The captain and chief mate should always consider the following:

- equipment limitations
- ability to operate and maneuver a ship in cold weather
- be able to manage the safe operation of vessels operating in cold waters
- be able to maintain safety of the ship's crew and passengers
- knowledge of weather characteristics

4 Preparation

4.1 Ship preparation

Due to severe icing, the ice can add additional weight to the vessel, which is equivalent to additional weight on deck. In such cases, the roll, trim, and CG of the vessel can change dramatically and quickly.

Figure 2 Vessel looses stability due to heavy icing (Team, 2018)

It is very important to properly prepare the vessel before going out to sea so that ice removal from the deck is successful and safe. The solution to this problem can be the advance preparation of tools and devices of various types, such as shovels, crowbars, brooms, steam equipment, etc. The crew should not forget about personal protective equipment such as gloves, safety shoes, waterproof clothing, and it is important to use a stretcher to which you can attach yourself to prevent a fall. (PWOM, 2017)

In preparation for de-icing, you need to do the following:

1. check the fastening of tarpaulins on hatches of cargo holds and bunker hatches, as well as fastening of covers on boats and deck auxiliary machinery
2. prepare tools for breaking and removing ice
3. all external piping must be drained
4. stretch the handrail for people to hold on to during ice breaking
5. constantly remove new snow, preventing it from caking into a dense mass, since snow contributes to the formation of ice

4.2 Crew training

As soon as the formation of ice on the deck is noticed, an immediate fight against the ice begins. The goal is to remove all ice that has formed from the deck and also to interrupt the rate of ice formation on the vessel. (Jansson, 2021)

In most cases, the entire crew of the vessel gathers for a general emergency to clear the ice. The work is time consuming and exhausting, therefore, before starting work, you need to draw up a clear work schedule. (Jansson, 2021)

It is also important to remember that the work of breaking ice can take an indefinite amount of time at which a huge amount of energy is spent. Therefore, you need to have strict time limits for work and rest during which you can recuperate, warm up and have a snack. The work, which can take several days, can have a deplorable effect on the condition of the crew, and in such cases the captain has every right to request assistance from land or from other vessels in the region. There were cases when the crew could not cope with ice removal and soon the ship sank, taking lives with it. (Jansson, 2021)

5 Planning of the passage

You should always take into account the speed and course of the vessel, because this is what primarily affects the amount of spray and water that falls on the deck, which soon turns into ice. There is one way in which it is possible to avoid the formation of a roll on one side of the vessel and for this it is necessary to alternately change the heavily sprayed side of the vessel to the opposite one. (PWOM, 2017)

Icing of the bow of the vessel occurs when the vessel's course lies against the wind and waves, the stern with favorable waves and winds, and the starboard and port sides of the vessel with wind and waves from the side. For safety reasons, it is imperative to always remember that when working on deck, the course and speed of the vessel should be taken into account so that the flooding and pitching is as little as possible. (PWOM, 2017)

It should be mentioned that the best position of the vessel in which controllability does not change is the bow to the wave with a low speed. If it is possible to maintain a stable course without deviations, then the pitching decreases and with this the flooding of the vessel by waves. With this control of the vessel, deck workers can be allowed to begin clearing the ice that has formed.

6 Research Method

In this study I was using quantitative research method. The questionnaire was made anonymous, so no personal or ship names were asked to make sure that a crew would feel comfortable to give honest answers. Questions were made simple and easy to answer considering the possible outcome of collecting and analysing the results.

6.1 Questionnaire

To create the questionnaire, I used Google Forms as this platform is easy to plan and collect results. The great advantage of this platform is that it easily creates statistics on responses and due to which you can get the overall result of the questionnaire.

Before sharing my questionnaire, I approved it with my thesis coordinators and, after taking into account the comments, I sent the questionnaire to people working on ship. The final questionnaire includes 13 questions.

6.2 Target group

As my target audience, I chose people of different ranks working on ships of different types. My questionnaire is aimed at a specific group of people to ensure the quality of the answers. In order to get the most optimal answers, I decided not to send out my questionnaire throughout the university.

The questionnaire was sent to people working on vessels of various sizes with the aim of obtaining mixed answers. I personally sent the questionnaire through various social media such as WhatsApp and Facebook. When I was submitting the questionnaire, I also made it clear that I would be grateful if they could distribute my questionnaire in order to capture a larger audience.

6.3 Amount of respondents

In total, I received 30 responses from crew members of different ranks. I originally planned that I would be able to collect enough responses within 48 hours, but since the interviewees were ship employees, not everyone had the opportunity to answer right away, so I gave

them one week to collect enough results. After I received 30 responses to my questionnaire, I closed it. Unfortunately, I was not able to collect more answers, but I was satisfied with the quality answers, and I was able to collect the data I needed.

7 Analysis of the questionnaire results

The results of the questionnaire were taken from Google Forms and the results are presented in the form of figures and tables. The results of each question will be analyzed using general statistics.

7.1 Type of vessel

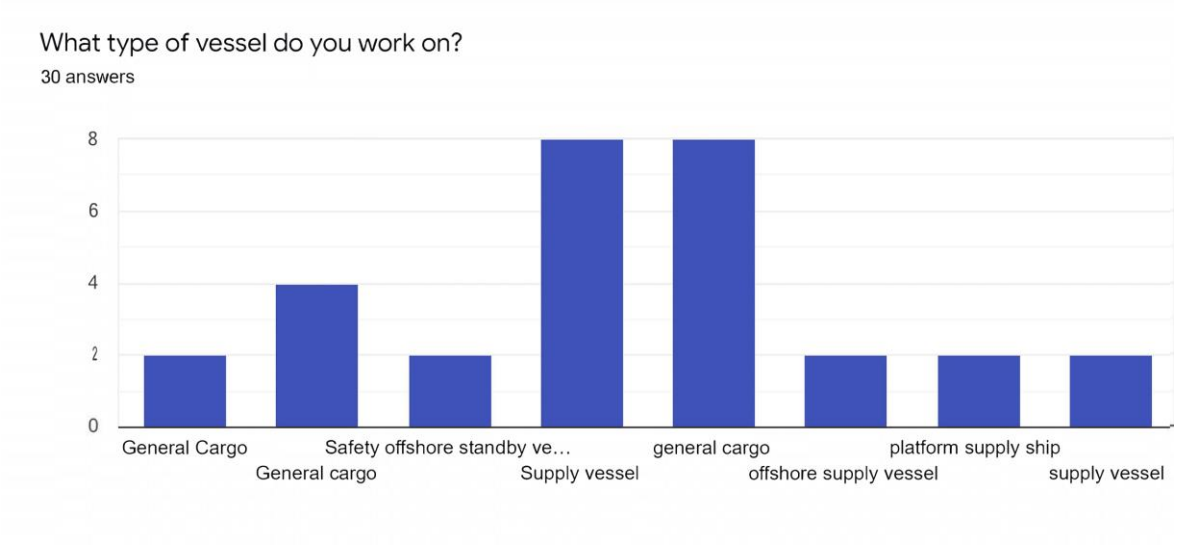

Figure 3 - What type of vessel do you work on?

Most of the responses were provided by marine workers with a 5 to 30 year experience. This question was important in order to understand what type of vessel the interviewed person is working on. Each vessel is specific and different in its own way, and thanks to this question, we will soon find out how the methods of dealing with ice on different vessels differ. Out of 30 interviewed, I received results from two different types of vessels. 16 interviewed are employees of the Platform supply vessel and the remaining 14 interviewed work on the Cargo Ships.

7.2 Length of the vessel

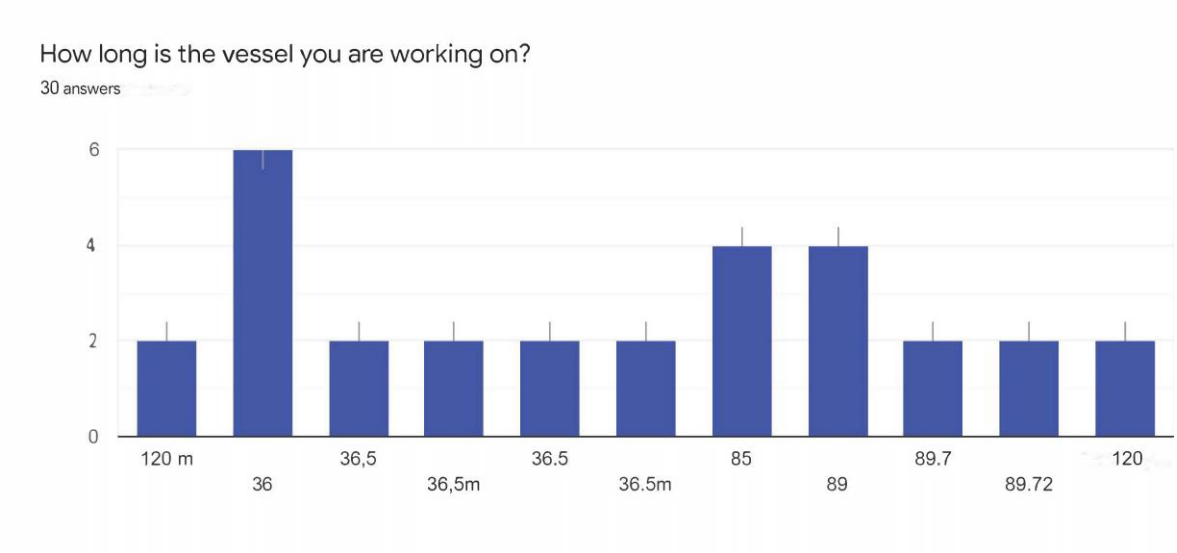

Figure 4 - How long is the vessel you are working on?

I was curious to know the length of the vessel on which the interviewee is working, because during my research I learned that the length of the vessel also greatly affects the icing of the vessel. For small vessels this problem is more serious due to the fact that their freeboard is less than that of large vessels and thus the frequency of deck flooding becomes higher. (Guest, 2005)

14 crew members of the Platform Supply Vessel responded that the length of their vessel is between 36 and 36.5 meters. The General Cargo ship workers were divided into three groups, in one of which two people work on a vessel whose length is 120 meters, in the second the length of the vessel of 8 crew members varies from 89 to 89.72 meters and in the last group the length of the vessel of the other 4 crew members is 85 meters.

7.3 Rank

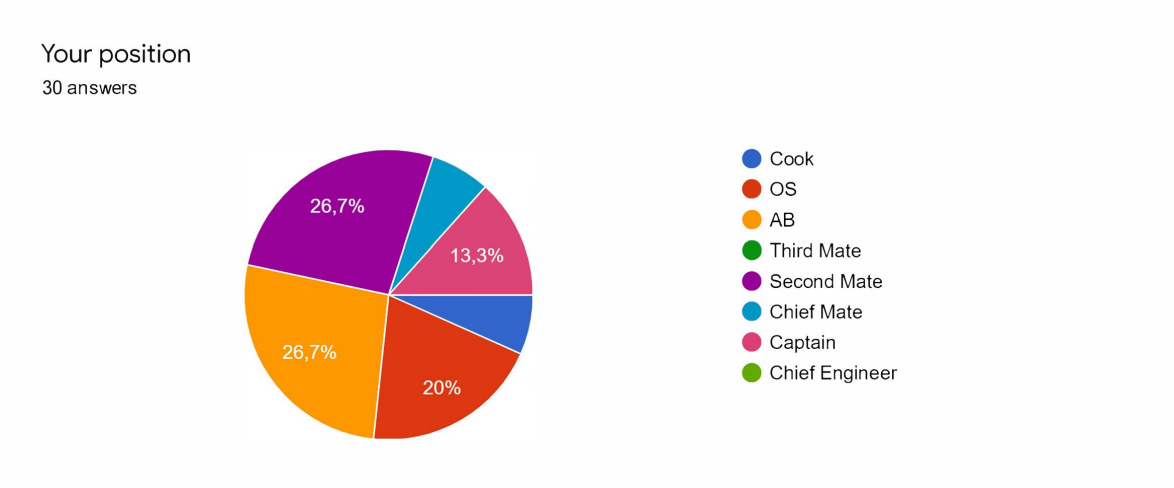

Figure 5 - Your position

My idea was to interview the entire crew, without exception, in order to take into account the experience of each employee. Each member of the ship's crew has a role and responsibilities. Most of those who responded to the questionnaire are crew members of the following rank: Second Mate and AB (26.7%), OS (20%), Captain (13.3%) and Cook with Chief Mate (6.7%). I did not receive answers from the Third Officer, since this position is already a rarity on ships, and from the Chief Engineer, for the reason that this is not part of his duties. I can say that I am satisfied with the results, because people who are involved in ice breaking have passed my questionnaire.

7.4 Trading area

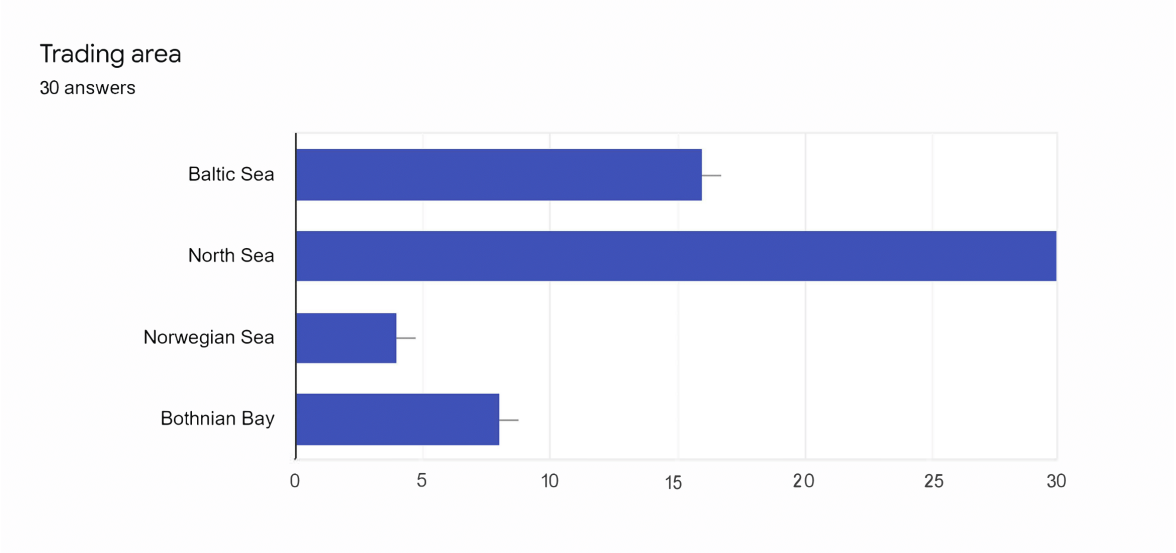

Figure 6 - Trading area

Crew positions vary as well as trading area. Different density, salinity and weather conditions. I wanted to know in which region the respondents work in order to find out the peculiarities of work in different conditions.

In this matter, there was an opportunity to choose several answer options. All 30 crew members interviewed work in the North Sea. Of the 30 crew members, 16 work in the Baltic Sea, 8 in the Gulf of Bothnia and 4 in the Norwegian Sea. Working by yourself means not only staying in one region, but the regions in which the ship is sailing.

7.5 Experience

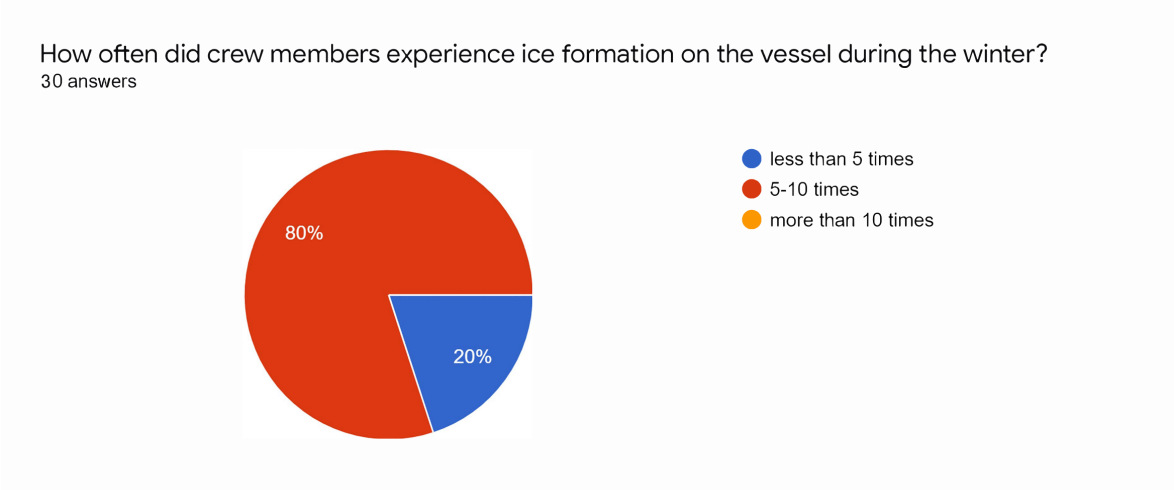

Figure 7 - How often did crew members experience ice formation on the vessel during the winter?

In the next question, I was interested in how much the respondents were really familiar with the problem of ice accretion on a ship in winter. Perhaps this is one of the important questions to which 80% of the respondents answered that during the winter they had from 5 to 10 cases of vessel icing. For 20% of the respondents, icing occurs less than 5 times in winter, which in fact cannot but rejoice, just as no one chose the option more than 10 times. This suggests that the Baltic and North Sea region is calmer than the northern latitudes.

7.6 Drills/ Safety Committee

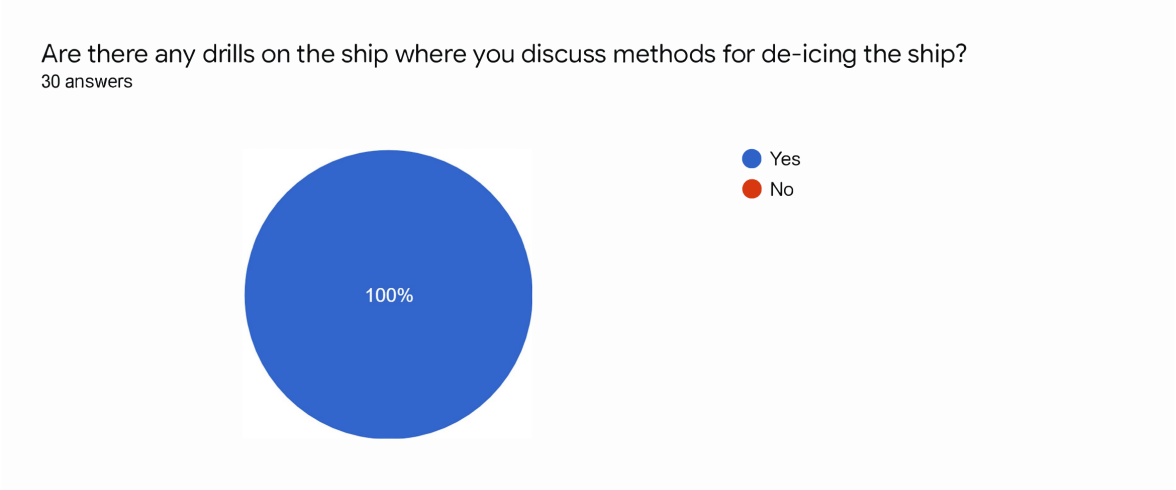

Figure 8 - Are there any drills on the ship where you discuss methods for de-icing the ship?

What I was pleasantly surprised by was that all the respondents answered that they have meetings on the ship where they discuss methods for breaking the ship off the ice. At such meetings, important topics should be raised such as safety and possible dangers when working on deck. Working on deck in winter is always dangerous, especially when ice removal work is in progress. You need to remember about safety and know the reason why the performance of this work is important.

CSWPMS Regulation 13.7.1 says: «The safety committee is a forum for consultation between the master, safety officials and others of matters relating to health and safety. It may be used by individual employers for consultation with the Company and seafarers. Its effectiveness will depend on the commitment of its members, in particular that of the master. Because of its broad membership, and with the master as its chairman, the committee has the means to take effective action in all matters which it discusses other than those requiring the authorisation of the Company and individual employers.» (Agency, 2016)

7.7 Deicing methods

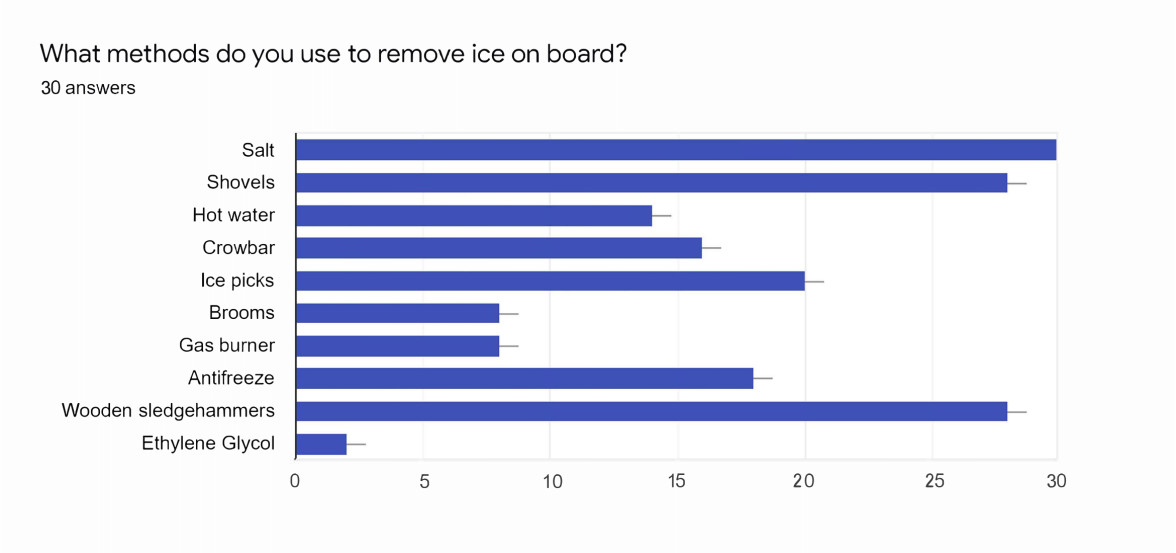

Figure 9 - What methods do you use to remove ice on board?

Now we come closer to the answer to my research question, which is partially revealed in the results of the next question. The goal was to find out what tools the crew members use to break ice from the deck of the ship. I was not surprised that all 30 respondents use salt for de-icing purposes on ships. Perhaps this is the most cost effective and efficient method of ice removal with minimal effort. On the second place in popularity are the instruments, which are also indispensable, but they require a lot of effort and time. Shovels and wooden sledgehammers were chosen by 29 people.

The less commonly used tools on my list are Gas burners and brooms. A gas burner will require a large amount of gas, which is limited on the ship. Also, gas is an open source of fire that cannot be used in cases where flammable cargo is on board. And brooms are simply useless when working with ice. One of the answer options was the ability to provide your own personal answer. This opportunity was used by 3 people who answered that they use Ethylene glycol. Ethylene glycol is part of antifreeze, so we can assume that 23 people chose this option.

7.8 Effective methods

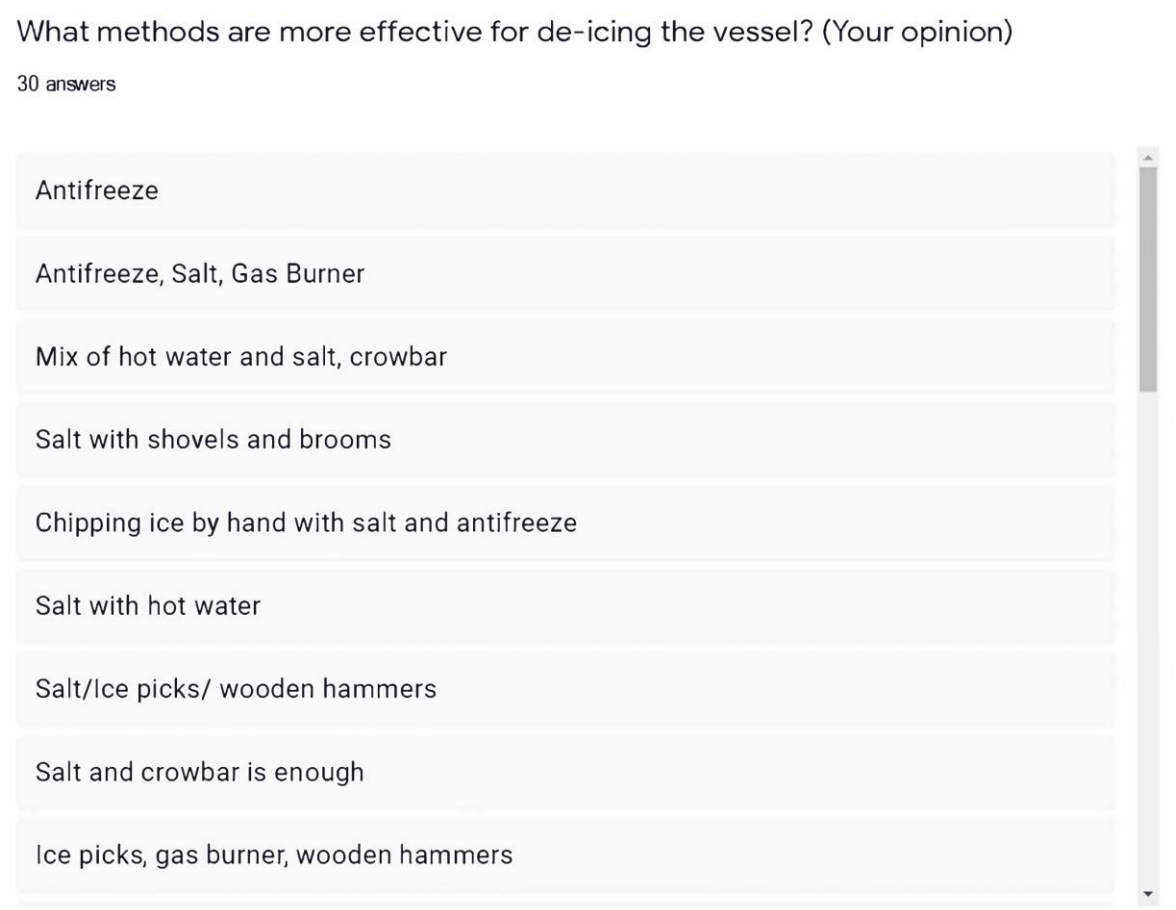

Figure 10 - What methods are more effective for de-icing the vessel?

I wanted to get the personal opinion of each interviewee in order to identify the most effective methods for removing ice. To answer this question, the respondents could use the answer options from the previous question and also add their own. The goal was to separate common methods and highlight the most effective ones. The winner was salt, wooden sledgehammers and shovels. Combining the past and this question, we can say that the courts of the interviewed people have all the tools they need.

7.9 Better equipment

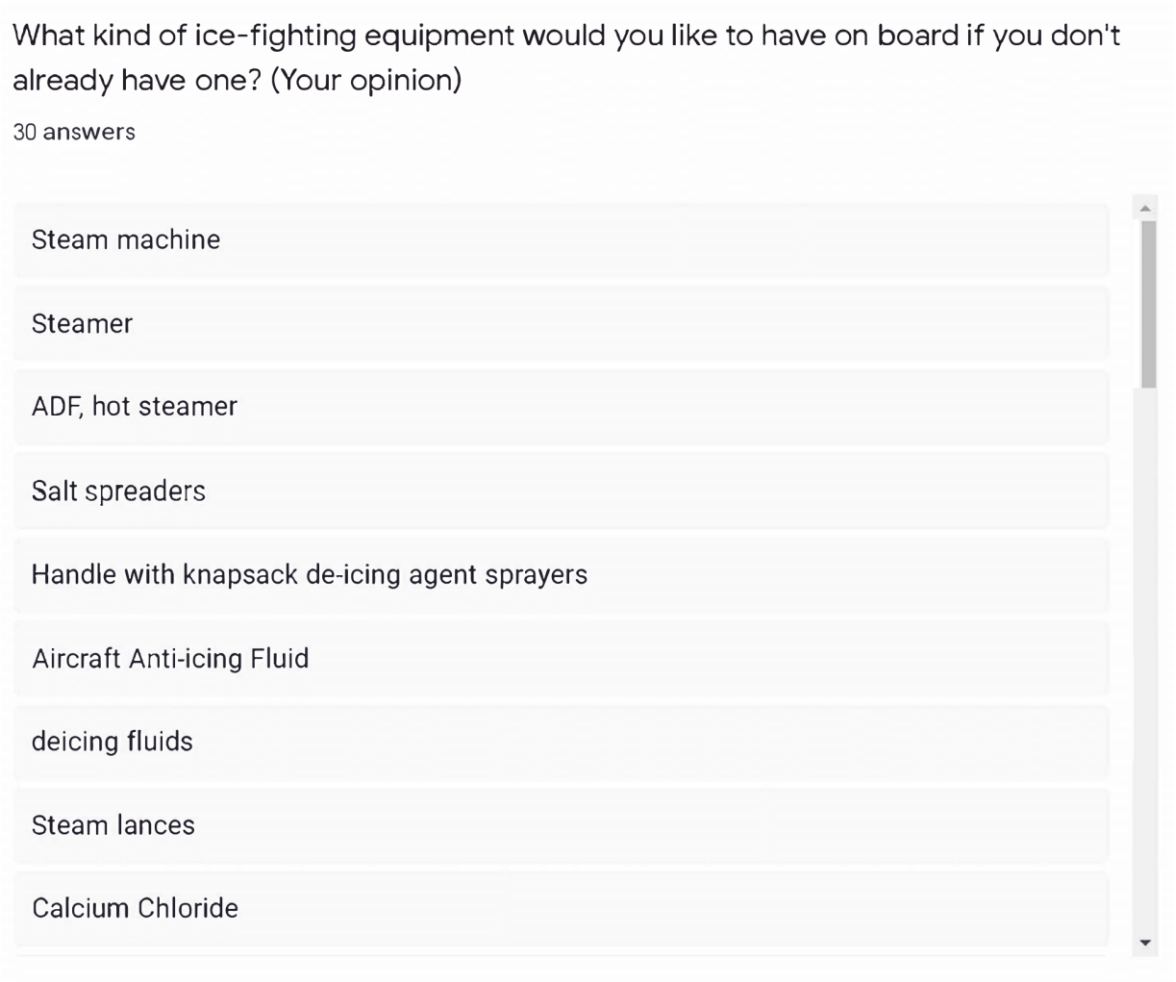

Figure 11 - What kind of ice-fighting equipment would you like to have on board if you don't already have one?

While studying various materials, I learned that there are more non-standard ways of dealing with ice. Therefore, I decided to ask the crew members what they would like to have additionally on the vessel to solve the ice problem. There were many answers and everyone was familiar with different tools.

The most popular were the steamer and anti-icing fluid. The steamer takes cold water from the tap and heats it up to 300 degrees. This steam passes through a pressure hose and tube where it is focused into a thin low pressure column used to cut through the ice. (Dam, n.d.) De-icing fluid is a fluid used for ground de-icing of aircraft prior to flight. It is a solution of glycol in water with various additives to improve performance. (Ground deicing of aircraft, n.d.)

7.10 Participants

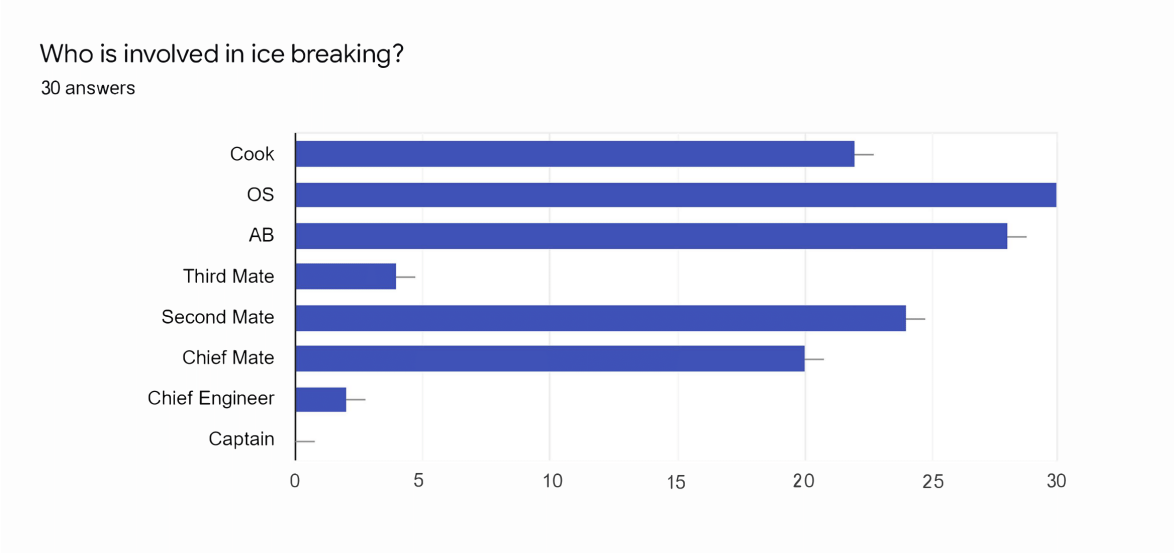

Figure 12 - Who is involved in ice breaking?

If the ship is in severe weather conditions, the ice breaking can take a long time. On the vessel I work on, there was a similar situation in which it was not possible to avoid splashing the side of the vessel, which soon led to icing on the starboard side of the vessel. I had the opportunity to experience and participate in such a situation myself, and I can definitely say that working with only one person, it is very difficult to solve this kind of problem. All crew members except the captain and chief engineer took part in breaking ice from the side of the vessel.

The purpose of this question is to find out who is involved in removing ice from the vessel and analyze how similar the results will be. The respondents had the opportunity to choose several answer options so that everyone could tell a real vision of the situation. From 25 to 30 respondents answered that the OS and the AB always take part in the work. From 20 to 25 respondents answered that the Chief Officer, the Second Officer and the cook are involved in ice breaking. The Captain and Chief Engineer showed the least interest, since this is not their direct responsibility. According to the analysis, I noticed that in all cases, the same people are involved in breaking ice, regardless of the type of vessel.

7.11 Time duration

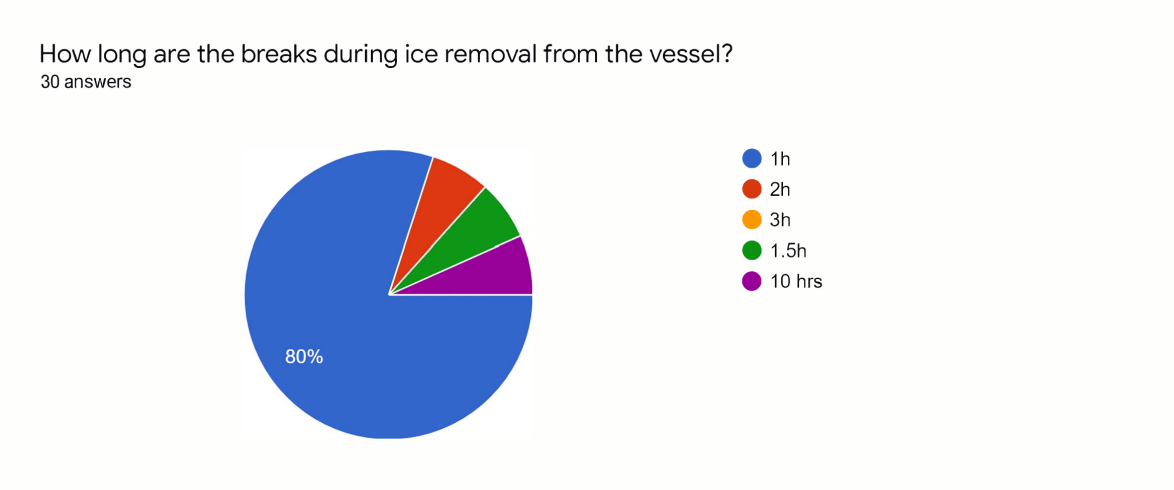

Figure 13 - How long are the breaks during ice removal from the vessel?

Long and hard work on deck in freezing temperatures takes a lot of energy from the crew. Energy expenditure can lead to accidents, frostbite of the limbs and other unforeseen hazards. Therefore, it is important to have breaks to recuperate, because breaking ice takes a lot of time. I decided to ask the respondents how long their breaks last. 80% of those surveyed said that on average, their break lasts an hour.

7.12 Question for Officers

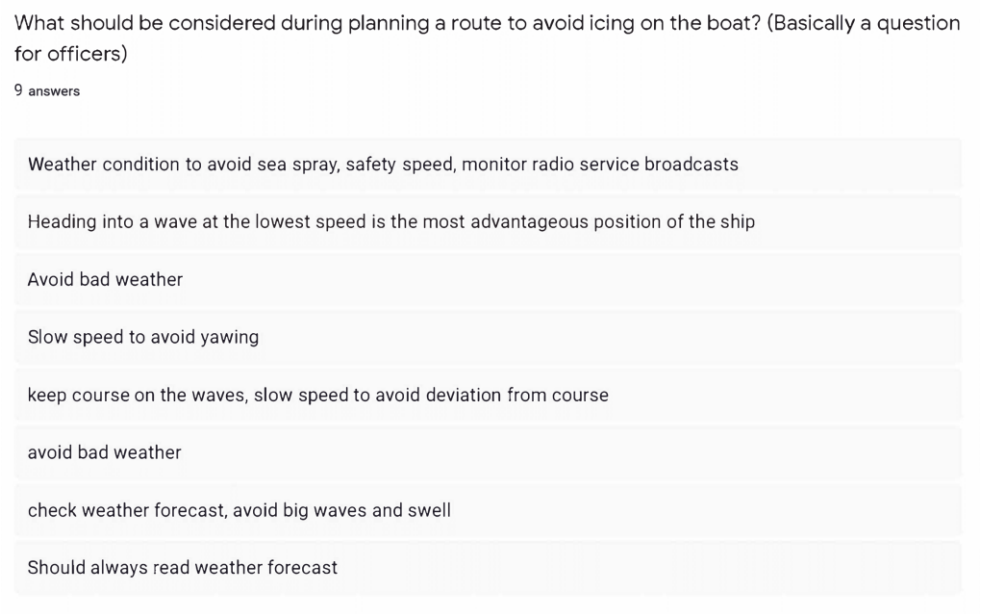

Figure 14 - What should be considered during planning a route to avoid icing on the boat?

Polar Code Regulation 2.3.3 says «In order to comply with the functional requirements of paragraph, the Manual shall include risk-based procedures for the following:

1. voyage planning to avoid ice and/or temperatures that exceed the ship's design capabilities or limitations;
2. arrangements for receiving forecasts of the environmental conditions;
3. means of addressing any limitations of the hydrographic, meteorological and navigational information available;
4. operation of equipment required under other chapters of this Code; and
5. implementation of special measures to maintain equipment and system functionality under low temperatures, topside icing and the presence of sea ice, as applicable.» (2.3 Regulations)

This question was optional and was mainly intended for deck officers, but anyone could answer it. Apparently, there were not many who wanted to answer or knew the exact answer, so I collected only 9 answers to this question. The answers satisfied me, since they did not differ much from each other and were quite correct. Most of the answers boiled down to the fact that if the goal is to plot a route in order to avoid ice accumulation on the vessel, then the weather forecast, vessel speed, swell and waves should be taken into account.

7.13 Safety precautions

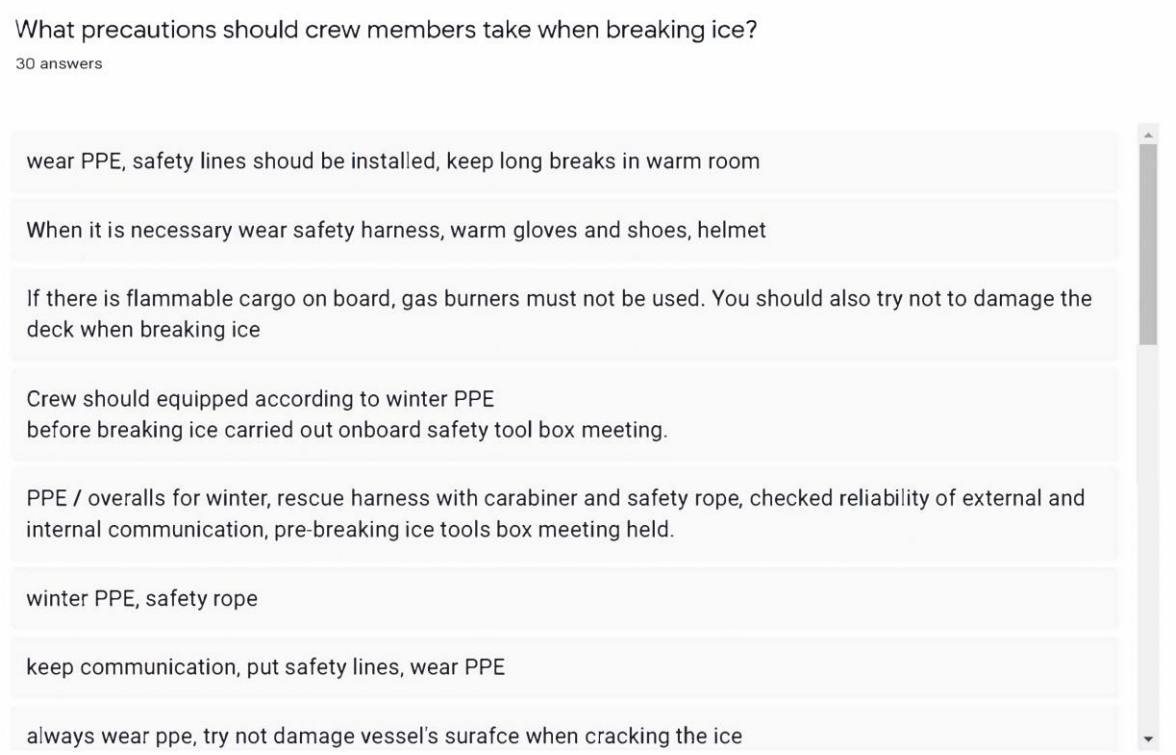

Figure 15 - What precautions should crew members take when breaking ice?

Of course, you should never forget about safety on board. Any normal day on board can lead to injuries and dangerous bruises if safety precautions are not followed. As I said earlier, working on an icy deck is very risky and without proper safety precautions, the work can end in failure for a crew member.

All 30 respondents answered openly and made it clear that they are familiar with the safety precautions on board during ice breaking from the deck. The most common responses were that when working on deck, it is imperative to wear appropriate work clothing, maintain communication, and attach yourself with a carabiner to fixed structures to prevent falling into freezing water or onto the lower deck. Also, the crew members noted the importance of the integrity and safety of the deck, because if it is damaged, additional difficulties may arise that will take more time to repair the deck.

8 Critical review

To collect information, I chose a quantitative research method and to achieve my goal, I created a questionnaire that I presented to the crew members. I decided to send the questionnaire to people with whom I personally know, due to the fact that the answers that I will receive from these people will be based on their experience and professional qualifications. I sent the questionnaire through Facebook and Whatsapp, because this is the fastest way to contact a person and get an answer from him. When I sent messages, I also asked to distribute the questionnaire between their contacts, but the distribution did not become as large as I originally planned. I had the idea to try to send out the questionnaire throughout the university, but I was afraid that due to the lack of experience among students, I would get a lot of incorrect information. My questionnaire reached several cargo ships and a couple of offshore vessels.

I can say with confidence that all the information collected gave me the opportunity to answer all the research questions that I posed to myself. I am pleased that my goals have been achieved and the research process has paid off. Also, I managed to learn a lot for myself and give others the opportunity to do the same.

9 Further studies

This study is delimited to marine workers of all ranks and crew members of various types of ships. To further explore my topic and question, I would choose a broader audience.

I believe that this topic could be given for consideration not only to the crew members, but also to people with minimal experience. Comparing the answers of people from two different social levels could give interesting conclusions and maybe some fresh ideas in my question.

Since I have delimited methods of dealing with ice as the main topic of my research, I think for further study it would be interesting to also describe in more detail the method of ice formation on the deck and analyze the methods of preparing the vessel to prevent ice formation on the vessel. These topics are equally broad and worthy of consideration.

10 Summary

The purpose of my work was to conduct research on the topic «What methods are used to prevent and fight ice formation on a vessel» and to identify the data, I interviewed crew members from different ships. The overall result impressed me, as I suspected that in the Baltic and North Seas such problems were not encountered as often as in Polar waters.

The study of my question made it clear that most of the marine workers are familiar with the possible problems with the ice formation of the vessel. Based on question 7.8, all 30 respondents are familiar with and have their own preferences with the method of removing ice from the deck of the ship. These results indicate that the crew members on ships are working on scenarios in which there is a likelihood of icing, and as a confirmation of this is question 7.6, where everyone unanimously answered "Yes".

The people I interviewed are crew members of three different companies that are involved in different sectors of the maritime industry. Regardless of the size of the vessel or the working region, companies always try to maintain a policy that minimizes incidental costs in order to save money. In many cases, secondary costs for deck work can save valuable time and keep work on schedule without delay. In question 7.9, I raised an issue in which I asked deck workers about equipment that could save them time and energy when clearing ice. The most common responses were the steam engine and antifreeze fluid used for aircraft. The equipment is not cheap, but it is also very effective in clearing ice from the deck.

Although there have been numerous conversations and reflections to this day to solve the ice problem on the vessel, no exact way has been found to resolve this due to the harsh nature of the environment and the vessel's routes in order to “get the job done”. There are many factors to consider, and it is usually because of the seasoned experience of the captain who truly knows his ship and the current situation as to what to do.

The questionnaire was successful, as it took one week to collect 30 responses. Using personal contacts with WhatsApp and Facebook Messenger was a good choice as responses were received fairly quickly. Since the respondents have been working at sea for a large number of years, it can be said that the respondents have a wealth of experience and were suitable for the study.

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