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Planlegging av Arktiske operasjoner

Fiskeflåtens og Polarkodens påvirkning av
Arktiske operasjoner

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Marin teknikk	
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Planning of Operations in the Arctic

The influence from the Polar Code and the Fishing Fleet on Arctic Operations

10.02.2013

NTNU

Tora Gjermstad Dypvik

Preface

This Thesis started in September 2012. I was so lucky that I could get a good participate at a workshop by SINTEF in Tromsø about "*Safe operations in the North"*. Here I got to meet different people who have been of great help later in the progress.

I started my work by getting familiarized with the Arctic challenges, and learning about Arctic fishing. I had a lot to learn about fishing and its challenges, and this paper could have ended up with only these. I got some training in the Star IPS by SIS. This was very helpful and necessary for understanding the system to evaluate. A different vessel was used in the software at that time, and this vessel cannot be linked to fishing or shipping. Anyways, it helped me to understand the system, and also to understand the SFI system. It was also very useful to know how maintenance systems work.

The contents and aim have changed drastically from the first drafts of this paper, which was maintenance management for fishing vessels in the Arctic. I realized it would not be possible to do a complete maintenance view, as it would be difficult to obtain enough information on the systems, and that I could not link it to the Polar Code. The experience from the fishing vessel has been very useful for the further work, and has helped me understand the variety in the Arctic conditions.

I would like to thank

- Edgar McGuinness and Ingrid Utne at NTNU
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- Kenneth Nordli and everybody else at Nergård Havfiske AS
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- Turid Stemre from the Norwegian Maritime Authority
- Friends and family

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Tora G. Dypvik

Summary

As the Arctic ice shrinks, it creates possibilities for extended activity in the area. Fishing vessels already have experience from operating in the Arctic. Now the summers are slowly getting longer, allowing for a longer operational period in the High North. This benefit also affects shipping vessels, which now can transfer goods with a reduced time through the Arctic passages.

Going out on such missions is however more risky due to the limitations in the infrastructure, icing and other aspects. Having to go home before the quota is filled up or being interrupted is bad economy.

To reduce the risk linked to the activity in the Arctic, the International Maritime Organization is working on the former guidelines for Polar water to make a new regulation, the Polar Code. The Polar Code is to be an add on to the MARPOL and SOLAS regulations.

This Code is still a draft, but the Star Information Systems, information and planning software provider, want their system to be prepared of the future regulation. By using the Arctic experience from the prawn trawler, J. Bergvoll, and the draft of the Polar Code, the Arctic challenge has been evaluated. The main fear is icing. The icing is also linked to the design of the vessels. For the shipping vessels, communication will also be a problem.

The challenge consists of being prepared for the Arctic conditions. To reduce the inherent risk, the challenges have been identified, and they have been evaluated from the view of the Polar Code. To be prepared, it is important to plan well ahead, knowing what to expect. The planning has been done with linking together the known risks in the area.

The Star IPS has been evaluated towards the demands in the Polar Code. The main findings are that the system can be of great help for the developing of the compulsory Polar Water Operational Manual. By adding an Arctic criticality to the relevant equipment, a list can be created of this equipment and be attached as necessary documentation of systems subject to damages due to the cold. The Star IPS also has the Starboard, where Arctic related maintenance jobs can be identified. The Starboard might also be exported to the voyage planning, so the critical maintenance jobs can be evaluated with the expected external Arctic risk. For the Arctic risk, a simple Excel sheet has been created to summarize the Arctic challenges.

During the work a lot of aspects and equipment specific to the Arctic have been identified. These have been gathered to drafts of check lists relevant to the Arctic.

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Abbreviations and acronyms

- AIS – Automatic Identification System (on vessels)
- AMSA – Arctic Marine Shipping Assessment
- BW – Ballast Water
- CMMS – Computerized Maintenance Management System
- DNV – Det Norske Veritas (classification society)
- EER –Emergency Evacuation and Rescue
- EPIRBS – Emergency Position Indicating Radio Beacon
- FAO – Food and Agriculture Organization
- Fi-Fi – Fire Fighting
- GT – Gross Tonnage
- HF – High Frequency (radio 3 MHz to 30 MHz)
- HFO – Heavy Fuel Oil
- HSEQ – Health Safety Environment and Quality
- IMO – International Maritime Organisation
- IPS – Information and Planning System
- ISM – International Safety Management
- ISO – International Organization for Standardization
- JIP – Joint Industry Project
- KPI – Key Performance Indicator
- LME – Large Marine Ecosystems
- MF – Medium Frequency (radio 300 kHz to 3MHz)
- MGO – Marine Gas Oil
- MOB – Man Over Board (small safety boat)
- NC – Non Conformities
- NEP – North Eastern Passage
- NMA – Norwegian Maritime Authority
- NTNU – Norwegian University of Science and Technology
- OCS – Onsoft Computer Systems AS
- PMS – Planned Maintenance System
- PWOM – Polar Water Operational Manual
- RFMOs – Regional Fisheries Management Organizations
- SAR – Search And Rescue
- SFI – Skipsteknisk Forsknings Institutt/Ship Research Institute(A grouping system of the ships' functions)
- SINTEF – Stiftelsen for Industriell og Teknisk Forskning/Foundation for Scientific and Industrial Research
- SIS – Star Information System
- SMS – Safety Management System
- STCW – Standards of Training, Certification and Watchkeeping
- UN – United Nations
- VHF – Very High Frequency (radio 30MHz to 300 MHz))
- WWF – World Wildlife Fund

1 Introduction

This project is a part of the joint industry project (JIP) *"Safety[1], environmental-friendly, and effective operations of vessels and installations in the Arctic".* The JIP is collaboration between Star Information Systems (SIS), SINTEF, University of Iceland, the maritime Safety and Survival training centre, Iceland, and the Norwegian University of Science and Technology, NTNU.

This projects focus is to meet the increase of maritime activity in the North through development of systems within safety and maintenance management for safer operations in polar areas. The methods and systems should then further be implemented as a part of the information systems on board and at land. The use of these applications is verified through vessels and platforms which are operating in the Arctic today. The project also aims to participate through the Norwegian Maritime Authority towards the International Maritime Organizations (IMO) work on the Polar Code. This is especially in considerations to the establishments of demands for safety and maintenance management for marine operations in polar areas.

SIS provides a maintenance system for ships and offshore installations, and they are interested in finding out how they can improve their systems for operations in the Arctic.

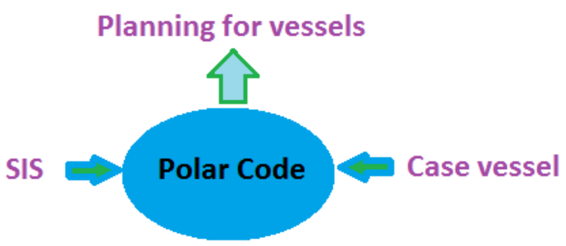

Figure 1 Project's information flow

First this paper will consider the situation in the Arctic today, including fishing in the area. This information is used together with a case vessel evaluation and relevant regulations to evaluate the possibilities for shipping in the Arctic later. For this, the Polar Code draft is evaluated. The demands from the Polar Code will be evaluated together with the other information to consider what will be the changes to planning in the Arctic in the future. This will be evaluated together with how the Information and Planning System from SIS can be adjusted to include the new demands from the Polar Code. Together this makes up an evaluation of the future needs for operating in the Arctic. The paper will include a check list specific to Arctic operations. From this, the total risk of a voyage can be visualized.

[1] Safety in this context means safety for the crew, vessel and the environment.

A lot of the background material is gathered from the oil and gas sector in Norway. The oil and gas industry hopes to learn from the fishing industry experience, so they can be prepared for the operations in the Arctic. The fishing vessels might also have a lot to learn from the offshore industry when it comes to safety. That is why information from both fisheries and offshore are applied in this paper. Politics will not be discussed in this paper. The differences in the regulations between fishing and shipping can be confusing.

This paper is linked to the Polar Code, and what demands and changes have to be changed when it is in force. For planning voyage information about weather and ice, logistics and resource planning are needed. In this paper some aspects linked to voyage planning are evaluated. Voyage planning consists of planning all aspects of the ship in operation. The navigators will have to plot the route, and they will have to be trained to operate in cold water. This part of the planning will not be included. The planning evaluated is planning around shore time and voyage concerns.

Since the project paper is not linked to this master, two documents have been used as background material

1. Bachelor Thesis from Signe Meling and Johan Trønsdal from the University in Tromsø (2012) – "*Maintenance management for vessels under Polar conditions*" [2]
2. Note from SINTEF Fisheries and Aquaculture, Ingunn Marie Holmen (December 2011) – *"The Polar Code and other relevant regulations and information sources for operations in Arctic conditions."* [3]

[2] Norwegian original title: *Vedlikeholdsstyring for fartøy under polare forhold.*

[3] Norwegian original title: *Polarkoden og andre relevante lover, forskrifter, regelverk og informasjonskilder for operasjoner i arktiske strøk.*

2 The Arctic Challenge

For identifying the challenges, the definition of Arctic should first be identified. The Arctic consists of the region of the North Pole with the Arctic Ocean. Depending on the definition chosen some parts of Russia, Canada, Greenland, Lapland, Norway, Alaska and Iceland are also Arctic areas (1).

2.1 What is the Arctic?

The land of the midnight sun

The Arctic is the top of the world. The Arctic is so far defined as above latitude 66 degrees, 32 minutes north (2). There are at least three different definitions today, see Figure 2, and with the Polar Code, a new one might be used as shown in Figure 3.

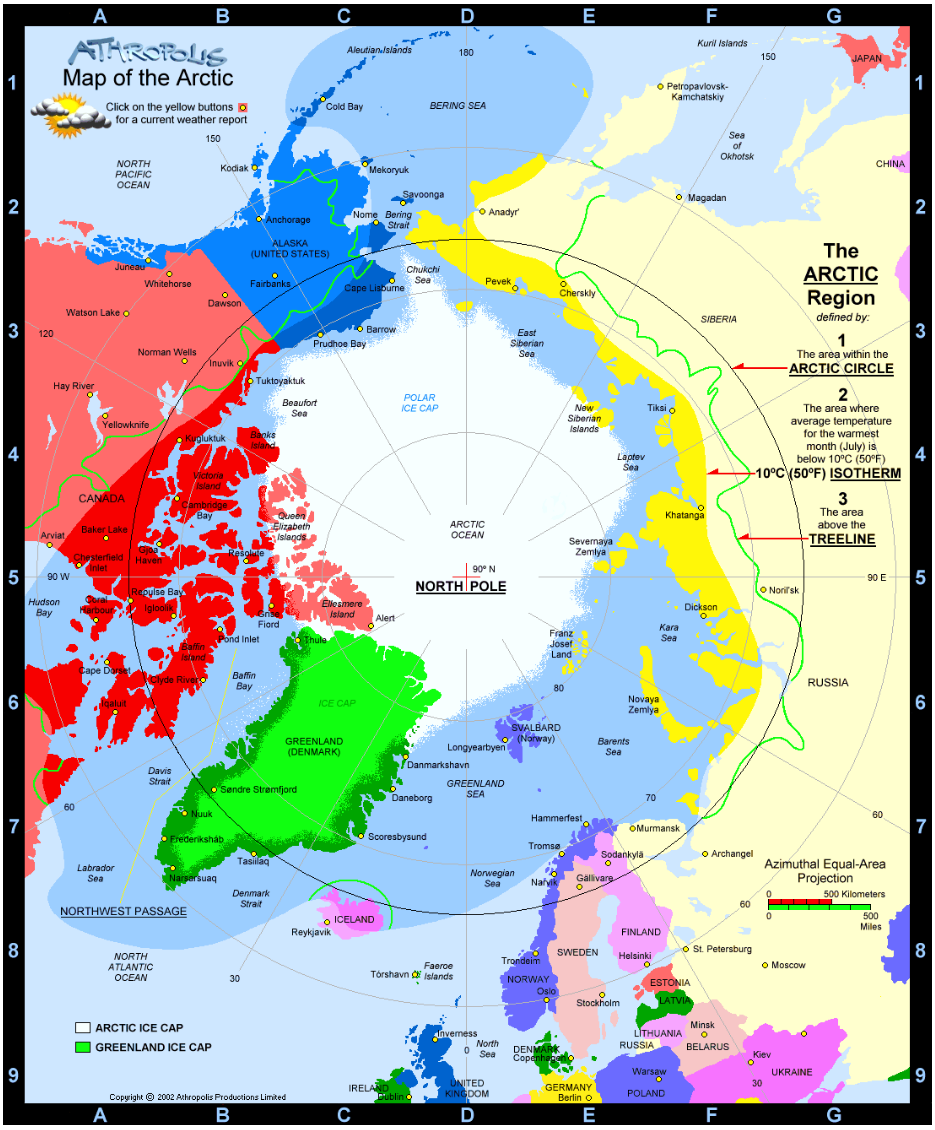

Figure 2 Arctic definitions (3)

Figure 3 Geographical demarcation of the Arctic water in IMO's guidelines (4)

2.1.1 A future focus area

The north areas are of a special interest in Norway. In 2005 the Prime Minister defined the north area as a prioritized area for the foreign politics. It is expected that there will be extensive industrialization in the area in the future. The development in industrialization is within both geological materials and petroleum resources. Also the reduction in sea ice is very likely to increase marine transport, including cruising activity, and access to resources in these areas (5)(6). Today, the main activities in the High North are of fishing and cruising vessels (7)

Figure 4 One Internet reaction towards the Arctic challenge (8)

Operating in Arctic has some elements that have been actively discussed in the media when it comes to the different aspects of safety in the area. Many organizations are worried for the environment and the living conditions of the Arctic fauna and species. Some of these are worries due to human impact on the nature, and what accident in the oil industry might lead to. On the other hand the risk for the people who are to work in this area. They will have the responsibility of systems that might not be operating correctly in the Arctic conditions. For instance, the cold weather affects the vessel with icing and higher wear on the engine due to ice (9)(10).

2.2 Concerns and challenges

The Petroleum Safety Authority in Norway (PSA) has made a survey with the challenges associated with Petroleum activity in the high north. Some of these challenges are also valid for shipping and fishing vessels (11).

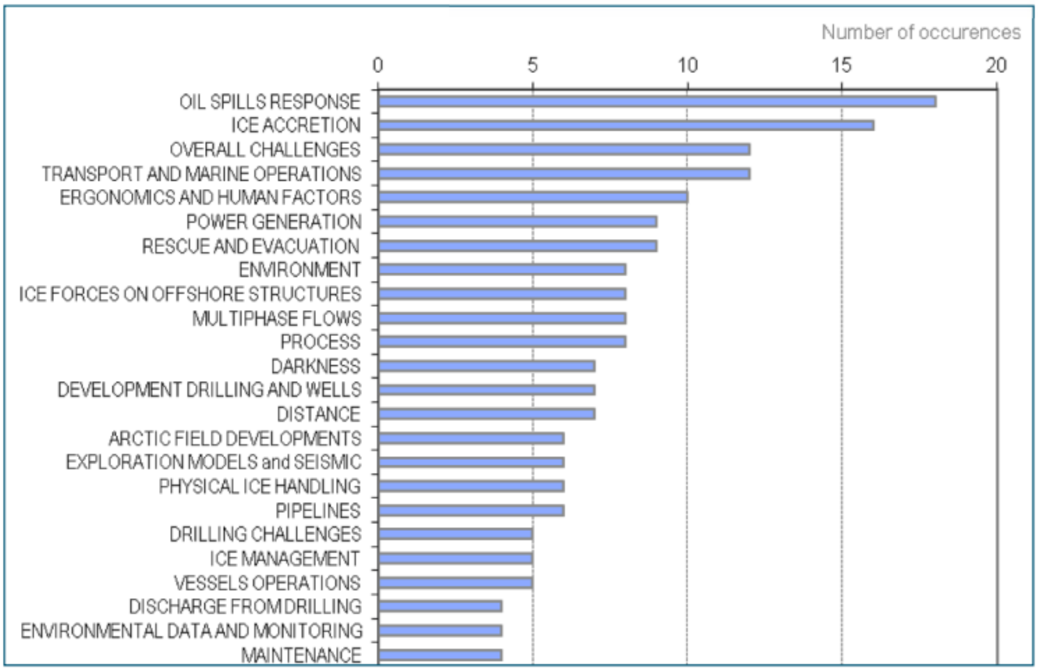

Figure 5 Concerns for Arctic petroleum activity (shortened)

Parts of the Arctic are without communication possibilities (12). The Arctic Ocean is also poorly mapped. Combined with icebergs changing the seabed these undependable routes are a big threat when it comes to grounding. Grounding is the second most commonly occurring accident in the Arctic after machinery failure and there is a long way to civilization in the case of an emergency (6).

The report *"Analysis of maritime safety management in the High North"* (7) has summarized the different challenges in the High North. The report has divided the challenges into five different topics:

1. Environment and geography
2. Emergency preparedness, SAR services and EER
3. Information and data
4. Communication, surveillance and tracking
5. National and international governance

The main findings are mentioned in Table 1 Arctic Challenges .

Table 1 Arctic Challenges (7)

Fear	Condition	Concern
Harsh weather	Coldness, sea temperatures, wave and wind, icing, polar lows, poor weather reports, limited historical data	Dangerous to work on deck, destabilizing of structures, decreased performance, slippery work areas, difficult to detect local conditions
Visibility	Darkness, fog, blowing snow	Makes operations harder to accomplish, reduces the time window for operations
Remoteness	Long distances between ports, infrastructures and other vessels	Challenging for SAR operations, helicopter’s limitation in reach, long time before rescue
Ice in water	Collision, reduced speed, reduced work window, non sufficient ice management systems	Damage of hull
Icing on equipment	From fog, freezing rain, green water trapped on decks, wind/wave driven seawater spray, poor observations for theoretical estimates	Modifies buoyancy and stability of floating structures, dangerous destabilization and de-icing operations, icing of communication and other equipment,
Limited SAR resources	Large distances	Reduced safety, long time before help comes
Unfit emergency preparedness equipment	Emergency evacuation and rescue equipment will be different from warmer areas.	Reduced safety since equipment might not be operational
Untrained personnel	Few navigators with experience	Not being able to manoeuvre safely, increased risk of collision
Low quality on meteorological and oceanographic forecasts	Challenging for maritime operations	Surprised by the weather or other conditions
Poor Electronic Navigational Charts, coverage	Maps are wrong or incomplete	Wrong decisions can be taken

Poor ice data charts	Ice floes and bergy bits (see page 14) are not covered in satellite images	Collision with ice, damage to hull, water intake, sinking
Limited AIS coverage	Limited structure and increased traffic	Not possible to identify surrounding ships in emergency situations, longer time to receive help
Poor coverage geostationary satellites	Not reliable above 75̊ N. Infrastructure not sufficient to meet demands	Services from these satellites cannot be considered reliable.
Poor coverage from terrestrial communication systems	Many areas are missing, and cannot meet increased demand (VHF etc.)	Reduced safety and more complicated operations
No international mandatory rules and regulations	No international mandatory rule yet, and existing regulations are too weak.	Easy to take shortcuts on safety
Increased requirements and new roles for VTS(vessel traffic service)	Clarify the role of VTS and its interface with authorities	Non correct and unsafe implementation and use of the required systems

From Table 1 most of the important challenges to the Arctic are mentioned. They all affect the safety in different ways, and are necessary to keep in mind when it comes to the challenges the increased vessel activity will encounter. Not much is done towards fishing vessels, and it is assumed that the navigators on fishing vessels that have operated in the Arctic might have sufficient experience (7). This might lead to a possible transfer of knowledge from the fishing vessels to other vessels that want to operate in the Arctic. Most of these challenges are included in the Polar Code. The Code in itself will be a part of the international mandatory rules for the area. Some of the concerns will be further investigated.

2.3 Design temperatures

A lot of the equipment and material are not made for working at temperatures below -20°C (13). This means that research, development and testing should be carried out to make sure that the material and equipment can handle the cold temperatures. This should happen as soon as possible since the increase in traffic has already started.

Even though the shipping and fishing vessels will operate in the summer months, it is of importance to make sure the equipment will not decay in quality under cold weather. This is just as important for normal operations as well as emergency operations (14). The survival suits and fire fighting (Fi-Fi) equipment also need to have their performance checked. Many chemicals will also have reduced quality and other problems in colder conditions. The problem with testing the equipment for less than – 20°C has to be further considered amongst the suppliers and producers. The Polar Code will come with regulations on knowing the design temperature, and the sooner the industry can provide such equipment, materials and tools, the better for everyone. Knowing that the materials are sufficient to deal with the Arctic conditions should be known before purchasing any the materials from the suppliers.

Batteries will be affected by the cold. The effectiveness of many components may also be reduced in cold weather. Components affected are ranging from deck machinery, emergency equipment to sea suctions (15).

Comparing this problem with the design temperature, the temperatures in Arctic are of importance. On Greenland the annual mean daytime temperatures are shown in Figure 6. At night it can be considered to be quite colder than the day average. In winter some places are already at a temperature of -20 °C. This means that the temperature will often be less than the design temperature for most equipment. The fishing vessels are operating in the summer months, hence the temperature is higher. In case a vessel gets machinery failure and has to go to port on Greenland for a longer period, the equipment might take damage of the cold (16).

For larger vessels, as those expected to be operating in the Arctic, it might be beneficial to have Fi-Fi equipment that can also be used for ice removal. The equipment need to be operational at low temperatures, and water should not be used as it might affect the stability. The hand held fire extinguishers of today is only approved for temperatures down to -30°C, which might be a problem for really cold conditions (17).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upernavik	-17	-20	-20.1	-13.1	-3.7	1.7	5.5	5.2	0.8	-4	-8.8	-14.2
Ilulissat	-14.8	-19.6	-19.9	-8.2	-0.5	5.1	7.5	5.9	2.4	-3.1	-7.8	-9.9
Aasiaat	-13.4	-15.6	-16.2	-9.6	-1.8	2.7	5.7	5.3	2.3	-2.3	-6	-9.9
Sisimiut	-12.8	-13.9	-14	-7.1	-0.2	3.6	6.3	6.1	3.2	-1.9	-5.9	-10.1
Kangerlussuaq	-19.8	-21.4	-18.1	-7.8	2.5	8.6	10.7	8.2	3	-5.5	-12.1	-16.4
Nuuk	-7.4	-7.8	-8	-3.8	0.6	3.9	6.5	6.1	3.5	-0.7	-3.7	-6.2
Paamiut	-6.6	-6.4	-6	-2.3	1.4	3.7	5.6	5.3	3.5	0.1	-2.8	-5.4
Narsarsuaq	-6.8	-6.1	-5.1	-0.1	5.2	8.3	10.3	9.3	5.5	0.4	-3.2	-6.1
Qaqortoq	-5.5	-5	-4.4	-0.6	3.3	5.2	7.2	7.2	5	1.2	-1.9	-4.4
Tasiilaq	-7.5	-7.7	-8.1	-4	0.7	4.2	6.4	6	3	-0.9	-4.8	-7.3
Ittoqqortoormiit	-16.1	-17.1	-16.5	-11.2	-3.5	1.1	3.3	3.5	-0.4	-6.4	-12.2	-14.7

Figure 6 Mean annual temperatures Greenland (16)

The Arctic is a vast area. Generally the temperature on the surface varies most over land areas, and less over the Arctic Ocean. The coldest place in the Arctic all the year around is Greenland (18).

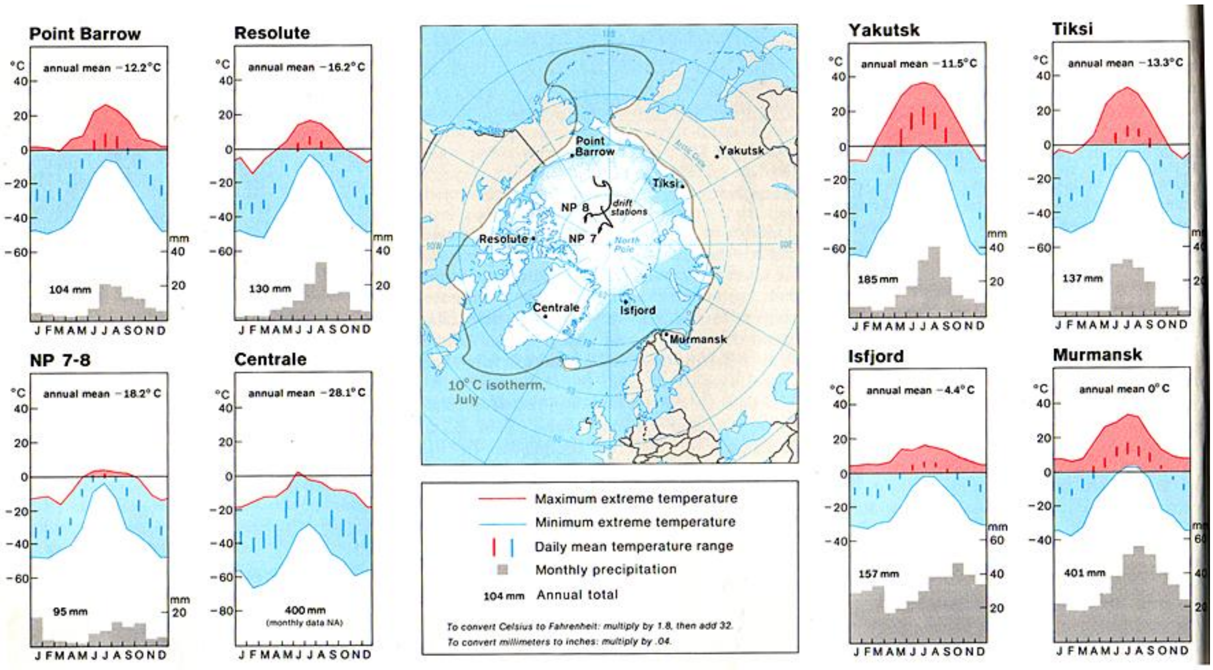

Figure 7 Temperature different places in the Arctic from the 70's (19)

Figure 7 is from the mid 70's, but gives an overview over the temperature different places in the Arctic. It can be assumed that if the equipment can operate at Greenland's winters, equipment can be used other places in the Arctic too, since Greenland has the absolute minimum temperature.

Table 2 Surface temperature - Jan Mayen 1958-2011(20)

Temperaturforhold

Posisjon	Maks.	Min.
69,00 N, 07,12 W	11,8	-18,4
70,00 N, 08,10 W	11,2	-23,8
71,00 N, 09,85 W	9,4	-27,6
71,23 N, 22,21 E (Goliat)	15,6	-12,8

Jan Mayen is on the edge of the Arctic definition in the Polar Code.

Table 2, shows a minimum temperature of -27.6℃ around Jan Mayen. This means there will be a problem with certification of most materials for vessels in this area too. The ice is also building up around Jan Mayen much quicker than next to Goliat in the Barents Sea, North West of Hammerfest (21). This means that there is a large variation in the temperatures in the Arctic waters. Also, going north might not necessarily give worse conditions.

The temperature range for all over Arctic is shown in Figure 8, showing results for temperature down to almost - 40℃.

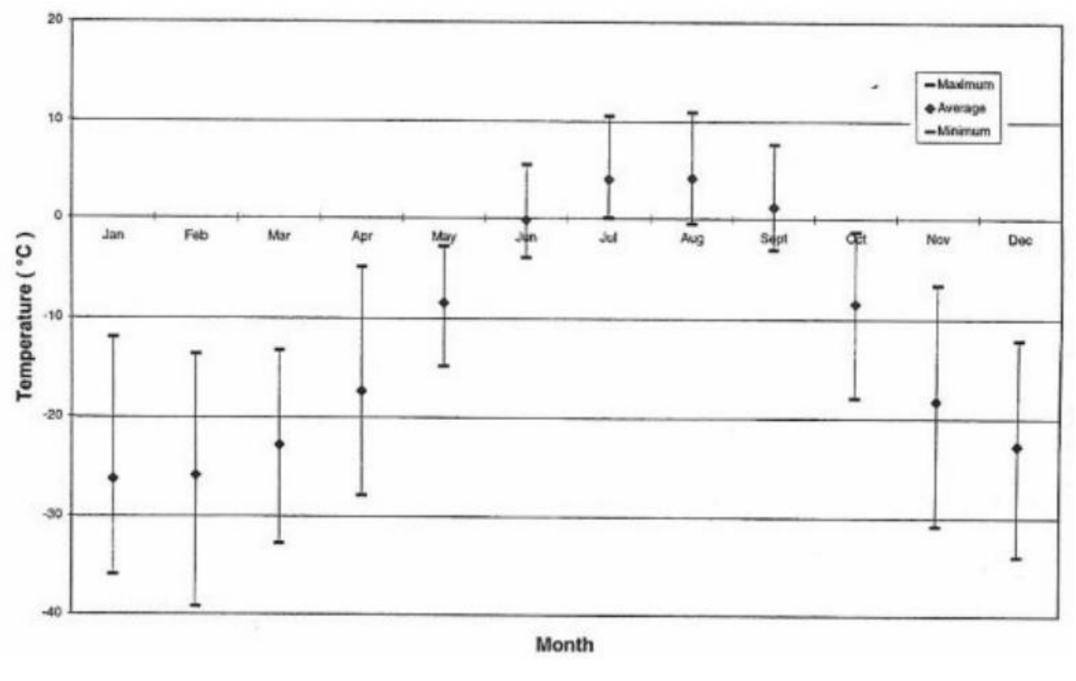

Figure 8 Annual temperature ranges in the Arctic areas (22)

2.4 Weather

The Arctic can be assumed to be considered a cold place, far away with terrible weather. Anyways, the Arctic is assumed to be getting warmer with more of the icecap melting away, see Figure 9. When the sea ice melts, it creates opportunities for fishing and shipping in new areas.

Some of these weather aspects will be summarized. In this chapter the different conditions are mostly found from the impact assessments for the Barents Sea South East and the area around Jan Mayen created for the Ministry of Petroleum and Energy in Norway. For Arctic shipping going east, this is not sufficient background material for the northern areas of Russia. The same can be assumed for the north western passage. Anyways, the problems can be assumed to be somewhat the same. Temperature has already been covered more thoroughly in chapter 2.3.

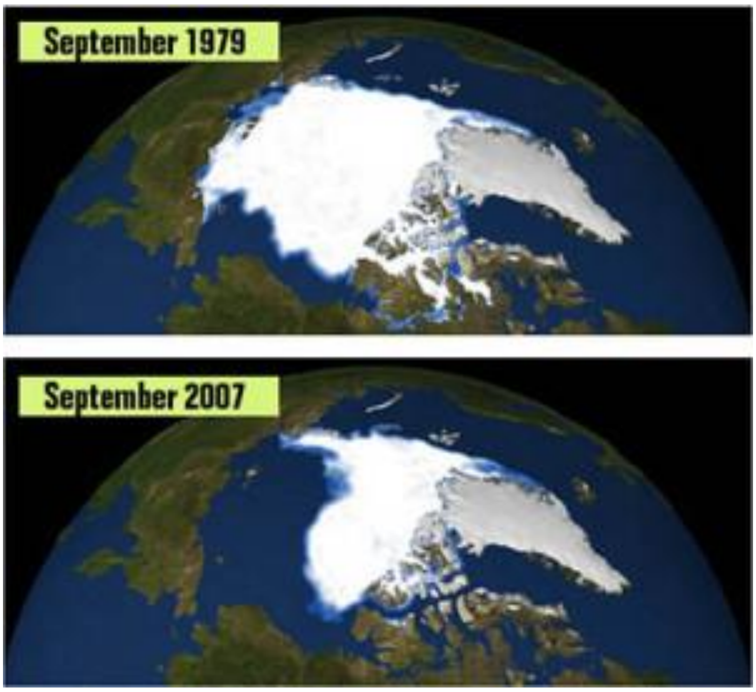

Figure 9 Melting Arctic Ice (23)

2.4.1 Ice

There are two main concerns when it comes to ice in the Arctic. It is ice accretion on the vessel, affecting the stability, and it is ice in the water, that can cause damages to the hull of the vessel.

2.4.1.1 Ice accretion

Icing might happen very quickly on the vessels in the Arctic (see Figure 10), and the accretion is by the sea men considered the biggest fear when it comes to operating in the Arctic (24). It is very heavy and dangerous work to have to remove the ice manually if it first starts to accrete. Ice accretion will affect the weight of the construction and hence also the design. This icing will affect both the normal operation as well as the emergency operations of vessels. Icing tends to be reduced above 15 meters, being beneficial for tall vessels (25).

Figure 10 Ice Accretions (26)

To avoid and to know when to expect accretion will be of importance to the operation of the vessels. These five characteristics are used to evaluate to what rate the ice accretion will happen (27):

1. Precipitation type
    a. Freezing rain
    b. Frost smoke
    c. Freezing spray
2. Wind speed
    a. Sea spray depends on wave height and period
    b. Wave depends on the duration of the wind and fetch
    c. Higher wind speed – greater ice accumulation
3. Air temperature
    a. Happens between -18℃ - 0℃
    b. Below -18℃, crystals are formed
4. Sea surface temperature
    a. Critical range between -2.2℃ to 8.9℃
5. Characteristics of the vessel
    a. Size
    b. Shape
    c. Speed
    d. Heading

2.4.1.2 Ice in the water

Ice breaking off the ice shelves and glaciers creates icebergs, which have been a well known hazard since the Titanic accident in 1912. Small icebergs are called bergy bits, and are of the size of a small house. Growlers are even smaller, not higher than 1 meter over the water surface and shorter than 6 meters long. The growlers are assumed to be more dangerous since they can still damage vessels, but they might be too small to be detected with the ice detecting equipment of today (28). Both fishing and shipping can occur in areas next to the ice shelf, therefore they are subjects of the risk of hitting ice in the water. Ice in the water affects the technical solutions and the design, and need a system for detection as well as surveillance.

Figure 11 One ship - iceberg interaction suggestion for Titanic (29)

2.4.2 Wind and waves

Waves are mostly related to wind. The wind and wave conditions are not worse in the High North than other places in the North Sea and the Norwegian Sea such as the area around Jan Mayen (21). When Polar lows (see chapter 2.4.3) are occurring, the wave height will increase (14). The wave height reduces further north and east along the northern part of Norway. However, other conditions might be present along the north eastern passage and other places in the Arctic.

See Figure 12 for the wave distribution along the northern Norwegian coast towards Greenland and Svalbard.

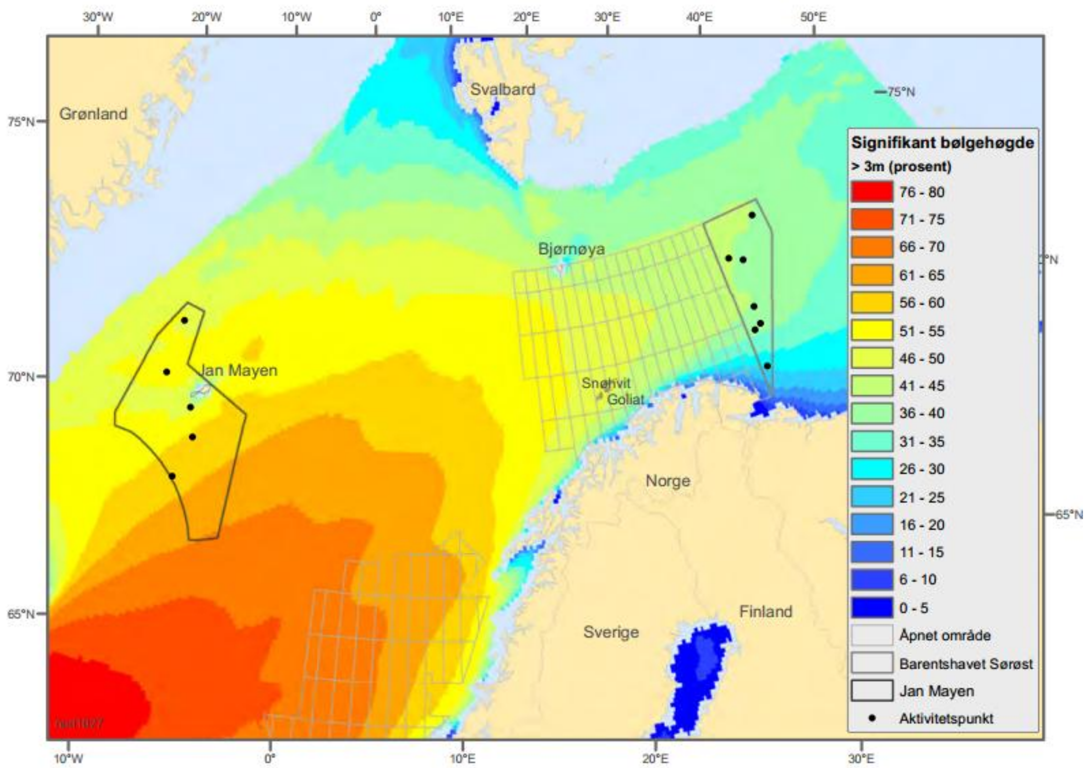

Figure 12 Significant wave heights (14)

2.4.3 Polar lows

Polar lows are small intense lows, that make the wind and waves conditions suddenly change. They can affect the ships operation as they create a sudden change of the weather conditions. For both normal and emergency situations they can create difficulties. Polar lows occur less in the area around Jan Mayen because of lower sea temperature (21). Polar lows normally in the period October to May.

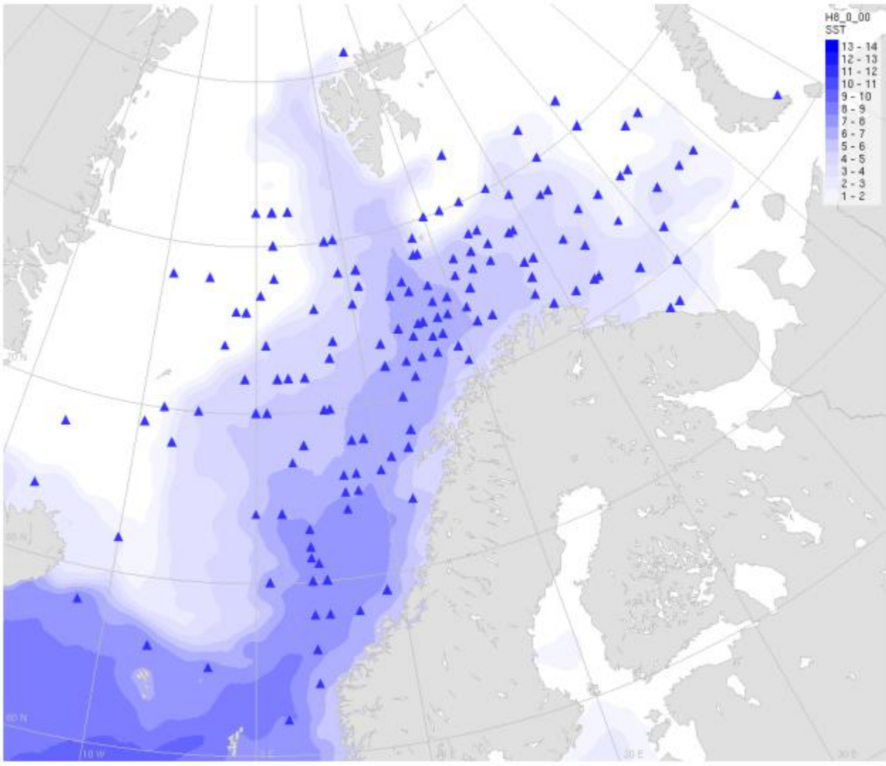

Figure 13 Area where polar lows have been created from 2000 to 2012.

From Figure 13 it can be seen that the Polar lows occurred 166 times from 2000 to 2012 (30). The ocean temperature is the blue shadings. The ocean going fishing vessels might be subjects to polar lows when fishing, while the shipping vessels will not really be affected, as this phenomenon happens outside the period the shipping passages being ice free.

2.4.4 Fog

Because of the poor visibility when it is fog, there is an increased chance of collisions between vessels or vessels and offshore structures. Fog will also create problems when it comes to helicopter services such as SAR. Fog and precipitation are reducing the view often both during winter and summer around Jan Mayen. To reduce this risk, measures have been taken in the form of establishing fixed shipping lanes 30 nautical miles outside the Norwegian coast from the Russian border to Rust (31). Both normal operations and emergency operations such as search and rescue will be affected by the reduction in visibility. For fog, it is assumed it is most frequent in the summer, a difference from most of the other factors. The annual mean cloud cover in the Arctic is about 70%, making it one of the cloudiest places on earth (21).

2.5 Pollution

Pollution comes in many forms for the Arctic environment. Anti-fouling, grey water, ballast water, chemicals and different waste from the vessel can all affect the vulnerable environment. Environmental toxins accumulate in the Arctic, maybe more than some other places due to the Gulf Stream, but the Arctic does not have a high human activity (32).

Oil spill from illegal discharge or accidents is the biggest threat to the Arctic marine environment, followed by strikes of marine mammals, introduction of alien species, disruption of mammal migration and noise pollution (33). Marine traffic of Russian oil has increased dramatically after 2002. Crude oil, bunker oil and refined products are shipped in small ice strengthened tankers to Murmansk.

2.5.1 Fuel

The fuel creates particles that can harm the environment. For operations in the Arctic it might be a need to change the type of fuel for the vessels to protect the environment from emission and possible leakages.

2.5.1.1 Marine Gas Oil versus Heavy Fuel Oil

To reduce the effects of pollution from fuel, Heavy Fuel Oil (HFO) will be forbidden to use in the protected areas around Svalbard from 2015 (34). Marine Gas Oil (MGO) is then an alternative. MGO is considered a pure distillate fuel (35). The advantage of MGO is that it is less viscous than HFO, and then requires less preheating before use, which is convenient in the cold Arctic areas. It is not always possible to run HFO machinery on MGO, since it can create technical problems. MGO also has low sulphur content, which is beneficial when it comes to emission of polluting fumes (35). If the vessels use MGO and not HFO the maintenance intervals are longer, since the MGO is a cleaner fuel. MGO is significantly more expensive, so many vessels with high fuel consumption choose to use HFO.

2.5.2 Ballast water

The ballast water used on some vessels contains biological material from where the ballast water is loaded. Alien species can affect the natural biodiversity in the area (36). When the ships are to discharge ballast water as well as other wastewater, special cautions has to be carried out to avoid alien species as well as other pollutants.

For ships that use ballast water, regulations will be strict. Around Iceland some regulations is entered into force, and Norway have national regulations on ballast water. This means that the Ballast water convention should be used when operating in Arctic areas. New built vessels should have some measures to treat or safely dispose ballast water under the regulations.

2.6 Navigation and communication

“There are serious limitations to radio and satellite communications and few systems to monitor and control the movement of ships in ice covered waters. “(7)

Radio navigation and tracking technologies are important for safe navigation, but in the Arctic the communication face problems *(7)*. For shipping through the lower parts of the north eastern passage, VHF-radio, MF- and HF-systems and satellites is generally adequate, but the communication becomes more problematic in the high Arctic.

Global navigation satellite systems, especially high precision positioning, has a lower performance. Problems occur since most satellites are going in geostationary orbit, also there is higher ionospheric variability, accretion of ice can occur on the antennas, the systems for augmentations have lower performance and there is a lack of land based stations. These problems give signal loss, signal attenuation, disturbances, and poor quality of the signal. Also the demands for real time requirements cannot be fulfilled (37).

The problems with the surveillance, monitoring and communication in the Arctic should be reduced. It is expected that in 2015 some new low orbit satellites will be operational (6). The AIS system should be extended to allow a further distance from land, so that the vessels can find each other’s position and then easier provide help in an emergency situation. In the future there is planned to make a multinational Arctic Search and Rescue instrument (6).

The lower knowledge and experience from operation in this area are of concern, since it makes it more risky for the crew (37).

A summary over the challenges normal communication system face in high latitude shows how the Arctic has reduced performance compared to other areas in the North.

	System	Characteristics	Polar (>80˚N)	Sub-Polar (70˚N - 80˚N)	Other (<70˚N)
Terrestrial systems	HF, MF	Safety related messages and voice communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications	OK, but unsuitable for digital communications
	VHF, digital VHF, GSM, 3G	Line-of-sight, voice and low data rate communications	No base stations,ship-to-ship OK	Few base stations, ship-to-ship OK	VHF is OK close to the coast, GSM/3G limited coastal coverage
Satellite systems	GEO satellites, including Inmarsat.	Medium capacity. Low to medium latency.	Not available	Potential problems with quality and availability	OK (except in fjords and similar special areas)
	LEO satellites; Iridium OpenPort	Currently max. 128 kbps. High and variable latency.	Potential problems with quality	Potential problems with quality	OK, except for areas around equator
	HEO satellites	Properties comparable to GEO. Currently unavailable.	Expected to provide good coverage, capacity and quality in the Polar and Sub-Polar areas. Spare capacity can be used in other sea areas. Not yet implemented.		

Figure 14 Communication systems performances in the High North (38)

In Figure 14 the following colour coding is used

- Green – available systems
- Orange – combination, and need further investigation
- Red – unavailable systems

The systems depending on geostationary satellites are not available, hence information that these provide has to be gathered elsewhere for safe navigation.

2.6.1 Daylight

One of the problems in the Arctic is the day light. Fishing and shipping are supposed to happen in the summer time, when the sea ice is low and the higher temperatures provide better conditions. In the winter, it is dark, and in the summer, the sun is up so late that the normal sleeping rhythm of the crew might be affected. For development of the oil industry the factor of the darkness should be considered both for safety, availability and available work window. This will most likely not affect the working schedule for the crew, and it might be beneficial for both fishing and shipping at night.

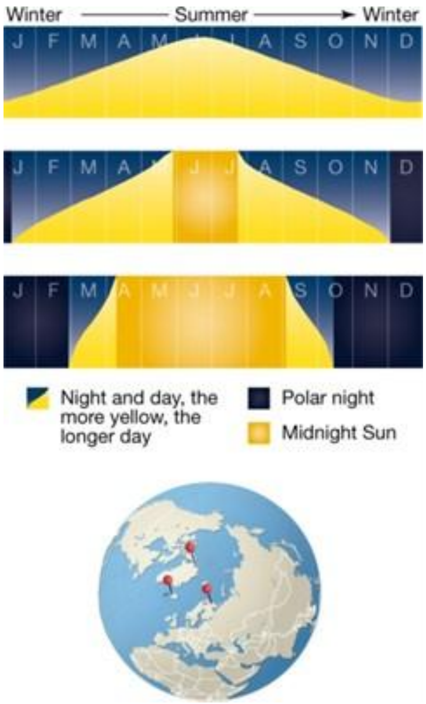

Figure 15 Extreme days and nights, Reykjavik, Murmansk and Alert (39)

2.7 Emergency response

"Except in limited areas of the Arctic, there is a lack of emergency response capacity for saving lives and for pollution mitigation" (7)

The emergency preparedness will not be sufficient for the expected increase in the activity in the North. In emergencies, experience is considered the most important success factor. This is taken into account in the Polar Code that emphasise the training of the personnel. The marine infrastructure today lack operational centres, vessels, decision support systems almost at all places in the Arctic. The lack of infrastructure coupled with the vastness and harshness in the Arctic, makes emergency response significantly more difficult (7).

For vessels going in traffic through the Arctic, the Search and Rescue (SAR) can be assumed to be of greater importance for the shipping vessels than for the fishing vessels. Fishing vessels often go out together and operate together. This can be assumed only if the vessels are not going in a convoy where they can receive help from the other vessels. The Arctic states will supply support to multinational Arctic search and rescue with the responsibility for different areas, see Figure 16 (40).

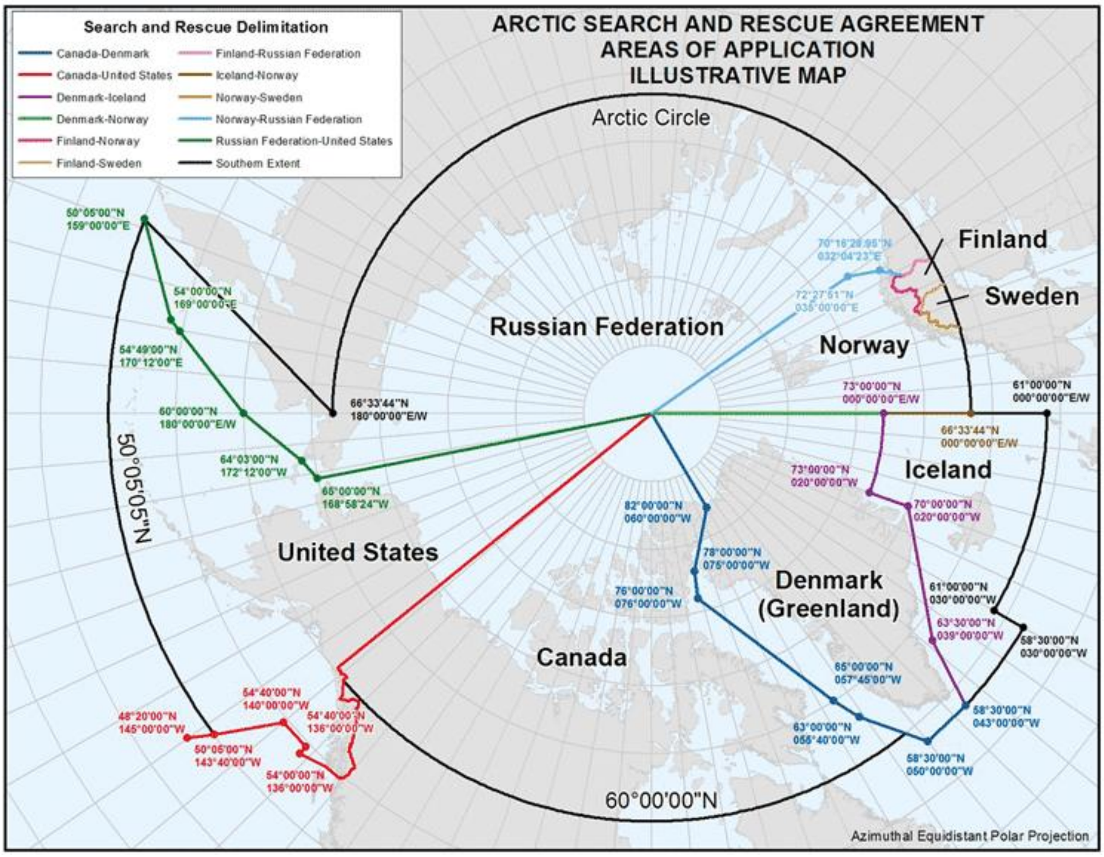

Figure 16 Arctic Search and Rescue agreement (41)

2.7.1 SAR

Search and Rescue

For the fishing vessels on their way to Svalbard, the SAR coverage is ok. The helicopter coverage of the area around Svalbard,

Figure 17, does not cover much of the coast area around Greenland. There are possibilities for refuelling at the different stations in the area, giving a higher radius, though it will take longer time.

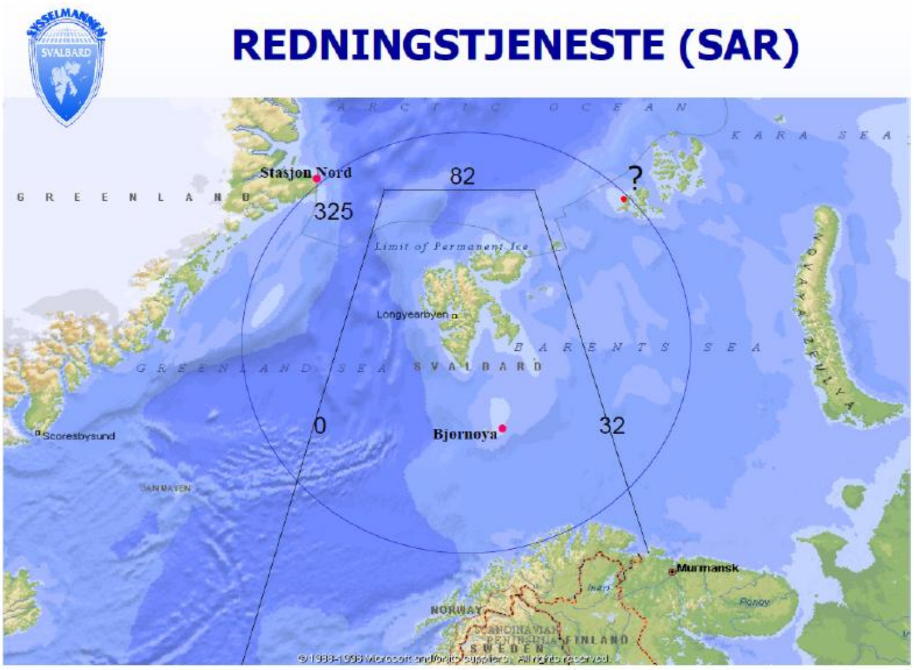

Figure 17 Helicopter coverage from Svalbard

3 Fishing in the Arctic

Fishing in the Arctic has occurred since the first persons appeared. Today bigger vessels are going fishing up in the north. The climate is rough and cold, and the environment vulnerable.

Most of the activity in the Arctic waters is by fishing vessels (6). Fishing vessels account for 2/3 of the ship activity in the Barents Ocean (14). In the Arctic area it is mostly prawn trawlers. Large scale fishing has been undertaken during the last decades. Fishing has been the main activity, and the vessels are now getting better for the Arctic conditions.

There are many well know fishing areas in the Arctic. In Figure 18 the main fishing areas in Europe are shown. Fishing is regulated by the United Nations' Food and Agriculture Organization (FAO) and they have separated the fishing grounds into areas. In Figure 18 the FAO area 27 can be seen. The Arctic fishing areas are north of 66.562̊. The adjacent area to the west, FAO 21 also consists of Arctic waters, see Figure 22.

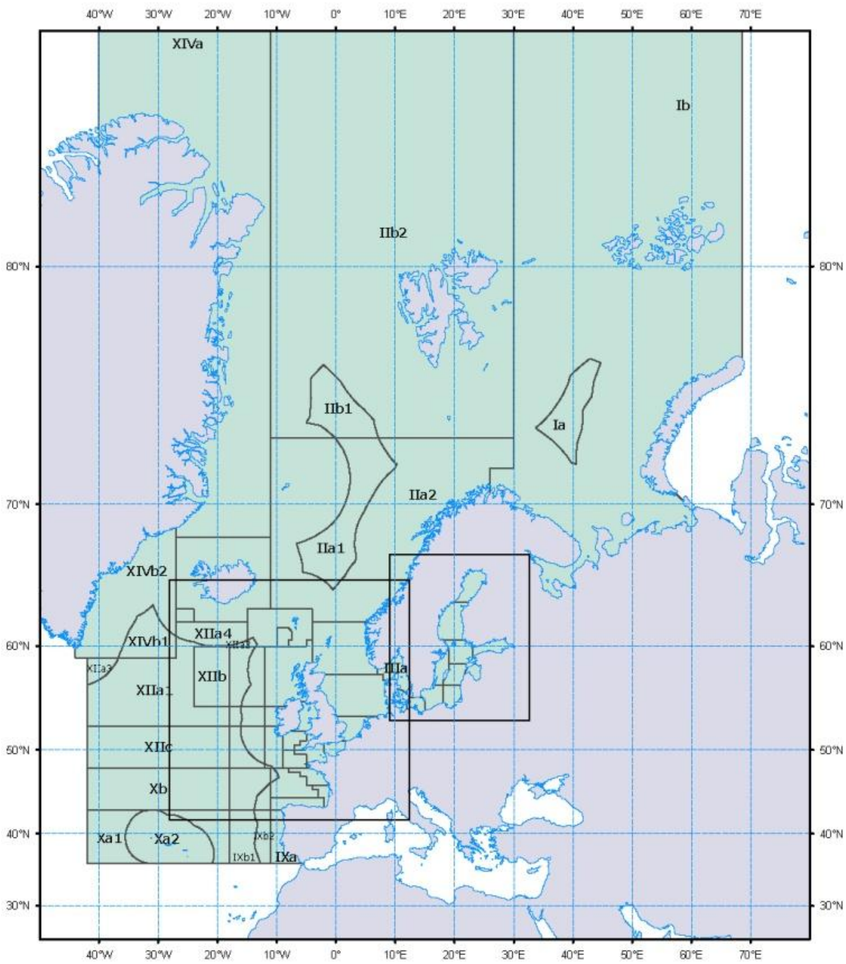

Figure 18 Eastern Arctic fishing areas (42)

The fishing consists of line and trawling of cod and haddock between mid October to May. In the summer sporadic fishing of Catfish occurs. The fishing season for capelin is for a month between the mid of January to the mid of February. Capelin is fished with nets and trawl. However, most of the active fishing conducted in the Arctic areas is undertaken by prawn trawlers and long liners, but also some sealing vessels. Sealing vessels normally have a different, much stronger hull, similar to those used on ice breaking vessels (24).

In the Barents Sea the following type of fishes are being fished (43):

1. Cod
2. Capelin
3. Greenland halibut
4. Rosefish

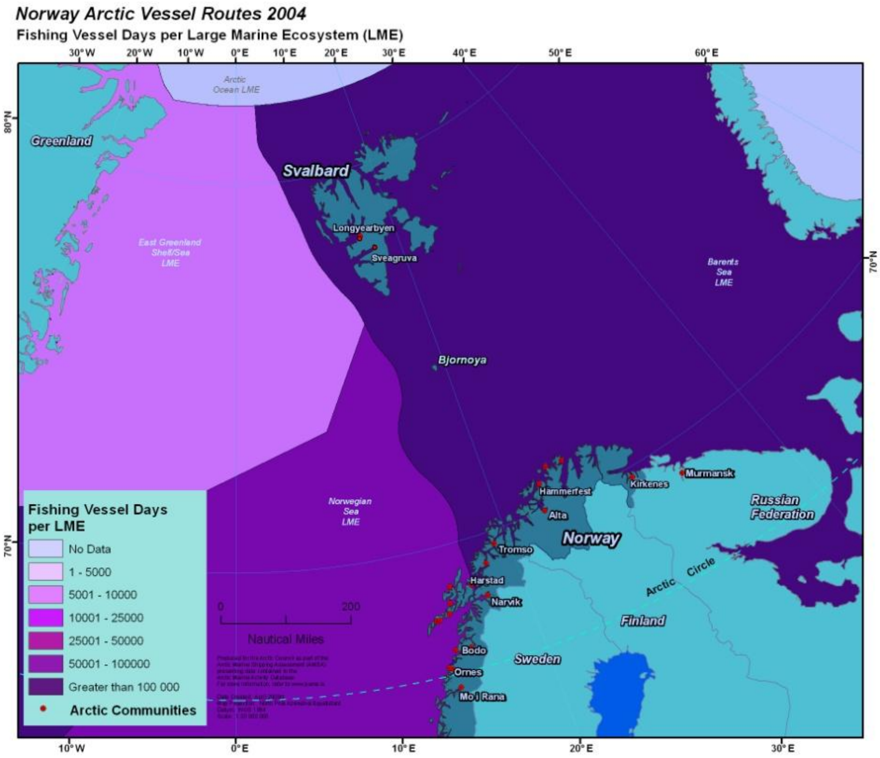

Figure 19 Fishing vessel days per LME

Figure 19 shows how many fishing vessels are operating in the Large Marine Ecosystems (LME) north of Norway, where parts of it would be considered as Arctic fishing (6).

The Norwegian fishing fleet in the Arctic are normally new compared to the Russian fleet. In the beginning of the 2000s, there was a renewal of the ocean going fishing fleet after prawns. Out of the Norwegian 41 trawl vessels for white fish, such as cod, 31 of these also have a license for prawns (44)(45). Renewal of the trawler fleet is within trawlers who have both prawn and cod licenses. This makes the prawn fleet in Norway, rather modern (44).

3.1 Regulations

Fishing north of 62° N is regulated. The fishing in the Arctic marine area is regulated by Regional Fisheries Management Organizations (RFMOs). Regulations are about quota limitations, bi-catch and separation grids, minimum provisions, mesh size etc. The equipment has to be controlled and vessels over 50 tons are subject to controls (46).

In Norwegian waters it is practical free fishing of prawns today, while internationally it is vessels quotas, fisheries agreements and concessions (47). Restrictions are set by the Total Allowable Catch (TAC) and allocating of national quotas (48). From the Norwegian fishing directorate 11 prawn trawlers have a license for Greenland (49). These fishing vessels are normally over 30 meters.

There are several, but not complete, bilateral conservation and management arrangements between the Arctic Ocean coastal states of the shared fish stocks. However, these might not be sufficient. A WWF[4] report (50) states that, there are no legal protections, or they are too weak, and that the fisheries are not well enough covered by international law (7).

The most important globally instruments related to the Arctic also applicable to the fishing are:

1. United Nations Convention on the Law of the Sea (LOS Convention),
2. The Fish Stocks Agreement
3. The United Nations Food and Agriculture Organization (FAO)
4. Compliance Agreement
5. Code of Conduct for Responsible Fisheries
    a. Technical Guidelines
    b. International Plans of Action (IPOAs)

The difference of fishing boat from other vessels is that it is not going through many international waters, but it is more based on where the fish is swimming, and the route cannot be easily planned ahead.

[4] *World Wildlife Fund,* International Organization linked to environmental issues.

3.2 Environmental concerns

Many researchers from over the world want to stop the fishing in new ice free areas in the Arctic until the fish stocks are assessed (51). Not only might the reduction of ice affect the fishing of the fish stock in the Arctic, the stocks will be affected by reduced salinity, increased acidification and other oceanographic and meteorological changes such as more storms and waves.

A large section of the Arctic marine area is not covered by the RFMOs or arrangement with competence over target species are lacking (48). The Arctic fish population is not clearly monitored, and there is also a suspicion on illegal, unreported and unregulated fishing (52).

About 70 % of the white fish captured in the world comes from Arctic waters. There are reported problems of illegal fishing of pollack and cod in the Arctic. WWF have calculated that about 100.000 tons of cod was illegally fished in the Barents Sea in 2005 (53) (54).

Figure 20 Cod (55)

3.3 Prawn trawling

Fishing of prawns started at the end of the 1900th century, with industrial fishing starting the 2000th century (46). The prawns fished in the Barents Sea, are Pandalus borealis, see Figure 21.

Figure 21 Pandalus Borealis - Northern Shrimp (56)

During the last few years, fishing of prawns have been reduced due to low prices. Recently the prize of raw prawns is increasing, so the activity might increase again. Important prawn trawl fields in the north are Nord-banken, Sølebanken, Tiddlybanken and Thor Iversen bank, see Figure 23. One of the prawn fishing areas that might be opened for petroleum activity later, is around Jan Mayen. This could lead to a conflict in the future (57).

The Northern shrimps are captured in the FAO 27 and FAO 21, see Figure 22. The Arctic Prawns are then fished in the northern part of these areas.

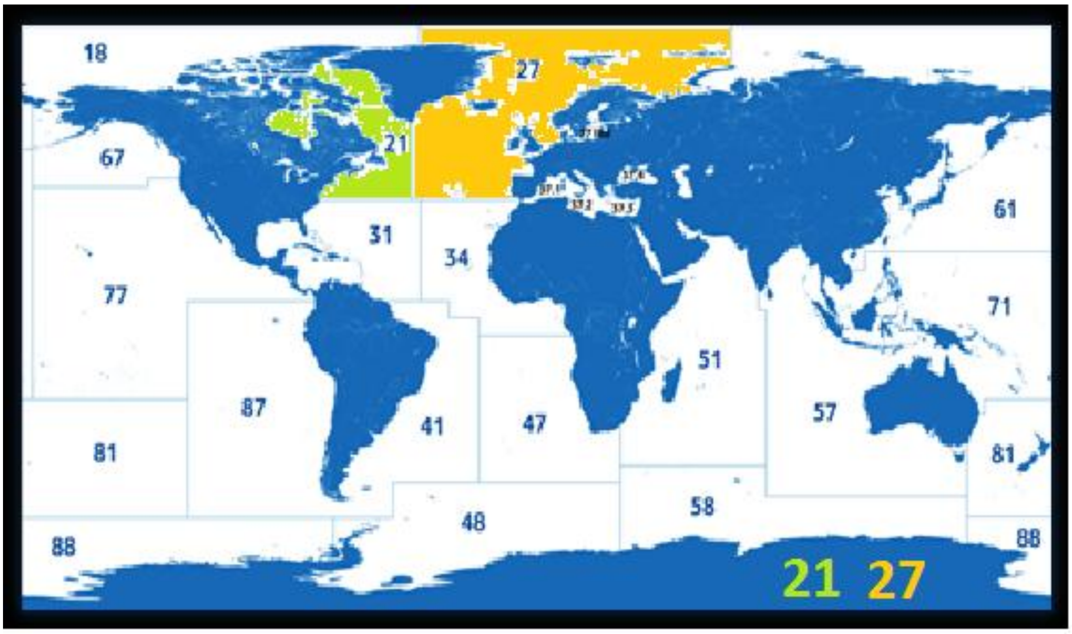

Figure 22 FAO 27 and FAO 21 (58)

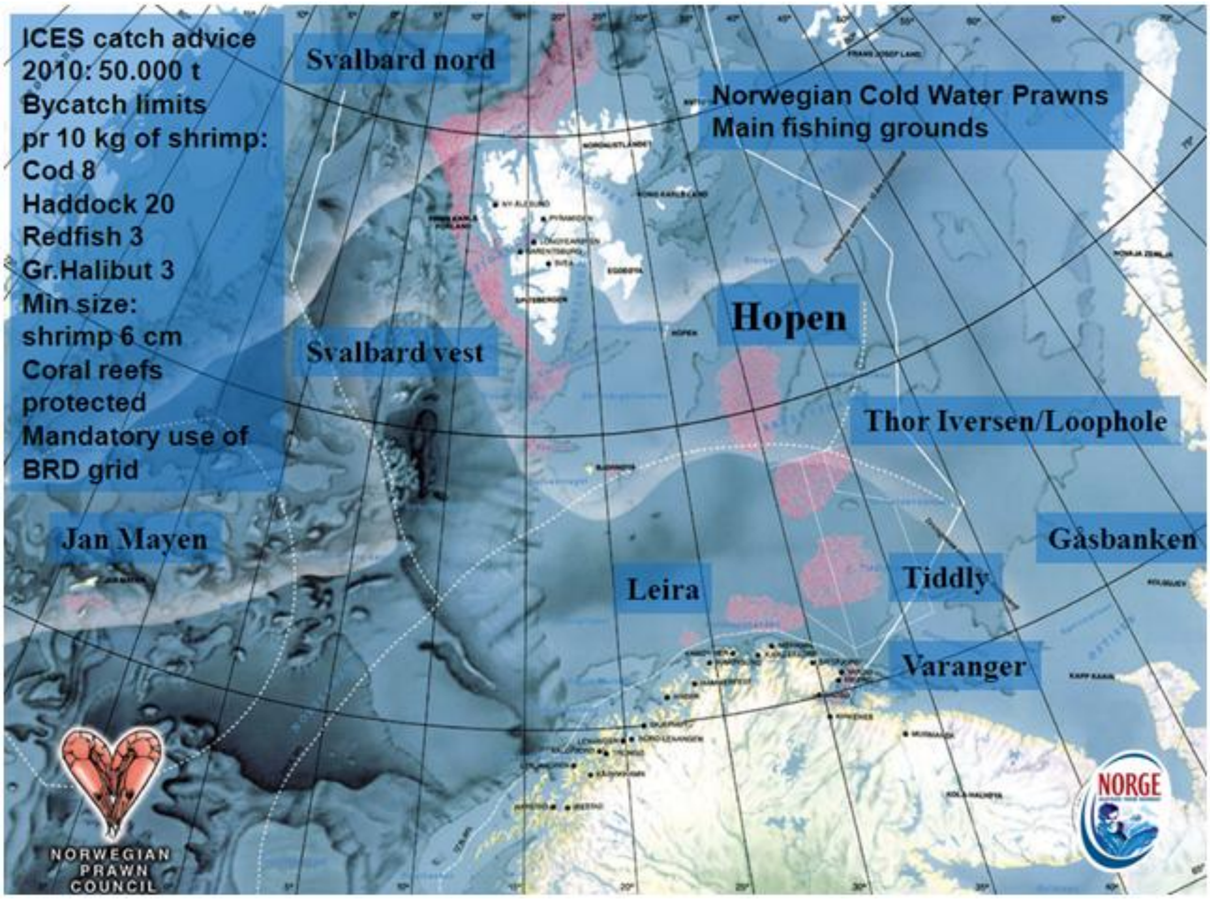

Figure 23 FAO 27 Prawn fields

In Figure 23 the main Norwegian prawn fishing grounds are the red areas. The vessels also go further west to the west side of Greenland to fish prawns on the Danish territory (57).

3.4 Accidents in trawling

SINTEF Fisheries and Aquaculture have made a report on accidents in the fishing industry. The report has its own chapter on the accidents on trawl vessels (59). For the trawl vessels in Norway it has been reported 896 personal accidents in the time period of 2000 to 2011. Eight out of these are death accidents, making up almost 1 % of the total.

The most typical accidents on trawlers occur when handling tools on deck, standing for 33 % of the accidents reported from 2000 to 2011. Other deck work count 17 %, making the deck work accountable for 50 % of the accidents. Further handling of the cargo is also risk based work. Handling and treatment of the catch stands for 10 % and further handling in the storage of the catch is also around 10 %. Of these accidents, about 76 % led to 72 hours or more of lost manpower, and can be considered serious injuries. Body parts such as hands, fingers and feet are specially exposed (59).

For the Arctic consideration, accidents linked to freezing, sea impact, falling on slippery area etc. need special attention, and therefore these concerns should be included in risk assessment before the ship leave for operation in the Arctic.

To increase the safety the Norwegian Maritime Authority has inspection on the fishing vessels. Many vessels lack maintenance systems, and are not having regular trainings (60). Within some vessel groups, up to 30% must be retained for not fulfilling the demands to safety. The trawlers in the ocean going fishing fleet are the vessel group with the highest share of reported personal injuries (59). The most common accident is grounding.

4 Case vessel – J. Bergvoll

Nergård Havfiske AS[5]

The vessel used as a case ship is J. Bergvoll, and it is a shrimper (Figure 24). It can load 430 tons of shrimp or 420 tons of white fish. The vessels length is 57.3 m, and the width is 12.6 m. Its gross tons are 1483 (61). The vessel was delivered as a new build from Solstrand AS in 2000 (62). The vessel has DNV class +1A1 and ICE-1B, which means the vessel can operate in moderately difficult ice conditions and in ice with a thickness of 30-50 cm (63). The hull complies with ICE-1A. J. Bergvoll is a stern trawler and has the possibilities to have unmanned machinery room, called E0 for the DNV classification.

Figure 24 J. Bergvoll

A typical Arctic trip for the case vessel is around 4 weeks out on the sea. At this point it has varied between 0-2 trips each year for shrimp in the Arctic and white fish in Arctic or near Arctic areas. The variation in the time spend in Arctic waters is large, and is dependent on both the fishing and the prices. The crew when trawling prawns consists of 15 people. It has 2 complete crew sets which runs in a 1:1 system.

[5] Thanks to Captain Kyrre Hansen, factory boss Lorentz Johansen, Axel Poulsen on Machinery and Kenneth Nordli and everybody else at Nergård Havfiske AS for the good help on this section.

4.1 Trawling in the North

Back in the early days of industrial fishing it used to be more vessels in the Arctic, but these vessels were smaller (64). As industrialization came with bigger vessels the smaller vessels got phased out. Thus the safety increased as the vessels were more built for the conditions.

The crew of the vessel considered it important that the vessel is a good boat. For operations in the Arctic area, it is emphasized that the bigger vessel the better. Size is an important factor for the operating environment.

4.1.1 The trawling

Prawn trawling is a form of bottom trawling. J. Bergvoll is normally using twin trawls, see Figure 25. The trawl nets are submerged and spread by the two large trawl doors and towed by thick steel wire warps across the bottom for anywhere from 5 to 7 hours at a time.

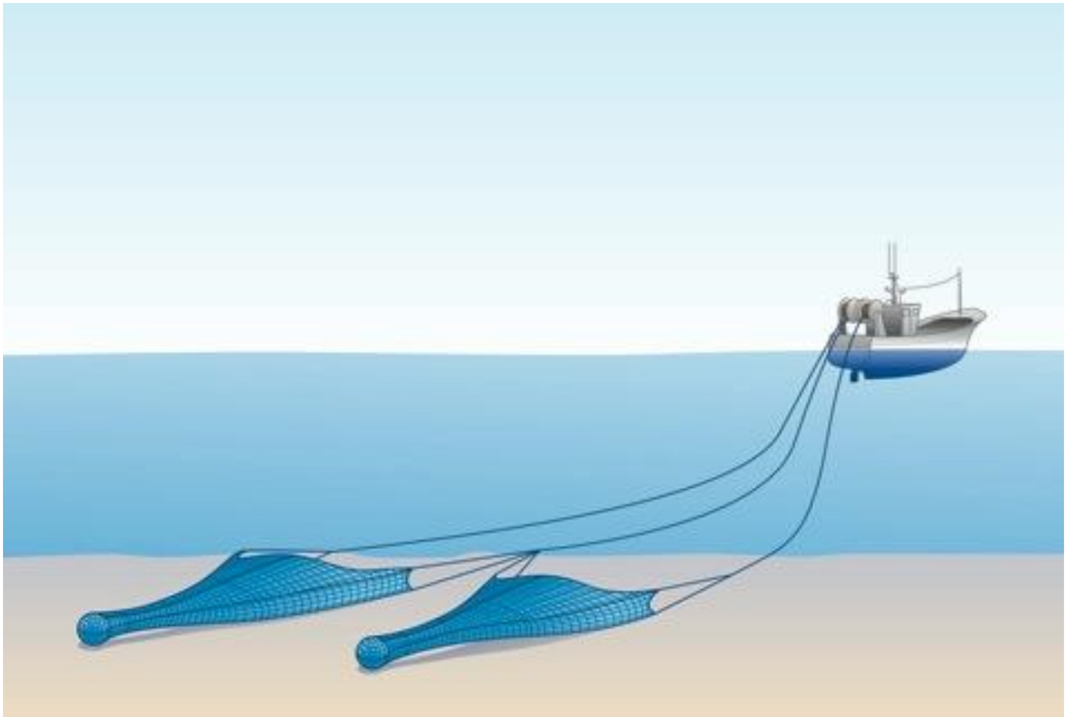

Figure 25 Twin trawl (65)

Figure 26 Trawl door in red

Figure 27 Gear

The aft of the vessels consist of equipment for fishing, with deck space for the codend. The codend will be slipped over the trawl slip, and the block in the middle will separate the codends. See Figure 28 Aft deck J. Bergvolland Figure 29 for the aft of J. Bergvoll. One of the winches is in the bottom left corner.

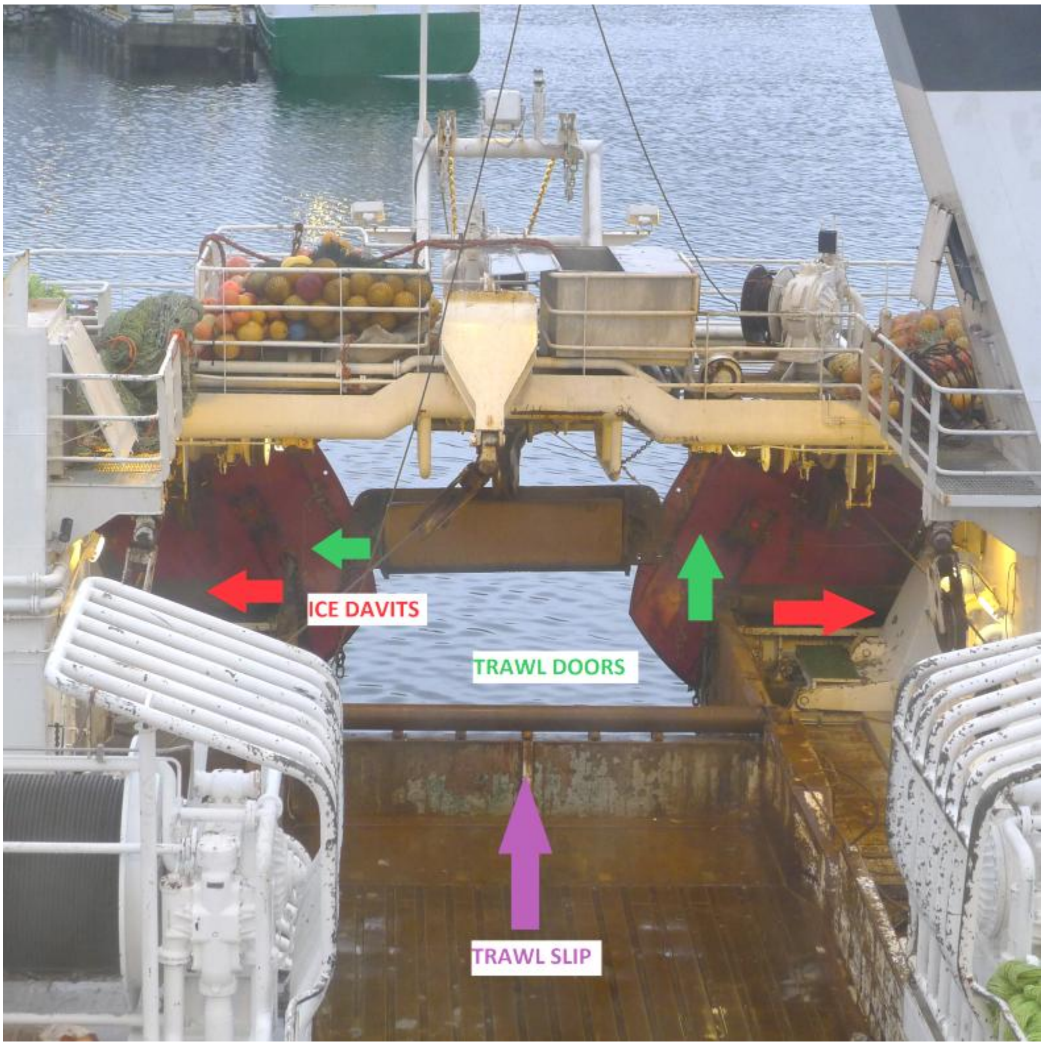

Figure 28 Aft deck J. Bergvoll

To take up the codend when operating in the Arctic, it is important to find a slot without ice. The ice can damage the codend, so finding safe areas in the ice for hauling is one of the reasons why tows can sometimes take up to 7 hours. For trawling in ice, ice davits are used, see Figure 36. The ice davits run on the hydraulic oil. Problems do occur with the ice davits when for instance fresh water gets into the hydraulic oil, and freezes. The importance of the use of the ice davits is emphasized when operating in the Arctic. Using the ice davits, the wire warps will not be damaged by ice pack.

Figure 29 Deck of J. Bergvoll

4.1.2 Cooperation

Vessels often go out in convoy, 2-3 vessels together, working in similar geographic areas. The cooperation between the vessels of the fleet is reportedly good, with vessels staying in contact via phone or VHF radio. In cases where a vessel is lacking in some necessary equipment or spares they arrange borrowing or buying it internally, so that operations can be continued unimpeded. Sometimes equipment will also be shipped out if the need is justified, via other vessels or indeed by helicopter. The same view on cooperation is true in the occurrence of emergency situations, where cooperation is an import management tool applied by the vessels. See chapter 4.6.

4.1.3 Nearby ports

If an emergency occurs in the operation area north of Svalbard, it would take the vessel 6-12 hours to get to the port New Aalesund. If operating around Hopen, it would take 12 hours to get to safe port in Longyear City, depending on the conditions. These values are very rough since the values might differ a lot due to the weather and the fishing areas. Therefore preparedness of both personnel and vessel are essential parts of the work conducted here.

4.1.4 Reported difficulties

The crew of the vessel visited believed that working in non Arctic areas is much simpler, and would prefer working outside Arctic waters. For operations in the Arctic special concerns on safety are raised. This is because of the special precautions required, and the need to work much quicker in this colder operating area.

4.1.4.1 Frozen equipment

When operating in the Arctic, freezing happens more frequently and more rapidly. Typical problems in trawling are that the net freezes quickly when out of the water in the cold and windy conditions. This causes a lot of difficulties in tying and untying knots since the rope will freeze over with ice quickly and become unworkable. The codend will stiffen, and make the work of emptying the catch harder too. Also, if there is damage to the net, it is difficult to repair as the net first has to be moved to be defrosted in a certain area onboard using heaters such as heat guns on the deck. This is very demanding work for the crew and it takes a lot of time to defrost. This is especially demanding if they have to repair the net, because using gloves is a handicap in mending nets. Special gloves are used, where fingers have been cut off to be able to work with knots, but there is still a need for frequent breaks out of the cold in order to reheat the extremities.

4.1.4.2 Ice accretion

Ice accretion on the vessel is the main fear when operating in the Arctic. Icing on deck is usual. When ice accretion happen it force the people out to manually remove the ice with ice clubs from the vessel, putting the crew at risk. This is necessary due to the increased probability of capsizing due to the increased weight high on the vessels superstructure. This is heavy, cold, manual and exertive work conducted in freezing conditions. Emptying of the anti rolling tank can be conducted within a short time period if icing does occur[6]. This acts to lower the centre of gravity and re-establish control of the vessels stability. This vessel does not have steam in the railing to prevent accretion. Other vessels that operate more often in the Arctic have steam in gunwale and hot water some places around hatches and hatch frames to limit icing.

6

Regulation on fishing vessels over 15 m

4.2 Preparing for Arctic

This section is built on a phone conversation with Kenneth Nordli at Nergård Havfiske AS. He is responsible for planning the technical preparation for the fishing vessels at Nergård Havfiske AS such as necessary equipment and purchases for the vessels.

Nergård Havfiske AS has five vessels to operate. On land, two men are working on the planning of each voyage. One person plans the technical and one person plans around the organization of the crew.

4.2.1 Operation time

The transit time to the east of Greenland is about 4 days, while going to the west takes around 5 days. A total length of a voyage will be around 4 to 6 weeks. The transit time will be a great part of the operation time, up to 35% of the complete voyage. Normal time period for operating east of Greenland is 5 weeks, while a voyage to the west could lasts for 6 weeks. This is dependent on how they solve the crew solution in the summer, since the crew is normally going in a 4 weeks on – 4 weeks off rotation.

4.2.2 Crew

They preferably never send trainees or new fishermen, on their first trip to Arctic. However this might depend on how well they can plan the crewing. Normally 1-2 weeks before crew change a meeting will be held with the shipper on land. They will go through, change the plans, add new problems and questions and then it might be followed up by a new meeting. For Arctic operations, this meeting will be held earlier, so they all can have better time for the planning.

The captain manually maintains a list of the certification that is required to be maintained onboard, in a self made system in excel.

4.2.3 Meetings

About 3 months or longer in advance, a meeting will be held with the captain, and the other departments of the ship being the machinists, the factory boss, the deck boss, and the steward. It is mostly meetings over the phone. If necessary, the shipyard and external service personnel are invited as well. Under the phone interviews, information about the current state of the ship is considered. For the planning they check against the captains previously developed check list determined from long experience. So far, the case vessel does not have a separate check list to go through before bigger operations in the Arctic. This check list will be checked with the captain and the captain then consults his department leaders.

4.2.4 Inventory counting

The departments will carefully go through the equipment, and check that what should be onboard, actually is onboard. The different departments have different ways of checking the state of their department, but the inventory will always be checked to be correct. This is to ensure that used and unused equipment has been correctly registered, and to avoid the event of not having a spare when it is needed.

The inventory will be checked with a computerized maintenance management system. For J. Bergvoll this is a program called PreMaster, see chapter 4.2.9. An inventory list can be printed and be manually checked with the actual number.

4.2.5 Lists and reports

All the departments will create necessary lists and reports on the current situation of their department. A list will be made over work that has to be done and what equipment to purchase and picked up and controlled from storage. The spares will be determined out of what are identified at the information meetings and the feedback from the different departments. When the necessary feedback is received from the departments, service personnel and the class society, then the planning of the preparation time in shore can start. An action list over the necessary work has to be optimized for the given time frame.

4.2.6 Spare parts

For Arctic operations more spares will be added than under normal conditions. On the vessel the control of the existing stock of supplies, spares, tools etc. has to be carefully carried out. More equipment is normally brought after a more throughout evaluation, also because the voyages to the Arctic are longer.

Typical extra spares are electro engines, parts for the hydraulic system, cylinders, gears, winch and equipment for the factory. For the main engine the components such as the fuel oil system’s pumps and injection vents are all checked, so the operating condition are known. In general vents are mentioned of importance for sufficient operation.

For the machinery the necessary spares are filter, vents, pumps and electronics. The most primary things to be included are extra oil and filters, equipment for the trawling activity, and then wear parts in the machinery such as sealing rings, shaft-sealing, pumps and cylinder parts.

Sometimes it is possible to borrow equipment to the production hall as well as machinery spares etc. from the other vessels operating together on the same fishing area, see chapter 4.6

4.2.7 Preparation at shore

The vessel fishes prawns around Greenland and in other cold areas. Normally the vessel will be at shore for 1 day, but before going to the Arctic, the vessel may be at shore for between 2-4 days. This is to have time to conduct all the necessary maintenance, get hold of necessary parts and ensure the safety is as safe as possible.

For Arctic consideration, the ballast system is often mentioned, due to the discharge of alien species. On this vessel, they are normally not using ballast, since the filling of cargo balances the use of fuel. Hence, they only have to refuel and not fill ballast water at shore.

The vessel was at shore under the survey, and maintenance on the engine was conducted at the same time as the fish was unloaded.

Figure 30 View from the bridge at shore in Senja

4.2.8 Maintenance planning

For operations in the Arctic maintenance might happened at different time spectres than before. The reliability of the systems is of such a great importance, that a lot of equipment might be maintained before the trip, even though it was due later. Extra equipment and tools will be put on board so all conceivable problems can be fixed at sea.

Some of the equipment runs on longer and shorter time intervals than given by the supplier. The class related jobs will never be postponed, since this can interfere with the given licence, and the vessel might be withheld. Some equipment also has to have surveys from the Norwegian Maritime Authority. This is the intermediate survey, every two years, and the main surveys every four years.

The vessels maintenance system, PreMaster (chapter 4.2.9), creates job lists which are considered a sufficient list over the machinery work. PreMaster also includes deck machinery and other ship systems. The main maintenance on the trip is repair of equipment that breaks, or when something has to be fixed due to bad weather conditions such as icing, snow and storm. A long term planning of the maintenance is what is considered most economically viable.

4.2.9 PreMaster

The technical chief engineer keeps track of the regular maintenance of the vessel systems by using PreMaster, a ship management solution. This system is in the same family as the Star IPS (see chapter 7). Here planning of the maintenance, analyse risk, report events and perform other necessary administration affairs can be carried out. This system is used both on the vessel and in the shore base for monitoring spares and maintenance onboard.

The key modules in PreMaster are (66)

- Maintenance and Spares
- Procurement
- Crewing
- Reporting including ISM
- Quality and Risk assessment reporting
- Document administration
- Flow control specifically designed for ship owners and managers

The PreMaster system is used by the engineers, and there the machinists keep track of what purchases and maintenance jobs that have to be completed due to the schedule. The machinist also check the counters, to find out if a maintenance job will have to be done when in the Arctic, or if rescheduling is an option. In the PreMaster the machinists will check what spares are low or needed, and the machinists will place the orders.

The personnel on land will get PreMaster in the beginning of 2013. This will help the land personnel on keeping track of what are needed and to maybe take action with more difficult orders.

For planning of the maintenance onboard, most schedules for checks and monitoring of the machinery are also managed using PreMaster, including a program for keeping track of the components and spares. The system is used primarily to prompt time based conduction of particular actions on a pre set date basis. The records for testing and certificates needed to the class authorities, here DNV, are included in PreMaster system. This management tool is however imperfectly applied with elements of the system remaining underutilized, in example components and spares are not ordered through this program, despite this function being available.

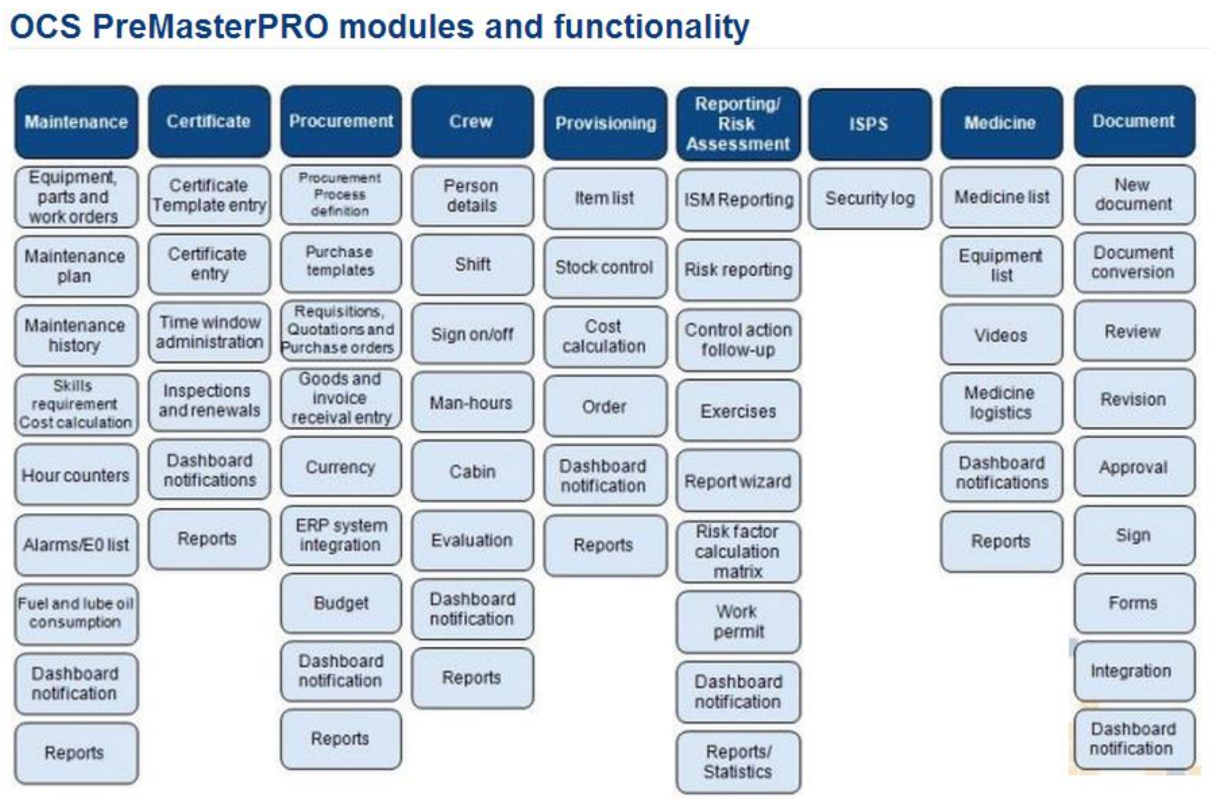

Figure 31 Modules in PreMaster (67)

Fishing vessels in general maintain a large inventory of spares onboard for most eventualities since it is rarely convenient to resupply while in operation, nevertheless spares might be used up quickly in some circumstances requiring a cessation of operations in order to resupply. The chief engineer and the machinist plan the maintenance operations, their scheduling and time requirements and are responsible for the purchasing of services, spares and the consumables for the vessel. They are therefore most busy when ashore. It is while the vessel is ashore on port call that most maintenance occurs since many maintenance procedures cannot be conducted at sea without affecting the fishing operations of the vessel.

The maintenance task list can be printed. Here planned maintenance shows up under the completion day. This list consists of the different components for the machinery department, but would only be valid to this one vessel, as all vessels are different.

4.2.10 Safety

Safety is prioritized. Some equipment that has not been used, or that has had small errors on it before, will have to be overhauled to best condition or new items installed before going out in the Arctic. If the operation is forced to stop or is interrupted far away from shore because of failing equipment, the cost is almost certain to be higher than if the equipment is fixed beforehand in port. Everything has to be checked to ensure 100% operability and reliability and the crew should be prepared for the conditions, methods and the equipment that have changed.

It was mentioned from the crew that it could be safer getting a machine break down in the Arctic, because it would be a longer distance to drift onto something compared to shore based fishing.

The personal safety is also emphasised, and the company has made a safety video of all their vessels, as well as an instruction book. Here, the main information about personal protection clothing and emergency routes can be found.

Figure 32 From the Safety video of J. Bergvoll (68)

4.3 Machinery

The machinery maintenance conducted onboard fishing vessels working in the Arctic is reportedly conducted in the same manner as that in more southerly clines. Even though the cold conditions and ice contribute towards a more rapid degradation in the condition of the engine and other fishing equipment, extra maintenance is not reportedly required or conducted. The reasoning behind this is that the equipment on a fishing vessel is designed to be robust and dependable under operation while repairs can be easily affected when a fault occurs as the equipment is kept uniformly as simple as possible. This is more due to the historic nature of fishing where unimportant components are extensively run towards failure rather than applying programs of condition monitoring and preventive maintenance. In some part this is also due to the availability of built in redundancies in many of the systems used onboard, with the exception of the main engine, see Figure 33, which remains the highest priority maintenance element of any fishing vessel.

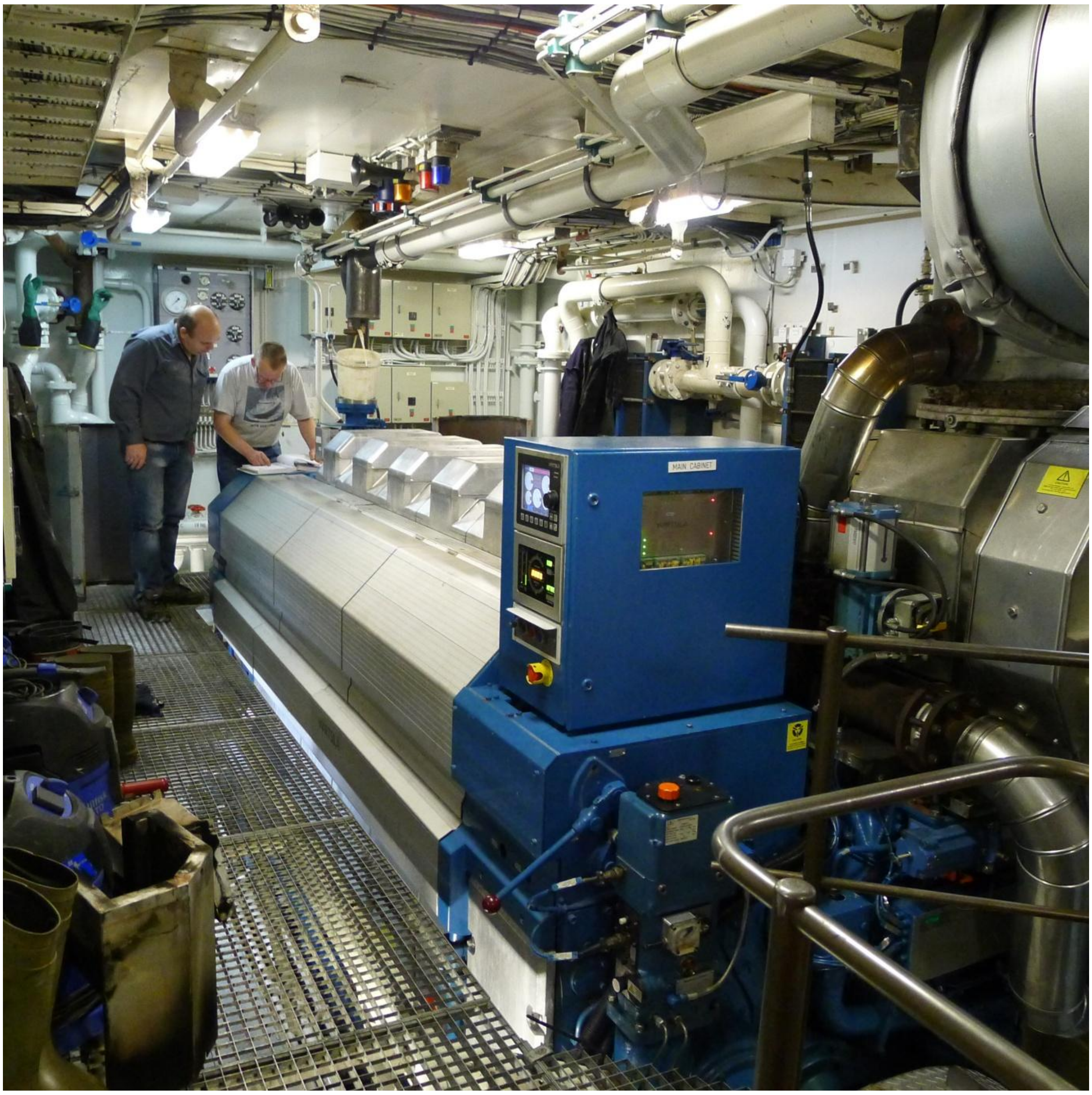

Figure 33 Part of the engine room of J. Bergvoll

The ship visited had the E0 classification, meaning that the engine room can be unmanned while the vessel is at sea. The engine is fitted with an alarm system that will notify the responsible person with an alarm in the cabin. This equipment is regularly re-certificated every year to DNV's standards. Even though they have the possibility to be unmanned they prefer and normally always have a person in the engine room monitoring the functioning of the systems. Problems with fires have not occurred on the vessel. The machinery runs on MGO diesel oil.

In the cooling system it is a thermostat on the fresh water side. So even though the sea water in the cooling system is very cold, this can automatically be adjusted for ensuring the correct cooling, being beneficial when operating in colder water temperatures.

For complex maintenance and repair of the engine, service personnel from Wärtsila are brought aboard during port calls to complete the work. It is not possible to have external service personnel to be sent out to operations in Arctic or other places, so this needs to be planned in advance with the ship schedule for landing. The ship also undergoes bi-yearly docking during which time sensitive equipment and machinery are extensively maintained, repaired or replaced. This is reportedly essential in maintaining the longevity of the machinery.

The experience is considered very important when it comes to judging the state of the equipment. In example, the hydraulic system is considered to be sufficiently robust to require only standardised time based maintenance operations. Since the redundancy in place is sufficient to manage the requirements should there be a failure of the primary system having two hydraulic pumps and one spare pump. Importantly however, for environmental considerations the hydraulic oil itself is not changed during fishing operations (69). This work is only conducted when in port, with the necessary disposal facilities near to hand.

The maintenance of significant items of main machinery, such as the winches and the freezer are completed in-house as without this equipment they would not be able to continue operating should a fault occur at sea, however for maintenance on the freezing compressors external services are required.

4.4 Factory

Since the vessel is normally fishing after white fish, a lot of equipment has to be changed to be prepared for prawn trawling. Equipment in the factory area has to be removed, protected and changed, and all the equipment has to be checked for operability. Specific lines in the production area have to be closed down. Much of the equipment might have been standing unused for a while, and it must be ensured that every single part is working correctly, and that all the necessary spares can be provided onboard.

For prawn processing they would be put straight into the plate freezer. This equipment was not on board during the visit. It is very cold to work on deck in the Arctic. Parts of the crew have to work in the freezing room anyways, so the crew is familiarized with cold working conditions.

The production hall has three gutting machines. Each gutting machine has about 9000 parts. It is always a man maintaining these machines, but since there are three of them, the redundancy is considered sufficient.

The head and gutting machines are a German type called Baader 444 (70).

Figure 34 Baader 444 gutting machine

Figure 35 Conveyor belt (green) and plate freezers (white)

4.5 Critical equipment

The most critical equipment and systems are the main machinery and the propulsion system. The electricity runs on the main engine, but can be shifted to the auxiliary engine. Hence leading to the second most critical equipment is the auxiliary engine and third is the fishing gear.

It is very rare that icing in the sea chests occur. Even though icing has never occurred in the sea chest at this vessel, they are equipped with compressed air to back flush the system. For the engine this is considered an important system.

On trawlers such as J. Bergvoll which is made for trawling both white fish and prawns in cold water, it is typical to have ice davits. Ice davits are placed at the aft of the ship, one on each side of the trawl slip. When it is ice, the vessel creates a ridge in the ice when moving. The ice might damage the trawl wire. Hence the ice davits are used to steer the wires into the middle of the ridge, avoiding contact with ice. The ice davits runs on the hydraulic system, and therefore the vessel will need an enhanced hydraulic system. The hydraulic run cylinders on the ice-davits moves the davits over the trawl slip, where the wires will go out almost next to each other. The ice davits are normally controlled from the aft of the bridge. The maintenance consists of greasing the cylinder on the ice davit, while the hydraulic system needs its own maintenance (71).

Figure 36 Ice Davits, upper part and socket.

4.6 **Borrowing**

Do unto others as you would have them do to you

If some of the vessels in distant water operations finds out that they are lacking some equipment; the vessels arrange to borrow from each other. This system works fine and it seems like all the vessels are willing to helping each other out, made easier by the fact that most vessels use similar equipment types onboard. Even though the vessels are competitors they see the value of giving and being able to receive this help themselves.

If it is small things to be sent, it will be wrapped carefully, then it is attached to a rope and a floater or buoy, and it will be paid out astern from the vessel that has the equipment. Then the other vessel will come pick it up when the donating vessel is at a safe distance ahead.

For bigger parts, they will be use the man over board boat (MOB). Either before or after lowering the MOB, the packet will be put in the MOB. This operation can only happen if the weather is calm. The MOB will drive over, and the packet will be picked up by the crane, or in some case the whole MOB will be picked up.

Figure 37 MOB (72)

4.7 Weather experience

"Sometimes the weather is really bad, and sometimes only nice…"

The weather varies a lot in the prawn fields around Greenland. Even though they are lying on the ice boarder, it is relatively clear in the summertime. The perception of the storms around Greenland is that they are not much worse than the ones that occur when they operate close to shore. The storms might however occur later in the season in these areas, than closer to shore.

Storms and icing are always an extra threat in Arctic operations as icing of the superstructure is the biggest fear. When minus degrees and sea on deck, icing is likely to occur, and the crew will have to go out and manually remove the ice with clubs.

Ice will be floating in the water, and it will be even harder to spot when the fog is present. The fog can occur very frequent.

4.8 Navigation and ship control

During operations the bridge is normally always manned with at least one person. The navigation equipment is considered sufficient with numerous redundancies for each of the major systems. The navigation aids are working sufficiently for these areas in the Arctic.

The most critical navigation equipment for Arctic areas is reported by the fishing operators to be the ice spotlights, which have a special blue light enabling the spotting of ice in the water ahead. The light intensity can be adjusted which is of importance as it is very foggy often, and spotting ice becomes very difficult without this feature. The vessel visited had two ice spot lights. The vessel normally keep at least one spare light bulb onboard. The price of a light bulb is around 5000 NOK.

Figure 38 Ice spot lights (73)

This vessel does not use ballast water due to the potential of freezing, but uses the fuel oil tanks instead to ballast itself. The vessel can ballast itself with a total of 450 tons of oil. The minimum amount of oil required onboard the ship to maintain stability is 78 tons. The vessel is however run in a manner by which this low level is never met, hence sufficient ballast is always maintained.

4.8.1 Mapping

For fishing vessels, the maps around Greenland are sufficient. Every hour the vessel automatically sends in their position via a satellite tracking system, to inform the authorities about where they are fishing. The vessels will also automatically send in mapping information with the results from the soundings from the echo scanner.

For the areas of fishing there is a good basis of information from the long history of plying these waters. The vessels are generally operating at well known fish banks, and therefore there is a plethora of historical information, and the vessels know they can safely operate at these areas. The depths and underwater topography are well known. However, 15-20 years ago the map information was much thinner, the advent of computerised sounding information and track recording has greatly benefited the fishing vessels in their navigation of these waters.

5 Rules and regulations

All vessels are subject to different rules and regulations. This chapter will mention some of the most relevant ones for shipping and fishing vessels. The most important maritime laws will be mentioned short in this chapter.

The Norwegian vessels operating in the north areas today are following the main laws and guidelines that are applicable for the Barents Sea today:

1. The Port and Fairway Act
2. The Pilot Act
3. The Planning and Building Act
4. The Pollution Act
5. MARPOL
6. The Seaworthiness Act

Definitions

To make it easier to try to separate between the different regulations the vessels have to obey, the definitions of the most common words are included:

- **Act –** *"the formal product of a legislative body"* (74)
- **Agreements** - "*Agreements" are usually less formal and deal with a narrower range of subject-matter than "treaties*". Agreements are not a subject for ratification. (75)
- **Code** – "*A systematically arranged and comprehensive collection of laws"* (76).
- **Convention** – Same as Treaty (75) "*Whereas in the last century the term "convention" was regularly employed for bilateral agreements, it now is generally used for formal multilateral treaties with a broad number of parties"* (75)
- **Law –** *"The system of rules which a particular country or community recognizes as regulating the actions of its members and which it may enforce by the imposition of penalties"* (77)
- **Protocol** - "*The term "protocol" is used for agreements less formal than those entitled "treaty" or "convention""* (75)
- **Regulations** - *"a rule or directive made and maintained by an authority"* (78)
- **Rule –** *"one of a set of explicit or understood regulations or principles governing conduct or procedure within a particular area of activity"* (79)
- **Treaty –** *"First of all it has to be a binding instrument, which means that the contracting parties intended to create legal rights and duties. Secondly the instrument must be concluded by states or international organizations with treaty-making power. Thirdly, it has to be governed by international law. Finally the engagement has to be in writing"* (75)

5.1 Regulation on fishing vessels over 15 m

Regulations on construction, equipment, operation and surveys of fishing vessels with a length of 15 meters and above[7] [8]

This regulation on fishing vessels covers some of the same aspects as SOLAS does for the merchant ships. The regulation links to the strength and stability of the vessels, as well as required equipment. Some of the rules are specific, depending on the size of the vessel. This means that some regulations differ if the vessel is over 24 m, under/over 45 m. and over 75 m.

This regulation is the one most referred to from Nergård Havfiske AS, and it is valid for all new vessels to be built. Rebuilds of vessel only have to obey to the extent the Norwegian Maritime Authority finds is reasonable and practicable.

This regulation is the Norwegian version of the Torremolinos, see chapter 5.1.1. It contains rules of the stability, arrangements, navigation, electrical systems etc.

It is the ship owners, the captain and the crew that has to ensure the vessel fulfil the standards. This means that all of the personnel onboard have a responsibility. The regulation has five appendixes.

The contents of the regulation can be seen on the next page.

[7] Complete Norwegian name: *Forskrift om konstruksjon, utstyr, drift og besiktelser for fiske- og fangstfartøy med største lengde på 15 meter og derover*.

Complete English name: *Regulation on construction, equipment, operation and surveys for fishing and catch vessels with greatest length of 15 m. and above.*

[8] Summary in APPENDIX VII

Contents

1. General provisions
   a. Provisions, surveys, certificates, trade areas etc
2. Construction and watertight integrity
   a. Watertight doors, airing, vents, draft lines, fishing arrangements etc
3. Stability and seaworthiness
   a. Criteria's, filling of fish, operational conditions, water on deck, wind, roll, damaged stability etc
4. Machinery, electrical systems and periodically unmanned engine rooms
   a. Internal ship communication, machine installations, electrical power sources etc
5. Fire protection
   a. Materials, detection, emergency exits, heating, storage of gas etc
6. Protection of the crew
   a. Railings, warning, work clothing, stair ways etc
7. Life saving appliances and arrangements
   a. Buoys, signals, radar transponders, MOB, safety suits, etc
8. Procedure for emergency
   a. Alarm, instructions, safety drills, etc
9. Radio communication
   a. Functional demands, guarding, power sources, personnel, maintenance
10. Navigation equipment and arrangements
    a. AIS, instruments, view
11. Accommodation and health
    a. Water, ventilation, lights, cabins, dining area, hospital area, hygiene
12. Final provisions

5.1.1 Torremolinos Protocol

The Torremolinos International Convention for the Safety of Fishing Vessels

Internationally, many countries are following the *Torremolinos Protocol* for fishing vessels. For editing rules for fishing vessels, changes are suggested as add on to the Torremolinos. This is for keeping the system more simple. Then changing the rule for the fishing vessels will be easier and smoother. The Torremolinos protocol however, is not ratified in Norway, but it exists rewritten in the form of the *Regulation about fishing vessels on 15 m. and above* (80).

This convention entered into force in 1977(81). 50 % of the worlds fishing fleet with vessels over 24 m ratified this Convention one year later. This convention touches into the same parts as the SOLAS, but at a level the fishing vessels can consent.

5.2 **Ship Safety and Security Act**[9]

"This Act shall safeguard life, health, property and the environment by facilitating a high level of ship safety and safety management, including preventing pollution from ships, ensuring a good working environment and safe working conditions on board ships as well as appropriate public supervision of ships."(82)

The law on ship safety is the old seaworthiness act from 1903. The Seaworthiness Act was repealed on 1.July in 2007 and replaced by the *Ship Safety and Security Act* (83). The new law wants to reduce the so called "cowboy activity" that's been a problem among sea men (84)

This law includes the SMS. It also contains information about the technical and operative safety, such as hull strength, maintenance of equipment, stability, crew qualifications, control and rest.

This rule applies to all Norwegian vessels, wherever they are operating, and for all foreign vessels in Norwegian waters.

5.2.1 Safety Management Systems

Ship Safety § 7

"The company's duty to establish, implement and develop a Safety Management System

The company shall ensure that a Safety Management System which can be documented and verified is established, implemented and developed in the company's organization and on the individual ships in order to identify and control the risk and also to ensure compliance with requirements laid down in or pursuant to a statute or in the actual Safety Management System. The contents, scope and documentation of the Safety Management System shall be adapted to the needs of the company and its activities. The company shall ensure that the master and other persons working on board are given the opportunity to participate in the establishment, implementation and development of the Safety Management System."

5.2.1.1 Applicability to fishing vessels

Fishing vessels did not have to follow § 7 before 1.April in 2010, so the use is rather new still (85)(86).

[9] Norwegian name: S*kipssikkerhetsloven, see APPENDIX V*

5.3 **SOLAS**

International Convention for the Safety of Life at Sea

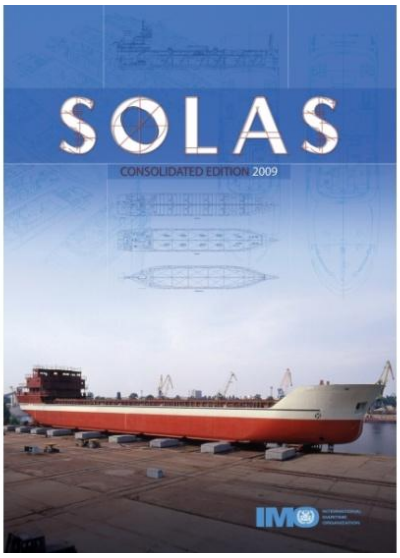

Figure 39 SOLAS (87)

After the Titanic accident the SOLAS Convention was made. The SOLAS convention is regarded the most important of all international treaties concerning the safety of merchant ships (88). The objective of this Convention is specifying minimum standards for construction, equipment and operation of ships, compatible with their safety. In 1974, 71 countries participated in making the last Convention. It is been updated and amended many times since then. The Convention consist of the following:

1. General Provisions
2. Construction
    a. Subdivision, stability, machinery, electrical installations
    b. Fire protection, detection, extinction
3. Life-saving appliances and arrangements
4. Radio communications
5. Safety of navigation
6. Carriage of Cargoes
7. Carriage of dangerous goods
8. Nuclear ships
9. Management for the safe operation of ships
10. Safety measures for high speed craft
11. Special measures to enhance maritime
    a. Safety
    b. Security
12. Additional safety measures for bulk carrier

The flag states stands as responsible part to ensure compliance with the standards. The only chapter valid for all vessels, even small crafts and yachts, is chapter V; *Safety of Navigation* (81)(89)

5.3.1.1 Applicability to fishing vessels

Under Regulation 3 in SOLAS, it states that the present SOLAS regulations, do not apply to fishing vessels (90). The fishing vessels are non SOLAS vessels, which mean they don't have to obey to some of the rules for other vessels such as in shipping. Only the *SOLAS Convention on Safety of Navigation* applies for fishing vessels (91).

5.4 ISM

International Safety Management [10]

"*1.2.1 The objectives of the Code are to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular, to the marine environment, and to property.*"(92)

Figure 40 ISM Code (93)

Internationally, this code applies to cargo vessels over 500 GT, passenger vessels with 100 or more passengers, and RoRo-ferries[11] with 12 or more passengers (86).

This code states that the vessels must have an operating SMS. It provides information about the SMS and its content. The content of the ISM code is safety and environmental protection policy, designated persons, authority, maintenance of the SMS, report of unconformities, verifications, documentation, resources and emergency preparedness. All these groups are describes in matters of identification, documentation, establishing, maintaining, inspecting, ensuring, creating measures, reports and provide. Most vessels have used the ISM code since April 2010.

The *Norwegian Maritime Authority* wants a demand for the ISM code on fishing vessels over 500 GT. Other fishing vessels will get a demand for a SMS. That SMS should consist of demands to system for maintenance, risk assessments, and descriptions for responsibilities and duties (86). The *Norwegian Maritime Authority* is currently working on a strengthened regulation for fishing vessels above the size of 500 GT. The regulation for fishing vessels over 500 GT is assumed to be effective from January 2014 (85).

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[10] Summary in APPENDIX V

[11] Roll On - Roll Off

The main requirements for a SMS (86)

1. *Establish, carry out and develop SMS*
2. *Documents and verification*
    a. *To be shown when requested*
3. *Map and control risk*
    a. *Risk assessments*
4. *Ensure compliance with requirements*
    a. *Ensure regulatory requirements are fulfilled*
        i. *Renew certificates*
        ii. *Service on rescue vessels*
        iii. *Etc.*

Above are the requirements which are of specific interest. This is due to some fishing vessels operating in international waters, or in Danish areas outside of Greenland.

There is a whole section linked to maintenance. The rules and regulations are important here. It is not mentioned what good or sufficient maintenance is. The ship will however need an operational maintenance routine.

Every 5th year the ship has to renew its *Document of Compliance*. This is normally combined with docking and surveys.

5.4.1.1 Applicability to fishing vessels

The fishing vessels have a high accident rate, and to try to reduce this, the government wants to include them in the *ISM code.* Of interest for the fishing fleet today is the new demand for a safety management system (SMS). The demand for a SMS includes a safety and environmental protection policy.

The status of the ISM code is that the *Norwegian Maritime Authority* is making a regulation that is expected to be valid for fishing vessels from January 2014. This regulation however, is an extension of the *Law of Ship Safety § 7* (see page 54), demanding that the fishing vessels will have to develop, maintain and use a safety management system. The first version of it will only be valid for fishing vessels over 500 GT. The case vessel, J. Bergvoll, is 1499 GT (94) hence it has to apply to this regulation when it is entered into force.

5.5 MARPOL

International Convention for the Prevention of Pollution from Ships[12]

MARPOL, Marine Pollution, is a convention for prevention of pollution from marine activities, and especially from shipping. It touches the use of chemicals and the possible effects of oil spill. It contains rules on use of double hull, sewage- and bilge water treatment and chemical demands for the fuel, such as low sulphur.

Annexes (95)

- Annex I Prevention of Pollution by Oil
- Annex II Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV Prevention of Pollution by Sewage from Ships
- Annex V Prevention of Pollution by Garbage from Ships
- Annex VI Prevention of Air Pollution from Ships

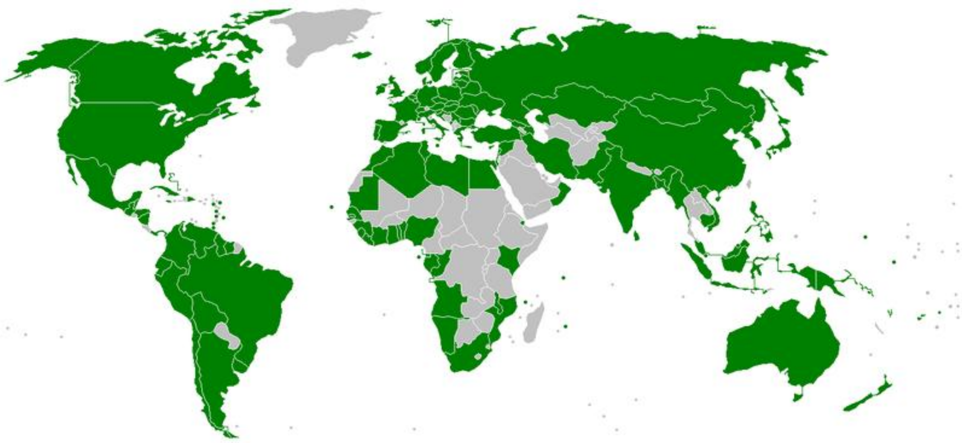


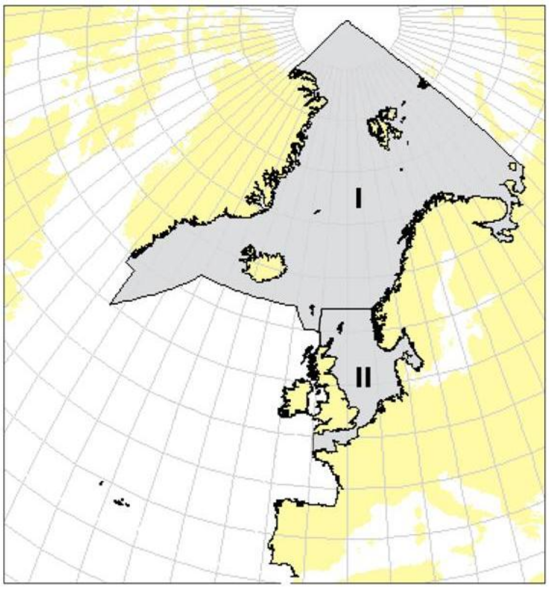
Figure 41 Parties to the MARPOL 73/78 convention on marine pollution (96)

[12] For more details on the Norwegian version, see APPENDIX IV

5.5.1 Ballast water convention[13]

"Norway perceives the possible introduction of invasive species as a real threat and has implemented national regulations awaiting the BWM[14] Convention to enter into force" (97)

This convention is about how to avoid the introduction of alien species and pollution and other unwanted side effects from the Ballast Water (BW). This convention operates around treatment, intake and disposal of BW. It has different zones for rules for handling of ballast water. The main rule is not to dispose of BW within a certain area from the shore. In the Arctic the BW handling will be strictly regulated. This is a matter of maintaining the ecosystem stability of the Arctic without bringing alien organism which might affect the natural biodiversity of the area.



[13] See APPENDIX III

[14] Ballast Water Management

6 Polar Code

Disclaimer: The version of the Polar Code evaluated in this paper is from the 16th of February 2012. The code is not complete and all assumptions are built on the strictest possible outcome, and are evaluated as good as possible.

"The Goal of this Code is to provide for safe ship operation and the protection of the Polar environment by addressing significant risks specific for the Polar waters and not explicitly considered by other instruments of the Organization"

The Polar Code is an add-on Code with additional requirements to SOLAS and MARPOL. The completion date is predicted to be in 2014. It is been decided to make the Polar Code mandatory through MARPOL and SOLAS (98). The Polar Code addresses the specific risk factors for operation in the Arctic (13).

IMO's maritime safety committee started the development of the Polar Code in 2009. The Sub-Committee on Ship Design and Equipment coordinates the work (98). It is built on, and extends the *Guidelines for ships operating in Arctic ice-covered waters* (99). The purpose of this code is to set requirements for navigation and maritime operations in Polar waters without risk for emission and pollution. SOLAS vessels have to operate under the Polar Code when it is ratified. The key principles have been to use a risk based approach to adopt a holistic approach to minimize the consequences of identified risks.

The Polar Code is also made for safeguard towards the threat of structural damages due to sea and icebergs. The code is made to include demands to design, outfitting and operation of relevant vessels, including crew size and competence. Nothing in this code shall be taken as conflicting with the UN's[15] *Convention on the Law of the Sea* from 1982, and other international instruments applicable to polar waters.

[15] United Nations

Contents of the Polar Code

- Chapter 1: Polar Water Operational Manual
- Chapter 2: Structural integrity
- Chapter 3: Stability, intact and damaged
- Chapter 4: Watertight and weathertight integrity
- Chapter 5: Anchoring arrangements
- Chapter 6: Habitability, accommodation, emergency, escape measures
- Chapter 7: Fire safety and protection
- Chapter 8: Life saving appliances and arrangements
- Chapter 9: Navigation
- Chapter 10: Communications
- Chapter 11: Alternative design
- Chapter 12: Operational requirements
- Chapter 13: Crewing, manning, training
- Chapter 14: Emergency control
- Chapter 15: Environmental protection

Most of these chapters are linked to construction and the functional requirements of the vessel.

Some of the main points of the Polar Code will be discussed here. For a more detailed summary of the Polar Code, see APPENDIX II

6.1 Polar Water Operational Manual

"The manual shall be a ship specific document structured and formulated in a way that the information required is readily available to the Master and crew."(Polar code §1.2.1)

The definition of the Polar Water Operational Manual is yet not decided (100).

The aim of the Polar Water Operational Manual (PWOM) is to provide sufficient information to the master and the crew. The manual will be a supplement to the Polar Ship Certificate, which will not be valid without this manual.

This manual will consist of

- The ship's particulars
- Systems subject to damage by freezing
- Safe distance and speed in ice covered waters and in convoy
- Lower and upper ice waterline
- Manoeuvring characteristics
- The voyage plan
- Stability calculations for ice accretion
- Operational temperatures
- Minimum design temperatures of machinery and the ship essential systems
- The ship's capabilities and characteristics
- Communication and navigational equipment limitations in high latitude and alternatives provided

For helping out in the identification of risk, the development group of the Polar Code have created a matrix than can be used to identify additional hazards in Polar waters.

From the Polar Code the following hazards inherent in Polar waters are

1. Physical environmental conditions
2. High latitude as it affects navigation, ice imagery and communication
3. Environmental sensitivity; and
4. Remoteness

6.1.1 Voyage plan

"In performing voyage planning, in addition to SOLAS V/34 known key areas for marine mammals, national and international designated protection areas shall be taken into consideration." (Polar Code § 12.4)

The voyage plan should include considerations towards key areas for marine mammals and other environmental protected areas. The timing is also important as these animals migrate. A recommended part of this voyage plan is including density and distribution maps with seasonal distribution. One of the reasons for this is to avoid collision with cetaceans and other marine mammals (101), where the bowhead whale is of special concern due to its vulnerability to ship strikes. It is expected that the amount of Arctic marine mammal also might increase (101). The dangers of such a collision can vary from minor to extreme, such as damaged propellers, cracked hulls and seawater piping to mention some. Knowing the areas would also be beneficial for not only collision with shipping vessels, but also beneficial for the fishing vessels.

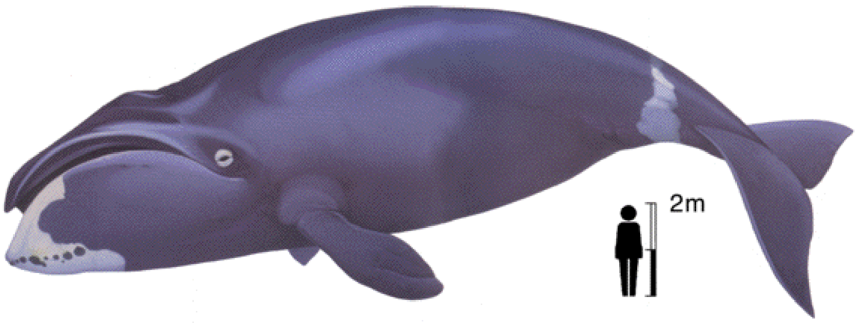


Figure 42 Bowhead Whale (102)

The voyage plan can be included under the "document" module in different management systems, see section 8.7.1 Voyage plan.

6.1.2 Training

Ice Navigator – any individual who, in addition to being qualified under the STCW convention is specially trained and otherwise qualified to the direct movement of a ship in or near ice-covered waters.

The Code suggests special training for operation in Arctic. They will be called Ice navigators. This training is towards movements in ice covered water. The extent of the necessity of giving courses with training and certificates are still under discussion. These navigators should learn to follow the recommendations from the Polar Water Operational Manual. It will consist of Speed/Ice curves, stopping distance and other aspects linked to speed and safe distance. Qualified and trained personnel are important for safe operations, and also for understanding the need and importance of correct maintenance. (103)

6.2 Fishing vessels

The fishing vessels are non-SOLAS vessels. The Polar Code will therefore not affect the current fishing vessels. In the second edition of the Polar Code, fishing vessels are planned to be included, due to their high accident rate and their high presence in Arctic (13). Considering 2/3 of the ships are fishing vessels, an own regulation should be created, if the purpose is safe and clean operations in the Arctic.

Fishing vessels might have to wait for some years until their applicability under the Polar Code is determined, but the fishing vessels might be able to avail of looser rules. The provisions for the fishing vessels will start in 2013 and might be finished in 2016 (13). Norwegian wise, this would be an add on to the *Regulation on fishing vessels over 15 m*.

For new builds of fishing vessels, they should consider what outcome might come out of the Polar Code when it might affect fishing vessels in 2016.

Until then, these regulations should be used (104) (105)

1. *Torremolinos Protocol – Ice accretion*
    - *Icing allowances for stability calculations, ship design to minimize ice accretion, means for removing ice*
2. *Code of safety for fishermen and fishing vessels*
    - *Reduction of formation of ice and icing allowances for stability calculations for fishing vessels of 24 m and over in length*
3. *Voluntary guidelines for small fishing vessels - Design, construction and equipment*
    - *Provisions regarding ice accretion and combating of ice formation for fishing vessels between 12 m and 24 m in length.*

During the work of the Code some feedback has arrived for consideration for the fishing vessels. Different countries are to have a say about the development of the code. Iceland has submitted a document that emphasises the use of the Torremolinos Protocol towards the Polar Code and Fishing vessels (106):

"*Iceland supports the development of requirements which apply internationally to fishing operations in polar waters, however, such requirements must be developed as add-on requirements to the Torremolinos Protocol.*"

7 Star IPS

Most vessels of a considerable size are already using some sort of software to help them to manage different aspects of the ships operations such as maintenance, safety, purchasing and document control. Such systems can be beneficial towards the requirements from the Polar Code about the Polar Water Operational Manual.

7.1 About SIS

Figure 43 Logo SIS (107)

Star Information Systems (SIS) is a provider of maritime software management solutions and services. Star Information Systems have offices in Trondheim, Oslo and Singapore. The software has been used onboard vessels since 1997. Microsoft is the platform, and Oracle and MS SQL Server works for databases. The systems can be used on 3rd party software. The software consists of modules for planned maintenance, project management, procurement, asset management, insurance and claims management, key performance indicators (KPI's), reporting and inventory control (108).

SIS is a part of the research project and their software will be used to evaluate towards the future need in the Polar Code. The most relevant modules in the software will be evaluated in this chapter.

7.2 Star IPS

IPS – Information and Planning System

The Star IPS is software for ship and rig owners. Its purpose is to help the owners and managers to operate their fleet both safe and efficient. The Star IPS is used onboard the vessel, either as a stand-alone system, or in interaction with a hub for the whole fleet. The Star IPS system consists of different modules than can be combined (109).

The purpose of the Star IPS is to help companies keep track of the work packages on board a vessel, and to provide the documentation requirements that feed into a safety management system. Star IPS consists of modules than can be opened and edited to fit the management of different aspects. All parts of the company, such as the captain, the machinist and the personnel on land are able to use this system. The system is used differently in different part of the management and on the vessel. It allows the engineers to structure their work, and the leaders can get their performance factors.

The system consists of folders that can be opened and edited, see Figure 44 and Figure 45.

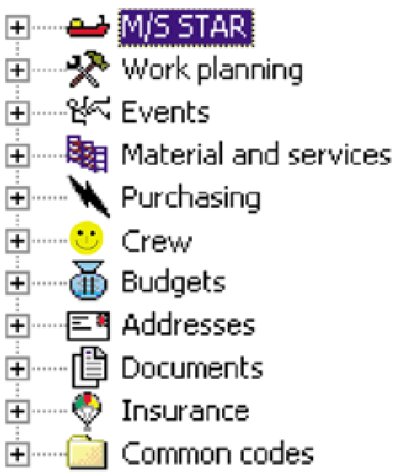


Figure 44 Star IPS

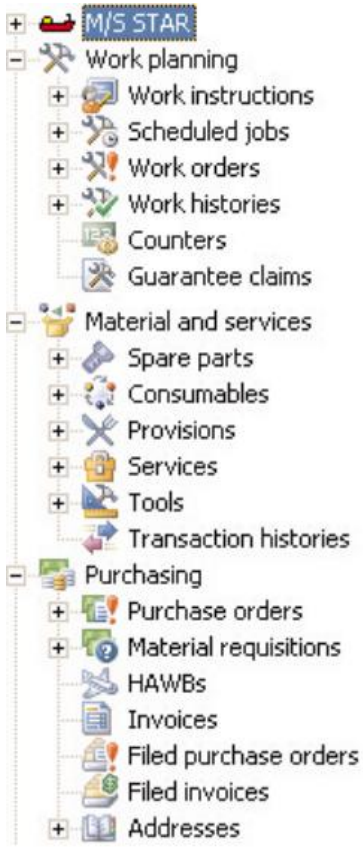


Figure 45 Star IPS extended

Modules

- *Star Maintenance (PMS)*
- *Star Asset Management*
- *Star Guarantee Claims*
- *Star Project (Dry-docking)*
- *Star Event (Safety/HSEQ)*
- *Star Audit & Inspection*
- *Star Insurance*
- *Star Document*

These main modules can be combined in the Star IPS to help the management of the ship. Some of these modules are also operational by themselves. In Figure 46 different modules are used to show an overview and the user interface of the activities linked to the vessel.

The vessel can be divided into technical accounts that can be broken down into the smaller parts (110). The different modules and accounts in the system consist of:

1. The vessel(s) or platform(s)
2. Work planning
3. Asset management
4. Safety management
5. Equipment templates
6. Equipment
7. Material and services
8. Transaction histories
9. Purchasing
10. Budgets
11. Crew
12. Documents
13. Forms
14. Form data
15. Insurance
16. Reports
17. Projects
18. Common codes

When the software was evaluated, the example database present was from an operative anonymous vessel.

Since this project's case study is based on a fishing vessel, the Star IPS will also be evaluated from a fishing vessels perspective. Even though fishing vessels have different regulations, a simplified case where possible regulations towards the Arctic for both types of vessel are taken. This is because shipping vessels which are to operate in the Arctic are and will be SOLAS vessels, and the fishing vessels might follow later as mentioned in Chapter 6 Polar Code. There may be gaps in the analysis when applied directly to the anonymous vessel for this reason, but this can be considered a preliminary investigation into the applicability of the Star system and regulatory compliance necessities.

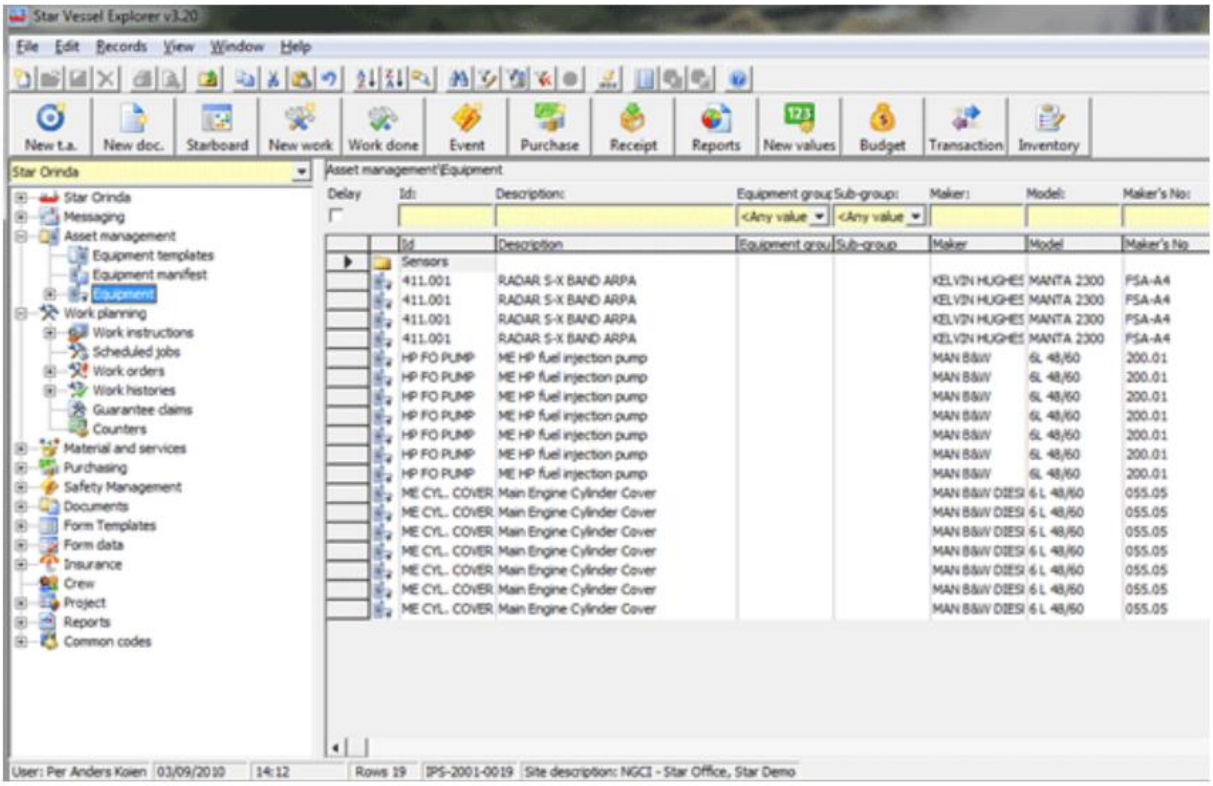


Figure 46 The Star Vessel Explorer (109)

7.3 Vessel

The vessel is broken down into different technical accounts, each part involving different components of the ship systems (111). Typical groupings are built on the SFI system[16] (see Figure 47). The available subgroups are considerably cut down, with only the identification of the main groups being left for consideration. The systems are simplified in this instance so as to not share sensitive information about the vessel from the evaluation.

In this module all the necessary information about the vessel will be gathered into subgroups and they can be linked together through connections. The numbers of parts are linked to the SFI coding system to sort and link components. The spares are linked to the systems where they are to be used, to the work order, purchase orders, and can also be linked to the necessary tools. Together the SFI system and the linked subsystems build up the management system to control all aspects of the ship operations. In example, all the systems and components depending on the hydraulic oil can be linked with the maintenance and the purchases linked to the hydraulic system.

The Star Fleet System Management can be used for higher management solutions. Here purchase orders and the KPI's can be created.

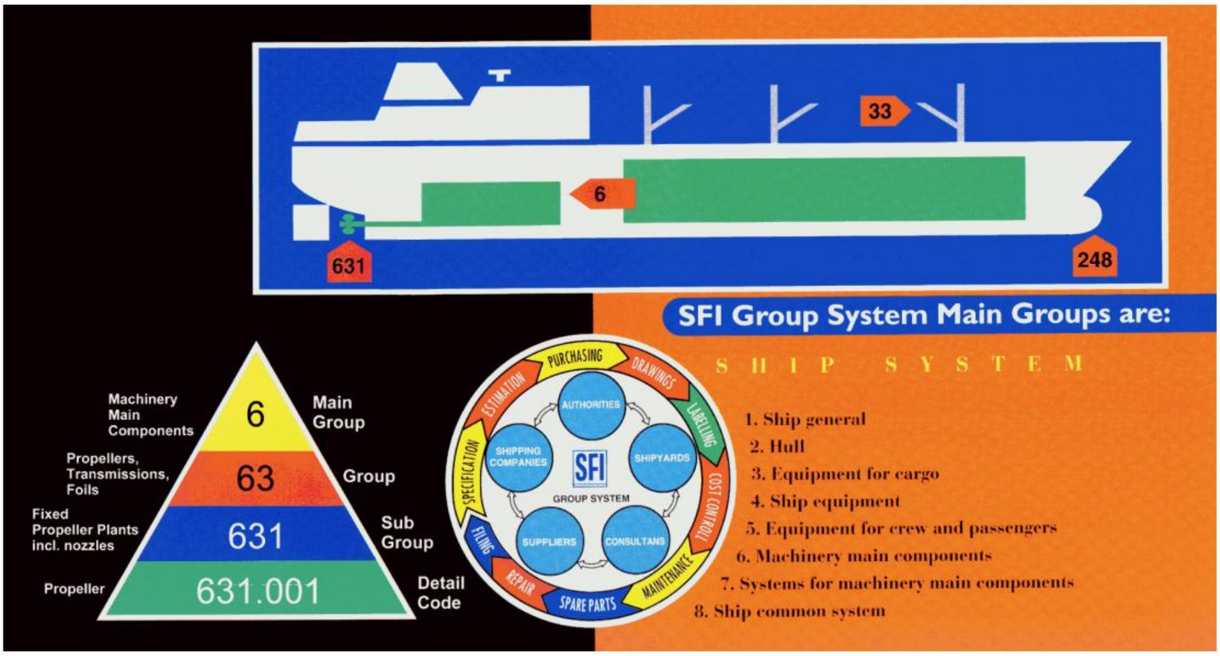


Figure 47 The SFI Group System (111)

[16] From *Skipsteknisk ForskningsInstitutt* (SFI), a system created at MARINTEK in 1972 with the purpose to be a common, independent code to help the flow of information between enterprises and the industries (80).

7.3.1 SFI groupings

The system consists of an increase of numbers as the detail increases, see Figure 47. The subgroups would normally be marked with numbers according to the SFI system. For instance, all the equipment for cargo would be numbered under 3, as this is the main group.

1. Ship general
    a. Specification, insurance, guarantee/mending work
    b. Consumption articles, ship repair special service
2. Hull
    a. Materials
    b. Internal/external material protection
    c. Outfitting, deck housing
3. Equipment for cargo
    a. Cranes, hatches
    b. Special and liquid cargo equipment
    c. Auxiliary systems, rigging and winches
4. Ship equipment
    a. Manoeuvring, navigation, communication
    b. Anchor, mooring, towing,
    c. Repair, maintenance, cleaning, workshop
    d. Lifting and special equipment
5. Equipment for crew and passengers
    a. Lifesaving, protection and medical
    b. Heating, ventilation, furniture, sanitary
    c. Internal and external deck covering
6. Machinery main components
    a. Propulsion engines and machinery
    b. Aggregates, main and emergency power production
    c. Boiler, steam and gas generators
    d. Propellers, transmission, foils
7. Systems for machinery main components
    a. Fuel, lube, cooling systems
    b. Compressed air, exhaust and air intake systems
    c. Water systems – distilled, condensate
    d. Automation systems for machinery
8. Ship common systems
    a. Ballast and bilge systems, gutter pipes
    b. Fire fighting, wash down
    c. Air & sounding systems
    d. Hydraulic oil
    e. Electronics, electric power supply, distribution, cable installation

More detailed components are not listed to avoid sharing sensitive information from the database vessel.

7.4 Star Maintenance

Maintenance planning has to be considered for voyage planning. Star Maintenance can be used standalone or as a part of the Star IPS (112).

The Star Maintenance is made for assisting the crew with planning the maintenance of the ship. It can also be used to report work done, keep stock and handle supplies. It is a Planned Maintenance System (PMS).

Detailed work instructions can be made and the jobs can be displayed in a maintenance board, such as the Starboard (see Figure 52). The Star Maintenance is in compliance with standards organizations, and can record the job logs. Critical equipment can be organized and tracked. The stock can be controlled and requisitions can be created and sent directly to the vendor.

Use Star Maintenance to:

- Implement company standard for maintenance
- Plan preventive maintenance work
- Generate common work instructions
- Schedule maintenance jobs
- Generate work orders
- Report work done
- Report corrective work done
- Keep stock and handle supplies
- Issue material requisitions and purchase orders
- Handle receipt and report deviations
- Control plant inventory
- Provide reports, statistics, and KPIs
- Replicate data between vessel and office

Figure 48 Star Maintenance possibilities

7.4.1 Work planning

The work planning in Star IPS consists of the following sections:

1. Work instructions
2. Scheduled jobs
3. Work orders
4. Work histories
5. Counters

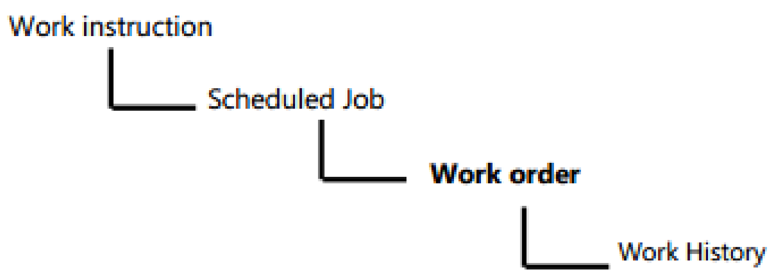


Figure 49 The line of work (113)

Definitions

"A Scheduled job is a maintenance routine with a certain interval according to specifications" (114)

"A work order is either a corrective maintenance job or a work order activated from a scheduled job" (114)

"A counter based job is a maintenance routine where by the interval is based on a counter. The job schedule is dynamic and depends on the running hours registered" (114)

7.4.1.1 Purpose

This module assists in the planning of work to be conducted on the vessel. Here the work to be carried out can be created, edited and checked off. The work will appear in the IPS Starboard, where they will show up in a calendar of scheduled work. Work instructions are instructions that describe what and how the work should be done. It can contain check lists, procedures and links to other work that might be related or affected. The work instructions can be repeated and be linked to counter values on equipment.

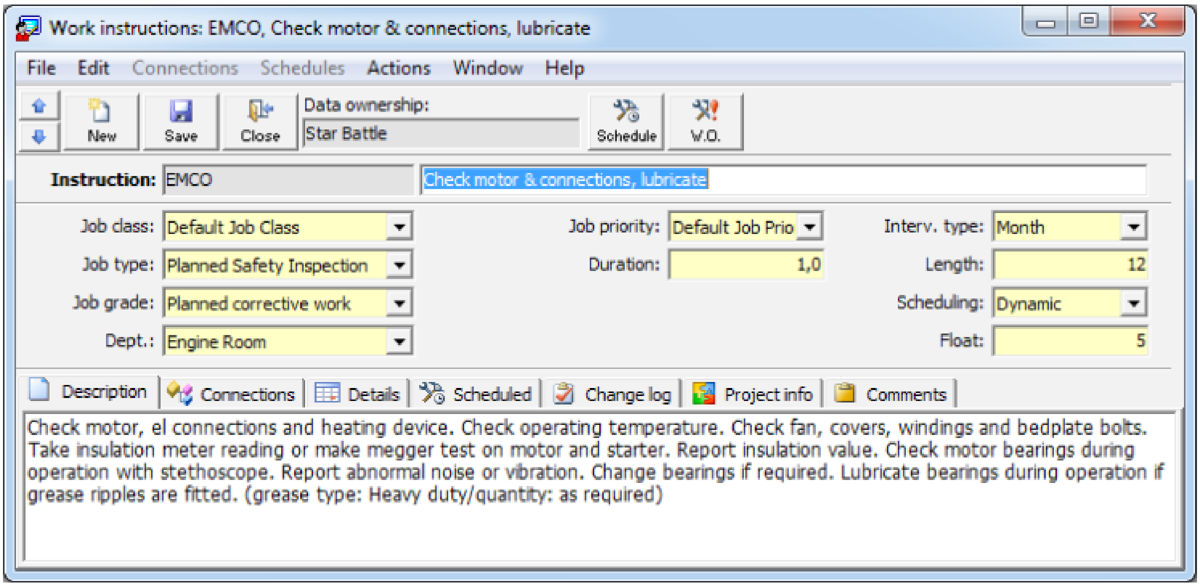


Figure 50 Example of work instruction (112)

A scheduled job is put into the system to happen at a certain time or time interval. Intervals might be built on experience, regulations and to the supplier’s recommendations. The schedules are normally given from the suppliers, and will be followed normally at least in the guarantee period. Sometimes these intervals are considered changed built on the engineers experience, and then the intervals can be changed in the scheduled job.

The jobs are programmed to occur in the Star Starboard, which gives an overview over the scheduled jobs. A list over the scheduled jobs can be printed so the crew can see what jobs have to be done, how they should plan it, who should do it and what equipment and spares that are needed. The actual time periods can be saved so the real intervals between the jobs can be found. When monitoring the system towards the use of corrective maintenance evaluations can be performed. The result from the counter will automatically give the time for the next maintenance check or job. If condition based maintenance is to be conducted, it can be carried out to the same manner as the counter jobs. It is also possible to mark jobs and equipment with different criticality.

7.5 Star Inventory

"Materials and Services is a generic term for spare parts, consumables, services, provisions and tools."(114)

Star IPS has the module Star Inventory. It can be used to assist material and service management onboard. This module is linked to the parts needed in the daily operation of the vessel, and is therefore linked to the Star Maintenance, and of interest for Arctic operations.

To keep track of the necessary material and services this section is helpful.

The sub-modules consist of

1. Spare parts
2. Consumables
3. Provisions
4. Services
5. Tools

Spare parts are parts that should be on board for the necessary maintenance and the expected need for parts on a certain trip. Consumables are parts that are used more freely, frequent and would normally be bought in bigger quotas than the spare parts. Provisions are typically food, drink and equipment for a journey. These products are of even more frequent and everyday use than the consumables. Services is service needed onboard the vessels. Tools are the tools that are needed for the vessels normal operation.

Figure 51 shows some of the possibilities when it comes to control over materials. The same filter can be added on all other components as well, allowing for easy browsing of the items onboard.

Fleet: Spare parts <= Reorder level

Vessel: Entire Fleet | Material Id: Not selected | Description: Not selected

Printed by: System Administrator   Print date: 23/11/2006 | Material Group: Not selected | Material Sub-Group: Not selected

M/S STAR		Maker	On order	In stock	Re-order level	Cost of item	In local	Value of Stock
Spare parts								
CO.HV2/240.3075	Valve seat LP suction	Sperre Industrier AS	1	2	2	0.00	0.00	0.00
CO.HV2/240.3076	Valve seat LP delivery	Sperre Industrier AS	2	2	2	0.00 SEK	0.00	0.00
CO.HV2/240.3109	Valve plate HP valve	Sperre Industrier AS	1	1	2	0.00 SEK	0.00	0.00
CO.HV2/240.3135	Valve washer	Sperre Industrier AS	Not set	Not set	2	0.00	0.00	0.00
LBOAT.MCM.001	Boat hook/ paddles		Not set	Not set	1	120.00 NOK	16.20	0.00
LBOAT.MCM.002	Bucket w/ lanyard		Not set	Not set	1	40.00 NOK	5.40	0.00
					Totals for M/S STAR		**21.60**	**0.00**
Total number of materials listed : 6					**Grand totals for report**		**21.60**	**0.00**

***Note: Spare parts re-order level > 0 and stock level <= re-order level*

Figure 51 Spare Parts (115)

7.6 IPS Starboard

"The Starboard is a planning board that shows selected scheduled jobs and work orders in a time period"(114)

12 Month Work Planning Report (Starboard)

~ Only Jobs/Orders due before 04/03/2008 are displayed ~

Note : Future due dates may change depending on the date jobs get reported and counter readings.

Id/Dept.	Description/Job class	Job type	Status	Due date/Priority	~ OVERDUE ~	01-01-07 ~ 31-01-07 1 Jan	01-02-07 ~ 28-02-07 2 Feb	01-03-07 ~ 31-03-07 3 Mar	01-04-07 ~ 30-04-07 4 Apr	01-05-07 ~ 31-05-07 5 May	01-06-07 ~ 30-06-07 6 Jun	01-07-07 ~ 31-07-07 7 Jul	01-08-07 ~ 31-08-07 8 Aug	01-09-07 ~ 30-09-07 9 Sep	01-10-07 ~ 31-10-07 10 Oct	01-11-07 ~ 30-11-07 11 Nov	01-12-07 ~ 31-12-07 12 Dec	01-01-08 ~ 31-01-08 1 Jan
571.301	AIR CONDITION COMPRESSOR			Criticality: Stand-by critical														
2005-0073 Personnel	ANNUAL SERVICE, CHECK VALVES 12 M 3 Cargo owner	4.6.1 Megger test	On hold	11/03/2007 6 week float				✓										
CO-AC.1 Engine	INSPECT, TEST SAFETY CONTROLS 3 M 1 Company	4.6 Testing/ calibration		14/06/2005 Non critical	x			✓			✓			✓			✓	
CO-AC.2 Engine	ANNUAL SERVICE, CHECK VALVES 12 M 1 Company	4.2 Service		30/11/2007 Non critical												✓		
CO-AC.3 Engine	OVERHAUL 24 M 1 Company	4.1 Overhaul		14/05/2005 Non critical	x					✓								
573.301	CONTROL ROOM AIR CONDITION COMPRESSOR....			Criticality:														
CO-AC.1 Engine	INSPECT, TEST SAFETY CONTROLS 3 M 1 Company	4.6 Testing/ calibration		06/04/2005 Non critical	x	✓			✓			✓			✓			✓
CO-AC.2 Engine	ANNUAL SERVICE, CHECK VALVES 12 M 1 Company	4.2 Service		03/04/2005 Non critical	x				✓									
CO-AC.3 Engine	OVERHAUL 24 M 1 Company	4.1 Overhaul		10/05/2005 Non critical	x					✓								
601.121	ME CRANKSHAFT			Criticality:														
ME.121 Electrical	MEASURE CRANKSHAFT DEFLECTION 4000 C			30/07/2005 <None>	x						✓							
651.137	AE 1 CRANKCASE DOORS W/ SAFETY VALVES....			Criticality:														
AE.137 Engine	INSPECT DOORS & SAFETY DEVICES 3 M 1 Company	4 Preventive maintenance		15/04/2005	x	✓			✓			✓			✓			✓

Figure 52 Example from IPS Starboard (116)

The Starboard shows tasks that when they are due. Such tasks are both maintenance, surveys, renewal of certificate, documents of compliance, licence renewal, tests, checks etc. Most typically it is used for maintenance jobs. The jobs can be separated between yard jobs, class related jobs and planned preventive maintenance. Based on safety observations, corrective maintenance can be performed, and so can be done with other safety management actions as well as safety drills.

In the Starboard the chores to be done is blue. It is possible to scroll ahead in time to see jobs to be done in the future. It also shows overdue jobs. Overdue chores are shown as red and green due to high and low criticality respectively. The Starboard interacts with Star IPS and its modules. Work orders can be signed off, and work history can be created.

Since the Starboard shows the work in advance, it is an effective tool for the engineers to plan their jobs around, also because it can be sorted due to criticality. The disadvantage might be jobs that are delayed or not checked off, that will show up and create a false image of the condition. This might be especially true for non-critical equipment, which might not be considered important enough to use time on checking off.

7.7 Safety management

SOLAS vessels need a safety management system under the ISM code, so will the fishing vessels from January 2014. The ISM code (§9.1) demands documentation of incidents and near misses so they can be followed up by the company. Procedures on adding events into the Safety Management System are also dependent on company policy.

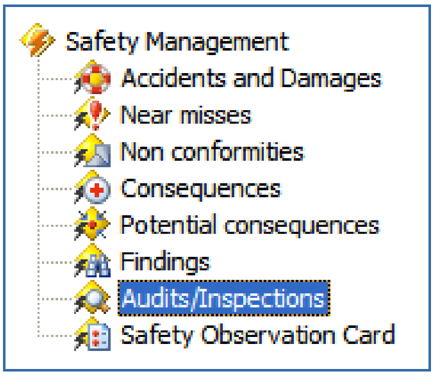
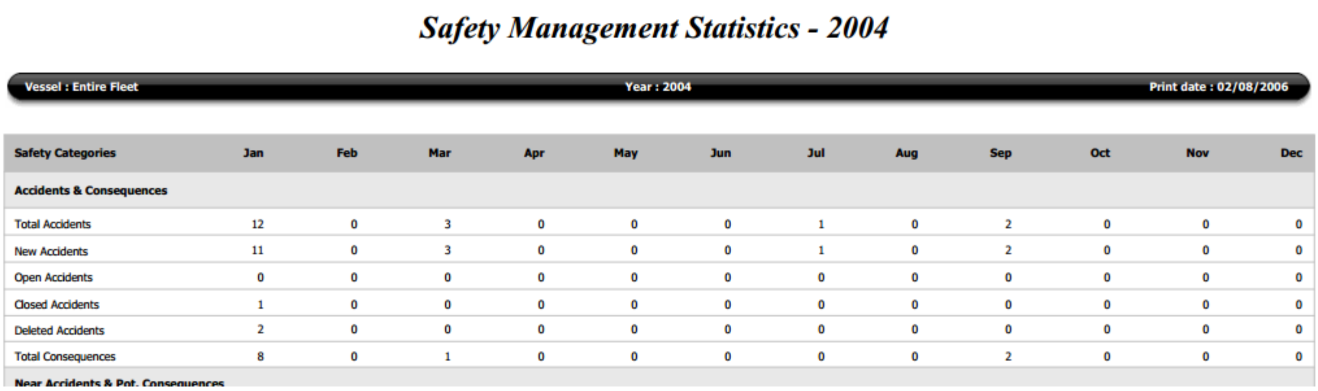


Figure 53 Safety Management modules (117)

Star Event

1. Incidents
2. Near miss
3. Non Conformities/observations
4. Corrective actions
5. Lesson learned
6. Safety alert
7. Procedures
8. Observation
9. Audits
10. Safety observation card



Safety Management Statistics - 2004

Vessel : Entire Fleet — Year : 2004 — Print date : 02/08/2006

Safety Categories	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Accidents & Consequences												
Total Accidents	12	0	3	0	0	0	1	0	2	0	0	0
New Accidents	11	0	3	0	0	0	1	0	2	0	0	0
Open Accidents	0	0	0	0	0	0	0	0	0	0	0	0
Closed Accidents	1	0	0	0	0	0	0	0	0	0	0	0
Deleted Accidents	2	0	0	0	0	0	0	0	0	0	0	0
Total Consequences	8	0	1	0	0	0	0	0	2	0	0	0
Near Accidents & Pot. Consequences												

Figure 54 Safety Management Statistics (118)

In the Star Event module damage to the vessel, equipment, accidents and near misses can be documented. From here incidents can be appraised while those happening due to bad weather and other unavoidable conditions can be filtered out. The system enables the taking of corrective actions and measures to be taken to prevent reoccurrence. Incidents and near misses are both events the personnel should register. Non-conformities and observations are more for general registration of what might go wrong later, and what need special attention. Corrective actions can be both planned and unplanned events, which should be registered to the satisfaction of the ISM code. Lessons learned can be from events without an accident as well as a well performed task, where knowledge worth attention will be listed. This could be an operation going very smooth due to a small change that improved the safety, or to an error that should be avoided later. Safety Alerts is needed for the documentation in the SMS. Procedures for work worth of attention are also needed. Audits are performed after events. Here reports on the incident and the measures can be found. The audits are important for the crew's motivation to see that the work they put into documenting the SMS, are followed up by the company. For the higher management graphs can be created.

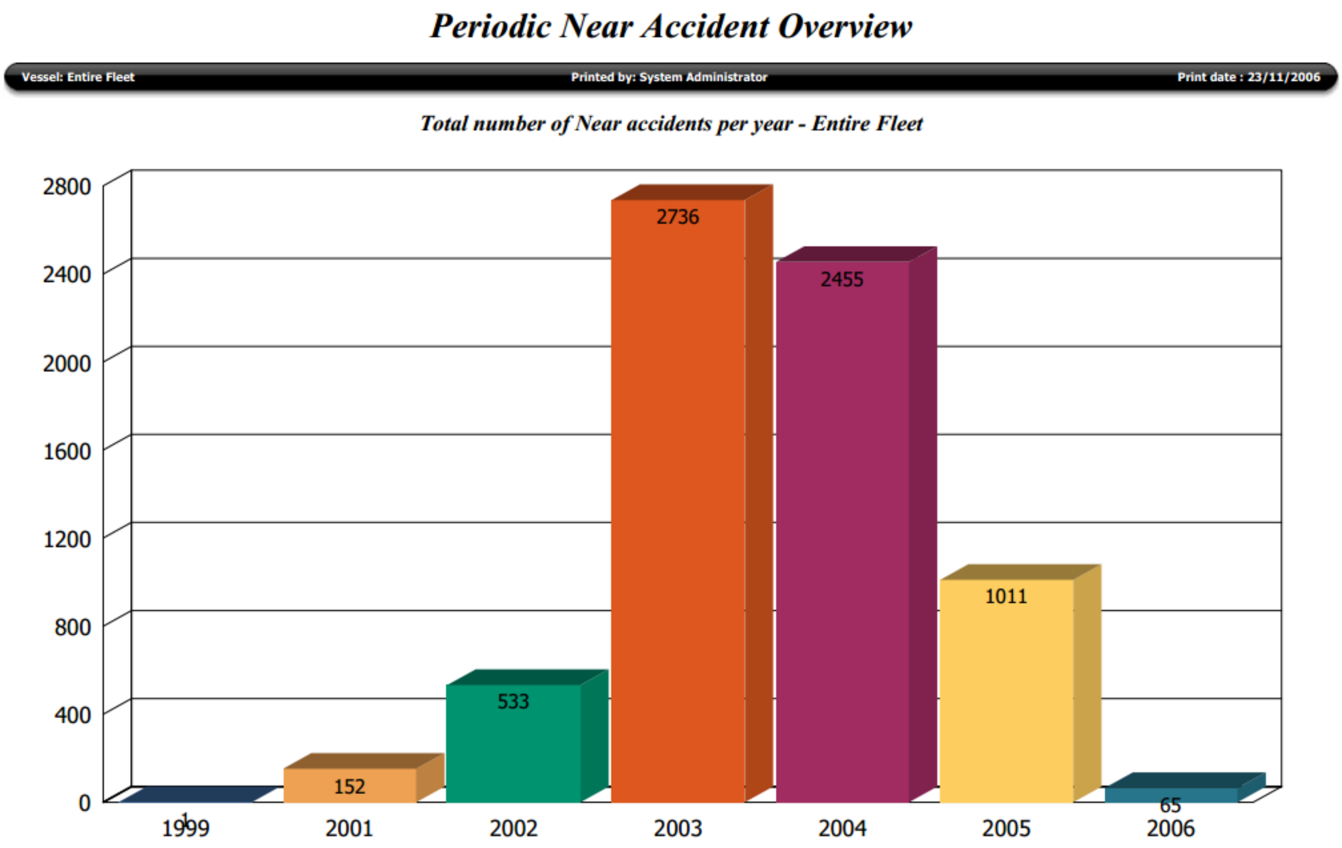


Figure 55 Periodic Near Accident Overview Star IPS (119)

8 Polar Code implementation to SIS

The Polar Code consist a lot of constructional demands for vessels, and less about the management systems and their demands. The best suggestions for implementing as much as possible from the Polar Code into SIS are given in this chapter.

The code is just like any other regulation for a vessel. Therefore the most important and most specific parts about the polar code will be considered.

Under this section, Arctic considerations can be included, to make sure the vessel is sufficiently fit for a longer voyage through Arctic conditions. SIS is interested in being prepared for when the new Polar Code is ratified and becomes applicable to vessels operating off the coast of Norway and into the Arctic Ocean. Equipment might be sensitive to temperature, humidity, wind and big waves. By using experience from the crew, and information from equipment/material provider, information can be gathered to ensure safer operations.

The vessels first affected are the SOLAS vessels, as discussed in chapter 6. In this chapter suggestions towards the Star IPS from the Polar Code will be evaluated.

8.1 Gap analysis

A Gap analysis can identify the necessary steps from the current state to a desired future state. The Polar Code in itself can be considered to be a GAP analysis on how to increase the safety in Arctic as the IMO has considered the future needs for Arctic operations. A GAP analysis consists of three steps and is normally carried out early in the project's phase (120). For SIS, the interest field would be within shipping vessels. This Gap Analysis will be on how to minimize the consequences of identified risks through the suggestions in the Polar Code.

The three steps are

1. Identify the future state
2. Analyze current situation
3. Identify how to bridge the gap

For the Gap analysis a fictive case vessel is used: a new built shipping vessel special designed for Arctic. The ship yard and the class society ensure the ship fulfils the regulation about construction on the vessel, and the outfitting is arranged for the expected conditions. The suppliers of the navigation equipment provide information over limitations of their equipment in Arctic waters. All the information has to be included into the IPS.

8.1.1 Identify future states

The future states are given by the Polar Code. The future state can then be the preferred IPS system for ships operating in the Arctic under the Polar Code. The future state is a system which has to be able to fulfil the new demands from the Polar Code. These demands are typically linked to weather, communication, safety and rescue, ice in the water, environment

In the future states the Star IPS has the possibilities to help with the necessary Voyage Plan and the Polar Water Operational Manual (PWOM).

The ship owners now want help to be prepared for a voyage. From the Polar Code the requirements for a voyage plan are:

1. *Anticipated environmental considerations along the route*
2. *The availability of SAR, salvage and repair capabilities, waste reception facilities and safe havens*
3. *National and international designated protection areas along the route*
4. *Known key areas for marine mammals and other migratory species*
5. *National and international systems of navigational control and reporting*
6. *Ship capabilities and characteristics as reflected in the PWOM.*

The PWOM shall be specific for the ship and available for the Master and the crew. The minimum functional requirements for the PWOM are:

1. *Ship's main particulars*
2. *Safe speed in ice covered waters in order to give advice on the relation between the ship's maximum recommended speed and in the different ice conditions it encounters*
3. *Safe distance in a convoy in order to give advice on the minimum admissible distance of the escorting ship according to the ship's spend and ice concentration in the channel*
4. *Lower and upper ice waterline*
5. *Manoeuvring characteristics*
6. *Minimum design temperatures for operation of machinery and ship essential systems*
7. *List of ship's systems subject to damage by freezing and measures to be adopted to avoid malfunction*
8. *Communication and navigational equipment limitations in high latitude and alternatives provided.*

SIS cannot solve all these points mentioned above. The most specific points will be taken further. What they will be able to do is contribute towards the ship's information and planning system.

It might be possible to include the vessels demand of safe havens and ports where they can discharge with garbage and waste if necessary.

8.1.2 Current state

The current state of the system is an operating IPS system with possibilities towards the management of the ships daily operations, as mentioned in chapter 7 Star IPS. It consist of work orders, the overview possibility Starboard, and material managements solutions.

8.1.3 Proposals

The proposals to reach the future states with an IPS system all lies within the current possibilities in the system today. The main part is doing the small changes to make it specific to the Arctic with tagging the equipment.

Table 3 Gap analysis

Current Situation	***Future State***	***Proposals***
Starboard consist of work orders	Hold possibilities for implementation of PWOM and the voyage plan	Starboard also consist of necessary port as marked in the time periods in Starboard. Allows for risk assessments, voyage plan and environmental concerns at the different areas along the route.
Materials and equipment are marked with criticality	Creates a list of ship's systems subject to freezing and the design temperature and measures to avoid malfunction	Easy access, browsing and creation of list through marking the equipment and materials with an Arctic criticality tag.
Projects for surveys	Include extra checks necessary for Arctic operations	Include the surveys and checks special for Arctic operations in the Projects.

8.2 Work planning

Most of the work to be conducted is the same as in other waters, and do not need any special requirements. For some operations in the Arctic, it might be necessary to change the risk of the jobs. Equipment subject to icing and chemicals and other liquids subject to freezing have to be easily identified, and the related risk should be included. This is applicable for the cooling water system but also other systems that are operating at other temperatures than they are designed for.

Some work orders might not be able to be performed immediately in bad weather or when the temperature is too low. Special jobs for the ship in the Arctic, such as preparations, extra maintenance and inspections can be added as normal work orders. When creating work orders, a criticality factor can be added. This already exists in the system, and it can be designed to the customers' desire. If a risk analysis of each work order is included, this can easily be taken care of the system or carried out at an earlier stage, and the crew can consider the essential nature of the particular situation.

The counters should be checked and be compared with the other jobs in the IPS Starboard so that the work can be performed in safe areas and time frames in the operation or under transfer conditions. The counter could, if necessary be changed for running under Arctic conditions. The supplier should be consulted first. Equipment subject to a change in the counter based maintenance might be linked to the rotating machinery since running in ice will give some extra wear on the moving parts.

To further identify critical systems, the ships unplanned corrective maintenance incidents can be evaluated from the work history. Those of the incidents that might have been critical in the Arctic should be included for the risk evaluation. The KPI's should also be checked when planning voyages with higher related risk such as Arctic conditions.

The risk assessments linked to the work instructions should be maintained and evaluated due to different aspects such as the weather. Hence, the use of this function should be emphasized. The more dynamic the risk assessment part can be; the better. Then it can contribute towards the PWOM.

8.3 Material and Services

In the Arctic the importance of having the necessary equipment is larger. Operating in the Arctic will mean the vessel is further from safe ports and may be beyond the point of easily getting materials shipped out. Good planning in this field could save the company both time and considerable money. If some extra spares are needed only because the vessel is going to operate in polar waters, then they can be labelled or given a code inside the Star IPS to identify them. This is also the case for the consumables used onboard. Such a code can be ticked in a box or mentioned as a traceable comment, so when browsing through the equipment, the Arctic specific parts can be identified. This could also be done by using the Arctic criticality label when registering the equipment. This would also be useful towards the creation of the compulsory list of Arctic critical equipment.

The trip can be planned from its length, and the necessary material can be provided. Checking the IPS Starboard will give an overview over what equipment and materials are needed for the planned trip. Here a check list or a kit for special Arctic operations could be made available to ensure the vessel is properly prepared for the Arctic conditions. The system is meant for keeping track over the materials onboard, and lists can be provided to help planning purchasing the correct equipment before a voyage to the Arctic.

8.4 Starboard

To make a system where the chores pop out as a different colour due to criticality in the Arctic might be too consuming, but using the normal filtering of work orders due to criticality will most likely be sufficient. If the work order or the scheduled job is marked for weather criticality, this might be beneficial for both operating in cold and warm areas.

8.5 Safety management

Determining what conditions and events which leads to specific incidents, can provide information to the risk assessments for Arctic areas. Some of the documentation needed for safety management can be included in the *Document* module in Star IPS. Here a procedure for Arctic operation can be added, and a specific check list can be added. From there the necessary measures and problems can be identified, and the crew can be increasingly prepared and aware of the risks and control measures. A list of extra and additional equipment needed for Arctic operations, as determined in the Polar Code, can also be added to the equipment list contained in the system. The Polar Code will establish a risk matrix. This matrix should be tried implemented on the system.

To be prepared for emergency might be more difficult when operating in the remote areas of the Arctic. For the personnel to be able to operate safely and use the SMS, it is important that they can read and easily understand what are in the SMS.

8.6 Projects

The project module is built for planning and managing ship repairs, typically dry-docking. When a vessel is planning its 5th year survey, they can arrange all the big changes to be made in this module. This will provide a list over necessary work to be done, and the order of which the work should be done can be planned well ahead.

This module can also be used to plan other critical events and operations for the vessel. This module can create repair and work lists, and is made for handling extras and changes on the vessel. These qualities would be beneficial for planning operations in the Arctic. Being prepared for operations in the Arctic might also require some preplanning of work at the dock before going to sea. Many ships might have to change some of the systems to fulfil the rules in the Polar Code. This module could then be of good use, if used properly.

8.7 Polar Water Operational Manual

The system must be able to handle and sectional breakdown the requirements contained in the Polar Water Operational Manual (PWOM). The PWOM should be linked to the documents list, and to the ship specifics and particulars, so that compliance with the code can be determined.

In this manual a list of the ship's systems subject to damage by freezing conditions should be made. It should also include the limitations of the communication and navigation equipment in this operational environment, including minimum design temperatures for operation of machinery and ship essential systems. By enabling the ticking off of temperature critical equipment when purchasing, installing and registering the equipment onboard, the vessels can prepare operations more easily. If this is not accomplishable, a codification scheme could be applied to the describing text of the equipment, so it can be more easily searched for within equipment/materials documents and records.

The designed operational temperatures should be included in the system such that operational difficulties for the Arctic environment are more easily distinguished. The more complicated the system become, the less likely it is that it will be used correct; therefore some simplification may become necessary. For old vessels it might be demanding to find the operation temperatures for the machinery and essential systems. If a list can be provided up front with the machinery and systems subject to follow the PWOM's it would make it easier to include the temperature for these.

Measures and precautions in the Arctic should be taken to avoid malfunction on the ship's systems due to freezing. This should be carried out by the crew, and should be added on to the list of systems in the PWOM. They could be found in the work order instructions towards the relevant systems.

8.7.1 Voyage plan

The Star IPS might not be of much help here. It would be better to have some kind of function in the mapping system where the key marine mammal areas can be included. Changes to the voyage plan have to be reported to the authorities.

8.8 Machinery limitations

The machinery has to deliver the required functionality. Some extra maintenance and inspections might be necessary for maintaining the functionality.

Make an Arctic tag

Adding connections and tags to machinery, spares, operational temperatures, risk, materials linked to icing and temperatures problems and other Arctic factors would be beneficial. Then all of the relevant systems can be found to make the list for the PWOM. Adding this, all of them is included, and the most important parts can be used for an evaluation of risk and then be a step on fulfilling the Polar Code requirements. The system allows modifications on the criticality of the equipment. For the list over components critical in the Arctic, they can easily be tagged with an Arctic criticality as well as critical for safety and other tags.

8.9 Propulsion

The Polar Code might demand a list over all equipment subject to freezing. For the planning of dry-docking, a filter could be applied to pick out the equipment subject to further damage due to operation in the Arctic. This could be the propeller and shaft, since the vessel might get extra wear here by operation in polar waters. After operating in the Arctic it would be beneficial to try to identify the exposure to the vessels due to the Arctic conditions. Then the ship's performance can be further investigated for later operations in the Arctic.

8.10 Crew- module

The other certificates and their due dates for the crew have to be documented, because of the ISM code. The Polar Code will have some requirements for training of the crew, which should be documented in this module. Other training records should already be kept in the Crew module. The navigators will also need ice training, and their training manual should be included. This is a part of the Polar Ship Certificate. This will not change the existing system at all since it will just be adding more documents to this section. If necessary, equipment that requires special Arctic training could be tagged.

8.11 Operational limitations

For preparing the system for voyages in the Arctic, as well as everywhere else, it is important to remember to keep the system easy and simple. Some vessels might not operate too often in Arctic conditions, and the crew might find it useless to add extra information, hence simplicity is very important. The Polar Code will demand knowledge about the components that are Arctic-affected, and making the system as simple as possible will make this less painful for the crew. For now, assuming the Polar Code will be very strict is the best option. Instead of only tagging/ticking off for Arctic, it might be just as beneficial for an input for operational and system limitations. This way, it could be useful for ships operating in warmer as well as Arctic conditions.

Ticking off for operational limitations, and putting in more describing information, the components/equipment should automatically show up in the list over systems subject to Arctic limitations in the PWOM. This has to be done before leaving for Arctic, since the information should be present in the PWOM. If the ships that already are operating in the Arctic Start to add this information now, they can have the information ready when the Polar Code gets ratified.

9 Planning for Arctic operations

This plan builds on Star IPS, the Polar Code and the experience from Nergård Havfiske AS.

Planning will here be focused around two events.

1. Preparation at shore
2. Planning of the Voyage

Some of the necessary background information on what to expect in the Arctic is identified in the previous chapters. This section will evaluate how planning can be performed to cohere to safe standards and the Polar Code in the Arctic.

A good voyage plan for navigators is a plan that will take the vessel safe and efficient from shore to its final destination without any incidents and near misses (121). The same aim can be taken further for planning Arctic Operations.

The Polar Code’s demands for a Polar Water Operation Manual (PWOM), where the extra measures to be taken should be included. The work of making the PWOM and the voyage plan can partly be performed together. The voyage plan can build on a version of the PWOM. The information about the PWOM is still quite unclear, but is evaluated as good as possible out of the Polar Code draft.

For the planning everybody related to the planning should be informed, and there should be somebody to take the lead of the planning, typically being the planning personnel on shore. This person has to identify all of the necessary things that should be done before the trip to the Arctic. When starting a long time in advance, the weather aspect cannot be included. However, the weather is of great importance in the Arctic, and even more important: the vessel should be able to withstand all the trouble the weather is going to create on the way. This is one of the main challenges, and the whole vessel should be prepared in every possible way to overcome any problems. The strategy of ordering more of everything might not work, as a vessel, as a lot of other things, have only a certain area for storage. This is the same for shipping and fishing vessels. It might be just as important to remove the things that will not be needed for the trip.

For the fishing vessel in the case study, all the department bosses hands in lists and reports on the state of their department. Doing this far ahead of the operation allows both of the crew, the one working, and the crew with their free period to all have a say in this matter. This will be of increased safety, as the natural redundancy of crew can notice different important aspect. Hence, at least 3 crew changes should be involved, so the first crew can submit their draft before the second crew can check and control, and then the first crew can evaluate the first changes again. All of this should be documented, so the owner of the ship can document that the crew have been informed and included on the process. The inclusion will also make it more likely that some of the chores will be thoroughly carried out as the crew will get an ownership towards the jobs to be done.

Discussion between all the departments can show improvement possibilities, and also work as redundancy. Some of the systems will be linked, and the more the crew know about the status of the ship the better. If everybody knows a component has a fault, the barrier of an incident due to that component can be reduced. Anyhow, it is also important to make sure people are responsible for their own section. Using a Computerized Maintenance Management System (CMMS) here will tidy the process of the maintenance work.

Navigators have to plan the route, and consider the weather conditions as well as the ice conditions and other elements such as keel clearance, position fixing, no-go areas and remember to report (121). Weather can determine the departure dates. The communication possibilities should be evaluated for a planned route and an emergency route in case the vessel will be exposes to measures they cannot be sure of from before. The vessels also have to add some extra time on the transit to include changing of the route due to ice, weather and other unforeseen incidents.

A traditional voyage plan consists of plotting of routes in Electronic Chart Display and Information System (ECDIS). This will not be evaluated in this paper.

Since different vessels have different critical and maintenance significant items, these are not evaluated in detail, as it would also be difficult to obtain all the necessary information from many vessels in operation.

The most important chores can be evaluated such that it complies with the SIS Starboard

9.1 Gantt diagram

A voyage plan for a vessel can roughly be divided between the Masters responsibility and the planning from the shore based personnel. These are different, but closely linked as making a complete voyage plan demands information from the vessel. The Master is responsible for the vessel when it is at shore; hence the Master has to be included into the planning from the management people on shore. If the economy, crew and time aspects allows for doing two Arctic trips after each other this would be beneficial since the vessel would not have to change the factory and the fishing equipment. Compared to normal operation with shorter transit time and better operational conditions, this diagram does not show the differences for the Arctic apart from the longer transit time, planning time and shore time. These two Gantt diagrams are built on the feedback from Nergård Havfiske AS.

9.1.1 Planning personnel on shore

The planning onshore depends a lot on the feedback from the different persons affected. It depends on the information received from higher in the hierarchy, the different groups on the vessels, the survey personnel and dock facilities. A lot of tuning has to be done for everything to run smoothly. Only one voyage is planned in this document. This means that where there are gaps, there are still other voyages to plan. Since the fishing vessels are normally not having more than two trips a year, just one special Arctic trip is included here.

Table 4 Gantt chart info for shore personnel

Management personnel

	Task
1	Planning, check IPS
2	Check available time at shore
3	Phone interviews
4	Request list from department bosses
5	Department bosses time to create lists
6	Treat lists from department bosses
7	Order dock/shore time
8	Phone interviews 2nd round
9	Purchase equipment and materials
10	Book extra service personnel
11	Follow-up, check IPS
12	Prepare vessel for shore/transit
13	Preparing at shore
14	Transit
15	Fishing
16	Transit
17	Offload, next trip preparations
18	Debriefing

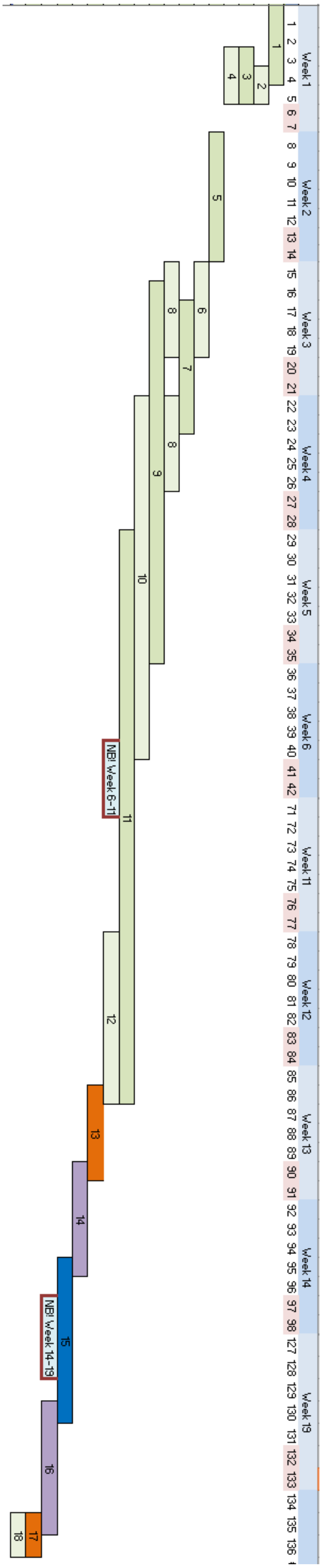


Table 5 Gantt chart shore personnel

9.1.2 Master

This table is made as an overview over the Masters responsibility from boarding the vessel to when the shift is finished. The master also has to do some preparation in advance. In Task 10, the master has to ensure machinery, fishing gear, navigation and communication systems are all operational. For the first three points this is the latest completion time of the preparations, and close to departure, only small changes should have to be done. In this table the start and end of work are included, to show that there is actually a gap of available time. If of interest, two Gantt diagrams can be added onto each other for the complete work flow.

Table 6 Gantt chart info for the Master

	Master's responsibility	**[days]**	
	Task	**Earliest start**	**Latest finished**
1	Prepare list for necessary work at shore	0	7
2	Phone interview with shore personnel	0	7
3	Prepare vessel for shore/transit	0	7
4	Plan route due to weather/ice/convoy	0	12
5	Offload cargo	7	8
6	Crew change	7	8
7	Preparing at shore	8	12
8	Maintenance	8	12
9	Fuel and waste	8	12
10	Ensure sufficient equipment	8	12
11	Transit	12	17
12	Re-evaluate route due to weather	12	17
13	Fishing	17	45
14	Maintenance of fishing gear	17	45
15	Planning of trawling route	17	45
16	Transit	45	50
17	Re-evaluate route due to weather	45	50
18	Offload	50	51
19	Debriefing	50	51

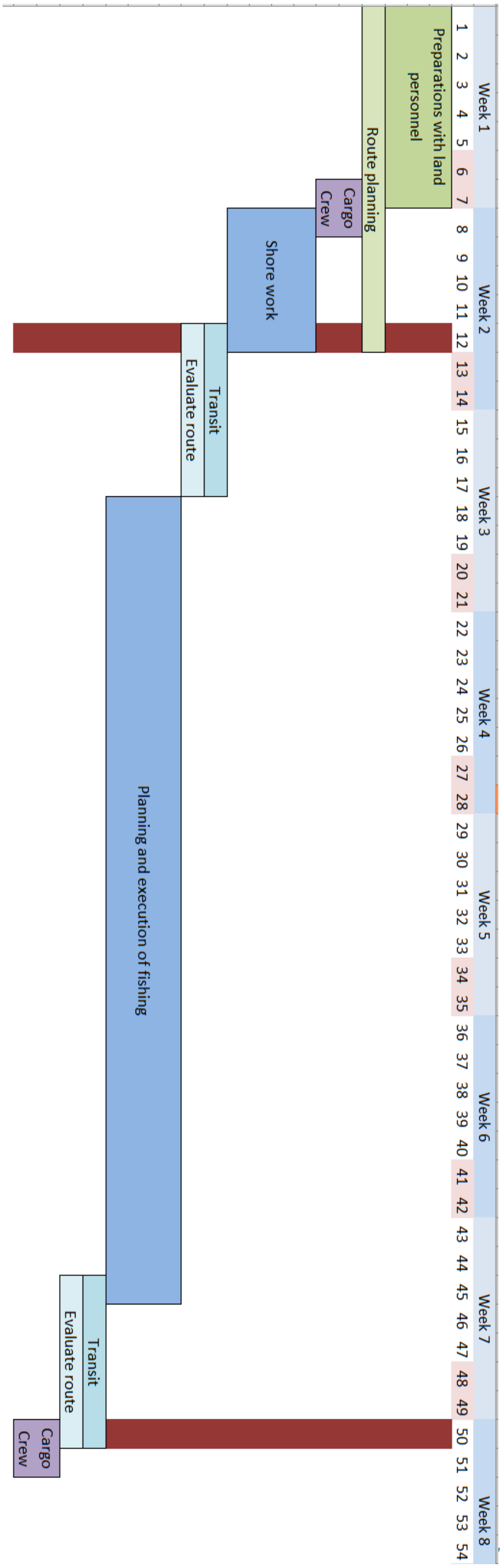


Table 7 Gantt chart Master

9.2 Risk assessment

From the Polar Code as well as the Norwegian Maritime Authority's regulation of 1.st January 2005, a risk assessment shall be developed. Dangers onboard the vessel should be identified, and an assessment of the hazards should be carried out. The risk assessment should be documented in writing. The report *"Future needs and visions for maritime safety management in the High North"* emphasise the development and implementation of tools for dynamic risk assessments for safer operations in the North. The dynamic part is of importance, since many factors can change quickly, and risk assessments should be maintained.

Vessels should have a risk assessment for ordinary operations. Having an own risk assessment for operations in the Arctic would contribute towards safer operations in the Arctic. The Polar Code's requirements are intended to mitigate hazards specific to Polar waters. For creating the risk assessments the known causes to problems or complications to Arctic operations can be done on the basis of the information from the Polar Code. A thorough preparation of potential emergencies should be identified, and the company should know how to react.

The Polar Code's requirements are intended to mitigate hazards specific to polar waters(122). Such hazards being:

- *A higher probability of occurrence of hull damage due to ice*
- *A higher probability of occurrence of grounding in coastal waters, due to limited hydrography, lack of navigation aids*
- *A higher probability of occurrence of top side icing due to low temperatures and strong wind*
- *Unusual modes of navigation such as escort and convoy operations*
- *High latitude effects of certain communications*

These as well as all other incidents in the Arctic have increased risk due to the limitation in the search and rescue possibilities.

From the risk assessments certain concerns can be included into the voyage plan as to fill out about the conditions.

9.3 Maintenance management

"On a vessel there is systems and equipment that will be worn, damaged and broken. The vessel's systems and equipment therefore need to be maintained. Inadequate maintenance can increase the risk for accidents and injuries. Maintenance is the combination of technical and administrative activities with a purpose to maintain and recover the state due to needs. Maintenance is linked to safety in many ways, errors in planning, executing and checking of maintenance could cause system errors."(123)

The systems to be maintained are very different from different vessels. Not only fishing vessels, but also what type of cargo vessels. Different cargo needs different systems for cargo treatment. Obviously fish, ore and gas cargo systems need different maintenance. Hence this section will be linked to the ships main systems.

Using CMMS is necessary for bigger vessels to keep control over all the maintenance that should be performed. When different crew are operating the vessel, people might perform the jobs differently, this to both bad and good. Having all the routines available and valid for Arctic Operations by performing risk assessments for the relevant orders, would be of importance to the voyage plan. This importance will be in the evaluation on when the jobs should be carried out. The technical condition of the vessel should be maintained at a high level for Arctic operations. Therefore it is important to report, analyse and improve the maintenance.

Creating the list over the specific maintenance linked to Arctic operations is of importance, as it will help to identify the workload. Clubbing ice has to be considered a very important and urgent maintenance job, since the vessel's stability can be drastically affected. This is also very labour heavy work. It would also be of importance to maintain the systems for heating, as downtime might lead to rapid ice accretion. Other jobs of importance are the inspection jobs linked to errors in systems. Especially vents have been considered important as freezing of liquids can create big problems.

Vibration checks on the shaft might also have to occur more often, as going through waters with ice will increase the vibration on the stern tube, propeller and shaft. For the crew, they also have to be aware that not all of the same chemicals used in non Arctic areas can be used here. Hence, it might even be of purpose to remove chemicals that are not be used in Arctic waters, and rather be sure that the vessel has sufficient of the approved chemicals.

Some bigger maintenance tasks have to be carried out at shore. As from the feedback from J. Bergvoll, this is machinery jobs, since the engine cannot be stopped under operation. Also, one big maintenance job before entering Arctic water is the cleaning of the hull and the use of biocide free anti fouling.

Maintenance is linked to the reliability. For the Arctic conditions, where SAR and communication and navigation aids are reduced, the reliability comes to a greater importance.

9.4 Shipping versus Fishing

Shipping activities are different from the operation of fishing vessels. The vessels are also of different sizes, and it follows that the equipment also differs.

Planning the operation of the shipping and fishing vessels, will be based on different problems and time frames. The shipping vessels load cargo in port, as the opposite of fishing vessels who are loading at sea over their whole fishing period. Both have to offload their cargo at the end, but for the fishing vessels, the income is less certain. This difference also creates a different in the operation when it comes to planning quay time, fuel and weather. The fishing vessels can more or less leave one area to go fishing in another if the weather becomes troublesome. The shipping vessels still have to proceed, and alternative routes can be used if troubles. Still this will most likely prolong the transit time. The shipping schedules consist of departure from port in a tight time frame and deliver the cargo on time. For a fishing vessel, they would catch an unknown amount of fish in an unknown time period, and then maybe deliver 1 or more times during one crew shift of up to six weeks.

With increased shipping in the Arctic, it is likely to assume the fishing fleet will benefit from the increase, in infrastructure and SAR availability in currently remote areas. More traffic means that there is a higher likelihood that if an unwanted incident occurs, help come quicker than what is currently the case. In Figure 56 the overlap of the fishing areas and shipping lanes can be seen.

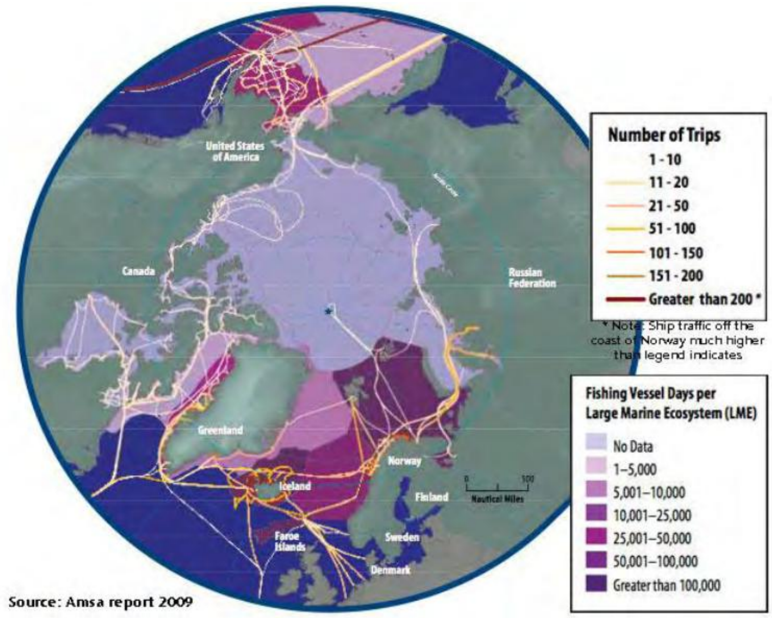


Figure 56 Fishing vessel days and sea routes (6)

Both shipping and fishing might benefit if the petroleum industry comes with higher demands on weather forecast and SAR coverage.

9.4.1 Hydrographical data

Nautical charting requires hydrographical data. Many areas in the Arctic lack hydrographical data. This will affect the shipping vessels more, as they are going to go through passages where little sonar activity has been conducted. This makes operations more difficult for vessels, since the information on the water depth and the nature of the sea floor material might be unknown (124). The water depth might also change due to big icebergs scraping the sea bed in their mitigation south. This can also make anchoring more difficult.

The fishing vessels have been operating in the same areas for years, and therefore they don’t have this problem to the same extend.

9.4.2 Fishing

The three most maintenance significant systems from the case vessel in this thesis are

1. The main engine
2. Winches
3. Freezer

The main engine is of big importance since without it the ship stops and cannot be operated, as well as many other important aspects such as electricity and heating.

The winches are needed for using the trawl, and hence most important for the fishing vessels operation. If the winch stops working under trawling, the repair might be quite challenging due to the cold.

The freezer is important, if not the catch will go bad. The freezer belongs to the production area. If freezing of the fish is not possible, the fishing operation has to stop. For all fishing in the Arctic, freezing of the catch is necessary for storage before going in to offload.

9.4.3 Ballast water

Ballast water is included here, as a critical system. Operating in the Arctic fishing vessels have found it is beneficial to use MGO to ballast vessels operating in the Arctic, since it freezes at a lower temperature. It also provide for a reduced risk for error at the ballast system.

Maintenance of ballast systems consist of cleaning of filters, and lubrication of vents. When at dock, vents will be tested that they open and close easily and the sea chest for sea water intake must be inspected for damage (125).

9.5 Voyage planning for shipping vessels

The shipping vessels will encounter different challenges before they can operate more fluently in the Arctic. For shipping vessels, a voyage plan will be mandatory soon as they are SOLAS vessels due to the Polar Code.

The summer season is originally between June and October, but the summer in the Arctic is getting longer. The North Western Passage will remain risky even in the summer season mid-July to the end of October. There are few ports along the North Western Passage and models indicate too heavy ice conditions for commercial shipping. Canada and Russia are planning the establishing of the Atlantic bridge between Murmansk and Churchill in Canada. Ice fastened to the coast line is hard to get through, so often a more northern route will be chosen, depending on the wind.

The vessels are to operate in waters where it might be ice, depending on their hull strength. The concept of ice-free waters can be misleading. There is still the possibility of encountering multi-year ice such as icebergs, bergy bits and growlers (126). It might be harder and more risky to break through icy water areas, especially if the navigators are not expecting ice. Hence training of the navigators is of importance. This matter is important to take into consideration, and this is one of the problems that are being included in the Polar Code. The water depths are also very varying due to icebergs changing the sea bed and poor mapping as mentioned under chapter 2 The Arctic Challenge.

The Arctic Marine Shipping Assessment concludes that planning the vessels route with a certainty of reaching port on schedule is nearly impossible due to the variability of ice-free areas (126). The route to choose is very dependent on the ice conditions, and information about the ice and the weather are of great importance in this area. The problem then will be communication with weather information.

The plan should summarize some of the biggest and most significant maintenance chores that have to be performed under the voyage. Here the weather forecast should be included to ensure the vessel can operate, and the critical work can be planned towards the weather windows, and safer passages, to avoid extra risk during operation. Information on the course, speed, weather, duration/fishing time, crew onboard and other necessary information should be included in the plan. The plan should also consist of distance to SAR, salvage, rescue, repair, waste reception facilities and safe havens, from the requirements in the Polar Code.

For the voyage planning SOLAS chapter V is included, as it is emphasised in the Polar Code.

9.5.1 Planning of route

The weather forecast can be of reduced quality. This is due to grid-size and the lack of in-situ time series of met-ocean and ice information. The best model of the Barents Sea is SINMOD by SINTEF Fisheries and Aquaculture (31). This model can evaluate the ocean circulation. The Norwegian Metrological Institute runs a wave model of the Barents Sea twice a day. The institute have for ice introduced Fine Resolution Arctic Modelling and Prediction System, known as FRAMPS. Having vessel traffic services on board, will help the vessels to avoid collision and know how far away help is.

International shipping needs a certain size and standard of ports and facilities, and currently only a few of the ports in the north eastern passage can meet these standards. The information about the ice conditions has to be included for the planning. For the future

9.5.2 Economy

The fastest transport that has gone through the North Eastern Passage is the STI Heritage transporting Gas Condensate. It used only eight days, and had an average speed of 14 knots (126). A ship sailing through the North Eastern Passage from Kirkenes in Norway to China could therefore save about 16 days. From Kirkenes to South Korea, the amount of reduced days is 18, and Kirkenes to Japan, 20 days. A typical day rate for a bulk carrier could be around 15 000 dollars a day, and it would use fuel for 20 000 dollars a day, giving a total saving of 35000 dollars a day, about 200 000 NOK each day, and around 4 million NOK each trip. The extra costs would be the tariff and the channel charge for the route. The current potential is about 30-40 ships each season (127). The economically benefits of increased Arctic activity along this route could be huge, especially if the risk in the voyage could be reduced. If the ships are new, strong and clean, it could also reduce some of the total global pollution, though the Arctic will get higher concentrations of SO_X, NO_X and other exhaust fumes.

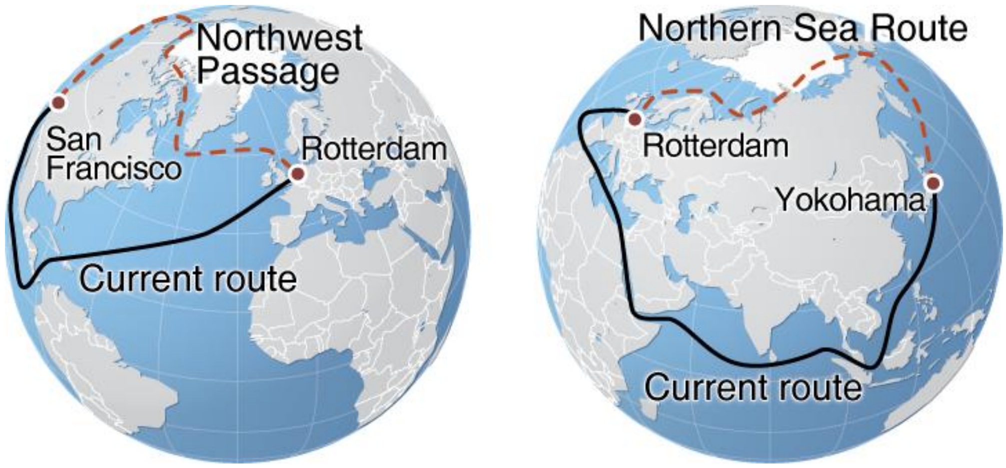


Figure 57 Northern Sea Route and the Northwest Passage compared with currently used shipping routes [17]

9.5.3 Advantages

These factors are making more shipping interested in expanding their operations through the Arctic region (128)(129).

- Shorter distance between Northern Europe to China
  - 40 % shorter than Suez Canal
  - 60 % shorter than via Cape of Good Hope
- Reduction in
  - Transport time
  - Fuel consumption
  - Environmental emission
  - Piracy risk
  - CO_2 emission

[17] With permission from Hugo Ahlenius, UNEP/GRID-Arendal

9.5.4 Hazards

Shipping in the Arctic encounters some of the same problems as the fishing vessels (126). Summarized

- Infrastructure for efficient transportation
- Port and port facilities
- SAR availability
- Satellite systems and radio communication on the routes
- Ice-breaker fleet for support
- Legal regime
- Resource activities – traffic patterns
- Cruise traffic route

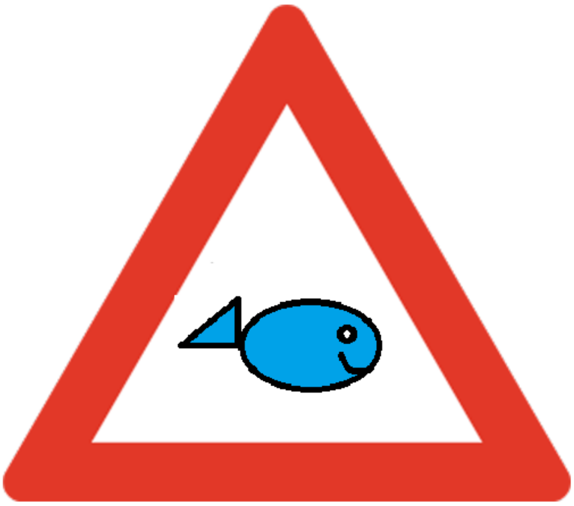


Figure 58 Danger of collision with marine mammals

9.6 Total voyage risk

As a part of the PWOM, a risk picture over the vessel's route can be created to give an overview over the total situation. This would be helpful for planning the complete voyage, and to be prepared for unwanted incidents. It could also be of use towards the insurance companies. The crew would also see the benefits of performing the risk assessments.

Risk awareness pictures could be implemented with the SMS and the Starbord in Star IPS. They could also be printed and kept readily available for the crew, so the daily challenges are known.

In Excel two routes, one for a shipping vessel, and one for a fishing vessel are made. All the demands from the PWOM and the voyage planning in SOLAS chapter V are included. Other concerns for the Arctic area are also included.

The system is made as simply as possible as this is of importance for new systems to be applied. Numbers between 0 and 4 are related to the risk of different operations, and put into an Excel sheet. The numbers are linked to different colours due to their expected risk.

The tradition warning colours are used

0. Red – high risk
1. Dark orange – medium plus risk
2. Yellow – medium minus risk
3. Green – no risk

For evaluating the total risk in an area or one day, the numbers can be added. In this system, the highest number gives the lowest risk. This could of course be turned around, and it could then be maybe used as a way of counting hazards. Both the likelihood and the consequence have to be evaluated to give the complete risk picture.

By separating the risk in four values, it is also less likely to be tempted to choose the middle value, as this sometimes is the easiest option, giving less thought to the decision. Awareness and preparedness of the crew are the aims. The number of values can easily be changed to fit different real life situations. Anyways, too many values should be avoided as this can create a false, or misleading, view on the precision of the data basis.

The different areas encountered along the route could be saved with different information about the conditions and their expected variations. As more shipping and fishing occurs, the better the database will be for later voyages. All this values are just example values, as no specific route has been evaluated.

9.6.1 Shipping vessels

If many alternative routes are taken, the delayed arrival time should be included, showing the new anticipated arrival time. This is not included here. The background time is taken from chapter 9.5.2.

The different areas of concerns and risks could be numbered and be linked to each other by subgroups. In this way, many small parts can create a more detailed picture. For instance, all concerns linked to the weather can be created under the same name, making the table tidier. Here, this is not performed, as it would not show all the hazards identified.

Table 8 Voyage risk for shipping vessels

Day	1	2	3	4	5	6	7	8	9	10	11	12	Alt. day 7
Area	Port	Area 1	Area 2	Area 3	Area 3	Area 3	Area 4	Area 4	Area 5	Area 6	Area 7	Port	Area 4.5
Safe havens within x hours reach	3	3	2	0	0	0	2	2	3	2	3	3	2
Sufficient port facilities	3	3	2	0	0	0	0	0	2	2	3	3	0
Waste reception facilities	3	0	0	0	0	0	1	1	0	0	1	3	0
Good weather information	3	3	2	1	0	1	0	1	2	3	3	3	2
Ice accretion risk	3	3	3	3	2	1	1	3	3	3	3	3	2
SAR facilities	3	3	3	2	2	1	0	0	1	3	3	3	0
Reduced communication	3	3	3	0	0	0	3	3	3	3	3	3	3
High risk navigation	1	3	3	3	1	1	3	3	3	3	3	3	3
High traffic density	0	0	3	3	3	3	3	3	3	3	0	0	3
Marine mammals awareness	3	2	0	2	3	3	0	0	2	2	3	3	3
Special legal concerns	1	3	3	3	3	3	0	0	3	3	3	1	1
Critical maintenance chores	0	2	1	0	1	2	0	2	1	0	3	0	2
Fog and Polar lows risk	3	3	3	3	2	1	0	2	3	3	3	3	2
Reliable maps	3	3	3	2	1	1	3	3	3	3	3	3	2
Areas of random concern	3	3	3	3	0	3	3	3	3	3	3	3	2
Possible delay	2	2	3	2	2	2	1	1	3	3	2	1	1
Risk	37	39	37	27	20	22	20	27	38	39	42	38	28

9.6.2 Fishing vessel

The same system is used for the fishing vessels. A time period for about 1 month is chosen. The areas are divided into the transit areas and the fishing areas. The fishing areas could be separated into smaller areas or just the name of the fishing grounds. This expected area separation can be more difficult for the fishing vessels, since they can move within certain areas to follow the shoal of shrimps. For the fishing vessels it might be just as beneficial to have the alternative routes that the activity can be built on, depending on the updated weather forecast.

The risk of polar bears is not included here, but it could be added.

Table 9 Voyage risk for fishing vessels

	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
Fishing vessels	Port	Area 1	Area 2	Area 3	Fishing	Fishing	Fishing	Fishing	Fishing	Fishing	Fishing	Fishing	Area 3	Area 2	Area 1	Port
Safe havens within x hours reach	3	2	0	1	3	2	2	3	1	2	2	1	1	0	2	3
Good weather information	3	3	3	2	2	2	2	3	2	2	2	2	2	3	3	3
Ice accretion risk	3	3	3	3	2	2	1	1	1	2	2	2	3	3	3	3
SAR facilities	3	3	3	2	2	2	2	2	1	2	2	2	2	3	3	3
Reduced communication	3	3	3	3	3	3	2	2	1	2	2	1	3	3	3	3
High risk navigation	2	2	1	1	2	2	1	1	2	1	2	2	1	1	2	2
High traffic density	0	2	1	1	2	2	1	1	2	1	2	2	1	1	2	0
Marine mammals awareness	3	3	3	3	1	1	1	1	1	1	1	1	3	3	3	3
Special legal concerns	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2
Critical maintenance chores	0	3	3	2	3	3	2	3	3	2	3	3	2	3	2	0
Fog and Polar lows risk	3	3	3	2	2	2	1	1	1	1	2	2	2	3	3	3
Reliable maps	3	3	2	3	3	3	3	1	3	3	3	3	3	2	3	3
Area of random concern	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3
Risk	31	35	30	28	30	29	22	23	23	24	25	26	28	30	34	31

9.7 New build comparison

The bigger, the better

When planning for future operations, it might be beneficial to have some thoughts about how a vessel can be built to adhere to the standards for Arctic operations. Such standards are given by the Polar Code and the can be fulfilled to the classification companies standard. The DNV standard is the one most referred too, and will hence be used here.

- Increased hull strength - ICE classing of hull
- Anti ice accretion hull shape
- Heating in relevant places at deck – gunwale, hatches, doors, walkways etc.
- Ensure equipment can operate in the cold

9.7.1 Ice

For designing a new ship for Arctic conditions with ice, it is important to remember the ice design in an early phase. Ice influences the design of the main dimensions, hull strength, machinery and equipment. The shape of the hull is also important, not only for strength and stability, but a smart design for avoiding excessive icing. It would be preferable to have good sea data from the area the vessel is to operate.

Ice comes in different sizes and properties, so the more information the designer can be provided with, the better. Vessel design is important when it comes to avoiding icing. For a renewal of the fleet the feedback from the fishermen is that the bigger the vessel, the better. The total rate of ice accretion is dependent on the vessel design, the speed relative to the waves, the heading, the relative wind and the load on the vessel. It is all dependent on the spray the vessel generates. This are factors such as ocean wave field, the length of the vessel, sea keeping ability, stability, freeboard and the hull shape.

As ice accretion is formed on masts, rails and other sections, the effective cross section increases, making the ice accretion accumulate. Being able to avoid the start of icing, especially of areas high up on the vessel (stability reason) would be beneficial. Having defrosting methods such as hot steam going through mast, rigging, rails, etc, exposed to spray would then be most efficient if the system is preventive. Even though the fishing vessels are not to operate in heavy ice conditions, it should be prepared for ice (22).

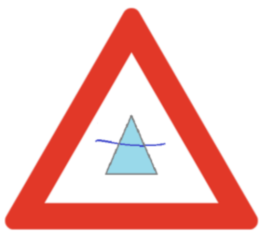


Figure 59 Ice in the water requires strengthened hull

9.7.2 Propulsion and machinery

The fishing fleet can pick up some of the technology from the ice breakers and the sealing vessels. This might increase the technical safety of the vessels. Propulsion machinery and shaft also need special attention when choosing equipment for the vessel. For more reliable propulsion power, redundant propulsion s required (130). The response of vibration and noise will differ from open waters. It is mostly the bow that experiences the ice impact, and the speed both ahead and astern will have to be considered safe. The vessels should be built within the comfort class of DNV, since the noise level will increase with 20-30dB when operating in icy water (57). The propeller is recommended to be of stainless steel, due to its strength and ductility.

9.7.3 Cold related issues

Depending on the lowest operation temperature, important equipment, the piping, the engine room, fire extinguishing system and hydraulic system in cold areas of the vessel and other areas require heating. If the design temperature is below -10°C, some ballast and fuel oil system also requires heating. Some areas at deck and other areas needed for manoeuvrability of the crew, requires de-icing solutions. The crew also needs special thermal protection suits, and the deck should be sand painted to avoid slipping. The materials in the hull and equipment such as chains, mooring winches and cargo pipes require low temperature grade materials. The vessel also needs a larger bunker capacity than normal in case the vessel will freeze in.

9.7.4 Environment

The systems that might have some leakages of chemicals during operation and maintenance are of importance due to the Polar Code's and MARPOL's environmental rules.

The new vessels should follow the requirements made for protecting the Arctic environment. The Polar Code also states that it should be no leakage of harmful substances from the stern tube bearings, seals, the hydraulic system and other components. The paint and anti-fouling on the hull have to be biocide free. The vessel should be outfitted with an engine not running on heavy fuel oil. Marine gas oil is accepted for Arctic areas. The systems that have daily leakage of oil such as the stern tube and controllable pitch propellers systems have to use non-toxic and biodegradable oil (130).

The ballast system is also of interest due to the potential of the transfer of microorganism from potentially global locations into the Arctic (6).

9.7.5 Critical systems

The systems vary between the types of vessel. Of the three most critical systems on the fishing vessels, two of them are directly linked to the fishing activity.

Systems which are relevant are the typical critical systems on a ship, such as the systems linked to the operation of the main engine. The systems which will be affected by the cold climate conditions will also be relevant. These systems should be individually identified for the specific vessel, and a coherent maintenance plan and environmental protection plan should be conducted.

No navigation equipment is considered to be among the maintenance significant items, but the ice light beams are of great importance when operating in the Arctic. They are very helpful when it comes to observing ice in a timely manner.

The deck machinery is directly exposed to the low temperature environment. This is typically equipment such as winches, windlasses, cranes and lifting appliances, hatch covers, vehicle ramps, davits and mooring fittings (122). The Fi-Fi equipment is also important, since it is subject to freezing.

9.7.6 Economy

For a vessel made specific for shipping in the Arctic, it should be considered that there are a lot of extra measures for the systems and extra equipment. This does not come for free, and for the whole winter period, the vessel might not legally need much of the Arctic demands, however, it can be assumed to be beneficial for winter shipping. The Polar Code demands documentation on quantifiable and measurable performance criteria’s for the vessel. This would contribute towards the economic expectations for the vessel.

10 Check lists for operations in the Arctic

There is no set of minimum kits for operating in certain areas. Equipment such as a simple propane heater had not been present under previous operations in the Arctic. It was mentioned that they did not have rifles onboard to protect themselves against polar bears if they get frozen in. It was mentioned from one of the crew that they had a helicopter fly out with rifles when they froze in for 21 days, when he was working for another company. The polar bears were walking around the vessel. They were unsure if the strength of the hull would be enough, and that they might have to leave the vessel.

Creating check lists with minimum kits for Arctic operations would smooth the planning process. Parts from the Polar Water Operational Manual can be used. However, the check lists alone are not sufficient, as systems change. Further investigation has to be taken to ensure everything is taken care of.

A check list for Arctic operations should also include all the other normal jobs and activities that have to be performed before a normal journey. However, for the construction of these check lists, everyday items are not includes, as they might take the focus away from the Arctic specific equipment. Most of these points are found when working on the background material. These check lists cannot be considered complete, as this is only factors found from regulations. For the different vessels there will be a wide variety due to different systems and operations.

The check lists are divided into subsections, due to the area of importance. Hence, some equipment is mentioned twice.

10.1 ArcKIT

Arctic Kit

For operating in the Arctic a minimum kit of equipment that might be beneficial can be brought.

A kit like this should contain equipment to make sure that the vessel has taken extra measures to be safe in the Arctic.

Summary

- A heater that can run without the main machinery
- Equipment for safer operation in fog
- Extra communication equipment
- Extra gaskets, vents, oil
- Extra light bulbs for ice detection
- Extra safety equipment for use in rescue boats
- Ice clubs
- Rifle to protect against polar bears
- Special gloves for cold weather
- Special suits for cold weather

10.1.1 Navigation

- Electronic position fixing system
- GPS compass for latitudes over 75 deg, also portable
- Gyro compass
- Ice search lights
- Light bulbs for Ice search lights
- Normal navigation equipment as maps, computers
- Possibilities to update Ice information
- Radar with enhanced ice detection
- Redundancy on critical navigation equipment
- Sufficient AIS system
- Weather receivers

10.1.2 Documentation and training

- Certificates
- Ice Navigator certificate
- Polar area first aid training
- Polar area training of crew
- Polar Ship Certificate
- Polar survival training
- PWOM
- Risk assessments

10.1.3 Life saving

- Communication in survival craft
- Design temperature of -30℃ for the equipment
- Emergency position indicating radio beacon, EPIRBs (131) placed outside
- Emergency supplies
- Group survival kits
- Personal Locator Beacon, PLB
- Personal survival kits
- Protective clothing
- Rifles (will also require paper work) (132)
- Search And Rescue Transponder, SART,
- Survival craft designed for being deployed in ice
- Thermal insulating materials
- Wear personal survival kit if mean daily temperature is below 0℃

10.1.4 Design

- Access to deck when ice and snow
- Alarm sounding
- Ballast tanks designed to avoid ice accretion
- Documented ice strength of vessel
- Fuel oil tank and piping for temperature of fuel
- Heated bridge windows
- Polar clothing to operate everything and walk everywhere
- Safe passages on deck dressed with full protection equipment
- Sea intake chest designed to avoid ice accretion
- Sea intake chest heating/back flushing
- Sea suction for fire extinguishing ice free
- Stainless steel propeller
- Tanks containing liquids away from the hull, should not freeze
- Tools of removal of ice/snow
- Vent pipes, intake and discharge pipes and associated systems designed do avoid blockage from ice/snow
- Winterization measures shall be connected to emergency power circuit
- Winterization protection of vent pipes

10.1.5 Useable at minimum anticipated temperature

- Ballast water
- Chemicals for cleaning bridge window
- Fire fighting
- Hatches and doors
- Hydraulic oil
- Life saving equipment
- Liquids and lubrications, quality

10.1.6 Heating

- Comfortable accommodation
- Emergency heater
- Engine room
- Fire fighting outfit kept warm
- Fuel and chemicals to their operational temperature
- Hydraulic system
- Means for de-icing
- Other heater than steam heater coil
- Pipes
- Portable and semi-portable Water and foam extinguishers

11 Conclusion

From the Polar Code the necessary regulations that can be applicable to the Star IPS have been evaluated towards the present system

The knowledge from the fishing industry is very linked to their main operation; fishing. Information from the Polar Code and Nergård Havfiske AS can be used as a frame for planning Arctic operations, both for fishing and shipping vessels. Many of the problems from the fishing vessels are linked to the Polar Code. The Polar Code will not be valid for the fishing vessels, but the years of experience from the fishing vessels can be used for safe shipping in the Arctic.

For the implementation of the planning of the future operations in the Arctic the Polar Code does not have very specific demands as it will be as an add on to the two existing regulations SOLAS and MARPOL. The regulations from the Polar Code will not drastically change the way the Star IPS system works today, as some adjustments can solve the most important points from the Polar Code requirements. The changes will be contributing towards the work of creating and maintaining the Polar Water Operational Manual.

For the complete planning of a voyage, all the aspects should be included. The crew should be aware of the risks for Arctic operation. A picture of the risk at different stages under the voyage could therefore increase the safety, as well as it could have its purpose for the management.

The experience from fishing vessels towards operating in the Arctic emphasises the points of having planned well ahead as well as respecting the basis of good cooperation. The Arctic area is big, with many variations, and for the planning, the areas to encounter might differ a lot.

11.1 Future work

For the relevant rules, a more thorough evaluation could have been conducted, and it might have given more details to the further work.

For the Arctic there are a variety of problem areas to evaluate. The topics to be prioritized are built on the discussions with Nergård Havfiske AS. Since shipping is a considerable part of this thesis, it would have been beneficial to also have interviewed somebody with the experience of Arctic shipping.

The Excel sheets to create a picture over the risks are still very simple and can be improved in many ways, especially towards alternative routes. They can also be extended to go more into detail and to have extended applicability.

For a complete planning, all the relevant data linked to the risks such as marine mammal areas, fog and polar lows probability, weather, ballast water disposal areas etc. should be identified and collected together, maybe in an interactive map. All the areas the vessel has to encounter can be evaluated from the know information, and risk assessments can be carried out. This has not been possible to do in this paper, nor has it been the intention. This can be interesting and useful further work.

For the check lists, it would be best if a vessel planning for a trip to the Arctic added their findings under the preparations, the voyage and the debriefing.

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13 Appendix list

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APPENDIX I

PROJECT/MASTER THESIS

Risk and reliability centered maintenance for maritime operations in the Artic

Project description

Marine activities in the Arctic area are increasing, but the vulnerability of the region requires a strong focus on safety and maintenance management to ensure safe operation of ships and rigs. In order to achieve a high level of safety it is necessary with an effective system for managing safety, maintenance strategies, maintenance planning and implementation of risk reduction measures during operation. The IMO's Polar code is of high relevance, especially with respect to establishment of safety and maintenance management for marine operation in the Arctic. In addition, the fishing fleet now has to adapt to the ISM code; fishing being one of the most dangerous work occupations.

The above issues constitute the background for the following project and master thesis:

1. Project thesis:
    a. Describe the challenges related to maritime activities in the Artic areas, focusing on safety, maintenance, and the environment.
    b. Identify the requirements to safety and maintenance management in the relevant maritime regulations, including the IMO Polar Code.
    c. Assess the existing computerized maintenance management system (CMMS) from Star Information Systems and identify gaps with current feasibility and use by ship and rig owners, and future implementation for Arctic operation and for the fishing fleet.
2. Master thesis:
    a. Based on the project thesis develop an overall methodology for safety management focusing on Arctic conditions and the fishing fleet.
    b. Develop a basis for the functional specification to a new and enhanced safety management system from Star Information Systems.

The project and master thesis will be part of the joint industry research project (JIP) "Safety, environmental-friendly, and effective operation of vessels and installations in the Artic". The JIP - project is collaboration between Star Information Systems, SINTEF, University of Iceland, the Maritime Safety and Survival Training Centre, Iceland, and NTNU.

A summer internship/summer job related to the project may be available upon request to Star Information Systems (contact: Per Anders Koien (peranders@sismarine.com)).

Faglærer: Ingrid Bouwer Utne

Veiledere: Ingunn Holmen, SINTEF Fisheries and Aquaculture, Per Anders Koien, Star Information Systems & Vincent Denissen, Star Information Systems

Star Information Systems (SIS) is a world-class provider of maritime software solutions and services. The software is tightly integrated to allow efficient and safe operation of ships and rigs, and include modules for maintenance (PMS/CMMS), asset management, project/docking management, safety/HSEQ, document management, insurance and guarantee claims, procurement and e-commerce, KPIs, and reporting. SIS' main office is in Trondheim. For more information, see http://www.sismarine.com.

APPENDIX II

Polar code

The draft of the polar code consists of the following chapters

Chapter 1: Polar water operational Manual

Chapter 2: Structural integrity

Chapter 3: Stability, intact and damaged

Chapter 4: Watertight and weathertight integrity

Chapter 5: Anchoring arrangements

Chapter 6: Habitability, accommodation, emergency, escape measures

Chapter 7: Fire safety and protection

Chapter 8: Life saving appliances and arrangements

Chapter 9: Navigation

Chapter 10: Communications

Chapter 11: Alternative design

Chapter 12: Operational requirements

Chapter 13: Crewing, manning, training

Chapter 14: Emergency control

Chapter 15: Environmental protection

There is also a part B, which will consist of additional guidance regarding the provisions of part A.

APPENDIX II

Chapter 1: Polar water operational manual (PWOM)

1. Provide master and crew with sufficient information for decision-making
2. Ensure availability of PWOM
3. Ensure the PWOM contains information about
    a. Ships particulars
    b. Safe speed in ice
    c. Safe distance in convoy
    d. Ice waterline
    e. Manoeuvring characteristics
    f. Design temperatures for operation of machinery and ship essential systems
    g. List of ship's systems subject to damage by freezing and measures to be adopted to avoid malfunctions
    h. Communication and navigation equipments limitations

Chapter 2: Structural integrity

1. Provide structures and equipment can withstand global and local environmental loads and conditions
2. Fulfil functional requirements
    a. Welding and coating of materials
    b. Dimension of structure – ice loads, bergy waters, corrosion
3. Fulfil regulations/requirements
    a. Construction of materials – design temperatures
    b. Ice strengthening
    c. Adequate structure defined from the PWOM.

Chapter 3: Stability

1. Ensure sufficient stability in intact and damaged conditions
2. Fulfil functional requirements to stability under
    a. Ice related damages
    b. Ice accretion (documented in PWOM)
    c. Measure ice accretion
3. Requirements
    a. Ice accretion included in ice related damages
    b. Calculations from ice accretion in PWOM
    c. Ice accretion should be monitored and measures taken to ensure values don’t exceed limits in PWOM.
4. Intact stability in ice requirements
    a. Carry out suitable calculations
    b. Positive intact stability with metacentric height of at least 150 mm, and a line 150 mm below the edge of the freeboard deck (ICLL)
    c. Correct calculations on ships that ride up onto ice
5. Stability in damaged conditions
    a. Withstand flooding from hull penetration from ice
6. Double bottoms between forepeak and afterpeak bulkheads

Chapter 4: watertight and weathertight integrity

1. Provide measures to maintain integrity
2. Fulfil functional requirements
    a. Closing appliances
    b. Ice and snow free doors, and deck area on emergency route
    c. Deck access for personnel
    d. Doors, hatches and closing devices can be operated in heavy winter clothing
3. Regulations/requirements
    a. Arrangements/equipment for ice removal around hatches and doors.
    b. Suitable hydraulic oil for minimum anticipated temperature, and provide heater for oil, not steam heating coils

Chapter 5: Machinery

1. Ensure machinery and essential operating equipment is capable of delivering the required functionality
2. Fulfil functional requirements
    a. Ensure sufficient manoeuvrability through design, construction and maintenance
    b. Ensure sufficient electrical power through design, construction and maintenance

3. Requirements to fulfil
    a. Ensure correct temperature of combustion air
    b. Ensure ready starting of cold emergency power units(PWOM)
    c. Ensure liquids and lube of sufficient quality for used in low temperatures
    d. Avoid icing of sea intake chest and ballast tanks
    e. Ice avoiding design of vent pipes, intake and discharge pipes and associated systems
    f. Avoid freezing of tanks containing liquids
    g. Ensure means to purge the systems for ice and snow
    h. Ensure effective separation of ice and venting of air through design of ice boxes
    i. Prevent freezing of sea bays, ice boxes, ship side valves etc
    j. Ensure correct temperature of fuel oil piping through design

Chapter 6: Habitability

1. Provide accommodation, work spaces and escape means remains safe during normal and emergency activities
2. Fulfil requirements
    a. Avoid injury under normal and emergency situations
    b. Maintaining safe areas
3. Public address systems should be audible
4. Sufficient dimension and clearance escape routes
5. Ensure sufficient view from bridge window

Chapter 7: Fire Safety

1. Ensure fire protection arrangements are effective and operable at all times
2. Fulfil requirements
    a. Equipment protected from ice accretion
    b. Considering bulky cold weather gear
    c. Suitable materials
    d. Avoid icing of equipment and machinery
    e. Protect the sea suction to the fire extinguisher from ice
    f. Ensure access and escape routes are free from ice
3. Fulfil regulations
    a. Correct placement of fire equipment
    b. on avoiding ice accretion on isolating valves

Chapter 8: Life saving appliances and arrangements

1. Provide safe escape and evacuation in case of an emergency
2. Adequate supplies for the intended voyage
3. Perform at -30℃
4. Consider deploying appliances onto ice
5. Sufficient personal and group survival kits
6. Fulfil rules on escape and evacuation
7. Fulfil regulations towards Search and Rescue
8. Fulfil regulations on communication and equipment on survival craft and rescue boat
9. Fulfil regulation on training on first aid of crew

Chapter 9: Navigation

1. Provide for means for safe navigation
2. Functional requirements
    a. Ensure systems are suitable for intended areas
    b. Ensure navigational equipment and systems
    c. Ensure access to ice information and detection systems
3. Capable of receiving ice and weather information
    a. Have and maintain ice imagery equipment
    b. Fitted with AIS
    c. Minimum navigation equipment
        i. Weather receiver high resolution
        ii. Radars with enhances ice detection
        iii. Have adequate communication and signal equipment
        iv. Search lights
        v. Sound reception system for exterior noises/signals
        vi. Gyro-compass
        vii. Two speed and distance measuring devices
        viii. Two independent echo-sounding devices
        ix. Electronic position fixing system
        x. Means for de-icing
        xi. GPS compass for latitudes over 75 deg

Chapter 10: Communications

1. Provide effective communication
2. Functional requirements
    a. Ensure suitable communication equipment(tracking and battery) on vessel and lifeboat

APPENDIX II

Chapter 11: Alternative design

1. Alternative design and arrangements have to meet the intent of the requirements in the Polar Code
2. Engineering analysis
    a. Determination
    b. Identification and prescriptive requirements where alternative design will not comply
    c. Determine performance criteria
    d. Technical justification and safety and environmental performance criteria
    e. Risk assessment
3. Design approved of administration, documentation
4. Communicate to the administration information
5. Re-evaluation requires new engineering analysis

Chapter 12: Operational requirements

1. Provide for adequate operational arrangements
2. Ensure ships are provided with sufficient documentation and have the necessary preparations for entering polar waters
3. Requirements for documentation
    a. Training manual for ice navigators
    b. Polar ship certificate
    c. PWOM
    d. Training manual
    e. Voyage plan
4. Voyage planning
    a. Consider known key areas for marine mammals and other environmental protected areas
    b. Distance to SAR, salvage, repair, waste receptions facilities and safe havens
    c. Ship capabilities and characteristics (PWOM)
5. Reporting
    a. Report planned voyage to SAR authorities and report changes
    b. Report to position report system SAR authorities can access
6. Procedures, plans and instructions under design temperatures and icing on
    a. Operational maintenance of fire systems
    b. Operational maintenance of lifesaving appliances and evacuation means
    c. Operational maintenance of anchoring, mooring and towing
    d. Mitigate pollution if spill or unintended discharge
    e. Communication and assistance procedures where SAR could be unavailable
    f. Sustainable living onboard when stacked on ice
    g. Survival and evacuation

Chapter 13: Crew

1. Ensure appropriate manned vessel
    a. Qualified
    b. Trained
    c. Experience
2. Functional requirements
    a. Take account for the provisions and lack of shores
    b. Be familiarized with cold weather survival
    c. Establish training program
    d. Provide ice navigators
3. Fulfil requirements for Ice Navigator/watch keeper
4. Fulfil and revalidate certification requirements for Ice navigator
5. Emergency preparedness
    a. Environmental conditions
    b. Ensure training – SOLAS
    c. Prepare training manuals with account to polar water environmental conditions
6. Ensure drills are suitable for polar water

Chapter 14: Emergency Control

1. Limit the consequences of incidents or accidents
2. Fulfil functional requirements
    a. Provide shipboard damage control
    b. Shipboard Oil Pollution Emergency Plan (SOPEP) particular to Arctic waters
    c. Capability to clean up spills
    d. Damage control equipment
3. Fulfil regulations of
    a. Facilitate recovery of oil and harmful substances
    b. Toxic exposure
    c. Emergency transfer of fuel

APPENDIX II

Chapter 15: Environmental protection

1. Prevent and eliminate harmful environmental impact from ships in Polar waters.
2. Fulfil functional requirements
    a. No spill of harmful substance if damage of outer hull
    b. Restrictions on HFO
    c. No noxious liquid or oily discharge
    d. No harmful leakage from stern tube
    e. On garbage and sewage treatment
    f. ALARP soot/carbon
    g. Reduction on NO_x and SO_x
    h. Biocide free anti fouling
3. Fulfil regulations on
    a. Food waste
    b. Sewage and washing water
    c. Waste water treatment
    d. Discharge of animal carcasses
    e. In-engine measures
    f. Diesel particulate filters
    g. Water-in-fuel emulsification
    h. Replacement of conventional fuel valves
4. Environmental tank protection
    a. No harmful substances in outer shell or in the double bottom. Extra double skin construction
    b. Separation of harmful substances and outer shell should be at least 760 mm.
    c. Sufficient storage and treatment of oily waste, garbage, grey-water and sewage.

APPENDIX III

Ballast water regulation

Chapter 1: General regulations

Chapter 2: Demands for handling of ballast water

- Handling of ballast water
- Replacement of untreated ballast water
- Treatment of ballast water
- Delivery of ballast water to ballast water reception facilities
- Plan for handling of ballast water and sediments from tanks
- Ballast water diary
- Inspection and certification

Chapter 3: Final provisions

Chapter 2: Handling of ballast water

1. Fulfil the regulations due to different regions, see pictures
2. Ensure replacement of ballast water is at legal volume, depth and distance from land
3. Use technology approved by IMO for cleaning of ballast water, and fulfil demand of viable organism released.

Figure 61 I: Barents sea, Norwegian sea, II North sea

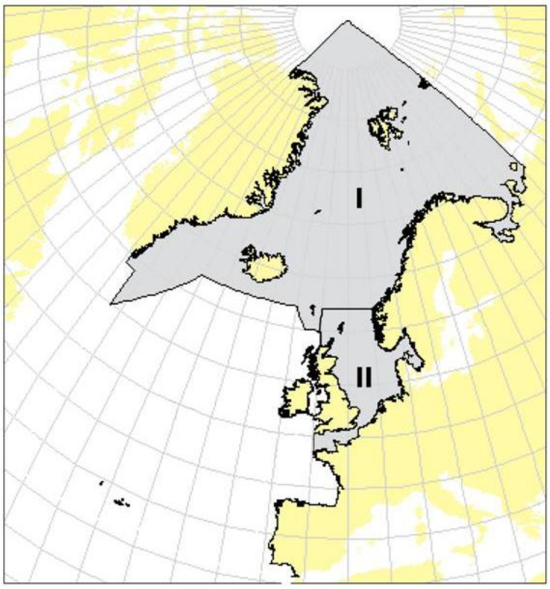
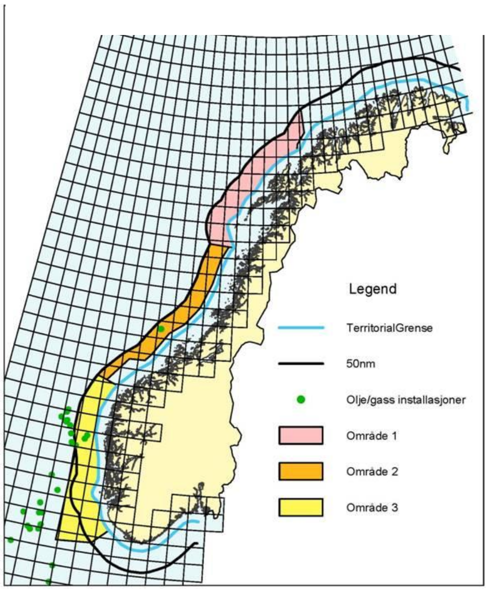


Figure 60 Areas with restricted release of ballast water



APPENDIX IV

Regulation on environmental safety for vessels

MARPOL

1. Ensure oil pollution is avoided from ships, appendix 1, MARPOL (2011)
2. Fulfil demands for double hull
3. Have equipment for gathering of bilge water containing oil and pipes for delivery of bilge water
4. Avoid pollution from harmful wrapped and unwrapped solid and fluid chemicals
5. Fulfil rules on sewage treatment and release
6. Ensure sulphur level of fuel is below 0.1 weight % when at berth or at anchor
7. Prohibition of organic tin compounds

APPENDIX V

Law on Ship Safety

Chapter 2: Safety Management Systems

- Establish and Develop system
- Document and communicate system
- Actively manage system
- Provide system reports to authorities
- Maintain system certifications

Chapter 3: Technical and Operative Safety

- Adhere to design build and outfit requirements
- Ensure hull strength and water tight integrity
- Safeguard machinery and electrical installations
- Maintain Fire protection, detection and fighting abilities
- Manage, maintain and update Navigation and Communication equipment
- Provide safety equipment consistent with vessel size
- Plan operations and maintenance onboard
- Ensure loading, cargo handling and ballast security within capacity of Stability assessments
- Maintain certification of vessel and attendant equipment
- Ensure consistent adherence to Maritime Navigational policy
- Maintain watch systems and controls
- Maintain records of crew qualifications and marine certifications
- Provide and maintain crew welfare facilities
- Responsibility for maintaining provisions rests with the captain

Chapter 5: Environmental Safety

- Pollution is prohibited
    - Prohibition of combustion, littering or introduction of toxic substance to the environment
- Provide technical means of maintaining environmental safety
- Ensure environmental friendly ship operation
- Maintain records of quantities of harmful substance onboard
- Ensure Pollution preparedness
    - Plan for pollution events
    - Plan for contacting authorities to report accidental discharges
    - Plan for clean disposal of harmful substances
- Discharge harmful substances to accredited disposal experts
- Plan for decommissioning and safe disposal of hazardous materials used onboard

APPENDIX VI

ISM

International safety management

SMS – Safety management system

http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-20080314-0306.html

1993 and the 2011 version

1. General
2. Safety and environmental-protection policy
3. Company responsibilities and authority
4. Designated persons
5. Master's responsibility and authority
6. Resources and personnel
7. Shipboard operations
8. Emergency preparedness
9. Reports and analysis of non-conformities, accidents and hazardous occurrences
10. Maintenance of the ship and equipment
11. Documentation
12. Company verification, review and evaluation

Chapter 1: General

1. Ensure safety at sea, prevention of human injury or loss and avoidance of damage to the environment
2. Provide for safe practices, assess all identified risks, improve safety management skills
3. Ensure compliance with mandatory rules
4. Develop, implement and maintain all SMS's procedures and instructions

Chapter 2: Safety and environmental-protection policy

1. Establish, implement and maintain safety and environmental protection policy in the organization on ship and at shore.

Chapter 3: Company responsibilities

1. Report, define, and document the responsibility, authority and interrelation of personell
2. Ensure adequate resources

APPENDIX VI

Chapter 4: Designated persons

1. Designate person(s) ashore having direct access to the highest level of management

Chapter 5: Master's responsibility and authority

1. Define and document the responsibility

Chapter 6: Resources and personnel

1. Ensure qualified personnel
2. Establish and maintain SMS procedures and training

Chapter 7: Development of plans for shipboard operations

1. Establish procedures, plans, instructions and checklists for key shipboard operations. for safety of the personnel, ship and protection of the environment

Chapter 8: Emergency preparedness

1. Identify potential shipboard situations and establish procedures and drills. .

Chapter 9: Reports and analysis of non-conformities, accidents and hazardous occurrences

1. Ensure situations are reported, investigated and analyzed
2. Establish procedures with measures

Chapter 10: Maintenance of the ship and equipment

1. Establish procedures to ensure the ship is maintained in conformity with the rules and regulations
2. Ensure
    a. inspection held at appropriate intervals
    b. Reporting of non-conformity
    c. Appropriate corrective action is taken
    d. Records are maintained
3. Identify equipment and technical systems the sudden operational failure may result in hazardous situations. Create measures with testing of stand by etc. systems
4. Inspections integrated in operational maintenance routine

Chapter 11: Documentation

1. Establish and maintain procedures relevant to the SMS
2. Ensure all relevant documents is on board