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Report

SPECIALLY DESIGNATED MARINE AREAS IN THE ARCTIC HIGH SEAS

NORWEGIAN ENVIRONMENT AGENCY

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MANAGING RISK

Specially Designated Marine Areas in the Arctic High Seas

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Summary:
The objective of this report is to explore the need for, and as appropriate make recommendations regarding, internationally designated areas in the high seas area of the Arctic Ocean that warrant protection from the risks posed by international shipping activities. Present and future shipping activities are presented and combined with findings of the vulnerability of the area to assess the need for protection. The available IMO measures to protect the area are described and assessed with regard to their applicability. A proposal for targeted protection of the area is presented.

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1 EXECUTIVE SUMMARY

The objective of this report is to explore the need for, and as appropriate make recommendations regarding, internationally designated areas in the high seas area of the Arctic Ocean that warrant protection from the risks posed by international shipping activities. It is emphasized that this report focuses solely on the high seas area of the Arctic Ocean. No assessment is made regarding the need to protect designated areas which are under the jurisdiction of the Arctic Ocean coastal states.

Part I of this report deals with the need for protection of the high seas area and presents a description of two main issues; a) the traffic and risk levels in the Arctic Ocean high seas, present and future, and b) the vulnerability of the biological resources found in the Area. A few main findings can be highlighted:

- Present ship traffic is found to be very limited, with 0.7 ship years[1] per annum registered from AIS data. Given the size of the area, this is very low by any standard.
- Future ship traffic is expected to increase, although the volumes are very uncertain. The *High* scenario used in this report point to an exposure of 15 ship years per annum.
- The risk of shipping accidents must be considered low in comparison with almost any other area. The return period for a serious accident in the *High* scenario is 5 years, with an expected pollution accident every 260 years.
- The most prominent natural property of the area is the sea ice conditions with strong seasonal variations. The sea ice is also expected to change considerably in the coming decades due to climate change.
- Even if the vulnerability of the area is evident, there are significant limitations to the present state of knowledge. In addition to the global uniqueness of the pack ice itself, it seems that the vulnerability to future shipping activity is most pronounced for polar bears and two species of gull (Table 10). They are primarily vulnerable to oil spills.

Part II of this report reviews the available IMO measures suited to protect vulnerable areas, in particular the Special Areas (SA) option and the Particularly Sensitive Sea Area (PSSA) option. Based on the review of available designated area measures, combined with the environmental conditions and the potential for ship traffic of the Arctic high seas, DNV conclude that it is difficult to find support for Special Area (SA) designation under MARPOL.

DNV further find support to pursue the application of a PSSA for providing additional protection of the Arctic high seas. Three possible avenues to pursue this option are outlined. The most feasible may be to establish a "Core sea ice area" as a sanctuary for unique and vulnerable Arctic high seas ecosystems, and to protect this through a PSSA designation with Areas to be avoided as an Associated Protective Measures (APM). This option ensures protection of an increasingly important core area, but will likely not impede movement on the high seas which is a major principle in international law.

[1] A measure of the accumulated activity for all ships in an area during a year. 1 ship year = 8760 ship operating hours.

2 INTRODUCTION

Arctic sea ice extent in the summer months has decreased significantly over the last decade due to the changing climate. Although the annual variation is large and predictions of future ice conditions are uncertain, there is a consistent trend: Arctic sea ice cover will most likely continue to decrease in the future. Less ice – both in terms of extent and thickness – means possibilities to extend the sailing season in Arctic waters. An extended sailing season may result in increased activity e.g. related to the extraction of Arctic natural resources, and for utilizing the shorter Arctic sea routes between North Atlantic and East Asian ports.

In light of the expected increased shipping activity in the Arctic, the 2009 Arctic Marine Shipping Assessment (AMSA) Report (Arctic Council, 2009) includes recommendations for Arctic States on enhancing Arctic marine safety, protecting Arctic people and environment and building Arctic marine infrastructure.

One of the recommendations from the AMSA Report, referred to as Recommendation II(D), calls for further assessments for regions of the Arctic Ocean: "*That the Arctic states should, taking into account the special characteristics of the Arctic marine environment, explore the need for internationally designated areas for the purpose of environmental protection in regions of the Arctic Ocean. This could be done through the use of appropriate tools, such as "Special Areas" or Particularly Sensitive Sea Areas (PSSA) designation through the IMO and consistent with the existing legal framework in the Arctic.*"

Following up on this recommendation, the Arctic Council's Working Group on the Protection of the Arctic Marine Environment (PAME) approved a project with the objective of exploring the need for, and as appropriate make recommendations regarding, internationally designated areas in the high seas area of the Arctic Ocean that warrant protection from the risks posed by international shipping activities. On behalf of PAME, the Norwegian Environment Agency has retained DNV to carry out this study.

It is emphasized that this report focuses solely on the high seas area of the Arctic Ocean. No assessment is made regarding the need to protect designated areas which are under the jurisdiction of the Arctic Ocean coastal states.

The first part of the objective, to explore the need for internationally designated areas for the purpose of environmental protection from the threat posed by international shipping activities, is addressed in two analytical steps in this report (Section 3). Step 1 is to assess the degree to which Arctic high seas area is under pressure from current or anticipated future shipping activity. The activity will be discussed in light of the record of shipping accidents and incidents in and near the area. Step 2 is to assess the vulnerability of the high seas area of the Arctic Ocean, in light of the shipping activity. This will build largely on the findings of the AMSA II(C) report (Skjoldal et al. 2013).

The second part of the objective, to make recommendations as appropriate regarding possible IMO measures available to protect one or more regions within the high seas areas of the Arctic Ocean, will be addressed through a screening process (Section 4). PAME member governments, individually or collectively, may then consider pursuing any such recommendation at the IMO.

In the screening process the options available will be discussed with respect to *i)* their applicability (i.e. if the criteria for their approval and adoption by IMO are met) and *ii)* their effectiveness in mitigating the threat(s) as identified in Step 1. This analysis takes into account existing measures and guidelines adopted by IMO applicable to the area, as well as ongoing initiatives to protect the area, e.g., the development of the future mandatory *Polar Code*.

Following the screening process, a detailed discussion will focus on precisely how one or more regions within the high seas area of the Arctic Ocean may be protected through one or more IMO measures, forming in essence a set of recommendations. Figure 1 gives an overview of the key analytical steps in this report, as outlined above.

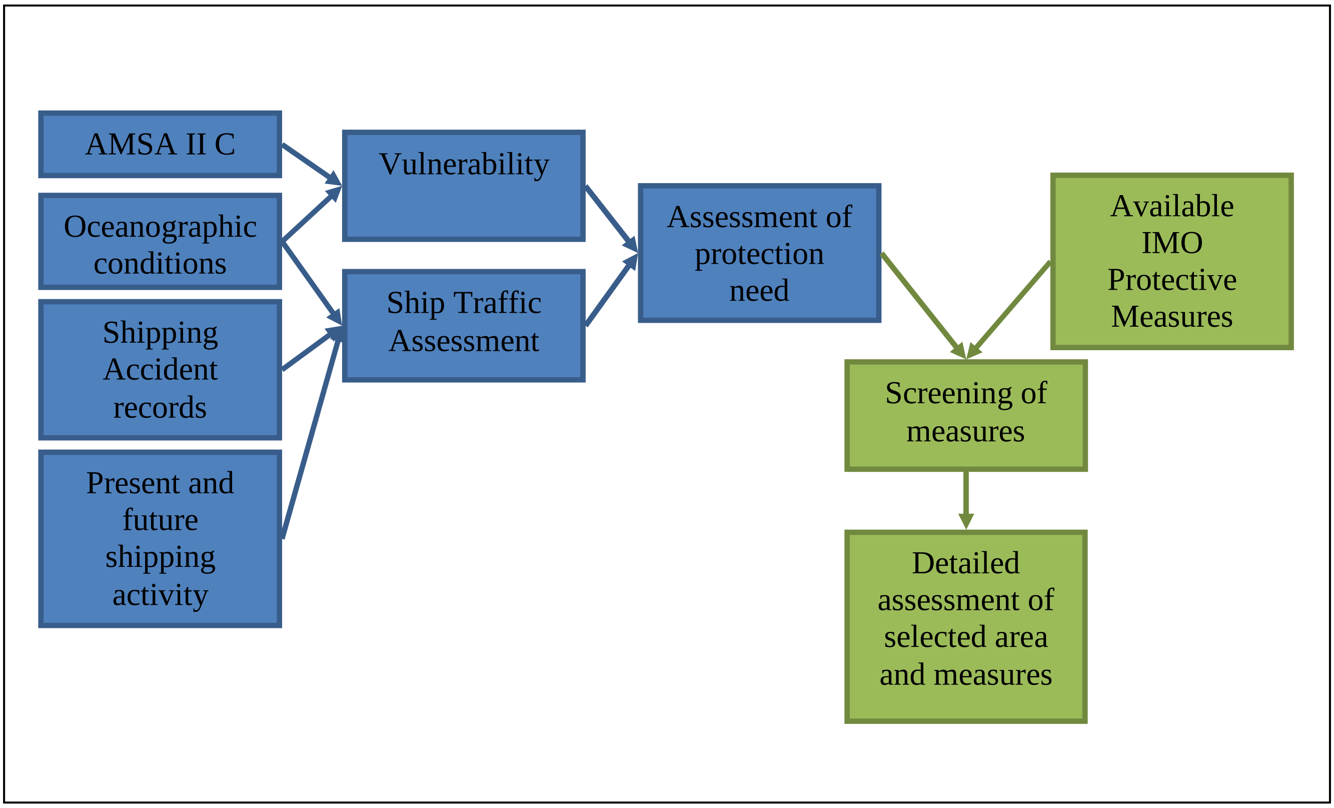

Figure 1: Overview of key analytical steps.

This report has been prepared by DNV, with comments and suggestions received from the project co-leads throughout the project, as well as from other PAME member states and NGOs following the preliminary project presentations in Iceland and Russia. In particular, the authors gratefully acknowledge the contributions from the Institute of Marine Research (IMR) to the description of the vulnerability of the arctic high seas in Section 3.4.

It should be noted that the views expressed herein are those of the DNV project team. As such, the report should not be seen as PAME policy recommendations but as advice from an independent consultant.

2.1 Definition of the Arctic high seas

Under the UN Convention on the Law of the Sea (UNCLOS) Article 86, high seas are sea areas beyond national jurisdiction, i.e. "all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State." As used in this report, "Arctic high seas" refers to "high seas" of the Arctic Ocean as defined in UNCLOS. The high seas region of the Arctic Ocean is defined to be waters beyond the 200 nautical mile exclusive economic zone (EEZ) as measured from claimed baselines of the Arctic littoral states. UNCLOS sets forth applicable rules on setting baselines from which the breadth of the maritime zones, including the EEZ, is measured.

Where baselines may validly be set has at times been contentious. For purposes of this report, Arctic States' claimed baselines are used[2]. Figure 2 shows the resulting definition of the Arctic high seas, with borders to the EEZ of Canada, the USA, Russia, Norway and Denmark (Greenland).

[2] This report uses PAME member governments' claimed baselines without prejudice to the position of any PAME member government on the consistency of such claimed baselines with applicable international law.

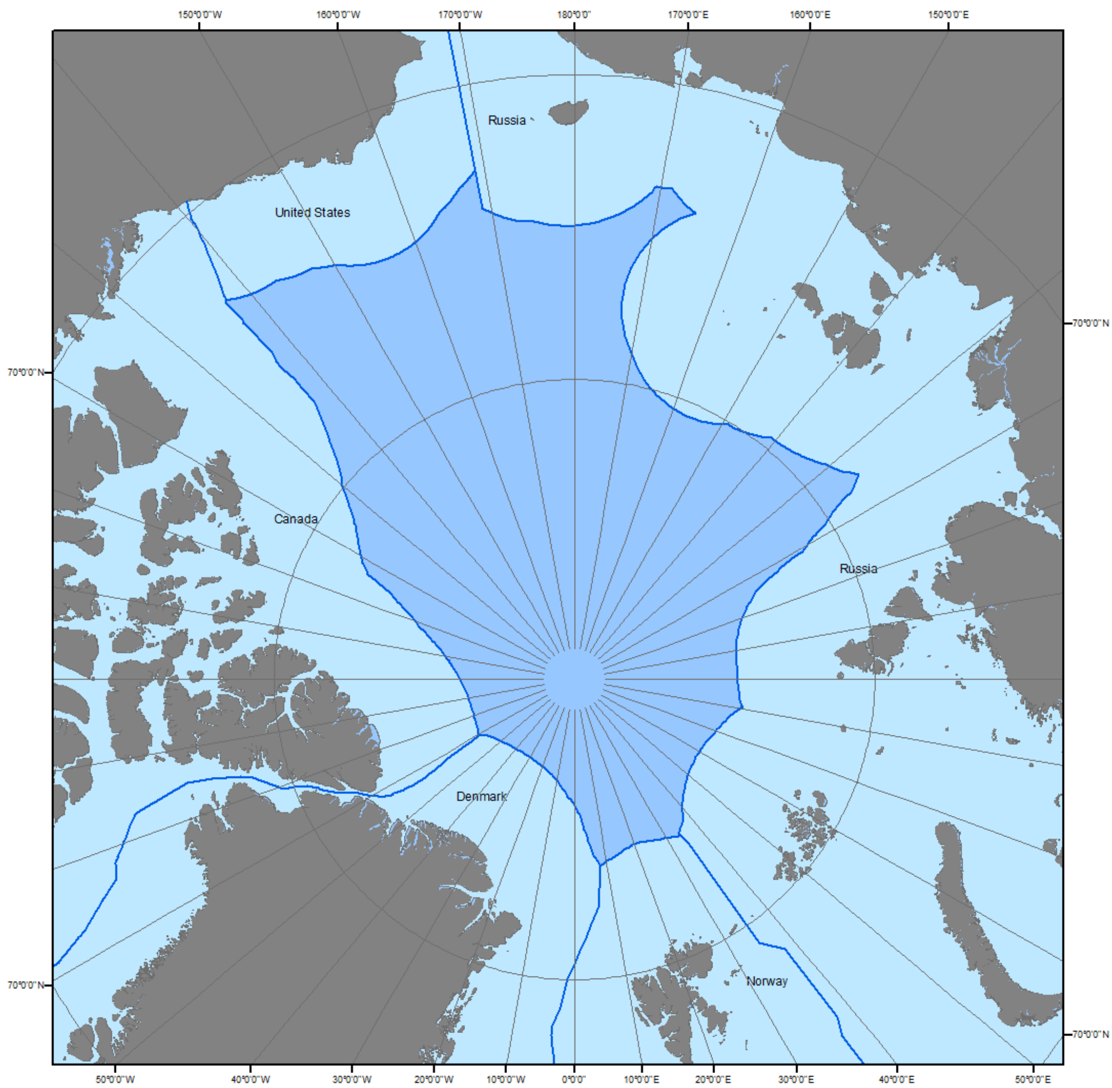

Figure 2. The Arctic high seas (Source; DNV using data from http://www.marineregions.org per 12 December 2012). The high seas region of the Arctic Ocean is defined to be waters beyond the 200 nautical mile exclusive economic zone (EEZ) as measured from claimed baselines of the Arctic littoral states. This report uses PAME member governments' claimed baselines without prejudice to the position of any PAME member government on the consistency of such claimed baselines with applicable international law.

3 PART I: THE NEED FOR PROTECTION

This section discusses four main topics;

- The ship traffic volumes in the Arctic Ocean high seas, including scenarios for future development,
- The level of risk of ship accidents as indicated by accident statistics, in particular relating to oil spills,
- The prevailing features of the natural properties of the Arctic ocean, including ice conditions, and
- The vulnerability of the species found in the area.

In sum these building blocks forms a foundation to assess the need for internationally designated areas in the high seas area of the Arctic Ocean.

3.1 Shipping traffic in the Arctic high seas

3.1.1 Current traffic – based on AIS-data

AIS data collected by the Norwegian Coastal Administration from a satellite in polar orbit for the year 2012 have been analyzed to give an account for the current traffic picture in the Arctic high seas.

The data show that 18 individual vessels entered the Arctic high seas in 2012 (Table 1). One ship was a passenger vessel. The remaining vessels are categorized as ‘Other activities’. These ships are mainly identified as research/survey vessels or icebreakers. Further description of the vessels is prohibited by the conditions of use for the AIS data, which states that they are only to be published on an aggregated level. The passenger vessels size was 13,000 GT, the remaining ships averaged 9,950 GT.

Table 1: Number of unique ships, and average ship size in the Arctic high seas area in 2012, per ship type category.

		Average size	
Ship type	**No. of ships**	**DWT**	**GT**
Other activities	17	3400	9950
Passenger vessels	1	4500	13000
Total	**18**	**-**	**-**

A total of 6,360 hours were spent by vessels in the area during 2012 (about 9 months, or 0.7 ship years[3]) (Table 2). The total distance sailed by these vessels during 2012 was 30,072 nm (Table 3). Activity shows a marked peak in August and September, and no activity in November through May (Figure 3).

[3] A measure of the accumulated activity for all ships in an area during a year. 1 ship year = 365 ship operating days = 8760 ship operating hours.

Table 2: Time sailed in the Arctic high seas area in 2012, per ship type and size category. (Hours)

Ship type	**< 1000 GT**	**1000-4999 GT**	**5000-9999 GT**	**10000-24999 GT**	**Total**
Other activities	-	180	2 601	2 751	5 532
Passenger vessels	-	-	-	828	828
Total	**-**	**180**	**2 601**	**3 579**	**6 360**

Table 3: Distance sailed in the Arctic high seas area in 2012, per ship type and size category (Nautical Miles)

Ship type	**< 1000 GT**	**1000-4999 GT**	**5000-9999 GT**	**10000-24999 GT**	**Total**
Other activities	-	894	10 105	16 095	27 094
Passenger vessels	-	-	-	2 978	2 978
Total	**-**	**894**	**10 105**	**19 073**	**30 072**

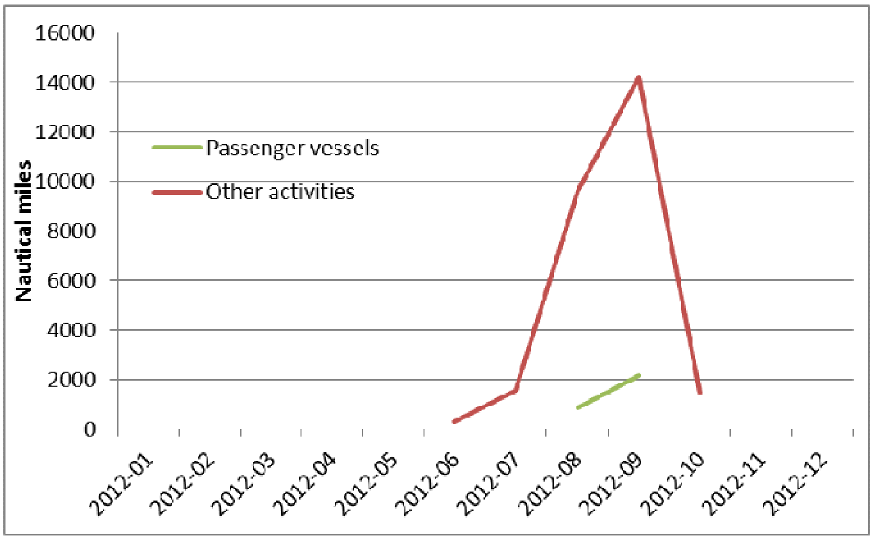

Figure 3: Distance sailed (nautical miles) in the Arctic high seas, per month in 2012.

Figure 4 shows that activity is scattered throughout the Arctic high seas in 2012, although the majority is observed on the side of the Pole extending towards the Bering Strait. It is noted that no trans-arctic shipping was observed in this region.

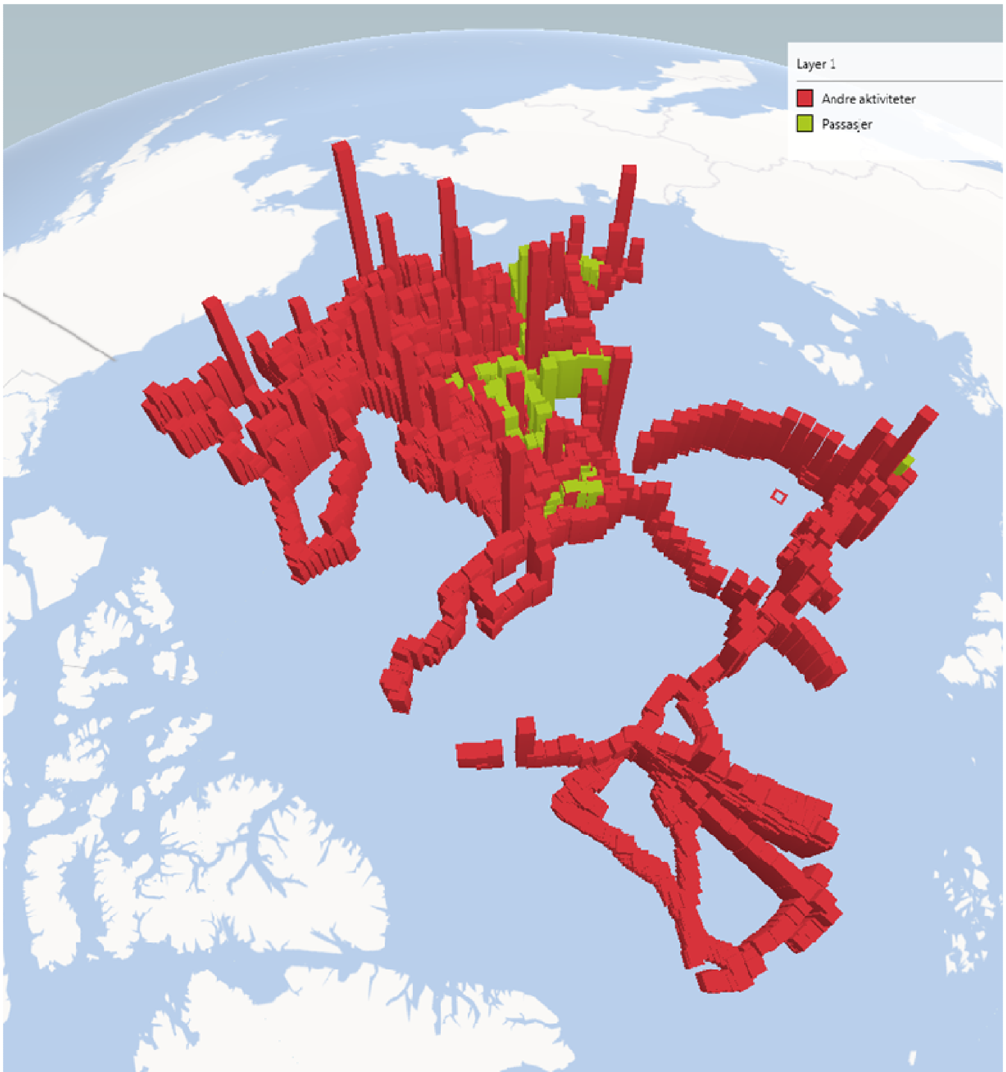

Figure 4: Geographical vessel traffic distribution in the high seas of the Arctic Ocean during 2012. (Distance sailed (nm) per 1°x1° grid cell).

3.1.2 Future ship traffic

The analysis of AIS data in section 3.1.1 clearly shows that current traffic in the Arctic Ocean high seas is very limited. Registered activity is related to research and tourism. There is no registered AIS activity from cargo vessels or fishing vessels. However, the current traffic levels are not the primary concern when assessing the need for protection. Rather, the possible increases in future shipping activity is the main issue.

It is likely that future shipping activity will entail a continuation or increase in research and tourism activity as well as potentially significant new cargo ship activity. The new cargo ship activity is expected mainly as a result of Europe-Asia transit shipping. Although significant portions of the transit shipping will likely occur outside the Arctic Ocean high seas, mainly along the Russian coast (Figure

5), passages intersecting or crossing the high seas area are expected. Increases in destination shipping to/from ports on the arctic coastlines will likely follow routes outside the Arctic Ocean high seas.

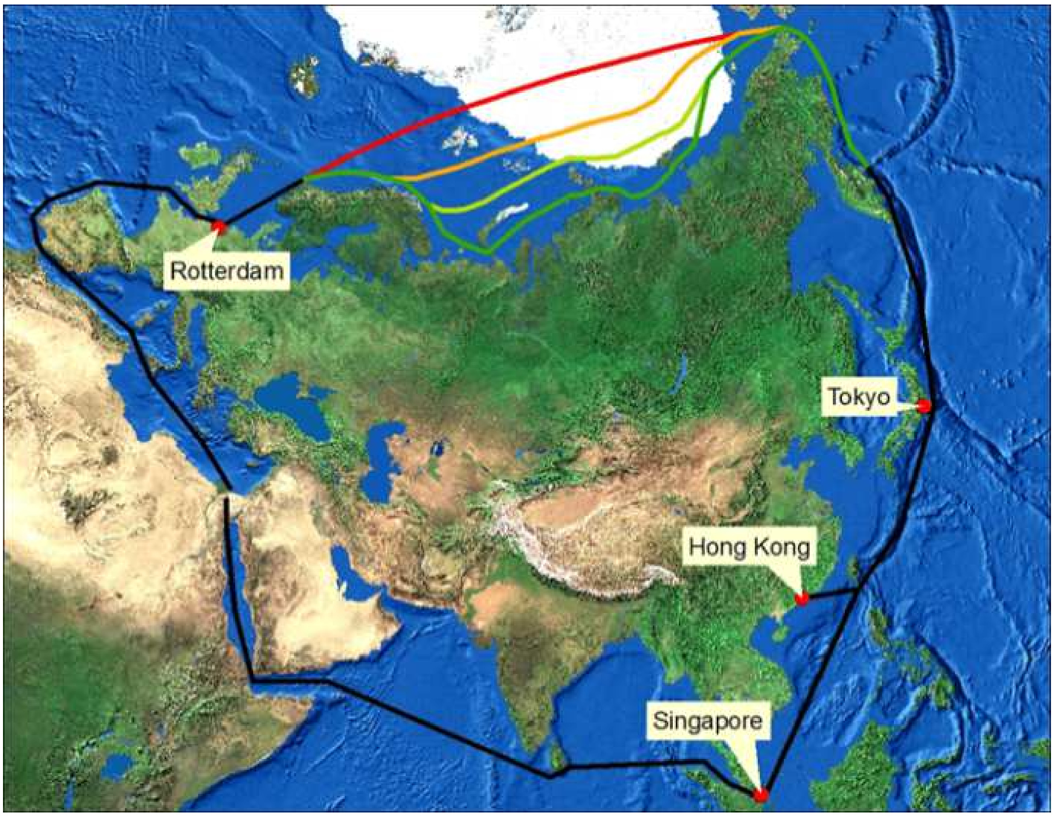

Figure 5: Possible Arctic transit routes vs. the Suez Canal route offers up to 40% reduced travel distance.

Because of the seabed properties (section 3.3.1) of the Arctic Ocean high seas, future activity related to offshore oil and gas exploration or exploitation is not expected. Similarly, due to the oceanographic and ecological properties of the Arctic Ocean high seas, future activity related to fisheries is not expected to be significant although it cannot be ruled out.

In the following sub-sections a review of available literature on future Arctic shipping activity is presented, with emphasis on possible traffic in the Arctic high seas. Broadly speaking, two types of studies have been identified; some studies make assessment on the ice cover, the navigation season and the accessibility for different ship types, without making explicit estimates for future ship traffic volumes (Serreze et al. 2007; Wang and Overland, 2009; Boe et al., 2009; ACIA, 2005; Smith and Stevenson, 2013; Khon et al. 2010; Overland and Wang, 2013). A few studies explicitly assess the potential for future traffic volumes (Paxian et al., 2010; Corbett et al., 2010; Peters et al. 2011).

Based on this review, three scenarios for future activity are established for the purposes of this study. A scenario approach has been used to cover the large uncertainty spans for the activity estimates found in the literature. The scenarios will be used to assess the threat from shipping in the Arctic Ocean high seas.

3.1.2.1 Studies on ice cover and accessibility

Recent trends indicate longer seasons with less sea-ice cover and reduced thickness (Serreze et al., 2007; Boe et al., 2009), implying improved ship accessibility around the margins of the Arctic Basin. Climate models project an acceleration of this trend and opening of new shipping routes and extension of the period during which shipping is feasible (ACIA, 2005; Boe et al., 2009). Some analysts have suggested that the Arctic may be ice free in September as early as 2030 (Wang and Overland, 2009), though others suggested 2066–2085 (Boe et al., 2009). Overland and Wang (2013) estimate nearly ice free summers in the Arctic by 2060 at the latest, and possibly as early as 2020 using three different approaches. One approach used by Overland and Wang (2013) is climate model projections. Figure 6 shows that there is a large spread of hindcasts and future trajectories.

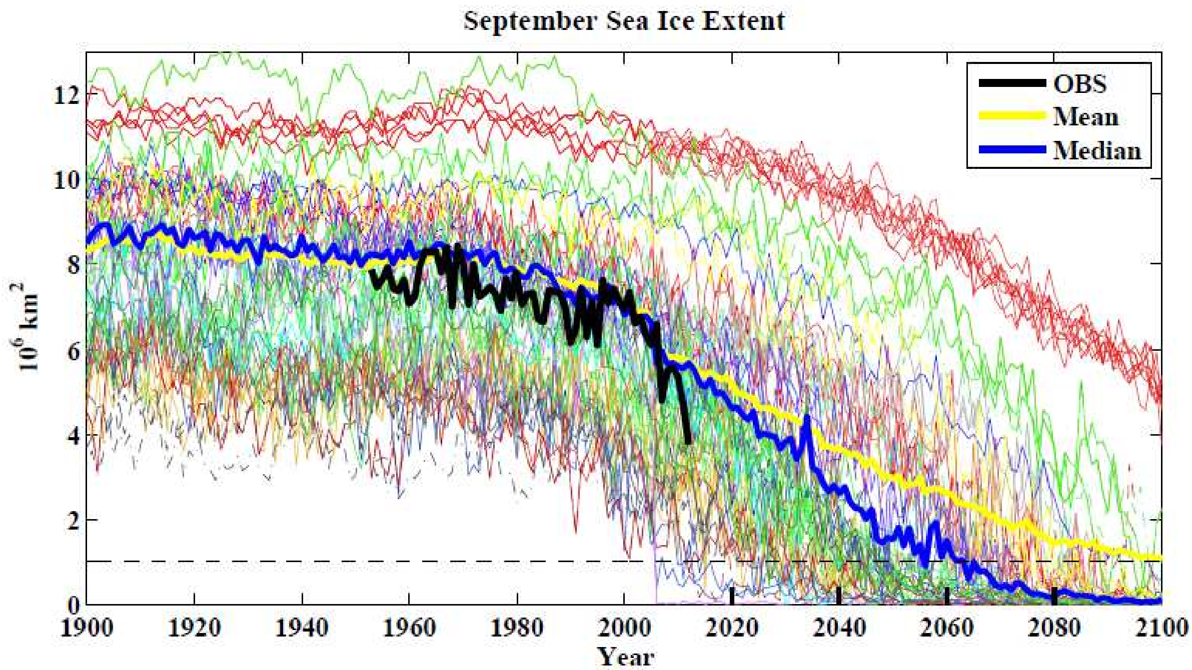

Figure 6. Simulated September sea ice extent based on 89 ensemble members from 36 CMIP5 models under the RCP8.5 (high) emissions scenario. Each thin colored line represents one ensemble member from the model. The thick yellow line is the arithmetic mean of all ensemble members and the blue line is their median value. The thick black line represents observations. From Overland and Wang (2013), their figure 3.

One set of projections estimates that the navigation season (defined as 25% open water and 75% sea-ice cover) for the Northern Sea Route (NSR) may increase from the current 70 days per year, to 125 days mid-century, and over 160 days in 2100 (ACIA, 2005, chapter 16). Ships with ice-breaking capability may extend the navigation season even further. Smith and Stephenson (2013) find that by mid-century, the trans-polar route across the pole is navigable by moderately ice-strengthened vessels (PC6) (Figure 7). By mid-century the NSR is navigable by open water vessels in any given year with 94% probability (compared to 40% in the past few decades). The North West Passage (NWP) will be navigable by vessels without ice strengthening with a probability of 53%. This study clearly shows the technical potential for transiting the Arctic, but makes no assessment of the magnitude of the traffic.

Khon et al. (2010) found that models predict that at the *end of this century* there will be free passage through the NSR for 3–6 months of the year and the NWP for 2–4 months. This may make the NSR up to 15% more profitable than the Suez Canal route (Khon et al., 2010), but they did not estimate future ship traffic in the Arctic.

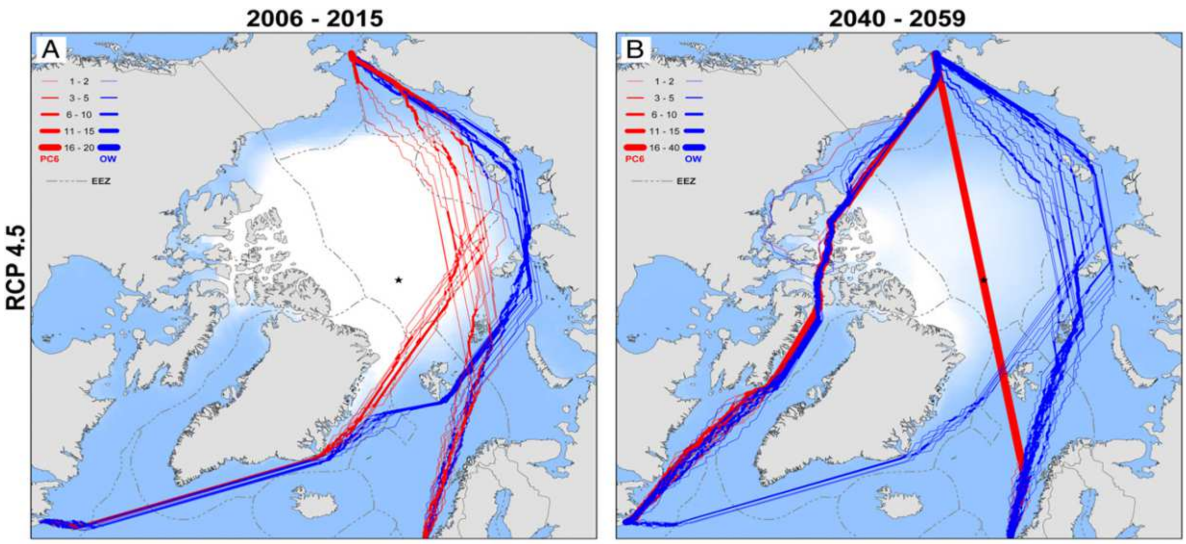

Figure 7. Modeled optimal September navigation routes for hypothetical ships seeking to cross the Arctic Ocean between the North Atlantic and the Pacific (Bering Strait) during historical baseline conditions (consecutive years 1979– 2005) as driven by ensemble-average GCM projections of sea ice concentration and thickness. Red lines indicate fastest available trans-Arctic routes for ice classed (PC6) ships; blue lines indicate fastest available transits for common open water (OW) ships. From Smith and Stevenson (2013), their figure 2.

3.1.2.2 Studies on future traffic volumes

Paxian et al. (2010) estimated present-day and future emission inventories that included polar routes. The ship traffic along the polar routes was estimated using an algorithm that calculates the shortest path for all global shipping movements, considering land masses, sea ice, shipping canal sizes, and climatological mean wave heights. Ship performance or cost considerations are not included. They estimated fuel consumption along the NSR and NWP to increase by a factor of 9 and 13, respectively, from 2006 to 2050 (Paxian et al., 2010). It is noted that in the following we use developments in fuel consumption and the number of transits interchangeably, under the assumption of constancy in ship technology and ship types and sizes (e.g. an X% increase in fuel consumption implies a X% increase in number of transits).

Peters et al. (2011) present results from a techno-economic model from DNV which accounts for the most relevant factors. The model calculates the costs of a selected Arctic sea route versus the Suez Canal route, enabling a comparison of the alternatives. Costs are calculated by utilizing detailed projected ice data, by modeling speed and fuel consumption of ships in ice, and by adding additional costs from building and operating ships suitable for Arctic operation (e.g. ice class). The comparison is made for routes originating in different Asian ports. If the Arctic route from a given port is favorable in economic terms, the model estimates the number of passages based on the projected amount of cargo to be transported and the selected ship concept (i.e. cargo capacity and sailing season).

Peters et al. (2011) found that part-year Arctic transit will be commercially attractive for container traffic from the Tokyo hub in 2030 and 2050. The predicted amount of containers that will be transported through the Arctic equals 1.4 million TEU[4] in 2030 (36% of the potential for the Tokyo hub) and 2.5 million TEU in 2050 (45% of the potential for the Tokyo hub). This corresponds to 480 transit voyages, or about 8% of the total container trade between Asia and Europe, in 2030 and 850 transits voyages, or about 10% of all container traffic between Asia and Europe, in 2050. Shipping activity related to petroleum extraction has been estimated based on projected production data (described in the previous section). This traffic is unlikely to impact on high seas traffic.

Corbett et al. (2010) constructed detailed inventories of all Arctic shipping activities, including transits of the NSR, NWP and other polar routes with reduced sea-ice extent. They assume a diversion of global traffic to the arctic at 1% of global shipping in 2020, increasing to 2% in 2030, and to 5% in 2050. Transits were estimated using a fixed percentage diversion of global traffic (1–5 %) and were found to be 2–4 times greater than reported by Paxian et al. (2010). In terms of polar transits these studies, however, do not explicitly model ship performance and economic costs of shipping in Arctic conditions.

Paxian et al. (2010) give a range of 0.73–1.28 Mt[5] for fuel consumption in the NSR in 2050, which is less than the estimate of 1.78 Mt presented by Peters et al (2011), but of the same order of magnitude. However, their study is not limited to container ships and considers only fuel consumption along the NSR, whereas this study also includes the parts of the journey that lie outside NSR. It seems reasonable to expect that the algorithm employed by Paxian et al. may slightly underestimate Arctic transit traffic since it is based on future projections of historical vessel movements, and since it will only consider vessel movements for eligibility if they travel directly from Asia to Europe.

The estimated CO_2 emissions calculated by Corbett et al. (2010) appear to be significantly higher than presented by Peters et al (2011). They give total emissions from all ship traffic in 2030 and 2050, but they have also estimated the proportion that container ships represent of the total traffic. Their estimates of the CO_2 emissions from Arctic container traffic in 2030 are 4.8 and 7.7 Mt CO_2 for a "business as usual" and high growth scenario, respectively, and for 2050 they estimate 12 and 26 Mt CO_2. These numbers are higher than presented by Peters et al (2011) by a factor 1.3–2 in 2030 and 2–4.6 in 2050.

We consider the numbers presented by Peters et al. (2011) to be the most reliable, with support from the findings of Paxian et al. (2010). However, we recognize high uncertainty in this estimate. The finding from Valkonen and Eide (2012) that not all ice scenarios allow for transit along the route selected by Peters et al. (2011) indicates that the number of transits is overestimated. However, the number of transits may also be underestimated, as inferred by the recent publications by Smith and Stephenson (2013) and Overland and Wang (2013) which indicate that the ice conditions may be more benign than assumed by Peters et al. (2011). Although Corbett et al. (2010) do not explicitly model

[4] Twenty-foot equivalent unit (TEU) is a unit of cargo capacity commonly used to describe the capacity of container ships.
[5] Mt = Mega ton = 10^9 kg

ship performance and economic costs of shipping, their estimate of 960 transits can be used as a high bound for the traffic.

3.1.2.3 Scenarios for future Arctic Ocean high seas shipping activity

The above review of studies presenting projections for future Arctic shipping activity reveals that there is considerable uncertainty in the estimates. To address this uncertainty in a structured manner, this study employs a scenario approach to forecast future traffic volumes in the Arctic Ocean high seas. Three scenarios are constructed: Low, Medium and High, building on the findings from the studies reviewed in the preceding sections. We consider that *Scenario Medium* to be a reference scenario, based on Peters et al. (2011), and stipulate that this scenario is more likely than the other two scenarios; with a 25-50-25 percentage distribution as an indicative likelihood estimate (for scenarios Low-Medium-High).

As a basis for the scenarios we use the year 2030. This is considered far enough into the future to expect significant increases in shipping volume (hence giving cause for protection) and close enough to be relevant for decision-making today, anticipating also a possibly lengthy process to get protection measures in place.

Scenario Low:

The traffic in this scenario strongly resembles the current picture with no transit activity and limited other shipping activity (section 3.1.1). In this scenario, ice conditions are deteriorating at a relatively slow rate. Important factors such as communication and Search and Rescue (SAR) capacity in the arctic are assumed not to develop significantly. Fuel prices may be relatively low, limiting the gains from reducing travel distance and time. Consequently, ship-owners are not willing to risk passages through the Arctic Ocean high seas. Although ice conditions and economic gains will likely motivate increased usage of the Northern Sea Route (within Russian EEZ), no transit activity will occur on the high seas.

A general improvement in ease of access due to less ice will result in increased activity relating to research and tourism. An increase from current activity of 0.7 ship years to 1.5 ship years is assumed. The season will increase giving longer tails to the present distribution of traffic in time, although the peak activity will remain in August/September.

Scenario Medium:

In this scenario a significant transit activity is expected, also in the high seas. We assume an estimate of 480 transits based on Peters et al. (2011), with support from the Paxian et al. (2010).

Note that Peters et al. (2011) predict traffic outside the Russian EEZ, but not across the pole. However the results of Smith and Stevenson (2013) indicate that this traffic may well go across the pole. Traffic will in all cases concentrate on the Russian side of the pole, possibly going across the pole, but not further to the Canadian side. In this scenario the main transit route with 450 passages will straddle the

Russian EEZ and the high seas (Figure 8, peripheral route). 30 transits will also occur near the pole (Figure 8, pole route).

The transits in the high seas will be dominated by container ships, with occasional contributions from dry bulk and tank vessels. The 480 passages are calculated to result in 4.5 ship years (see Table 4 for details). As in *Scenario Low* a general improvement in ease of access due to less ice will result in increased activity related to research and tourism. An increase from current activity of 0.7 ship years to 2 ship years is assumed.

In total 6.5 ship years are expected in the Arctic high seas in this scenario. The season will extend from June to November, peaking in August/September.

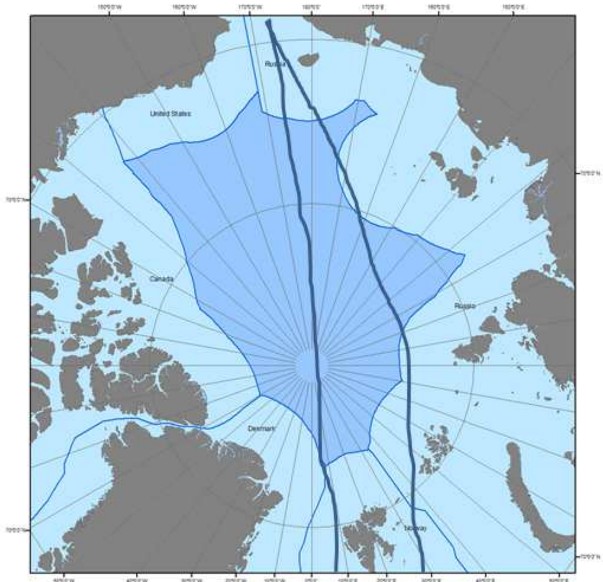

Figure 8. Assumed transit routes across the Arctic high seas, showing the route across the Pole, as well as a peripheral route. The assumed routes are based on the assessment shown in Figure 7 and used in Table 4 to calculate transit duration times.

Scenario High:

This scenario emerges as a result of dramatic reductions in ice cover, possibly in combination with restrictions on other trading routes, e.g. capacity issues in the Suez Canal[6]. Communication and SAR capabilities have been improved considerably, and confidence has been built over many years of increasing activity in the area. Fuel prices are likely high. 960 transits are assumed are based on the projections by Corbett et al. (2009).

[6] Suez capacity: In 24 hours the canal can pass about 76 standard ships, giving a theoretical upper bound of 27 740 transits per year. In 2012, 17 225 vessels transited (50 passages per day). Thus, there should be room for a 60% traffic increase in the Canal. Capacity can also be increased, e.g. through increasing average vessel size, increasing transit speed or through infrastructure improvements. (http://www.suezcanal.gov.eg/TRstat.aspx?reportId=3: http://en.wikipedia.org/wiki/Suez_Canal#Capacity)

In this scenario 400 transits are expected by ice strengthened vessels across the pole. Also, 560 transits are expected on the peripheral high seas route close to the Russian EEZ. Significant volumes of traffic also remain along the Russian Coast.

The 960 passages are found to result in 11.8 ship years (see Table 4 for details). This scenario sees a strong mixture of ship types with containers, significant bulk and tank traffic and general cargo vessels. As in *Scenario Low* and *Medium* there is an increased activity relating to research and tourism. An increase from current activity of 0.7 ship years to 3 ship years is assumed.

In total 14.8 ship years are expected in the Arctic high seas in this scenario. As in the other scenarios, the season peaks in August/September, but extends into December.

Table 4 summarizes the three scenarios. It is noted that the calculations of time in the Arctic high seas in the various scenarios are dependent on the assumed number of transits, the assumed distribution of transits between the Pole and the Peripheral route and the assumed transit speed. We have assumed a constant speed of 8 knots in the calculations. This is likely a conservative choice, considering that many of the ship must be assumed to be container vessels with open-water speeds of above 20 knots. If a higher speed was chosen, the time in the high seas would be reduced (15 knots gives 6.3 years pure transit time in the High Scenario, compared to 11.8 at 8 knots). Similarly, directing all 960 transits to the Pole route in the High Scenario (as opposed to the 400-650 split) gives a pure transit time of 16.4 years. It is noted for comparison, that in 2012, 46 commercial ships made the passage through the Northern Sea route (not in the high seas)[7].

Table 4: Activity and accumulated time in the Arctic high seas (AHS) under the different scenarios.

Scenario	Activity Type	Number of transits	Distance within AHS[8]	Speed	Time in AHS per transit	Accumulated time in AHS		
			(nm[9])	(knots)	(hours)	(hours)	(years)	
Low	Research/Tourism	-	-	-	-	13 140	1.5	1.5
	Transit - Pole	-	-	-	-	-	-	
	Transit - Periphery	-	-	-	-	-	-	
Medium	Research/Tourism	-	-	-	-	17 520	2	6.5
	Transit - Pole	30	1 200	8	150	4 500	0.5	
	Transit - Periphery	450	620	8	78	34 875	4.0	
High	Research/Tourism	-	-	-	-	26 280	3	14.8
	Transit - Pole	400	1 200	8	150	60 000	6.8	
	Transit - Periphery	560	620	8	78	43 400	5.0	

[7] Petroleum products constituted the largest cargo group. http://barentsobserver.com/en/arctic/2012/11/46-vessels-through-northern-sea-route-23-11
[8] From 75N 170W to 85N 10E = 2224 km = 1200 nm. From 80N 160E to 85N 110E = 865 km = 467 nm
From 75N 180E to 75N 170E = 287 km = 155 nm. http://www.movable-type.co.uk/scripts/latlong.html
[9] 1 kilometer = 0.54 nautical miles

3.2 Risk of ship accidents in the Arctic high seas

Although other potential negative impacts such as noise pollution, whale ship strikes and regular emissions and discharges to air and water are caused by normal ship operations, a main concern with increasing shipping activity is the increased risk of accidents leading to oil spills. Oil spills are also identified as the major threat to the vulnerability of the area (section 3.4).

This section reviews the current risk level in the area through an analysis of historic accident records. Also, a risk outlook is developed, building on the traffic scenarios presented in section 3.1.2.3.

3.2.1 Historic record of accidents

The following sections describe the analysis of available existing information on shipping accidents and accidents in the high seas areas of the Arctic Ocean that caused, or threatened to cause, pollution or harm to living marine resources or the marine environment. It should be noted that there has historically been very limited traffic in the high Artic seas, resulting in scarce accidental data.

Four relevant datasets have been identified and obtained: the IHS Fairplay database (previously Lloyds Register Fairplay) and databases from the relevant national authorities of Norway, Canada and Denmark (Greenland). Statistics from Russia and other relevant Arctic states may exist, but has not been studied in this report. For each of the sources, data for the Arctic has been extracted, and, to the extent possible, data specific to the Arctic high seas has been identified.

3.2.1.1 IHS Fairplay

The IHS Fairplay database contains worldwide accidents of merchant vessels of more than 100 GRT. Casualties from 1990 to 2012 have been analyzed. The IHS database locates each reported accident to one Marsden grid point[10]. The data from the squares covering the area north of 70 degrees (marked with red in Figure 9) have been analyzed. This is an approximate limit of the Arctic region.

In Table 5 accidents with environmental consequences have been identified (reported oil spill; other types of spills are not reported in the statistics used in this report). All the accidents occurred within Marsden squares 287 and 286 (marked in blue in Figure 9) and we found no reported accidents north of 80 degrees north (squares from 253 – 288). Thus, in the IHS Fairplay database there are no reported accidents in the high seas area of the Arctic Ocean.

[10] Marsden square mapping or Marsden squares is a system that divides a chart of the world with into grid cells of 10° latitude by 10° longitude, each with a unique, numeric identifier. Each one of the 540 10°x10° squares is allocated a number from 1 to 288 and from 300 to 551, plus the sequence extends to 936 in higher latitudes.

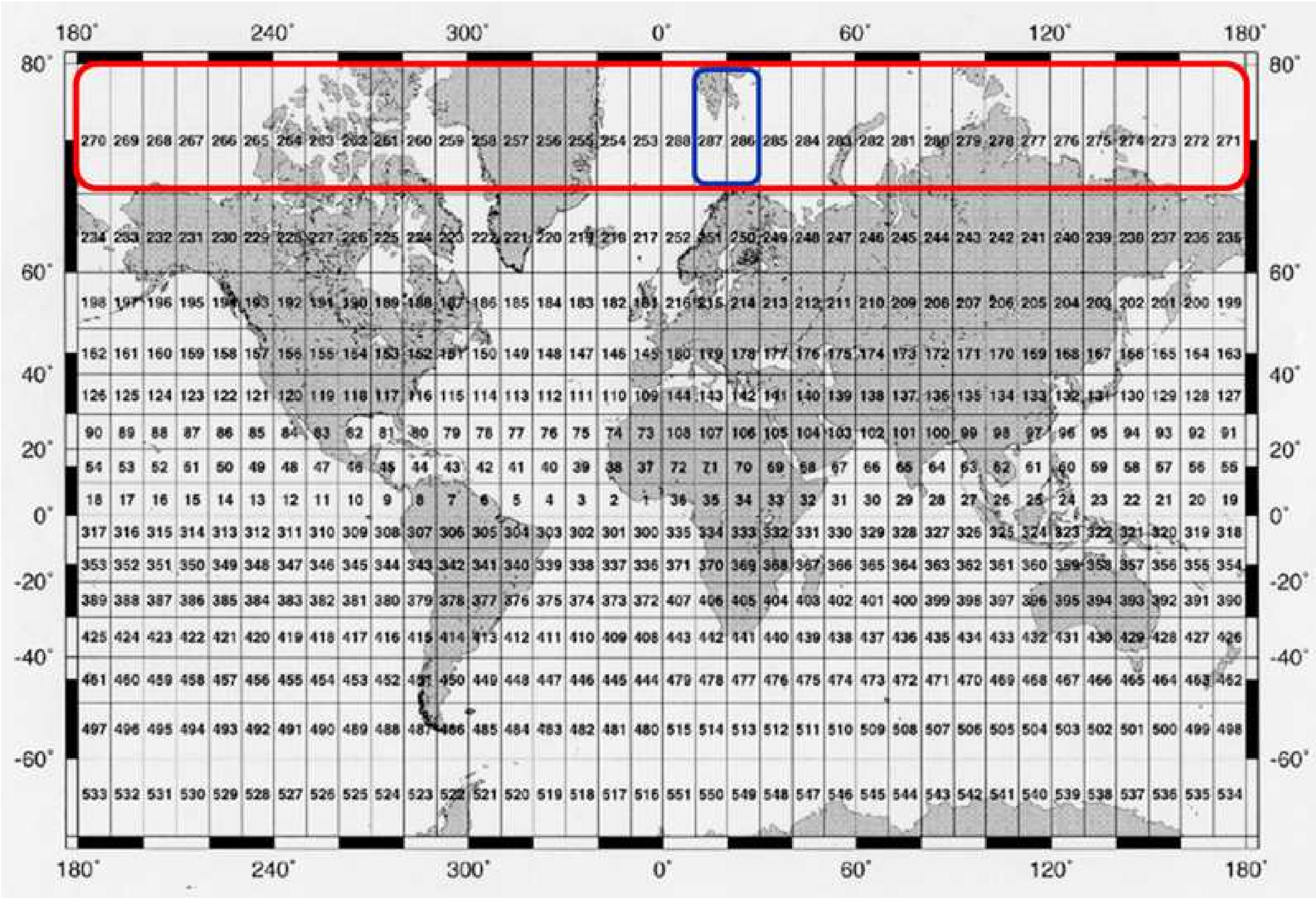

Figure 9. Area of analysis in the IHS database.

Table 5: Accidents with reported oil spill north of 70 degrees (IHS Fairplay, 1990-2012)

Incident	Date (month/year)	Conseq.	Severity Vessel type	Vessel size (DWT)	Year of built	Marsden square
Stranded	12/00	Oil spill	Total loss Bulk Carrier	52 000	1983	287
Stranded	05/09	Oil spill	Total loss Refrigerated Cargo Ship	1 500	1980	287
Fouled*	03/10	Oil spill	Damage Factory Stern Trawler	4 400	1979	286
Stranded	10/02	Oil spill	Total loss Stern Trawler	350	1975	286
Stranded	09/98	Oil spill	Damage Factory Stern Trawler	1 100	1971	287

*Reported: "*propeller fouled by fuelling hose in the Norwegian Sea, 75 miles west of Honningsvåg*"

3.2.1.2 Transportation Safety Board of Canada

All accidents in the database of the Transportation Safety Board of Canada from 2001 to 2010 have been analyzed in this study. No distinction has been made on consequence category. The database contains all accidents in Canadian waters, divided in six regions (see Figure 10). This analysis covers the region designated "Arctic", but it is noted that this region does not include the Arctic high seas. Thus no accidents have been reported for the Arctic high seas from this dataset.

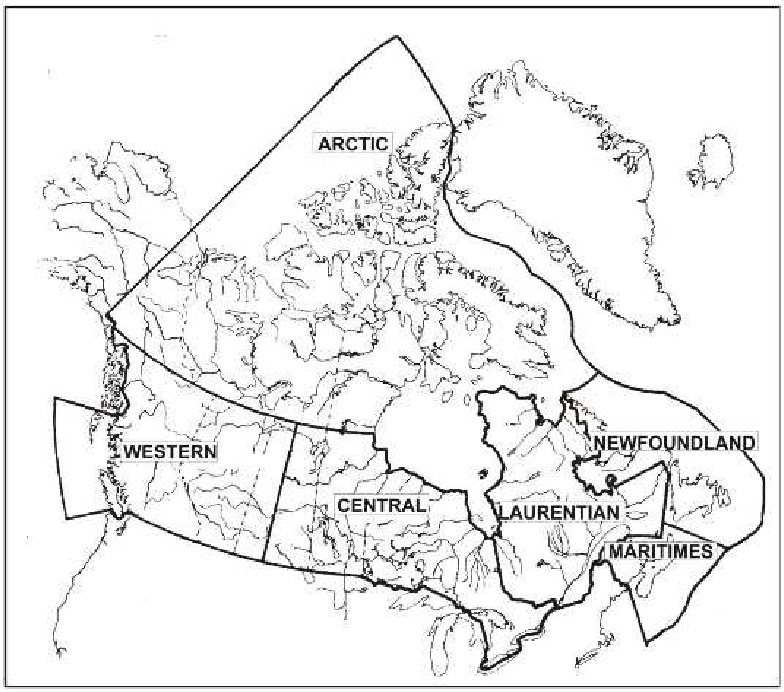

Figure 10. Area of analysis in the database of the Transportation Safety Board of Canada. It is noted that the area does not extend into the high seas.

We found that a total of 66 accidents have been reported in the 10 year period analyzed. An average of 6 accidents reported annually in the Canadian Arctic region (see Figure 10). (Source: http://www.tsb.gc.ca/eng/stats/marine/2010/ss10.pdf).

3.2.1.3 Danish Maritime Authority – Greenland waters

All accidents in Greenlandic waters from 2000 to 2006 have been analyzed based on the data from the Danish Maritime Authority. A total of 38 accidents were reported. No groundings were reported on the Greenlandic east coast, only on the west coast. No collisions among merchant- and / or passenger vessels were reported. Again, the region covered by this dataset does not include the Arctic high seas.

3.2.1.4 Norwegian Maritime Authority

The accident database from the Norwegian Maritime Authority contains accidents of merchant vessels (excluding passenger) of more than 20 GRT (Gross Registered Tonnage) which has occurred in Norwegian territorial waters, and accidents involving Norwegian flagged vessels worldwide. All reported accidents north of 66 degrees (Arctic Circle) have been analyzed in this study, covering the period from 1990 to 2012, the same period as data from IHS Fairplay, A total of 1356 accidents have been reported. However, the northernmost accident reported is located just north of Svalbard, well outside the boundaries of the Arctic high seas (marked on the map in Figure 11).

Table 6: Number of accidents per accident category (Norwegian Maritime Directorate, 1990-2012)	
Ships sunk / total loss	232
Total loss (not sunk)	40
Vessel seriously injured	307
Vessel injured	777
Total	**1 356**

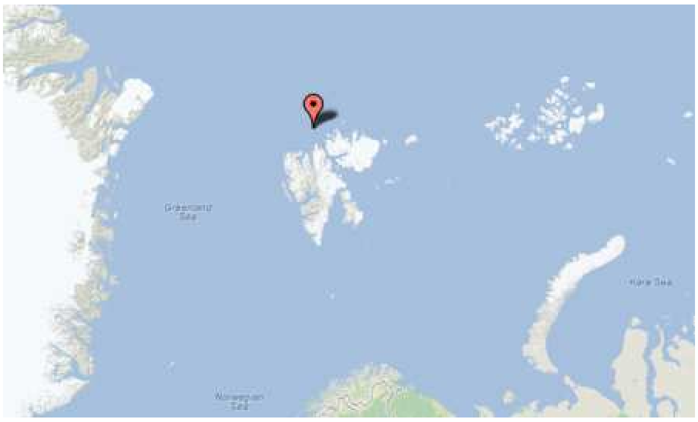

Figure 11. Northernmost accident recorded in the Norwegian database.

3.2.1.5 Discussion

It is noted that only the databases from IHS Fairplay and the Norwegian Maritime Authority cover the Arctic high seas, and the latter one only for Norwegian flagged vessels. Still, no accidents were reported for the Arctic high seas. This is a reflection of the very limited traffic in the area (section 3.1.1). Thus, it is apparent that historic records for the area give little or no insight into the risk levels which may be expected in under future traffic scenarios (section 3.1.2.3).

Thus, in the following section, a global accident statistics will be used to infer a future risk level for the Arctic high seas area.

3.2.2 Inferring a future Arctic high seas risk picture from global accident statistics

In the period from 1990 to 2012 (covering 1 108 295 ship years), a total of 21 033 serious accidents and total losses were recorded (IHS Fairplay Casualty Database), covering all ship operational modes, resulting in an accident frequency of 190 accidents per 10 000 ship years. This corresponds to roughly 2 accidents every year in a fleet of 100 ships. Removing Wrecked/Stranded (W/S) accidents (which have little relevance for the Artic high seas as there are no land or shallows on which to ground) this gives a frequency of 148 accidents per 10 000 ship years.

Table 7 shows the breakdown of accidents into accident categories, as defined in IHS Fairplay Causality Database. Discounting the W/S category, more than 2/3 of the accidents are related to hull/machinery damage and collisions. The remainder is made up by the categories Contact, Fire/Explosion and Foundering.

Table 7: Frequency of accidents for all cargo ships, incl. passenger ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	1.9
	Total loss	10.8
Fire/Explosion	Serious accident	14.5
	Total loss	4.2
Collision	Serious accident	29.9
	Total loss	3.5
Contact	Serious accident	13.9
	Total loss	0.6
Wrecked/Stranded	Serious accident	34.6
	Total loss	7.1
Hull/Machinery damage	Serious accident	66.8
	Total loss	2.0
Sum		189.8

In only 2% (408 cases) of the reported accidents pollution was also reported. This gives a pollution incident frequency of 3.7 per 10 000 ship years. 125 of the pollution accidents were related to the W/S category, giving a frequency of 2.6 pollution accidents per 10 000 ship years when excluding W/S accidents.

Apart from W/S accidents, the pollution accidents are dominated by the collision category (Table 8). Appendix B contains statistics specific for bulk, tank and container ships.

Table 8: Frequency of accidents causing pollution, all cargo ships, incl. passenger ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.1
	Total loss	0.2
Fire/Explosion	Serious accident	0.0
	Total loss	0.1
Collision	Serious accident	1.1
	Total loss	0.2
Contact	Serious accident	0.5
	Total loss	0.0
Wrecked/Stranded	Serious accident	0.6
	Total loss	0.5
Hull/Machinery damage	Serious accident	0.4
	Total loss	0.0
Sum		3.7

By combining the global accident frequencies with the scenarios for future traffic volume described in Section 3.1.2.3, it is possible to obtain a rough indication of the expected accident rates in the Arctic high seas.

It is important to note that this is a very crude assessment. Recent studies documenting underreporting of accidents in the major databases could indicate that the accident frequencies shown herein are too low (Psarros et al. 2010), perhaps by a factor 2 or more. Also, it is recognized that Arctic conditions are considered as more hostile than global averages in many respects, with additional challenges related to ice and icing, cold and darkness etc. Thus more accidents should be expected, as Arctic specific factors are not accounted for, e.g. increased risk of damage from ice. However, the “Contact category” typically includes damages from contact with docks or keys, of which there are none in the high seas. Furthermore, collision accidents typically occur in crowded waters, thus possibly overestimating the frequency in the low density areas of the high seas.

Table 9 shows the expected annual frequency of accidents and accidents resulting in pollution in the Arctic high seas in the various scenarios for 2030. Return periods for the accidents are also given[11]. The results indicate that in the High Scenario, a serious accident could be expected once every 5 years. In the (most likely) medium scenario an accident could be expected once every 10 years. Accidents with pollution are expected to occur only every few hundred years in all scenarios.

[11] For comparison, globally there is close to 1000 accidents per year. (So for every expected Arctic high seas accident, one could expect 5 000 accidents globally (in the high traffic scenario)).

Table 9: Expected number of annual accidents (ex. W/S) and return periods in Arctic high seas under different scenarios for 2030.

Scenario	Exposure	Serious accidents	Accidents with pollution	Return period serious accidents	Return period pollution
	(ship years)	(per year)	(per year)	(years)	(years)
Low	1.5	0.022	0.0004	45	2 564
Medium	6.5	0.09	0.0017	10	592
High	14.8	0.22	0.0038	5	260

3.3 Oceanographic and Meteorological Conditions of the Arctic high seas

To understand the challenges and the need for protection a basic understanding of the natural properties of the area in question is needed. This section provides an overview of the key oceanographic and meteorological conditions of the Arctic. Although the high seas area remains the area of interest, the discussion in this section includes a wider area.

There are a number of factors influencing the Arctic climate. The different factors interact with each other and produce weather patterns and climate feedbacks. This affects not only the Arctic climate but also areas far beyond the Arctic Ocean. The key factors (of which most are interrelated) are latitude, geography, sunlight, pressure, temperature, wind, humidity, clouds and precipitation.

As the Arctic climate is greatly influenced by surrounding areas, the effects of El Nino/La Nina and the North Atlantic Oscillation (NAO) is also present in the Arctic. The Arctic Oscillation (AO) is an index of the dominant pattern of non-seasonal sea-level pressure variations between 20 and 90 degrees north and varies over time with no particular periodicity, see Figure 12. When the AO index is positive the middle latitude jet stream blows strong, keeping the cold Arctic air locked in the polar region. In this phase, winds and storms are stronger in the North, it's colder in the North, and pack ice tends to be flushed out of the Arctic and leads to thinner ice. When the AO index is negative the zonal winds are weaker and greater movement of polar air in to the middle latitudes is experienced. In a negative phase, more stable weather patterns in the North with a general concentration of older pack ice in the CAO.

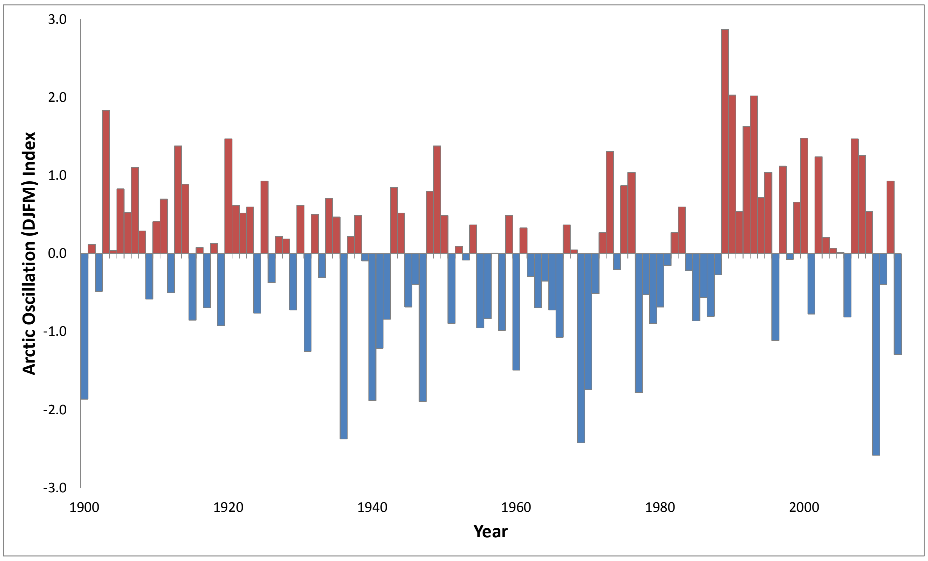

Figure 12. Arctic Oscillation (Source: NCAR (2013)).

A noticeable feature of the Arctic Ocean is the ice cover. There are huge variations in ice concentration, thickness and age, both with regards to location and season. These variations are essential for the diversity within the ecosystem. Ice cover reduces the exchange of energy between the ocean and the atmosphere by about 100 times. The sea ice also reduces the penetration of sunlight needed for the photosynthetic processes. However, recent research of the Chukchi Sea found higher than expected productivity of phytoplankton under the ice, especially in the marginal ice zone (Arrigo et al. 2012).

It is however important to note that the Arctic is a vast area. Within the frames defined by the “Arctic” there are huge local variations with regard to the climatic parameters.

3.3.1 Bathymetry

The main entries by ocean to The Arctic Ocean are through the Bering Strait (between the American continent and Siberia), The Fram Strait (between Greenland and Svalbard) and the area between Svalbard and the Northern tip of Norway. The Arctic Ocean differs from the adjoining North Atlantic and Pacific Ocean with respect to several factors. A distinguishing feature is the high ratio of connected shallow seas to deep basins, which in turn affects the subsurface currents and mixing of the water masses, see Figure 13.

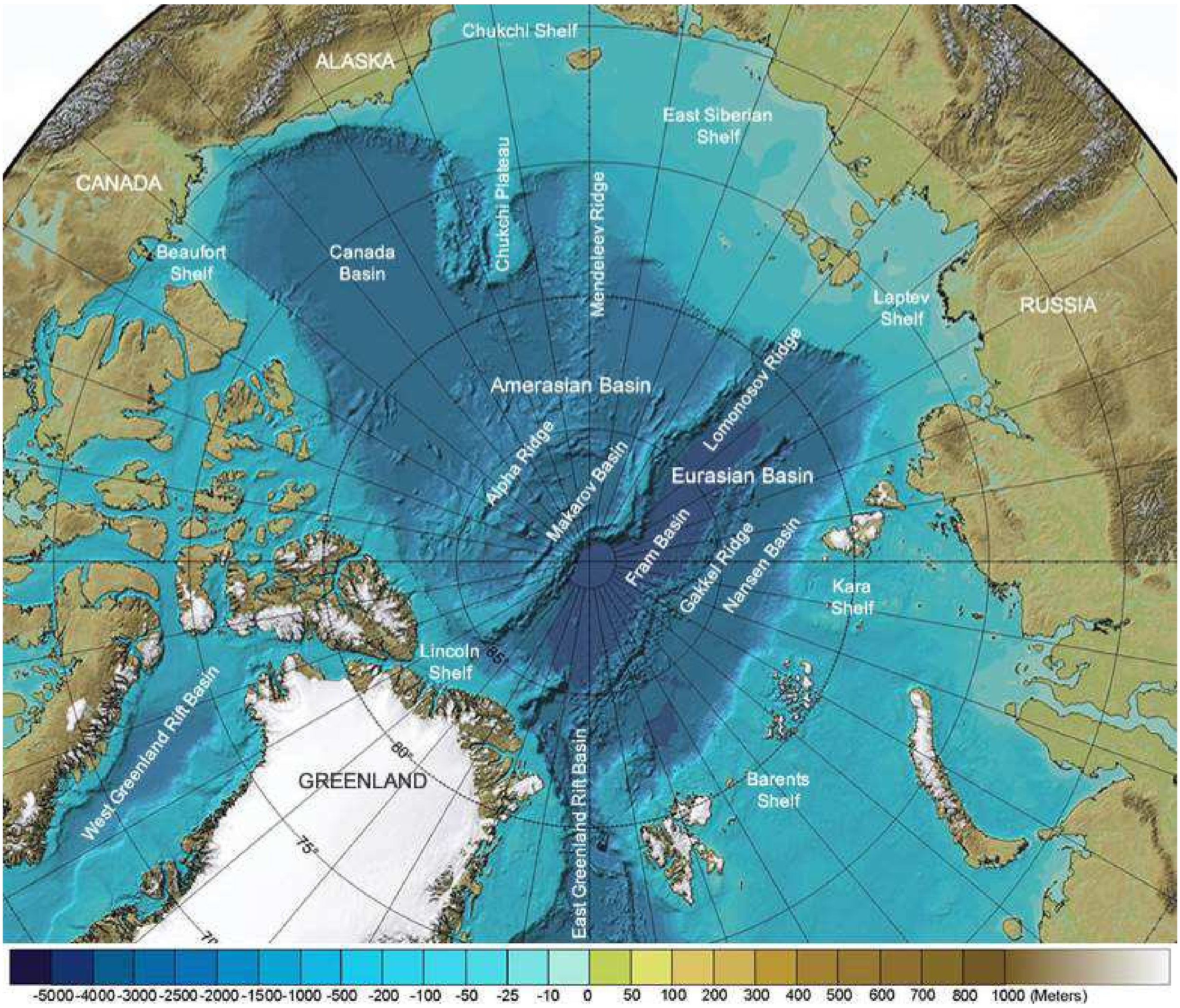

Figure 13. The Arctic bathymetry, (Source: King 2013).

The Arctic Basin is divided by the Lomonosov Ridge. It spans 1800 km from the New Siberian Island to Ellesmere Island. It has a width ranging from 60 km to 200 km and a height ranging from 3300 meter to 3700 meter above the sea floor. The ridge was first discovered in 1948 by Russian scientists. Currently it is claimed to be the extremities of the continental shelf of Russia, Greenland and Canada. However, in 2002 the UN Commission neither rejected nor accepted the Russian proposal, recommending additional research.

The Amundsen Basin (Fram Basin) is the deepest abyssal plain with depth up to 4400 meter. Together with the Nansen Basin it is collectively termed the Eurasian Basin. The largest basin in the Arctic is the Canada Basin with a mean depth of 3800 meter.

3.3.2 Oceanographic properties

3.3.2.1 Circulation

As the Arctic Ocean is largely isolated from the world oceans by land, the water flux is taking place through several gateways, shown in Figure 14.

- **Bering Strait** (between the American continent and Siberia) – the flux entering through the strait is limited due to the shallow water depth caused by the Chukchi Shelf. An approximate 0.4 m mean sea level difference between the Bering Sea and Arctic Ocean drives this net northward transport through Bering Strait (Stabeno et al. 1999).
- **Fram Strait** (between Greenland and Svalbard) a large flux of both subsurface cold Arctic water and sea ice is exiting the Arctic Ocean through the Fram Strait. The Strait is the main exit point for the sea ice that drifts out of the Arctic Ocean and melts at lower latitudes. A smaller component of the warm North Atlantic surface current is entering the Arctic Ocean close to the Western coast of Svalbard.
- **The Barents Sea (**the area between Svalbard and the Northern tip of Norway) – warm salty water penetrates into the Arctic through the Barents Sea. This water is part of the North Atlantic conveyer and has originated from the Gulf Stream.
- **Russian Rivers –** Russian rivers contributes to a large inflow of freshwater during the spring/summer months. This contributes to a rather fresh surface layer in the Arctic Ocean.
- **Nares Strait/Baffin Bay –** a relatively small amount of water and ice leaves the Arctic, and drifts into the Baffin Bay. This is due to the narrow Nares Strait chocking the transportation, combined with the shallow waters caused by the Lincoln Shelf North of the Strait.
- **Canadian archipelago –** There is also a limited amount of water leaving the Arctic through the Canadian archipelago, exiting through the Lancaster Sound into the Northern part Baffin Bay.

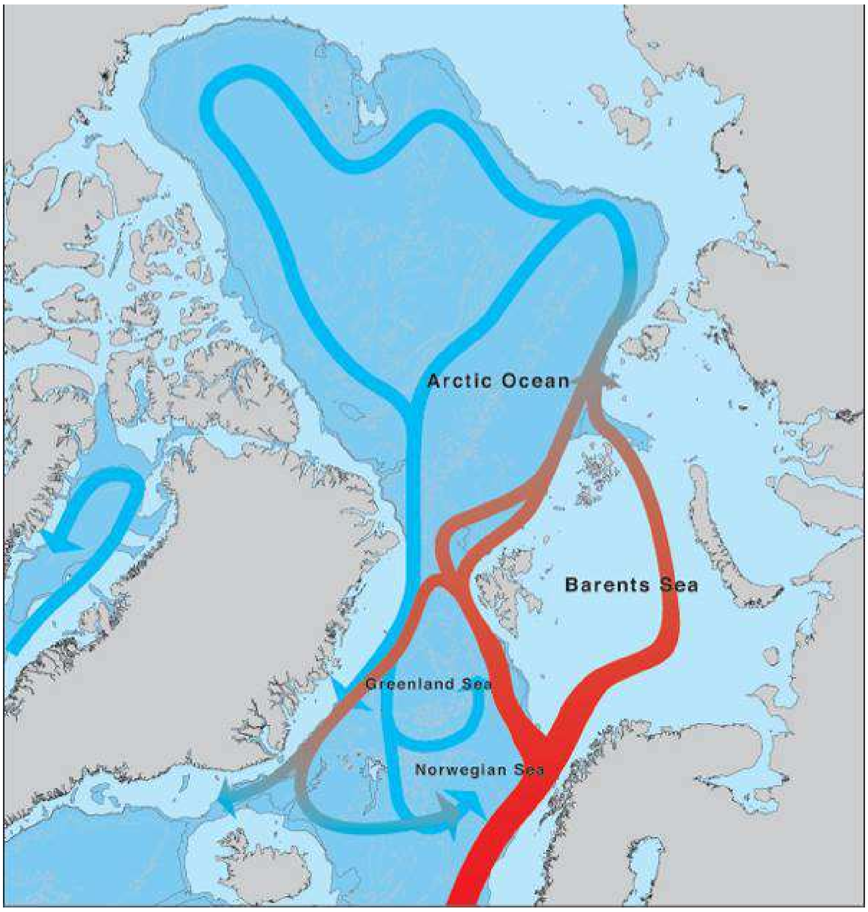

Figure 14. Arctic Ocean Currents (Source: The Norwegian Polar Institute).

The Arctic Oceans consists of several different water masses, ref Figure 15. In addition seasonally large amounts of fresh water are introduced to the system through the large Russian and Canadian rivers. The top four rivers supplying the Arctic Oceans with fresh water are the Yenise (Russian), Lena (Russian), Ob (Russian) and MacKenzie (Canadian), discharging 618, 539, 404 and 325 km³ of fresh water per year, respectively (Environmental Canada, 2013).

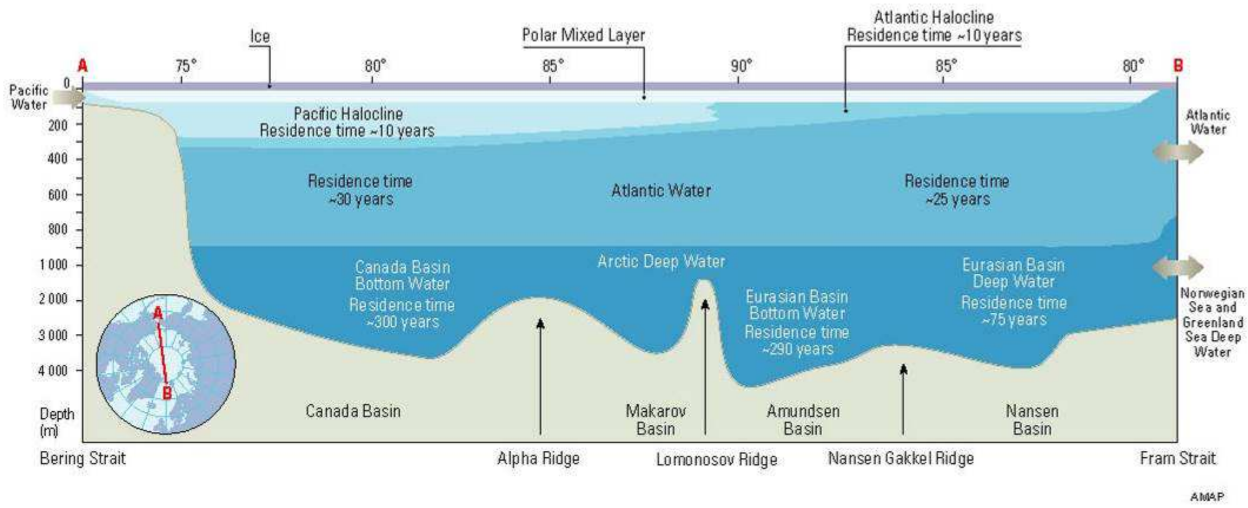

Figure 15. A schematic representation of the three-layer structure of the Arctic Ocean, with the Arctic Surface Layer above the Atlantic Water and Arctic Deep Water The residence time for the different water masses are also shown Water masses in the Arctic Ocean (Source: AMAP[12]).

The different water masses have different combinations of salinity, temperature and density. Convection eddies caused by the temperature difference between the cold fresh ocean surface and the warm, salt bottom water stop at the thermocline at the arctic deep water, leaving only heat conduction as upward heat transport. This effect causes moderate vertical mixing of the water masses, resulting in the surface mixed layer to be isolated from the influence of the deeper warm water masses by strong stratification within the halocline. The heat contained in these deeper water masses could drive significant melting if brought in contact with the surface layers and sea ice.

From Figure 16, it is evident that the properties of arctic bottom water remain relatively constant throughout the whole profile.

[12] http://www.amap.no/documents/doc/a-schematic-representation-of-the-three-layer-structure-of-the-arctic-ocean-with-the-arctic-surface-layer-above-the-atlantic-water-and-arctic-deep-water-the-residence-time-for-the-different-water-masses-are-also-shown/442

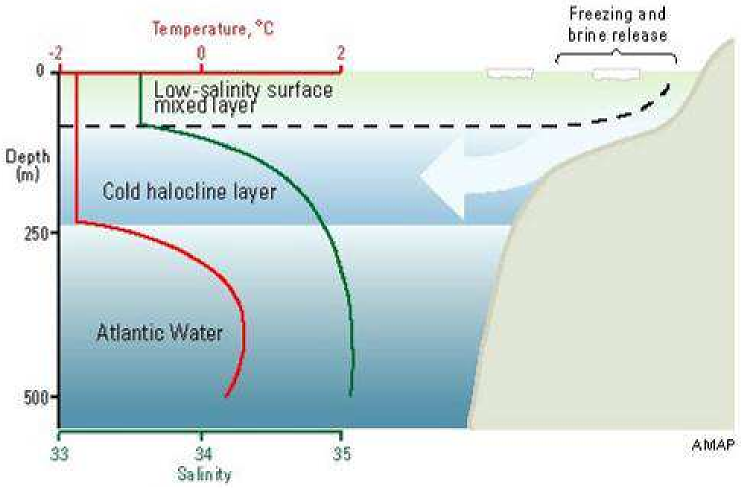

Figure 16. Schematic representation of the temperature and salinity structure of the upper Arctic Ocean (Source: AMAP[13]).

When the warm, salty water from the North Atlantic current reaches the cold Arctic water, it is cooled, ref Figure 14. The large difference in water temperature is inducing a rather strong thermo-haline circulation. The water travels cyclonically in a clockwise direction around the perimeter defined by the land and bathymetry of the ocean. This is known as the Beaufort Gyre. When the gyre weakens, volumes of fresh water originating from the Pacific through the Bering Strait and from the large Russian rivers, leak across the Arctic through the transpolar current. Large volumes of water exit the Fram strait as a cold and fresh water mass.

The warm to cold conversion and the thermo-haline circulation is essential for the large global conveyors and is also essential for the global oceans overturning, maintaining the earth's climate.

3.3.2.2 Surface Temperature and Wind

The surface temperature in the Arctic is highly variable both with regards to location and season. For instance, the North Pole is not the coldest part of the Arctic. This is due to heat transfer from the relatively warm water, keeping average winter temperatures around -30 to -35^{o} C. During the summer season the decaying sea ice keeps the surface from warming, and any additional energy goes into melting the ice, keeping the temperature at around 0^{o} C. This is clearly evident in the climatologies measured at the Russian drifting stations NP7-8 and Centrale, see Figure 17.

[13] http://www.amap.no/documents/doc/schematic-representation-of-the-temperature-and-salinity-structure-of-the-upper-arctic-ocean-and-how-the-halocline-layer-is-maintained-by-brine-rich-water-produced-on-the-shelves/531

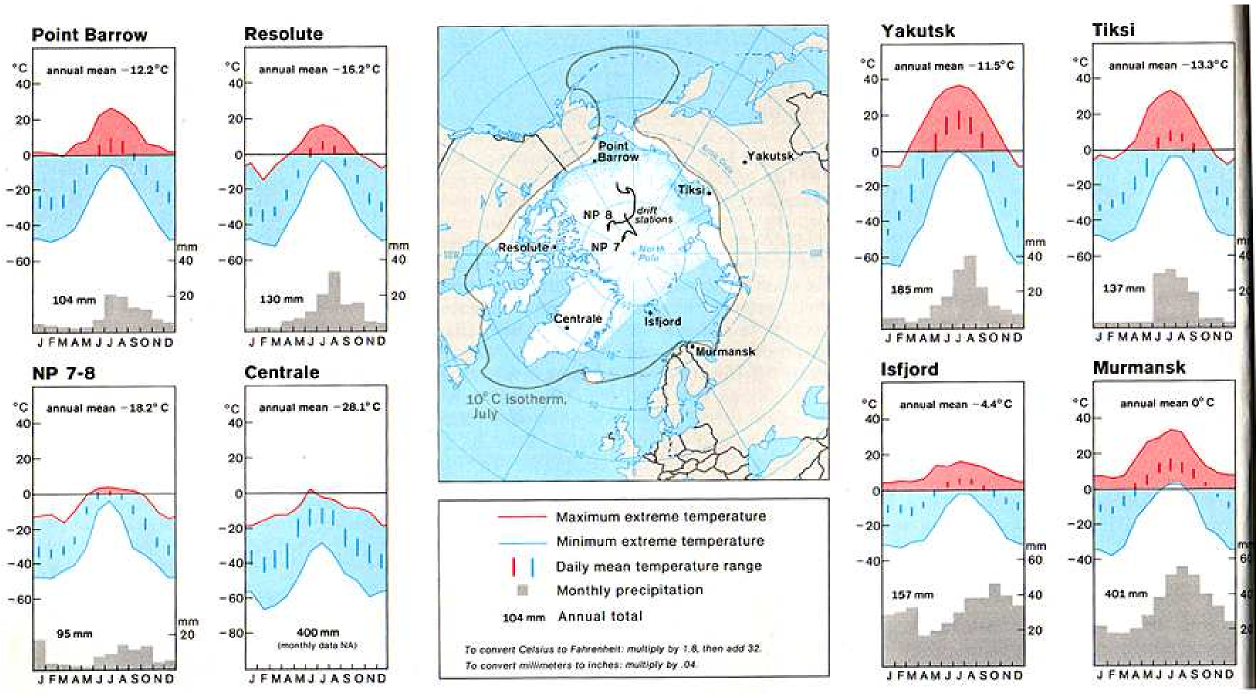

Figure 17. Monthly climatologies (Source: Polar Regions Atlas, CIA 1978, page 8).

The temperature variability during the winter months is relatively low for the ice covered arctic basin. As there is no sunlight during the winter, the main source of energy, and thus main source of temperature variability, is thermal radiation emitted by the atmosphere, see Figure 18.

There is however a large difference in the surface temperature regimes when comparing the ice free seas present in the Arctic with the ice covered waters due to the insulating properties, heat capacity and albedo effect represented by the ice cover.

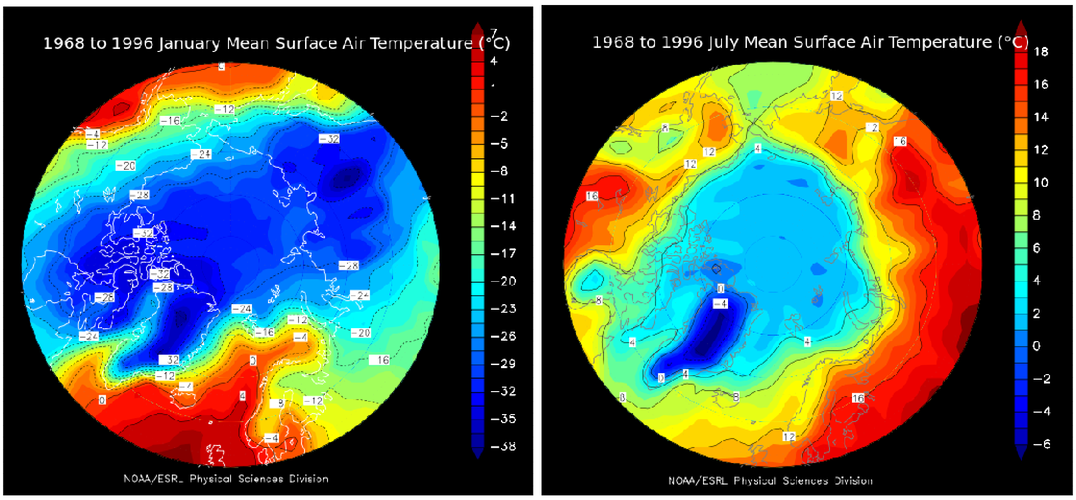

Figure 18. Average surface temperature in January and July (Source: NOAA[14]).

[14] http://en.wikipedia.org/wiki/File:JanArcticSfcT.svg

3.3.2.3 Wind

The main wind patterns are defined by the jet streams. The strength of the jet stream and amount of energy "escaping" the Arctic is partly described in the Arctic Oscillation. This defines the main driving forces for the wind regime present in the Arctic, see Figure 19.

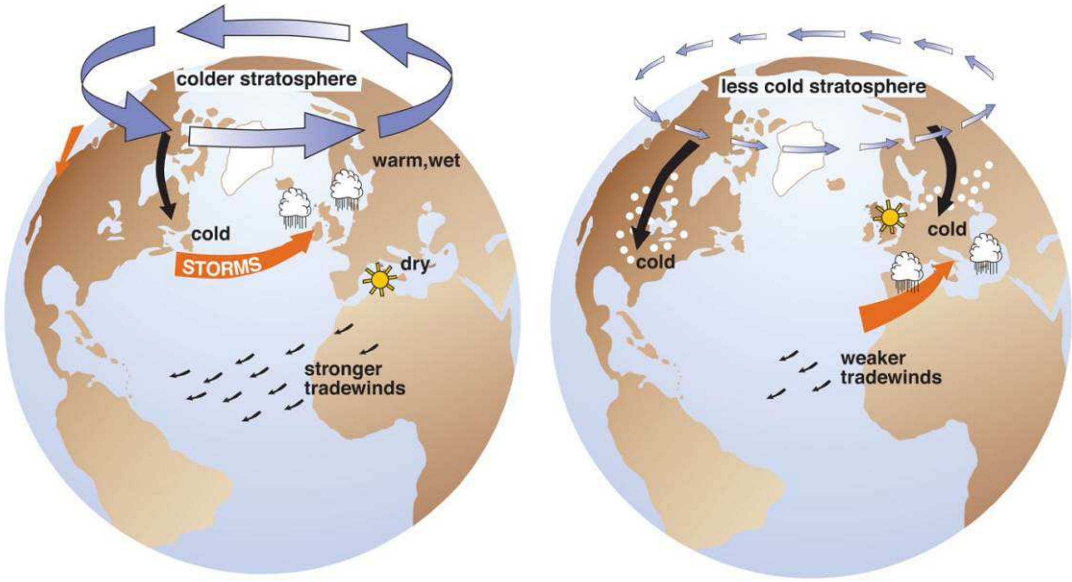

Figure 19. Effect of AO on the wind patterns (Source J. Wallace, University of Washington[15]).

There is however semi-permanent patterns of action present. These patterns define the wind regime on a local level and on a shorter time scale. The semi-permanent patterns and movement of the semi-permanent pressure centres are of great importance when developing weather forecasts. The main semi-permanent patterns are:

Icelandic Low – Low pressure centre located between Iceland and Greenland. The pressure is most intense during the winter and splits into two during the summer months.

Aleutian Low – Semi-permanent low pressure centre located near the Aleutian Island. It is characterized by many strong cyclones, especially in winter. The cyclones are formed in sub-polar latitudes in the North Pacific and usually reach their maximum intensity around the Aleutian Island.

North American High – A relatively weak area of high pressure is centred over Yukon during the winter. This centre is not as well defined as its continental counterpart located in Siberia.

Azores High – A high pressure pattern that forms in the subtropical Atlantic Ocean. Although it is located outside the Arctic Ocean it affects the Arctic weather as it is linked to the Icelandic low through the North Atlantic Oscillation.

[15] http://nsidc.org/cryosphere/arctic-meteorology/weather_climate_patterns.html

Siberian High – A cold anticyclone that forms over Eastern Siberia during the winter. The cold air outbreaks experienced over East Asia is often related to the Siberian high.

Beaufort High – A high pressure centre located over the Beaufort Sea. The centre is mainly present during the winter months.

A special phenomena observed in the Arctic is the “Polar Lows”. The polar lows are intense cyclones that typically form when cold Arctic air flows over relatively warm water. The cyclones are from 100 km to 500 km in diameter, and the wind-speeds typically average around 50 knots. The cyclones can form very rapidly, reaching their maximum strength in 12-24 hours. Due to the rapid development they are very difficult to predict and represent a risk for all maritime activity in the area.

3.3.3 Sea ice

The dominating oceanographic feature of the Arctic high seas is the sea ice. Sea ice is frozen sea water floating on the surface of the ocean. Sea ice is typically described either as first-year ice or multi-year ice, defined by WMO as:

- First-year ice: Sea ice of not more than one winter's growth, developing from young ice; thickness 0.3-2.0 m. May be subdivided into thin first-year ice/white ice, medium first-year ice and thick first-year ice.
- Multi-year ice: Old ice up to 3 m or more thick which has survived at least two summers' melts. Hummocks are even smoother than in second-year ice and the ice is almost salt-free. Color, where bare, is usually blue. Melt pattern consists of large interconnecting irregular puddles and a well-developed drainage system.

The sea ice cover is highly seasonal, with peak coverage in late winter (March) and minimum coverage in late summer (September), as shown in Figure 20. Although there is a significant yearly variation, the March ice extent covers the entire Arctic high seas, while the September ice covers most of the Arctic high seas. However, significant areas close to the Bering Strait can be ice free. During winter time most of the ice coverage will be first-year ice. The multi-year ice is largely concentrated on the North American side of the pole, north of Greenland and the Canadian archipelago as a result of the dominant oceanic circulation.

The sea ice pack is at times regarded as a semi-elastic cover. The two primary forces affecting the motion of the pack is wind stress (at the top surface of the ice) and water stress (the bottom surface of the ice).

Due to the uneven top surface of the ice the wind will exert an uneven force on the different ice floes. This will cause uneven motion of the ice floes, which in turn generates ridges and hummocks. The ridges and hummocks do in turn make the surface more uneven, generating more uneven motion of the different floes. With the absence of other forces, the ice typically moves at a speeds equivalent to about 2% of the wind speed.

The movement of the water will also exert forces on the pack, moving the ice over large areas. There are three types of current relevant:

1. Permanent Ocean surface currents - part of a larger ocean circulation system
2. Periodic currents – tides
3. Temporary currents – wind induced

During the deformation phase the above mentioned factors will influence the deformation of pack. As the combination of wind and current is highly dynamic, varying over both time and geographical location, this results in a highly variable ice thickness over the Arctic Ocean.

The older the ice and the longer the ice has been exposed to the forces generated by the wind and current, the higher ridge concentration is to be expected.

Figure 20 shows the pronounced difference between the ice extent in winter and summer. Figure 21 further illustrate the variability between individual years, showing the minimum extent from 2007 and 2011. Seasonal and yearly variability is also clearly shown in Figure 22.

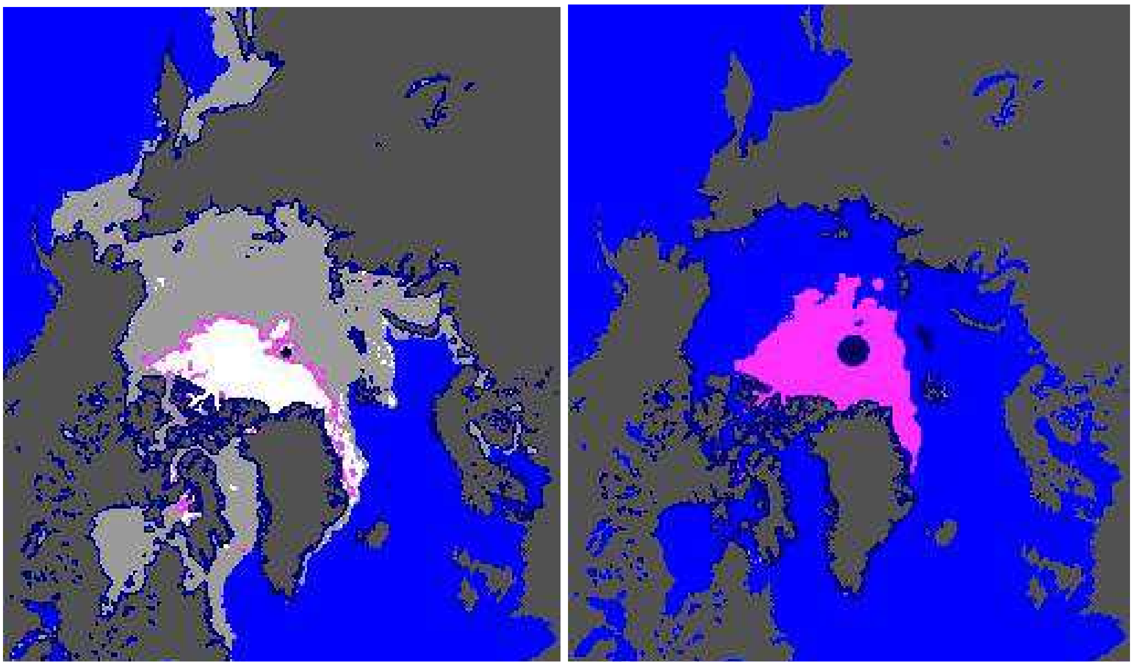

Figure 20. Left: First year (gray) and multi-year sea ice (white) on March 10 2013. For the Arctic Ocean high seas, the multi-year ice is largely concentrated on the North American side of the pole, north of Greenland and the Canadian archipelago. Right; sea ice extent on September 13 2012. (Source: Ocean and Sea Ice Satellite Application Facility (OSI SAF) High Latitude Processing Center[16]).

[16] http://osisaf.met.no/p/ice/index.html#type

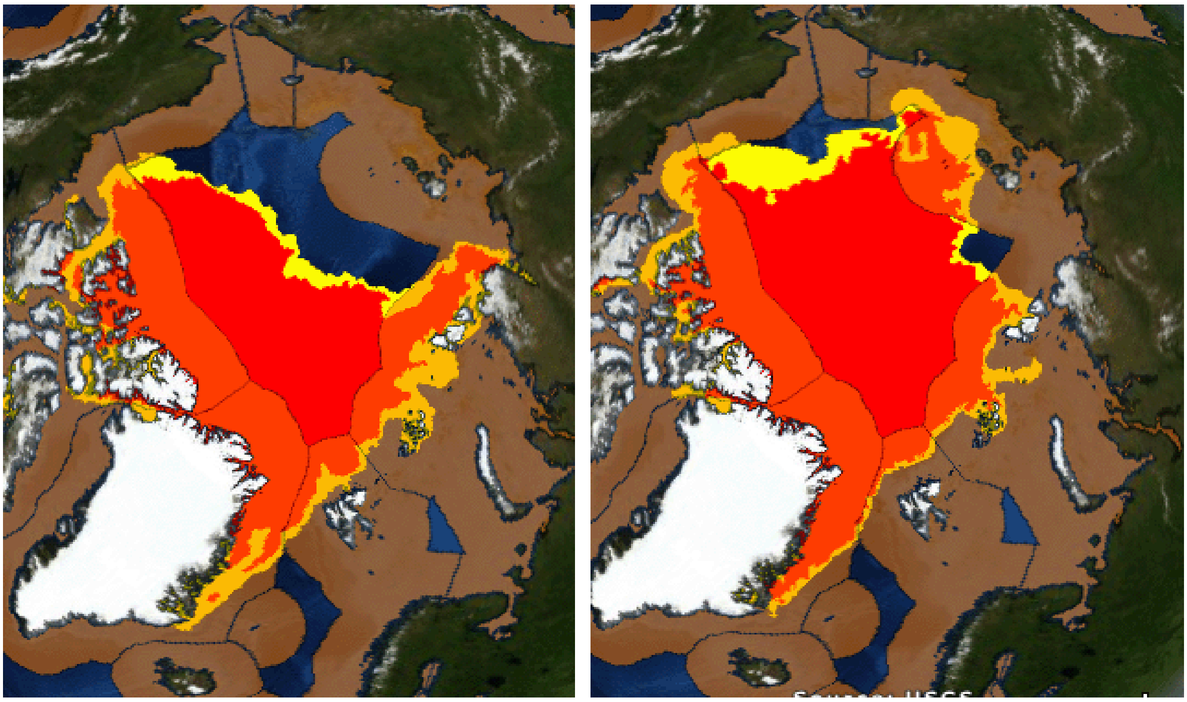

Figure 21. Minimum sea ice extent and areas of open ocean beyond EEZs in the Arctic Ocean for 2007 (left) and 2011 (right). The sea ice data used to represent the summer minimum extents for 2007 and for 2011 are from the U.S. National Ice Center (NIC) Marginal Ice Zone (MIZ) products for 22 September 2007 and 17 September 2011, respectively. The NIC MIZ product includes the pack ice of the sea ice cover in red, with ice concentrations of 80 to 100 per cent, and the actual MIZ in yellow, with concentrations below 80 per cent. The EEZ is indicated in brown in one of the figures and as a translucent brown overlay in figures for each minima. (Source; U.S. National Ice Center (via personal correspondence from Peter H. Oppenheimer, NOAA).

Over the last few decades the Arctic Ocean has experienced profound changes. During the summer seasons the average area covered by sea ice has shrunk (Figure 22), the amount of multiyear ice present has diminished and the ice thickness has been reduced. This development is expected to continue, with models showing further reductions of ice cover in the coming decades (Figure 23).

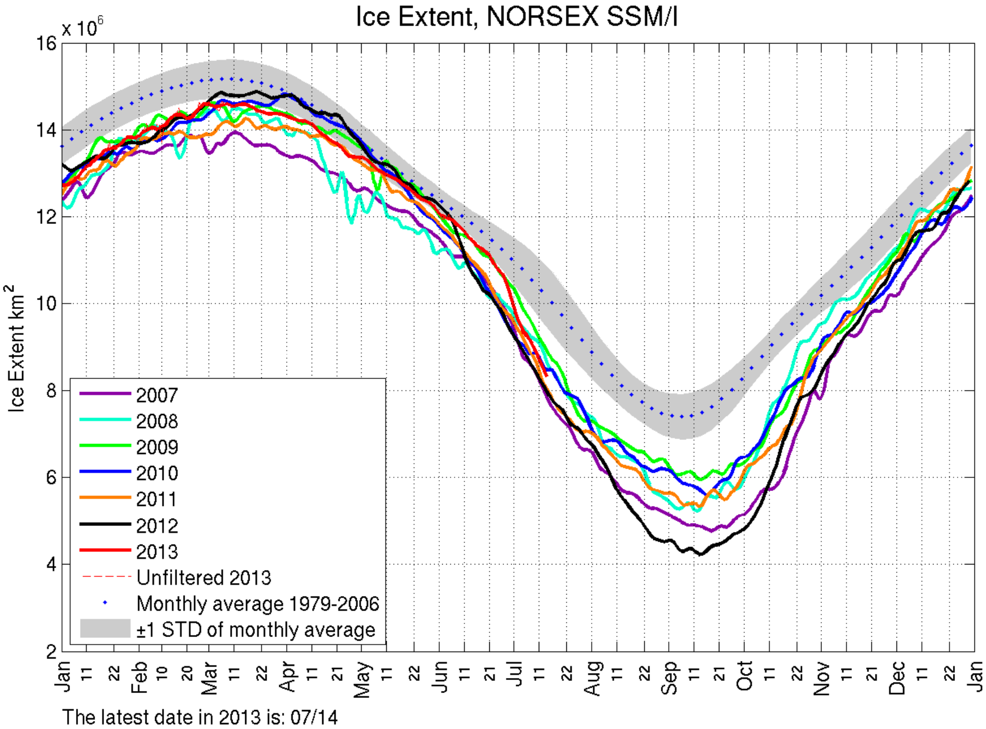

Figure 22. Arctic Sea ice extent (Source: Arctic Regional Ocean Observing System (Arctic ROOS)[17]).

Recent scientific publications are indicating early signs of acidification of the Arctic Ocean and the freshwater content in the Arctic Ocean is showing considerable variability with time. With regards to weather systems, a tendency of variations in surface air temperature and low/high pressure systems development and movement, have also been observed. Although an increased seasonal variability has been observed, periods with extreme sub-zero temperatures and high ice concentrations are still to be expected during the winter months.

As the industrial activity level in the region increases, so does the need for good metocean understanding and data. This is essential from both an operational perspective, on a day to day basis, in the development and calibration of models, and in the design phase. Currently there are very few records representing extreme events. To design infrastructure purposely built for the Arctic, reliable statistical data describing extreme events is essential. As the extreme events are rare, they are usually located in the far tail of a distribution. Low resolution data collected over short time periods and at irregular intervals forces the industry to extrapolate. The process of extrapolation is based on knowledge generated from more accessible parts of the earth and might not always be representative for metocean mechanisms present in the Arctic.

Further development of the knowledge related to the metocean mechanisms present in the Arctic in combination with an increased amount of data is essential for a sustainable development of the area within what is regarded as acceptable risk levels.

[17] http://arctic-roos.org/Members/admin/50-per-cent-increase-in-the-annual-minimum-of-the-sea-ice-area-in-the-arctic

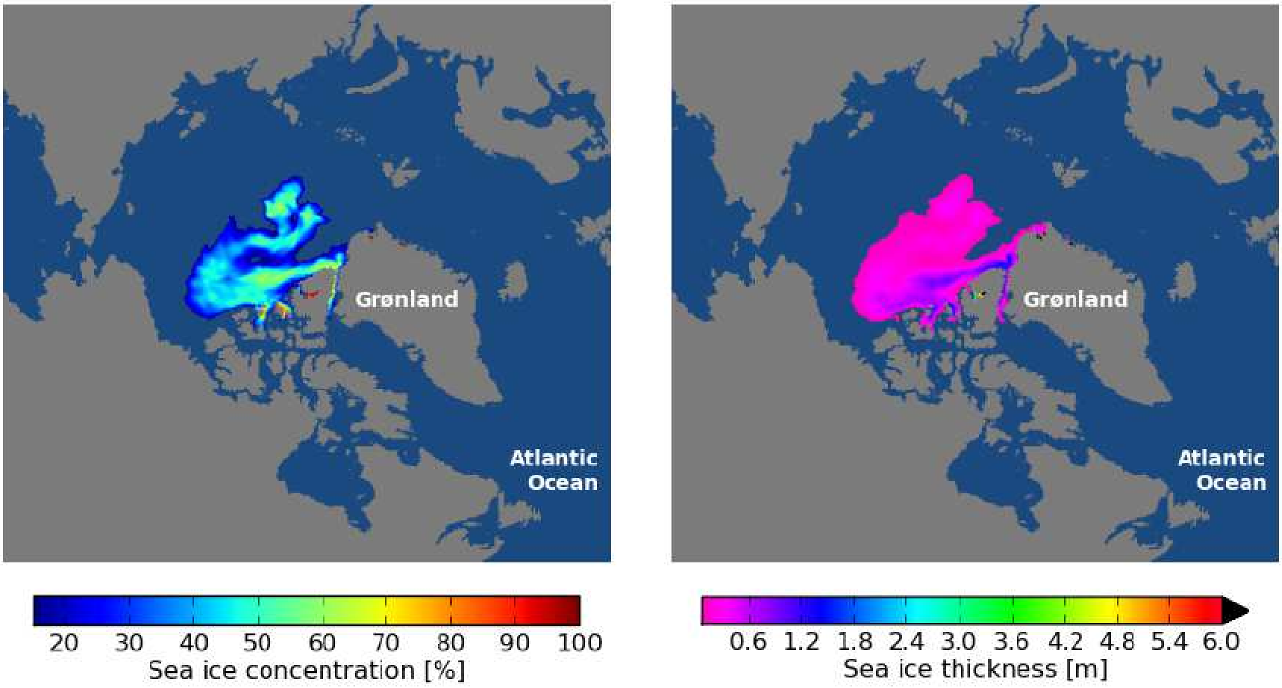

Figure 23. Modelled September sea ice concentration (left) and thickness (right) over the decade 2040-2050. (Huard and Tremblay, 2013. Their figure 3.15).

3.4 Environmental sensitivity of the Arctic high seas

Vital to assessing the need to protect the Arctic high seas, is the understanding of the environmental sensitivity of the area. In this section a brief overview of the sensitivity of the area is provided, building on the findings of the sections of the AMSA II C report dealing with the Central Arctic Ocean and supporting information from Chapter 6 (Status and vulnerability of Arctic ecosystems) of the Assessment of oil and gas activities in the Arctic by AMAP (AMAP 2007, Skjoldal et al. in prep.).

It is important to note that the AMSA II C report (Skjoldal et al. 2013) do not address the Arctic high seas specifically. Rather, the study considers an area named the Central Arctic Ocean Large Marine Ecosystem (LME). This area is shown in Figure 24. Compared to the Arctic high seas in Figure 2 it is clear that the two areas are not identical. Central Arctic Ocean LME includes the international waters (high seas) but also parts of national Exclusive Economic Zones (EEZs) of Canada, Denmark/Greenland, Norway and Russia. It is an extensive area[18] of about 3.7 million km^2 containing areas with heavy multi-year pack ice as well as areas with more newly formed ice. The most notable difference is that the Central Arctic Ocean LME extends further towards land close to Greenland, the Canadian Archipelago and the Russian Islands.

[18] More than 10 times the area of Norway, 5 times France or Texas, more than 50% larger than Greenland, larger than India, and almost half the size of Australia.

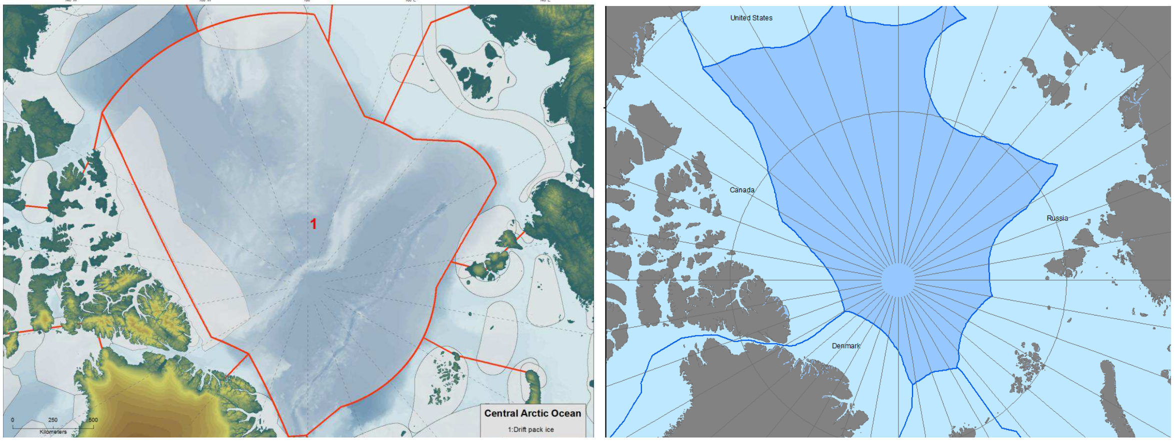

Figure 24. Left: The Central Arctic Ocean LME (From Skjoldal et al. 2013, their Figure 12), compared to the Arctic Ocean high seas (Right).

3.4.1 Drifting pack-ice

The AMSA II(C) report concludes that the drifting pack ice of the Central Arctic Ocean is globally unique as an environment and it contains unique ice-associated biota, and identifies the whole area as an area of heightened ecological significance. The drifting pack ice of the Central Arctic Ocean is characterized by very low primary productivity by specially adapted ice algae and phytoplankton in the water column below the ice. Also, sea ice amphipods (up to 6 cm) live in association with the ice, particularly in multiyear ice. The ice amphipods are important prey for polar cod and Arctic cod, and also for ringed seals. They also support directly or indirectly other species that live in ice-covered waters including polar bear, ivory gull and Ross's gull. Some belugas, narwhals, and ringed seals may venture into this area. There is a strong seasonality in the use of the areas by the animals which make them ecologically important. Thus the sensitivity and heightened ecologically importance may occur in a relatively short period of time. The AMSA II(C) also considered that the drifting pack ice of the whole Central Arctic Ocean area should be regarded as being of heightened significance but noted that the area is not homogenous, so not every area within it is of equal ecological significance.

The drifting pack ice is a threatened habitat with global climate change. It is predicted that summer ice may be largely absent from the Arctic Ocean by the end of this century if not earlier. It is also predicted that the last area with multi-year ice will be the region north of Canada. The AMSA II(C) report emphasizes that the multi-year pack ice may be of particular importance for maintenance of the special autochthonous ice biota. With climate change, and shrinking ice cover the areas north of the Canadian Arctic Archipelago and Greenland may be the last places for multi-year ice, the endemic sea ice biota and for many ice-dependent species, such as ringed seals, polar bears and other species. This region is a core area of high ecological significance due to its possible future role as a refugium of ice-dependent biota. However, it is noted that a significant part of these areas fall outside the Arctic high seas.

Importantly, the AMSA II(C) report finds that the endemic fauna associated with the drifting pack ice is sensitive to potential oil spills. However, the large extent of the pack ice would tend to lower the vulnerability of this habitat to an oil spill. Also, the low productivity of the area means that there is limited food for predators and the area does not attract concentrations of animals. Thus animal densities would generally be low. However, shrinking ice cover would increase the vulnerability due to the lesser extent of the habitat combined with greater mobility of spilled oil with more open water in summer. The AMSA II(C) report states that oil spills that could remain in this habitat for a long time would be the main concern, while disturbances from ships would be an issue of lesser concern in general due to the low density of animals and the very wide distribution of the ice communities.

In the following subsections, the occurrence of polar bear, Ross' and ivory gull, Bowhead whale and arctic cod in the high seas region is described further. Note that Figure 25 illustrates some of the areas discussed below, seen in relation to the high seas area and the future shipping routes described in Section 3.1.2.3.

3.4.2 Polar bear

Polar bear (*Ursus maritimus*) occurs with 19 more or less distinct (geographically and genetically) subpopulations in the Arctic. Six of the recognized subpopulations occur on the shelves surrounding the Arctic Ocean basins; these are the Barents Sea, Kara Sea, Laptev Sea, Chukchi Sea, and Southern and Northern Beaufort Sea subpopulations (Obbard et al. 2010). Bears of these subpopulations may follow the retreating ice north into the peripheral areas of the pack ice of the Central Arctic Ocean in summer.

Polar bears of the ***Barents Sea subpopulation*** have in recent years withdrawn with the sea ice into the adjacent parts of the Nansen Basin north of the Barents Sea. This subpopulation is distributed in the northern and central Barents Sea between Svalbard in west and Franz Josef Land and Novaya Zemlya in east (Obbard et al. 2010). An aerial survey suggested that about 2/3 of the Barents Sea polar bear subpopulation was present in the Nansen Basin of the Central Arctic Ocean between about 82 and 85^{o}N in August 2004. This may be typical for the more recent climate situation where the northern Barents Sea clears more or less completely for ice in late summer in warm years. The Barents Sea polar bears have been identified as one of the most vulnerable of the polar bear subpopulations (Durner et al. 2009).

The ***Southern Beaufort Sea subpopulation*** of polar bears is distributed west from the Amundsen Gulf to around Icy Cape in northwestern Alaska (Obbard et al. 2010). These bears have traditionally moved north with the receding ice edge into the Beaufort Sea during summer. Polar bears of this subpopulation venture far north in the pack ice both summer and winter, with satellite-tracked bears recorded north to around 80^{o}N (Durner et al. 2009). The Southern Beaufort polar bears are special in that they have maternity dens on drifting pack ice in the Beaufort Sea located north to 76^{o}N or beyond (Amstrup 2000). The ***Northern Beaufort Sea subpopulation*** is found north from the Amundsen Gulf in the eastern Beaufort Sea. These bears move north and east with the retreating ice in summer and the distribution includes the westernmost part of the Queen Elisabeth Islands (Stirling et al. 2011). The northern boundary of this population is not well known.

Polar bears of the ***Chukchi Sea subpopulation*** are distributed between Alaska and the eastern East Siberian Sea. These bears move north with the seasonally retreating sea ice into the Arctic Ocean in summer where satellite-tracked bears have been recorded north to around 78-79^{o}N (Amstrup et al. 2005, Durner et al. 2009). Polar bears of the ***Laptev Sea subpopulation*** are found from the Severnaya Zemlya in west to the western East Siberian Sea in east. Bears of this subpopulation also move out into the Central Arctic Ocean with records of satellite-tracked bears form northeast of the New Siberian Islands (Durner et al. 2009).

The ***Arctic Basin subpopulation*** is not well defined but is a 'geographic catchall' to account for polar bears that may be resident in areas of the circumpolar Arctic that are not clearly part of other subpopulations' (Obbard et al. 2010). Previous observations by Soviet/Russian aerial ice surveys and from the 'North Pole' ice drift stations and more recent observations from ice-breaking vessels have revealed that polar bears occur widespread at low densities all over the Central Arctic Ocean. Polar bears are found in the northernmost part of the Queen Elisabeth Islands and in the adjacent part of the Arctic Ocean off northern Canada and Greenland and these bears are assumed to be of the Arctic Ocean subpopulation. However, there is limited information on this subpopulation and its biology, e.g. location of denning areas which could possibly be on offshore pack ice.

3.4.3 Ivory gull and Ross' gull

Only two seabird species have their natural habitat in the Arctic Ocean; they are the **ivory gull** (*Pagophila eburnea*) and **Ross' gull** (*Rhodostetia rosea*). Both are adapted to feed in ice-covered waters and both occur there with significant parts of their total populations during summer. Ivory gulls breed on nunataks and other remote sites in northern Russia, Greenland and northern Canada. Severnaya Zemlya and islands in the northern Kara Sea are the main breeding areas for the species with more than 50% of the total global population. During the postbreeding season, ivory gulls from all Northeast Atlantic breeding populations (Greenland, Svalbard and Russia) migrate eastwards and stage in the ice edge zone in the NE Kara and NW Laptev seas in September-October before they migrate either west to Davis Strait region or east to the northern Bering Sea (Gilg et al. 2010). With less summer ice in recent warm years a substantial fraction of the total global population of ivory gulls is expected to have occupied the marginal ice zone in the Nansen Basin area of the Arctic Ocean.

The main breeding area for Ross' gull is on the tundra in northern Yakutia, from the Taymyr Peninsula and east to Kolyma River. After breeding the Ross's gulls move north to the ice edge and pack ice of the Arctic Oceean. Ross's gulls have been observed to move east through the Chukchi Sea in autumn, presumably to feed in the Beaufort Sea, and then to return west in late autumn.

3.4.4 Bowhead whale

Bowhead whale (*Balaena mysticetus*) lives associated with ice year-round, and exists with four stocks or subpopulations in the Bering-Chukchi-Beaufort seas, Sea of Okhotsk, Baffin and Hudson bays, and Greenland and Barents seas (the Spitsbergen stock). The species has been delisted and is now considered not threatened by IUCN. However, the Spitsbergen stock, which probably was the largest and was brought to the brink of extinction, is considered to be 'Critically endangered'. The stock was considered extinct in the first part of the 1900s, but there are encouraging signs that bowheads still occupy the former range of the Spitsbergen stock and could be numbering around 100 animals. The distribution area centers around the Fram Strait region, extending south in the western Greenland Sea and east into the northern Barents Sea to the Franz Josef Land area. Individuals have been sighted north of the Fram Strait to about 84^{o}N. Overall the number of sightings is relatively low reflecting the low population size of this Critically endangered population. Bowhead whales were known to move into the pack ice in the northern Fram Strait in the whaling period some hundred years ago when they were abundant. Since bowhead whales generally seek ice, the Spitsbergen whales can be expected to move into the marginal zone of the Arctic pack ice in the Nansen Basin. With less summer ice under future warming, the importance of this area may increase.

The Bering-Chukchi-Beaufort stock (BCB stock) or the Western Arctic stock of bowheads winter in the seasonal pack ice and polynyas in the northern Bering Sea and migrate in spring through the eastern Chukchi Sea to summer feeding areas in the eastern Beaufort Sea and the Amundsen Gulf. The whales move west again in early autumn to the Chukchi Sea where many move to the northwestern area around Wrangel Island before moving south in late autumn. Some of these whales may occur in the international waters of the Central Arctic Ocean north of the Chukchi Sea in the late summer season.

3.4.5 Arctic cod

Arctic cod (*Arctogadus glacialis*) is a small codfish that lives in the Arctic Ocean. It was found to be abundant over the Chukchi Rise (at about 77^{o}N) in winter, as observed under the ice from a drifting ice station. The fact that Arctic cod was found only in winter when the ice station was over the Chukchi Rise suggested that the fish was not drifting with the ice but rather undertook a winter migration probably to spawn in this area which is in the international waters of the Arctic Ocean. Arctic cod could possibly be an important species in the slope waters north of the Chukchi shelf and be a prey for marine mammals such as beluga whales feeding in this area in late summer. Arctic cod spawns in winter under ice and the larvae hatch in spring as the ice starts to melt. There is limited knowledge on the ecology of this species.

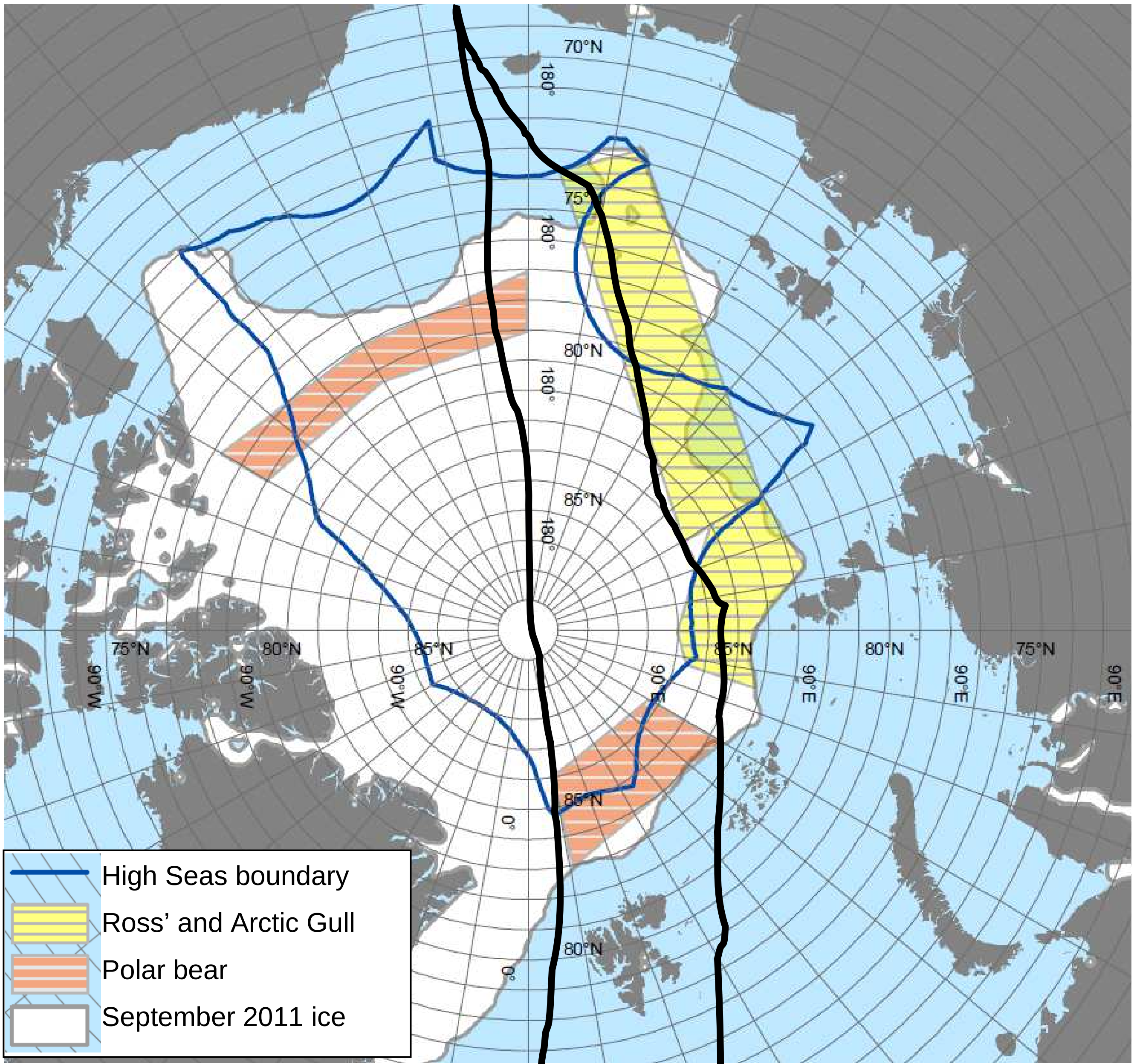

Figure 25. Indicative illustration of northernmost observations of Polar bears from Beaufort and Chukchi populations (top) and Barents Sea population (bottom), as well as Ross' and Arctic Gull. Also shown are the possible shipping routes (black lines), and the September 2011 ice extent. Note that this is only meant to indicate the position of the ice, which is flux (as seen in Figure 21 there are large yearly variations in the sea ice extent). The observations and the ice do not refer to the same reference year as the observations described. Note also that only the northernmost observations, as described in this section, are indicated. The full range of bear and gull habitat is not shown. Also not shown are the locations of cod, whale and any other species discussed in this report. This map is intended only as a means to help in understand the verbal description in this section. It is not meant to provide a full overview of species in the region. Use of this figure out of context is not advisable.

Table 10 summarizes the status for the species found in the Arctic high seas, with respect to their geographical distribution, the seasonality of their occurrence and the resulting overlap with expected shipping activity (section 3.1.2.3).

***Table 10**: Summary of potential overlap with future shipping activity for selected species found in the Arctic high seas*[19].

Species	*Area and season*	*Sensitivity*	*Potential overlap with shipping activity (ref. section 3.1.2.3)*
Amphipod	Year-round presence in the areas of multi-year ice and seasonal concentrations under 1st year ice.	Oil spill.	**Moderate.** Most ships will go through first year ice on the Eurasian side, but will tend to avoid areas of multi-year ice.
Polar Bear	Polar bears from several subpopulations use the peripheral areas of the pack ice of the Central Arctic Ocean as part of their summer feeding habitat. Polar bears may occur concentrated in this zone when the ice is at the seasonal minimum in autumn.	Oil spill (disturbance/ noise/ ship strikes).	**High.** Present on the ice edge in the late summer season when the peak shipping activity.
Ivory and Ross' Gull	In the post-spawning period the majority of the global population of Ivory Gull may occur concentrated in the marginal ice zone north of the Barents and Kara seas. Ross's gull uses the marginal ice zone of the Central Arctic Ocean for foraging during the post-breeding period in late summer and fall.	Oil spill.	**High.** On the ice edge in the late summer season when the peak shipping activity along the "peripheral route" is expected.
Arctic Cod	Arctic cod is found in the Canada Basin where it possibly spawns in winter under the ice in the Chukchi Rise area. The hatching occurs in spring and the small juveniles will be present presumably in the upper water layer in summer when shipping takes place.	Oil and other pollutants in the water.	**Low.** Shipping along both the "central" and "peripheral route" is likely to occur west of the Chukchi rise area (towards the Eurasian side).
Bowhead whale	The critically endangered Spitsbergen stock is found in the Fram Strait region and the northern Barents Sea. Sea ice in the adjacent Central Arctic Ocean may become increasingly important under climate change.	Ship strikes (disturbance/ noise)	**Moderate.** Shipping along the "central" route will exit/enter through the habitat near the Fram Strait.

Note that this assessment will necessarily be tentative and uncertain given that there is limited knowledge of the vulnerably of the area, in particular considering future changes to the ice cover, and that there is high uncertainty in the scenarios for future ship traffic, both with regard to the volumes, and to the geography (sections 3.1.2.3 and 3.2.2). A special note is made regarding the relevance of the changing the environmental conditions, in particular the sea ice extent (section 3.3.3). With changing ice, the geography of the habitats of the arctic species described in sections 3.4.2 through 3.4.5 will also change. A description of this change is beyond the scope of this report.

[19] Note that while DNV gratefully acknowledges the contributions of H.R. Skjoldal in describing vulnerability of the species, the assessment made in this section regarding the potential overlap with future shipping activity is made by DNV.

Keeping the significant uncertainties associated with the data in mind, an attempt is made to determine the extent to which a particular species can be expected to be impacted by shipping in the coming decades. A qualitative rating of the impact, graded *Low*, *Medium* or *High* is introduced. This rating should be used with care, and is meant to give an indication of the impact for each species, relative to the other species. Thus, the rating should change if e.g. a larger area is considered, in which higher traffic levels, or higher concentration of species is encountered. The scoring is provided as a tool to guide and focus efforts relating to the protection of the area.

As a general comment to the findings in Table 10, we find that a particularly critical aspect to consider for protection is the areas of multi-year ice which is diminishing and causing the densities of species to increase on the remaining ice. With diminishing ice, the area may become more important as a refuge, e.g. for polar bears. This also implies that an accidental oil spill has a larger potential to damage a large part of the populations.

3.5 Summary on Part I: The need for protection

This section has described two main issues; a) the traffic and risk levels in the Arctic Ocean high seas, present and future, and b) the vulnerability of the species found in the Area. A few main findings can be highlighted:

- Present ship traffic is found to be very limited, with 0.7 ship years per annum registered from AIS data. Given the size of the area, this is very low by any standard.
- Future ship traffic is expected to increase, although the volumes are very uncertain. The *High* scenario used in this report point to an exposure of 15 ship years per annum.
- The risk of shipping accidents must be considered low in comparison with almost any other area. The return period for a serious accident in the *High* scenario is 5 years, with an expected pollution accident every 260 years.
- The most prominent natural property of the area is the sea ice conditions with strong seasonal variations. The sea ice is also changing considerably in the coming decades due to climate change.
- The vulnerability of the area is evident although there are significant limitations to the present state of knowledge. In addition to the global uniqueness of the pack ice itself, it seems that the vulnerability to future shipping activity is most pronounced for polar bears and two species of gull (Table 10). They are primarily vulnerable to oil spills.

It is again emphasized that this report focuses solely on the high seas area of the Arctic Ocean. No assessment is made regarding the need to protect designated areas which are under the jurisdiction of the Arctic Ocean coastal states.

4 PART II: ASSESSMENT OF MEASURES

Given the present state of knowledge concerning the conditions of the Arctic high seas and threat posed by future shipping activity to the environment here, this section explores the IMO measures available to protect vulnerable areas. First a description of measures is provided in Section 4.1 and 4.2, followed in Section 4.3 by a discussion of the applicability of the various measures, considering the specific challenges described in Part I of this report. Section 4.4 presents concrete options for meeting the challenges using the measures deemed most applicable.

It is again emphasized that this report focuses solely on the high seas area of the Arctic Ocean. No assessment is made regarding the need to protect designated areas which are under the jurisdiction of the Arctic Ocean coastal states.

4.1 Protective international designated area measures available

The following section presents a description of measures for area based protection available under IMO for application in the Arctic Ocean high seas. Further details on the measures are provided in Appendix A.

4.1.1 Special Areas under MARPOL

Special Areas under MARPOL are areas where stricter provisions apply for the control of pollution from regular running operations, such as oily bilge water, tank/deck wash water, sewage, garbage, cargo residues and emissions to air. Special Area provisions do not include additional measures for the prevention of acute pollution (spills) from accidents.

Different areas have been designated as Special Areas under the different Annexes to MARPOL, based on their characteristics, ship traffic and the particular need for protection from the pollution aspect controlled by the respective Annex. In Special Areas, a limited set of predefined stricter regulations applies, as set out under the respective annex, see Table 11. Thus, Special Area designation does not, as PSSAs (see below), enabling for selecting between different suitable measures.

Table 11: *Special Areas and their additional requirements under relevant annexes to MARPOL*[20]

Pollution aspect; Annex to MARPOL	***Additional Special Area (incl. ECAs) provisions***
Oil; Annex I (10 adopted Special Areas)	*Discharges oil and oily mixtures from machinery spaces (bilge water):* Both inside and outside Special Areas, discharges are prohibited, except when the oil concentration in the effluent does not exceed 15 ppm after passing through approved oil filtering equipment. For ships above 10 000 GT, the equipment shall have concentration alarm and automatic stopping functionality. **In Special Areas, the alarm/stopping device is also required for ships between 400 and 10 000 GT**. **In the Antarctic Special Area, effluents are not permitted for discharge, regardless of concentration and equipment in use.** *Discharges from oil and oily mixtures from cargo spaces of oil tankers (wash water/slop):* Outside Special Areas, discharges are prohibited, except when having in operation an oil discharge and monitoring system securing sufficiently low concentrations and rates. **In Special Areas, effluents from cargo areas are not permitted for discharge, regardless of concentration and equipment in use.**
Noxious Liquid Substances in bulk; Annex II (1 adopted Special Area - Antarctica)	Outside Special areas, discharge of residues of classified substances, such as in tank wash water, is prohibited, except when in line with given operational requirements and discharge standards, i.e. at very low concentrations and rates. **In Special Areas, Noxious Liquid substances are not permitted for discharge, regardless of concentration and operational procedure in use.**
Sewage; Annex IV (1 adopted Special Area – Baltic Sea)	Both outside and inside Special Areas, all ships must have in use either an approved sewage treatment system, a comminuting and disinfection system, or a holding tank for retention of all sewage. Discharge of sewage is prohibited, except when: • the distance to land is more than 12 nautical miles, or • the sewage has been comminuted and disinfected in an approved system, and the distance to land is more than 3 nautical miles, or • the sewage has been through an approved sewage treatment plant, and the effluents does not produce visible floating solids nor discoloration **The additional requirement in Special Areas is only relevant for passenger ships, for which discharges will only be permitted from a sewage treatment plant that also removes nitrogen and phosphor (ref the particular challenges with eutrophication in the Baltic Sea SA)**
Garbage; Annex V (8 adopted Special Areas)	In the recently revised Annex V, similar strict regulation of garbage applies both inside and outside special areas. Basically any discharge of garbage is prohibited, except from grinded food waste and limited fractions of non-harmful cargo residues and cleaning agents in wash water, which can be discharged according to given criteria. **In Special Areas, certain additional requirements should be fulfilled before grinded food waste and non-harmful cargo residues and cleaning agents in wash water can be discharged.**
Emissions to air; Annex VI Special Areas = Emission Control Areas (ECA)	Outside ECAs (global requirements): SO_x: - Maximum 3,5% sulphur in fuel. - From 2020/25*: Maximum 0,5% sulphur in fuel

[20] An overview of the existing Special Areas (incl ECAs) is given by IMO at http://www.imo.org/OurWork/Environment/PollutionPrevention/SpecialAreasUnderMARPOL/Pages/Default.aspx

2 adopted ECAs for SO_x only. 2 adopted ECAs for both SO_x** and NO_x	(Exhaust gas cleaning accepted as an alternative to low sulfur fuel) NO_x: - Tier II emission level for machinery installed on ships after 2011 **Inside ECAs:** **SO_x:** - **Maximum 1% sulphur in fuel** - **From 2015: Maximum 0,1% sulphur in fuel** **(Exhaust gas cleaning accepted as an alternative to low sulfur fuel)** **NO_x:** - **Tier III emission level (80% reduction from tier II) for machinery installed on ships after 2016***.**
*Date TBD pending 2018 review, but 2020 will apply in EU waters **PM emissions are indirectly covered through the regulation of SO_x. ***May be delayed, pending on IMO discussions	

In addition, but not included as a specific Special Area measure, MARPOL Annex I has a separate chapter with regulation for the Antarctica, prohibiting the carriage and use of heavy grade oils.

4.1.2 Particularly Sensitive Sea Areas (PSSA)

As Special Areas, PSSAs are areas that - based on their conditions and exposure to ship traffic - needs additional protective measures under IMO. However, an important difference is that PSSA is not a measure under MARPOL, where a particular set of stricter standards apply for equipment and operational discharges. Rather, when approved as a PSSA, specific measures can be used to control the maritime activities in that area, including discharge and equipment requirements for ships of the type required in an SA (see above), and other measures such as routing measures and ship reporting systems (see Section 4.2 below).

The toolbox is thus wider and more flexible in PSSAs and depends on the particular conditions and threat from ship traffic in the area. Most importantly maybe – in contrast to Special Areas – PSSAs are not limited only to provisions for regular operational discharges, but also enables measures for prevention of acute pollution and disturbance.

The criteria for the identification of PSSAs and the criteria for the designation of Special Areas are not mutually exclusive. In many cases a Particularly Sensitive Sea Area may be identified within a Special Area and vice versa.

4.2 Other measures (Associated Protective Measures in PSSAs[21])

IMO has developed several other measures that may be used to establish protection for the marine environment from international shipping activities. When IMO Member Governments pursue such measures in conjunction with a PSSA application, they are referred to as 'Associated Protective Measures.' However, Member Governments may, alternatively, pursue such IMO measures independently in an area—without a PSSA application—and, when doing so, must present such measure(s) to the appropriate IMO bodies for approval and/or amendment.

The different measures are described in more detail in Appendix A and briefly summarized here. They include different routing measures and ship reporting systems, with the essential purpose to reduce risk of accidents; by reducing the likelihood for accidents and/or by reducing the damage potential in case something happens.

4.2.1 Routing measures

Variants of ship routeing systems have been established in most of the major shipping areas of the world today, and believed to dramatically reduce collisions and groundings. IMO's responsibility for ships' routeing is specified in SOLAS Chapter V, which recognizes the IMO as the only international body for establishing such systems.

Elements used in traffic routeing systems include:

- Traffic separation schemes and traffic lanes
- Separation zones/lines
- Roundabouts
- Inshore traffic zones
- Recommended routes
- Deep water routes
- Precautionary areas
- Area to be avoided
- Non-anchoring zones

4.2.2 Ship Reporting Systems/Vessel Traffic Services (VTS)

Vessel traffic services - VTS - are shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to

[21] It is noted that measures such as those described in this section can be applied independently of a PSSA status. This alternative will not be further elaborated on in this report.

extensive management of traffic within a port or waterway. Generally, ships entering a VTS area report to the authorities, usually by radio, and may be tracked by the VTS control centre.

A VTS can be used to operate a Ship Reporting System (SRS). SRSs increase knowledge of ship movements and can facilitate a timely response to any developing maritime emergency. A SRS will provide for covered ships to report the vessel name, radio call sign, position, course, cargo and speed to a shore-based authority and such authority should have the capability of interaction with such vessels.

SOLAS Chapter V (Safety of Navigation) states that governments may establish VTS when, in their opinion, the volume of traffic or the degree of risk justifies such services.

4.3 Assessment of applicability and effect

4.3.1 Special Areas under MARPOL

Parts of the Arctic high seas may fulfil several of the ecological and oceanographic criteria for Special Area designation, ref the review of conditions in Section 3.5.

Another question is however whether the additional requirements to operational discharges and equipment in SAs (Table 11), provide any significant improvement in pollution level and protection of the arctic marine environment compared to normal MARPOL regulations; given the particular Arctic conditions, pattern and volume of ship traffic, overlap with upcoming requirements (especially the Polar Code) and todays industry standards for ships to be operated in the Arctic.

Normal MARPOL provisions allow only limited residues of controlled substances and wastes to be discharged to sea. However, such limited and otherwise accepted discharges may be considered unacceptable when accumulated in sensitive areas to more significant amounts due to particularly high traffic volume or frequent cargo operations – hence, the establishment of SAs, with even stricter requirements. This aspect generally makes the SA tool less relevant in areas with relatively limited traffic, even if the area has its clear sensitivities.

Considering acute pollution from accidents is different, where in principle one vessel is enough to create severe environmental damage – thus special risk reducing measures may be justified even if the traffic is low, due to special characteristics of the shipping and navigational risks of a sensitive area. This is however outside scope for SAs under MARPOL, but relevant for the other tools as discussed below (PSSAs and associated protective measures).

A brief evaluation of applicability in the Arctic high seas of the SA requirements under the respective annexes (as summarized in Table 11) is given here:

Annex I (Oil), II (Chemicals) and V (Garbage)

DNV expects requirements equal to or stricter than the SA requirements to be included in the mandatory Polar Code, for instance (as per the current, MEPC 65, suggestions on the table):

- Certain categories of ships (based on the ice conditions they are allowed to operate under) may face stricter requirements than MARPOL with regard to separation from the outer shell of tanks used for the carriage of oil and oily mixtures (annex I), and noxious liquid substances (annex II).
- Zero discharge requirements may be implemented for oil and noxious liquid substances.
- Distance to ice - provisions may be implemented for discharge of food waste.

Also, for all ships, it is likely that the Polar Code will require that the oil pollution emergency plan required by MARPOL Annex I shall take into account operation in polar waters.

Moreover, the total quantities of legal operational discharges both with and without Special Area requirements in the Arctic high seas under these annexes will be very low, given the prospected shipping activity and trade pattern in the Arctic high seas (se section 3.1.2.3). Estimates of discharges in Norwegian coastal waters, with significantly heavier traffic than what can be expected in Arctic high seas, support this assumption (DNV 2009a, 2009b, 2010, 2011, 2012, 2013).

The additional SA requirements for oil filtering equipment in SA's under Annex I, should today be considered as industry standard for equipment delivered to ships; 95% of ships classed by DNV have oil filtering equipment with the extra SA required alarm functionality (DNV 2013).

DNV do not find any significant gap between the current level of environmental protection and the protection offered through the designation of Special Areas under these annexes in the Arctic high seas.

Annex IV (sewage)

Until 2011, annex IV did not have provisions for designation of Special Areas. The newly adopted Special Area provisions for regulation of sewage differs from normal sewage regulations only by requiring removal of nutrients (nitrogen and phosphor) from passenger ships' sewage when discharging in SAs.

The adoption implies that the Baltic Sea is granted such status, due to the extensive challenges with nutrient surplus and eutrophication over decades[22].

DNV has not found any information suggesting eutrophication challenges in the Arctic high seas, neither from nutrient input from shipping nor from other sources. The general assumption for these

[22] The Baltic Sea is relatively shallow and enclosed water body, serving as the recipient for nutrients from agriculture, industry and sewage from more than 80 million people. The addition of nutrients in sewage from 2000 ships on a daily basis, including nearly 100 million passengers a year, was considered to justify the additional protective SA measures in the Baltic Sea.

vast and deep sea areas with low (or no) human nutrient input, is rather that they are non-problem areas with regard to eutrophication. The same was concluded for the Norwegian parts of the North Sea in a study carried out by DNV on applicability of Annex IV SA requirements in Norwegian waters (DNV 2012). This work concluded that the relatively high ship traffic in the North Sea, including extensive passenger traffic, did not represent nutrient supplies with any significant environmental effects that would justify additional SA requirements.

There may however be areas, such as enclosed fjords in the Svalbard Archipelago, where the presence of cruise ships and discharges of treated sewage (but not with nutrient removal) may lead to local eutrophication effects throughout the season. This is however not an issue relevant for Special Area designation in the arctic high seas. In addition, an issue that is often raised with regard to sewage in the Arctic is the slow decomposition rate. This aspect is however not influenced by any additional SA requirements, but depended on the same requirements to sewage treatment systems and discharges that applies both inside and outside SAs.

DNV do not find any significant gap between the current level of environmental protection and the protection offered through the designation of Special Areas under annex IV in the Arctic high seas.

Moreover, the Polar Code will likely implement distance to ice-provisions for discharges of sewage effluents.

Annex VI (Emissions to air)

The primary negative impacts addressed by the stricter emission requirements in current ECAs, are public health effects such as respiratory diseases, and environmental effects such as acidification and eutrophication of terrestrial ecosystems and damages on forestry and crops. Typically this can apply to areas with dense human populations and vulnerable terrestrial ecosystems (primarily vegetation and freshwater systems), where extensive ship traffic in addition to high level of additive emissions and exceeded critical levels of pollution from land based sources justify stricter than the normal MARPOL requirements. In a few enclosed marine ecosystems such as the Baltic Sea, suffering from man-made nutrient surplus and high levels of pollution, the additional deposition of airborne nitrogen and sulphur from ship emissions directly to sea is also considered significant (Stipa et al. 2007).

Although the above pollution aspects are not evident in the Arctic high seas, other particular challenges from ship exhaust in the Arctic are in focus, mainly:

- Deposition black carbon (BC) may play a role in accelerated melting of ice, because such light absorbing aerosols can decrease the surface albedo (reflectivity) of ice and snow. In polar areas where the ice cover and dynamics currently is believed to be highly affected by global warming processes, this additional aspect of accelerated melting by deposition of air pollutants on ice has got special attention.

- Sulphate and other aerosols; BC and soot etc. may affect local/regional climate forcing processes by influencing solar radiation in air masses. Tropospheric ozone formed by ship generated NO_x is also of relevance for such processes. The effects in terms of regional warming/cooling are however complicated with feedbacks between aerosols, clouds, radiation, snow and ice cover, and vertical and horizontal transport processes. The relative significance of expected contribution from shipping compared to the far larger input to the Arctic from long transported emissions is not known.

The environmental and climate effects of these mechanisms in the Arctic are only beginning to be understood, and the significance and regulation of ship emissions in the Arctic setting is currently investigated by IMO. It is not clear to which degree the relatively low traffic volume in Arctic high seas, even in high case scenarios, will represent regionally accumulated or locally concentrated emissions at a level that have significance for the above challenges.

However, as DNV understands from current scientific status, this is an area of potential harm from shipping in the Arctic that is principally different from other areas, and where the strict application of MARPOL Annex VI standards (i.e. similar to ECAs), for instance as an Associated Protective Measure under PSSA, could represent a significant reduction in ship emissions. Even if the ECA requirements to NO_x and SO_x is not currently “targeted” to mitigate the specific arctic air pollution challenges, the solutions that may be applied to meet 0.1 % sulphur/NO_x Tier III, such as LNG, exhaust gas cleaning or MGO could also be beneficial in the special Arctic air pollution picture. The knowledge of this is still limited, and one should not forget about associated risk prevention perspectives, such as risk from spills of HFO versus MGO versus LNG.

Summary

DNV do generally not find any significant gap between the current level of protection offered through the designation of Special Areas in the Arctic high seas, and the normal MARPOL requirements for ships operating in the Arctic high seas. The Arctic high seas will experience relatively low ship traffic, even if the most optimistic high ship traffic scenarios become true. The reduction potential for regular operational discharges with SA designation seems low; especially if one consider the overlap with equal upcoming requirements in the Polar Code and today’s industry standards for ships to be operated in the Arctic.

In addition, the SA requirements does not provide additional protection against acute pollution (spills) from accidents, which is identified as the major threat to the vulnerability of the area (Section 3.4)

The only stricter regulation in SAs under MARPOL considered by DNV of potential significance is the ECA requirements for emissions to air (Annex VI). This may be of importance when considering mitigation of the particular arctic air pollution challenges, i.e. regional climate forcing and melting of ice from black carbon. These requirements could be investigated further as a potential associated measure under PSSA designation; however conclusions should await ongoing work in IMO on BC formation and mitigation.

4.3.2 PSSA

As far as DNV can judge, the Arctic high seas embodies several of the attributes required for PSSA designation; both with regard to ecosystem uniqueness and rarity, vulnerability to degradation and for scientific and educational significance. In addition, it is vulnerable to damage by international shipping activities; primarily by acute pollution, but also from disturbance and elements of air emissions, ref the discussion above. Another particular element of the Arctic high seas is the rate of changes, including climate changes and ice cover variation. The extreme variation in what can be expected to be open (navigational) waters and what ice covered represents particular challenges both from en ecosystem perspective and a navigational perspective.

To become a PSSA, there must be an associated protective measure with an identified legal basis that can be adopted by the IMO to prevent, reduce, or eliminate the identified vulnerability of the area. But there is a complicating issue that has to be dealt with, which is the fact that the areas for navigation will change from year to year, due to variation in ice cover, thus one could imagine a need for dynamic use of measures such as for instance routing.

In contrast to SAs, PSSA enables a more tailor-made “package” of measures, targeted to the specific ship traffic and challenges in an area. Measures that may reduce the likelihood and consequences of accidents, including areas to be avoided, can be established as part of the PSSA designation, contrary to in SAs.

Even if the developing IMO Polar Code will cover fundamental risk reducing measures with additional requirements for the safe design, construction and operation of ships in Polar areas, additional protection may be achieved by measures associated with a PSSA.

Looking at the particular characteristics of the Arctic high seas, different APMs may have different applicability:

- Measures such as traffic separation schemes, traffic lanes and separation zones/line and roundabouts are in general not regarded particularly relevant in the Arctic high seas, with few or no areas with expected high concentration of shipping activity.
- Inshore traffic zones and deep water routes are generally not relevant measures in most of the area, as it consists of no coastal waters and is typically deep or very deep waters (Figure 13).
- Non-anchoring zones is typically aimed at areas where anchoring would be common, but where anchoring will damage vulnerable natural systems, such as corals or other fragile habitats. There are no available information indicating that you will have significant conflict areas in the Arctic high seas between frequent anchoring and fragile bottom habitats.
- Areas to be avoided, recommended routes and precautionary areas could as DNV sees it be relevant to direct traffic away from certain areas posing particular risk or containing particular environmental elements. In general, areas to be avoided should be established only in places where:

  - inadequate survey or insufficient provision of aids to navigation may lead to danger of stranding;
  - where local knowledge is considered essential for safe passage;
  - where there is the possibility that unacceptable damage to the environment could result from a casualty; or
  - where there might be hazard to a vital aid to navigation.
- Ship reporting systems could be relevant in the Arctic high seas, by increasing knowledge of ship movements and risk picture, and potentially facilitating a response to developing maritime emergencies.

The potential application and adoption of PSSAs and associated measures is discussed in closer detail in Section 4.4.

4.4 Suggested approach to protecting the Arctic high seas

Based on the review of available designated area measures, combined with the environmental conditions and the potential for ship traffic of the Arctic high seas, DNV concludes that it is difficult to find support for Special Area (SA) designation under MARPOL. DNV do not generally find any significant gap in risk level and environmental protection from pollution from ships between application of Special Area requirements and application of normal MARPOL requirements in the Arctic high seas.

MARPOL SAs do not allow for tailor-made use of measures and target reductions in regular, operational emissions and discharges, rather than acute pollution. The few elements in MARPOL SA requirements identified of relevance for the Arctic high seas, are the stricter requirements for prevention of air pollution under annex VI – however if found relevant, such strict application can be included as an associated protective measure in a PSSA.

DNV further find support to pursue the application of a PSSA for providing additional protection of the Arctic high seas. The area seems to meet many of the criteria for PSSA designation:

- Firstly, there is a strong argument to be made regarding the uniqueness of the pack ice of the Arctic (Section 3.4). This alone could justify *Criterion 1* for additional protection of the area by a PSSA.
- Further, there is evidence suggesting that particular ecosystems and several species, including polar bear, ivory gull and Ross' gull, occur around the ice edge during summer in areas where future shipping activity can be expected in increase (Section 3.5). Although this shipping activity must be considered low or moderate by most standards (Section 3.1.2.3), the aforementioned biological resources could be considered vulnerable to this projected shipping activity. Thus, fulfilment of *Criterion 2* can be argued.
- Lastly, *Criterion 3* for the designation of a PSSA calls for the identification of associative protective measures (APMs) which effectively mitigates the identified threat. PSSA allows for tailor-made use of measures and may address accidental risk reduction, avoidance of disturbance and relevant aspects of reduction of regular discharges. Fulfilling this criterion is a challenge due to a key feature of the threat; the vulnerable resources are found primarily in conjunction with the moving ice edge, meaning that the location is challenging to define precisely. This challenge is due both to the strong seasonal variations in the distribution and movements of the ice and the associated species, and the basic limitation to our present knowledge on this, but also to the additional and accelerating effects of climate change. Currently, the ice edge moves hundreds of kilometers between the maximum winter ice extent and the summer minimum extent. With climate change, even the location of the maximum and minimum extents is difficult to define.

The ideal APM would follow the ice edge (and thus the vulnerable species) and route shipping away from it. This could be implemented by designating the Arctic high seas area as a PSSA in its entirety, with the APM including a VTS (vessel traffic system) and SRS (ship reporting system) to monitor traffic and enforcement of Areas to be avoided (preferably obligatory rather than recommendatory) in the PSSA. The Areas to be avoided should to be identified in a dynamic way, reflecting the movement of the ice edge and the vulnerable resources. While this could potentially provide very effective shielding of sensitive areas, it will likely be difficult to design, administrate and effectuate. One main issue is the practical problem of defining the “Area to be avoided”. This would likely call for massive knowledge gathering efforts and active monitoring of both sea ice and the relevant species e.g. by satellite tracking. This dynamic approach would probably lead to low levels of predictability for shippers planning to use the area for transit. At the same time, the Areas to be avoided should be designed as to minimize the negative effect on the freedom of movement on the high seas. It will likely be very challenging to gain political acceptance for imposing restrictions on this fundamental principle of maritime law. In the overview given in Table 12, this is Option 1.

A more moderate version of this option would be to have a PSSA where a VTS and SRS are established to monitor traffic and give guidance and advice. The PSSA status could enhance the awareness and vigilance of the mariners using the area, thereby maybe reducing the risk of accidents. However, it is clear that this option offers very limited direct added protection, and is not very targeted towards the specific challenge at hand. In the overview given in Table 12, this is Option 2.

Thus, although it is recognized that best level of protection is achieved by using a flexible targeted protection over large areas of moving ice, DNV has not, given the constraints of this project, been able to formulate a viable, practical approach to doing this. The roughly outlined approach presented as Option 1, is considered to place too big a burden on the shipping community, effectively blocking the whole high seas area during the summer and autumn months. This is a strong violation of the principle of free movement on the high seas, which do not seem to be justified by the evidence presently available.

An alternative must thus be considered which strikes a better balance between the need for protection (particularly in the future – where vulnerability could be increased, and shipping likely form a bigger threat) and the burden imposed. A proposal could then be to establish one or more “Core sea ice area” as a sanctuary for vulnerable Arctic high seas ecosystems, and to protect this vigorously. In the coming decades such a core area may become increasingly vulnerable, as it forms a unique and diminishing habitat for many of the discussed species and ecological processes. In the overview given in Table 12, this is Option 3. Although we don’t know exactly where the ice will be, we can make qualified guesses, e.g. based on modeled future ice extents (Figure 23). Furthermore, such an area may be threatened from traffic crossing directly over the pole (or very close). The associated protective measures (APM) would be to designate the PSSA covering the defined “Core sea ice area”, and impose Areas to be avoided for all ships, perhaps with the exception of Research vessels and other activities allowing for the area be open to some form of mixed use.

On the downside, this option leaves large areas left without added protection. However, it is noted that designating only a limited part of the Arctic high seas area as a PSSA could still place a massive area under protection. It is noted that the 2012 minimum ice cover was 3.61 million km^2, and even 20% of this equals an area the size of France. Furthermore, although this option does not provide perfect protection, it is politically feasible. While it will place some restrictions on the freedom of movement on the high seas, most of the Arctic high seas will is still be open, and the closed area is not likely to be of prime interest to commercial interests.

Thus, this option ensures protection of an increasingly important core area, but will likely not impede movement on the high seas which is a major principle in international law. On a final note the establishment of a PSSA has the additional benefit of being used as a framework for possible new measures, in case of unexpected increases in activity and need for protection. Such an approach is well harmonized with IMOs emphasis on the precautionary principle.

***Table 12**: Overview of discussed protection options.*

Option	***Description***	***Pros***	***Cons***
1	- The Arctic high seas area is designated a PSSA in its entirety - A VTS with SRS is established to monitor traffic. - Areas to be avoided are enforced in the PSSA in a dynamic fashion, reflecting the movement of the ice edge etc.	- Potentially very effective shielding of sensitive areas	-Likely major impact on freedom of movement on the high seas - Low levels of predictability - Difficult to administrate and effectuate
2	- The Arctic high seas area is designated an PSSA in its entirety - A VTS with SRS is established to monitor traffic and offer guidance	- The PSSA status enhances awareness and vigilance	- No direct added protection
3	- One or more “core sea ice area» is defined to establish a PSSA - Areas to be avoided enforced	- Ensures protection of an increasingly important core area. - Will likely not impede movement on the high seas.	- Large areas left without added protection

5 CONCLUSIONS AND RECOMMENDATIONS

In light of the expected increased shipping activity in the Arctic, the 2009 Arctic Marine Shipping Assessment (AMSA) Report includes recommendations for Arctic States on enhancing Arctic marine safety, protecting Arctic people and environment and building Arctic marine infrastructure.

Following up recommendation II(C) from the AMSA study, this report explores the need for internationally designated areas in the high seas area of the Arctic Ocean that warrant protection from the risks posed by international shipping activities.

Part I of this report deals with the need for protection of the high seas area and presents a description of two main issues; a) the traffic and risk levels in the Arctic Ocean high seas, present and future, and b) the vulnerability of the biological resources found in the Area. A few main findings can be highlighted:

- Present ship traffic is found to be very limited, with 0.7 ship years per annum registered from AIS data. Given the size of the area, this is very low by any standard.
- Future ship traffic is expected to increase, although the volumes are very uncertain. The *High* scenario used in this report point to an exposure of 15 ship years per annum.
- The risk of shipping accidents must be considered low in comparison with almost any other area. The return period for a serious accident in the *High* scenario is 5 years, with an expected pollution accident every 260 years.
- The most prominent natural property of the area is the sea ice conditions with strong seasonal variations. The sea ice is also changing considerably in the coming decades due to climate change.
- Even if the vulnerability of the area is evident, there are significant limitations to the present state of knowledge. In addition to the global uniqueness of the pack ice itself, it seems that the vulnerability to future shipping activity is most pronounced for polar bears and two species of gull (Table 10). They are primarily vulnerable to oil spills.

Part II of this report reviews the available IMO measures suited to protect vulnerable areas, in particular the Special Areas (SA) option and the Particularly Sensitive Sea Area (PSSA) option. Based on the review of available designated area measures, combined with the environmental conditions and the potential for ship traffic of the Arctic high seas, DNV concludes that it is difficult to find support for Special Area (SA) designation under MARPOL.

DNV further find support to pursue the application of a PSSA for providing additional protection of the Arctic high seas. Three possible avenues to pursue this option are outlined. The most feasible option may be to establish a “Core sea ice area” as a sanctuary for unique and vulnerable Arctic high seas ecosystems and species, and to protect this through a PSSA designation with Areas to be avoided as an APM. This option ensures protection of an increasingly important core area, but will likely not impede movement on the high seas which is a major principle in international law.

It is noted that the protection of the Arctic high seas area poses unique challenges, not previously encountered anywhere. The complexity of the matter includes the limited knowledge of present state, but primarily the extensive uncertainty regarding future development, both with regard to ice conditions and vulnerability, but also with regard to ship traffic. It is thus not straightforward to make recommendations. A main result of this report is in the narrowing of focus for further work. We show that SA is likely not a tool with a significant protection potential. Further we show that the PSSA "Core area protection" may be an avenue to pursue, although more work is required to make a sufficiently rigorous argument for this.

It is again emphasized that this report focuses solely on the high seas area of the Arctic Ocean. No assessment is made regarding the need to protect designated areas which are under the jurisdiction of the Arctic Ocean coastal states.

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APPENDIX A: IMO MEASURES FOR AREA-BASED PROTECTION

(Based the PAME II-2012 document "IMO Measures for Area-Based Protection" by USA Norway, Finland, Canada, Russia, Denmark & Sweden, with minor updates.)

Background

AMSA Recommendation II(D) provides that:

Arctic states should, taking into account the special characteristics of the Arctic marine environment, explore the need for internationally designated areas for the purpose of environmental protection in the regions of the Arctic Ocean. This could be done through the use of appropriate tools, such as 'Special Areas' or Particularly Sensitive Sea Areas (PSSA) designation through the International Maritime Organization (IMO) and consistent with the existing international legal framework for the Arctic.

While PAME Member Governments are awaiting finalization of the AMSA Recommendation II(C) report on areas of heightened ecological and cultural significance before more actively exploring the need for internationally designated areas for the purpose of environmental protection in regions of the Arctic Ocean through AMSA Recommendation II(D), the United States, Norway, Finland, Canada, the Russian Federation, Denmark and Sweden would like to provide information regarding measures available through the International Maritime Organization (IMO) to better inform PAME's future consideration of projects to implement AMSA Recommendation II (D).[23]

International Maritime Organization (IMO) Shipping Measures

The IMO is the United Nations' specialized agency responsible for the safety and security of shipping and the prevention of pollution from ships. Through a comprehensive body of international conventions, the IMO has developed numerous measures—both recommendatory and mandatory—that can be used to help protect the Arctic marine environment from negative effects caused by international shipping activities. These include, among others, the following:

I. Special Areas under MARPOL

ii Special Areas under Annex I, II, IV and V

The International Convention for the Prevention of Pollution from Ships ("MARPOL") provides for the designation of particular areas of the ocean as "special areas." Although MARPOL has six annexes that address marine pollution from the discharge or emission of harmful substances, special area designation is only available under Annex I (oil), Annex II (noxious liquid substances in bulk), Annex

[23] This paper and the information it contains is without prejudice to the position that a PAME member government may take regarding any future proposal for IMO measures in the Arctic region or elsewhere.

IV (sewage), and Annex V (garbage).[24] A special area is defined as "a sea area where for recognised technical reasons in relation to its oceanographical and ecological conditions and to the particular character of its traffic, the adoption of special mandatory methods for the prevention of sea pollution by oil, noxious liquid substances, sewage, or garbage, as applicable, is required."[25]

In 2002, the IMO Assembly adopted the *Guidelines for the Designation of Special Areas under MARPOL 73/78* (*Special Area Guidelines*),[26] which provide guidance to MARPOL Contracting Parties in the formulation and submission of applications for the designation of Special Areas. To obtain special area designation, a proposing government must show that the area requires a higher level of protection from ship-generated pollution than other areas, and that basic MARPOL requirements do not provide adequate protection for the identified area. A special area may encompass or straddle the maritime zones of two or more States, or even an entire enclosed or semi-enclosed marine area.

Designation of special areas is to be made on the basis of three criteria: (1) oceanographic conditions; (2) ecological conditions; and (3) vessel traffic characteristics. The first criterion, oceanographic conditions, determines whether the conditions of the area may cause harmful substances to be concentrated or retained in the waters and/or sediments of the area—including circulation patterns or stratifications (salinity or temperature), low flushing rates leading to long residence time, extreme ice state, or adverse wind conditions. The second criterion considers whether ecological conditions indicate the need to protect the area from harmful substances in order to preserve certain area resources—including endangered marine species, areas of high natural productivity, migratory routes for sea birds, and critical habitats for fish stocks. The last of the three criteria, vessel traffic characteristics, asks whether the vessel traffic of the area is such that MARPOL requirements for areas other than special areas would be insufficient to control the discharge of harmful substances by ships given the oceanographic and ecological conditions of the area. Information on the availability of adequate reception facilities in the proposed Special Area is also taken into consideration in the review of a Special Area proposal as adequate port waste reception facilities are one of the necessary preconditions for bringing into effect Special Areas adopted by the IMO.

Unlike PSSA designation, Special Area designation is effected through an amendment to the respective MARPOL Annex. A MARPOL Contracting Party(ies) may submit to MEPC, for its consideration, a proposal to designate a given sea area as a Special Area.[27] The Special Area proposal should contain a draft amendment to MARPOL 73/78 as the formal basis for designation, and a background document setting forth all the relevant information to demonstrate that the area fulfills the

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[24] *See* Report of the Marine Environment Protection Committee on its Sixty-Third Session, *approved* Mar. 14, 2012, IMO MEPC 63/23/Add.1, annex 27 [hereinafter *2013 Special Area Guidelines*].
[25] *Id.* at 2.1.
[26] *See Guidelines for the Designation of Special Areas Under MARPOL 73/78 and Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas*, *adopted* Jan. 15 2002, IMO Resolution A.927(22), annex I [hereinafter *Special Area Guidelines*]. MEPC 63 approved revised Guidelines for Special Areas in 2012. *See 2013 Special Area Guidelines*, *supra* note 26.
[27] *Id.* at 3.1.

criteria put forth in the *Special Area Guidelines*. "The formal amendment procedure applicable to proposals for the designation of Special Areas is set out in article 16 of MARPOL 73/78."[28]

Special Areas under Annex VI: Emission Control Areas (ECA)

MARPOL Annex VI provides for the designation of Emission Control Areas (ECA): areas where the adoption of special mandatory measures for emissions from ships is required to prevent, reduce, and control air pollution from nitrogen oxides (NO_x), or sulphur oxides (SO_x) and particulate matter, or all three types of emissions.[29] ECAs are designed to prevent, reduce, and control air pollution from ship emissions as well as adverse impacts on land and sea areas, as well as human health, caused by such emissions. MARPOL Annex VI imposes a global, and gradually declining, cap on sulphur content in fuel used onboard any ship[30] as well as a significantly lower cap for ships operating within a designated ECA.[31] An alternative to the low-sulphur fuel requirement is the use of an exhaust gas cleaning system or other technological methods that equivalently limit SO_x emissions within an ECA. Annex VI similarly imposes caps on nitrogen emissions and particulate matter, with more stringent standards in designated ECAs, and prohibits any deliberate emission of ozone-depleting substances

Appendix III to MARPOL Annex VI provides a list of criteria that must be fulfilled in order to obtain ECA designation. Criteria include such things as information pertinent to the meteorological conditions of the area, the nature of the ship traffic, and assessment of the types of pollutants from ships operating in the area.

Similar to a Special Area designation, the designation of an ECA is effected through an amendment to MARPOL Annex VI. A Contracting Party(ies) to Annex VI may submit an ECA designation proposal to the IMO for its consideration.[32] "The formal amendment procedure applicable to proposals for the designation of ECAs is set out in article 16 of MARPOL 73/78."[33] To date, the IMO has agreed to four proposals submitted pursuant to this provision, establishing two Sulfur Emission Control Areas in the Baltic Sea and the North Sea and English Channel, and two Emission Control Areas in North America and the U.S. Caribbean waters around Puerto Rico and the U.S. Virgin Islands.[34,35]

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[28] *Id*. at 3.4; *see also* MARPOL 73/78, *supra* note 14, art. 16.
[29] *See* MARPOL 73/78, *supra* note 14, annex VI, reg. 2, para. 8.
[30] The global cap on sulphur content in onboard fuel was originally set at 4.5%, was reduced to 3.5%, effective January 1, 2012, and is set to be reduced to 0.5% in 2020. *See id.* annex VI, reg. 14.
[31] The current global cap on sulphur content in onboard fuel for vessels operating within an ECA is set at 1.0% and is set to be lowered to 0.1% in January of 2015. *See id.*
[32] MARPOL 73/78, *supra* note 14, annex VI, app. III, para. 2.2.
[33] *Id*. para. 4.3.
[34] *North American emission control area comes into effect on 1 August 2012*, http://www.imo.org/MediaCentre/PressBriefings/Pages/28-eca.aspx.
[35] Further information is available from the U.S. Environmental Protection Agency's website for Ocean Vessels and Large Ships: http://www.epa.gov/otaq/oceanvessels.htm#north-american and http://www.epa.gov/otaq/regs/nonroad/marine/ci/420f11024.pdf.

II. Particularly Sensitive Sea Areas

A Particularly Sensitive Sea Area (PSSA) is an area of the marine environment that merits special protection through action by the IMO because of its significance for recognized ecological, socio-economic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities. To date, the IMO has designated 13 PSSAs worldwide.[36] In 2005, the IMO Assembly adopted the *Revised Guidelines for the Identification and Designation of PSSAs* (*Revised PSSA Guidelines*).[37] The *Revised PSSA Guidelines* provide guidance to IMO Member Governments in the development, drafting, and submission of PSSA proposals, and provide the IMO with the assessment criteria for such proposals.[38]

A. Identifying a potential PSSA

The *Revised PSSA Guidelines* set forth detailed requirements that must be included in an application for PSSA designation. To be identified as a PSSA, three elements must be present: (1) the area must have certain attributes as identified by the *Revised PSSA Guidelines*; (2) the area must be vulnerable to damage by international shipping activities; and (3) there must be an associated protective measure with an identified legal basis that can be adopted by the IMO to prevent, reduce, or eliminate the identified vulnerability of the area.[39]

To satisfy the first required element above, the area must meet at least one of the following criteria: (1) ecological criteria such as uniqueness or rarity of an ecosystem, diversity of an ecosystem, or an ecosystem's vulnerability to degradation by natural events or human activity; (2) social, cultural and economic criteria such as the significance of the area for recreation and/or tourism; and (3) scientific and educational criteria such as the provision of baseline criteria for biota.

B. Process for the designation of PSSAs

An IMO Member Government may submit a PSSA application to the IMO's Marine Environment Protection Committee (MEPC), which meets approximately every eight months.[40] It is important to note that a PSSA designation is not a stand-alone measure—it can only be achieved in connection with one or more associated protective measures (APM) that are to be, or have been, approved by the IMO.

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[36] The 13 PSSA designations include: Great Barrier Reef, Sabana-Camaguey Archipelago, Malpelo Islands, the sea area around the Florida Keys, Wadden Sea, Paracas National Reserve, Western European Waters, Torres Strait, Canary Islands, Galapagos Archipelago, Baltic Sea area, Papahānaumokuākea Marine National Monument, and the Strait of Bonifacio. *See Particularly Sensitive Sea Areas*, IMO, http://www.imo.org/OurWork/Environment/Pollution Prevention/PSSAs/Pages/Default.aspx (last visited June 12, 2012).

[37] *See Revised Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas, adopted* Dec. 1, 2005, IMO Resolution A.982(24) [hereinafter *Revised PSSA Guidelines*].

[38] *See also Guidance Document for Submission of PSSA Proposals to IMO*, MEPC.1/Circ.510 (May 10, 2006) [hereinafter *PSSA Proposal Guidance Document*] (providing guidance to assist IMO Member Governments in meeting the requirements of the revised 2005 PSSA Guidelines, resolution A.982(24)).

[39] *See id.* at 1.2.

[40] Nothing would appear to preclude any IMO Member Government, regardless of whether they border the area of the High Seas included in the PSSA proposal, from submitting a PSSA proposal to MEPC. However, such a proposal is more likely to be favorably received if bordering States are co-sponsors.

APMs are indispensable to a PSSA in that they “define the means by and the extent to which a PSSA is protected against environmental threats posed by international shipping.”[41] Thus, any PSSA application must contain a proposal(s) for at least one APM that the IMO Member Government intends to submit to the appropriate IMO body. If APMs are already located within the area proposed for designation as a PSSA,[42] then the PSSA application must identify the threat of or actual damage being caused and show how the area is already being protected from such identified vulnerability by the existing APM. The MEPC will not make a final decision on PSSA designation until the accompanying APM(s) is considered and adopted by the Maritime Safety Committee (MSC). Once MSC adopts the APMs, MEPC will formally designate the area an official PSSA through a formal resolution.

Available measures fall into two general categories: (A) Navigational Aids (ships’ routing systems and ship reporting systems); and (B) Strict application of discharge restrictions under MARPOL (as in Special Areas/ECAs).

I. Routing Measures and Ship Reporting Systems – Navigational aids without PSSA designation

The IMO has developed an array of measures in addition to PSSAs that may be used to establish protections for the marine environment from international shipping activities. When IMO Member Governments pursue such measures in conjunction with a PSSA application, they are referred to as ‘associated protective measures.’ However, Member Governments may, alternatively, pursue such IMO measures independently in an area—without a PSSA application—and, when doing so, must present such measure(s) to the appropriate IMO bodies for approval and/or amendment.

Ships’ Routeing Systems

Regulation 10 of Chapter V of the *International Convention for the Safety of Life at Sea* (SOLAS), as amended, provides for the establishment of ships’ routeing systems and recognizes the IMO as the only international body with the authority to develop guidelines, criteria, and regulations at the international level for ships routeing systems.[43] Ships’ routeing systems are systems of predetermined routes and corollary measures that are “recommended for use by, and may be made mandatory for, all ships, certain categories of ships or ships carrying certain cargoes when adopted and implemented in accordance with the guidelines and criteria developed by the [IMO]” and are designed to “contribute to the safety of life at sea, safety and efficiency of navigation, and/or protection of the marine

[41] Markus J. Kachel, *Particularly Sensitive Sea Areas: The IMO’s Role in Protecting Vulnerable Marine Areas*, 13 HAMBURG STUDIES ON MARITIME AFFAIRS, 2008, at 1, 184-85.
[42] Protective measures may be established to protect an area in the absence of, or prior to, PSSA designation. *See Revised PSSA Guidelines*, *supra* note 3, at 7.2; *see also infra* at Section II, Other IMO Tools.
[43] *See International Convention for the Safety of Life at Sea*, Nov. 1, 1974, 1184 U.N.T.S. 2, ch. V, reg. 10. [hereinafter SOLAS].

environment."[44] The *General Provisions on Ships' Routeing*[45] recognize the following measures as ships' routeing systems:

1. *Area To Be Avoided*

An "Area to be Avoided" (ATBA) is an area within defined limits that should be avoided by all ships or certain classes of ships, in which navigation is particularly hazardous or in which it is exceptionally important to avoid casualties.[46] In general, ATBAs should be established only in places where:

- inadequate survey or insufficient provision of aids to navigation may lead to danger of stranding;
- where local knowledge is considered essential for safe passage;
- where there is the possibility that unacceptable damage to the environment could result from a casualty; or
- where there might be hazard to a vital aid to navigation.

2. *No-Anchoring Area*

A No-Anchoring Area is an area "within defined limits where anchoring is hazardous or could result in unacceptable damage to the marine environment. Anchoring in a no-anchoring area should be avoided by all ships or certain classes of ships, except in cases of immediate danger to the ship or the persons onboard."[47]

3. *Traffic Separation Scheme*

A Traffic Separation Scheme separates opposing streams of vessel traffic, and segregates inshore traffic, by appropriate means—for example, separations lines or zones—and by the establishment of traffic lanes.[48] Additional lanes may be provided within a traffic separation scheme for ships carrying hazardous liquid substances in bulk, as specified by the *International Convention for the Prevention of Marine Pollution from Ships* ("MARPOL").[49]

4. *Recommended Track*

[44] *Id.* ch. V, reg. 10, para. 1.
[45] *General Provisions on Ships' Routeing*, *adopted* Nov. 20, 1985, IMO Resolution A.572(14), as amended [hereinafter *Ships' Routeing*].
[46] *Id.* at 2.1.13.
[47] *See id.* at 2.1.14; *see also id.* at 5.6 (providing guidance on the planning of No-Anchoring Areas).
[48] *See id.* at 2.1.3, 6.8-6.11.
[49] *International Convention for the Prevention of Marine Pollution from Ships*, Nov. 2, 1973, 1340 U.N.T.S. 184, *as modified by Protocol*, Feb. 17, 1978, 1340 U.N.T.S. 61 [hereinafter MARPOL 73/78].

A Recommended Track is a "route that has been specially examined to ensure so far as possible that it is free of dangers and along which ships are advised to navigate."[50]

5. *Two-Way Route*

A Two-Way Route is a "route within defined limits inside which two-way traffic is established, aimed at providing safe passage of ships through waters where navigation is difficult or dangerous."[51]

6. *Inshore Traffic Zone*

An Inshore Traffic Zone is a "routeing measure comprising a designated area between the landward boundary of a traffic separation scheme and the adjacent coast, to be used in accordance with the provisions of Rule 10(d), as amended, of the *International Regulations for Preventing Collisions as Sea, 1972* [COLREGS]."[52]

7. *Roundabout*

A Roundabout is a "routeing measure comprising a separation point or circular separation zone and a circular traffic lane within defined limits. Traffic within the roundabout is separated by moving in a counterclockwise direction around the separation point or zone."[53]

8. *Precautionary Area*

A Precautionary Area is a "routeing measure comprising an area within defined limits where ships must navigate with particular caution and within which the direction of traffic flow may be recommended."[54]

9. *Deep-Water Route*

A Deep-Water Route is a "route within defined limits which has been accurately surveyed for clearance of sea bottom and submerged obstacles as indicated on the chart."[55]

Ship Reporting Systems

Ship reporting systems (SRSs) are designed to provide coastal States with notice of the presence of all or specified categories of ships within a specific zone of adjacent waters.[56] In general, SRSs increase knowledge of ship movements and can facilitate a timely response to any developing maritime emergency. A SRS will provide for covered ships to report the vessel name, radio call sign, position, course, and speed to a shore-based authority and such authority should have the capability of

[50] *Ships' Routeing*, *supra* note 11, at 2.1.10.
[51] *Id.* at 2.1.8.
[52] *Id.* at 2.1.7 (emphasis added).
[53] *Id.* at 2.1.6.
[54] *Id.* at 2.1.12.
[55] *Id.* at 2.1.11.
[56] JULIAN ROBERTS, MARINE ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION: THE APPLICATION AND FUTURE DEVELOPMENT OF THE IMO'S PARTICULARLY SENSITIVE SEA AREA CONCEPT 129 (2007).

interaction with such vessels. Regulation 11 of SOLAS, as amended, provides for the establishment of ship reporting systems and recognizes the IMO as the only international body for developing guidelines, criteria, and regulations on an international level for SRSs.[57] The IMO *SRS Guidelines* set forth guidelines for voluntary systems as well as the criteria for the development of mandatory systems[58] for "all ships, certain categories of ships or ships carrying certain cargoes."[59]

Summary

As noted, AMSA Recommendation II(D) calls on PAME Member Governments to explore internationally designated areas through the IMO in order to protect the environment from shipping in the Arctic Ocean. This paper serves to provide background information on the measures available at the IMO to better inform PAME's future discussions and recommendations regarding the need for enhanced protection for one or more areas of the high seas within the Arctic marine environment consistent with international law.

[57] *See* SOLAS, *supra* note 8, ch. V, reg. 11.
[58] *See Guidelines and Criteria for Ship Reporting Systems*, *adopted* Dec. 9 1994, IMO Resolution MSC.43(64) [hereinafter *SRS Guidelines*].
[59] SOLAS, *supra* note 9, ch. V, reg. 11, para. 1.

APPENDIX B: GLOBAL ACCIDENT FREQUENCIES PER SHIP TYPE

Vessel category A1 (tank)

Considering tanker vessels in isolation (*Table 13*), we find that an accident rate of 136 accidents per 10 000 ship years, or 108 when removing Wrecked/Stranded (W/S) incidents. Pollution incidents are more than twice as frequent for this ship type compared to the cargo fleet as a whole, with 8.2 per 10 000 ship years. The distribution of incidents on the different accident categories resembles the cargo fleet. The distribution of incidents with pollution on the different accident categories (*Table 14*) resemble the cargo fleet, although more incidents are related to collisions, and fewer related to W/S.

Table 13: Frequency of Incidents, tank ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.8
	Total loss	3.3
Fire/Explosion	Serious accident	15.9
	Total loss	4.4
Collision	Serious accident	28.1
	Total loss	1.3
Contact	Serious accident	7.4
	Total loss	0.2
Wrecked/Stranded	Serious accident	24.9
	Total loss	3.1
Hull/Machinery damage	Serious accident	45.4
	Total loss	1.2
Sum		136

Table 14: Frequency of Pollution Incidents, tank ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.2
	Total loss	0.4
Fire/Explosion	Serious accident	0.1
	Total loss	0.2
Collision	Serious accident	3.5
	Total loss	0.2
Contact	Serious accident	1.0
	Total loss	-
Wrecked/Stranded	Serious accident	1.1
	Total loss	0.6
Hull/Machinery damage	Serious accident	0.9
	Total loss	0.1
Sum		0.2

Vessel category A2 (Bulk)
For bulk vessels (*Table 15*) we find that an accident rate of 217 accidents per 10 000 ship years, or 159 when removing W/S incidents. Pollution incidents are on par with the cargo fleet average with 3.2 per 10 000 ship years. The distribution of incidents on the different accident categories resembles the cargo fleet average. The distribution of incidents with pollution (*Table 16*) on the different accident categories resemble the cargo fleet average, although more incidents are related to W/S, and fewer related to collisions.

Table 15: Frequency of Incidents, bulk ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.7
	Total loss	6.9
Fire/Explosion	Serious accident	13.5
	Total loss	3.1
Collision	Serious accident	37.3
	Total loss	3.3
Contact	Serious accident	17.7
	Total loss	0.7
Wrecked/Stranded	Serious accident	51.3
	Total loss	7.2
Hull/Machinery damage	Serious accident	72.3
	Total loss	3.2
Sum		217.2

Table 16: Frequency of Pollution Incidents, tank ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.1
	Total loss	0.2
Fire/Explosion	Serious accident	-
	Total loss	-
Collision	Serious accident	0.6
	Total loss	0.3
Contact	Serious accident	0.4
	Total loss	0.1
Wrecked/Stranded	Serious accident	0.5
	Total loss	0.9
Hull/Machinery damage	Serious accident	0.3
	Total loss	-
Sum		3.2

Vessel category A33 (Container)

Container vessels (*Table 17*) show an accident rate of 222 accidents per 10 000 ship years, or 182 when removing W/S incidents. Pollution incidents are on par with the cargo fleet average with 4 per 10 000 ship years. The distribution of incidents on the different accident categories resembles the cargo fleet average, although more accidents fall in the Collision category. The distribution of incidents with pollution (*Table 18*) on the different accident categories resembles the cargo fleet average, although more incidents are related to contact.

Table 17: Frequency of Incidents, container ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	0.6
	Total loss	2.1
Fire/Explosion	Serious accident	20.3
	Total loss	1.9
Collision	Serious accident	61.2
	Total loss	1.5
Contact	Serious accident	18.8
	Total loss	-
Wrecked/Stranded	Serious accident	38.2
	Total loss	2.4
Hull/Machinery damage	Serious accident	74.2
	Total loss	1.0
Sum		222.2

Table 18: Frequency of Pollution Incidents, container ships (per 10 000 ship years)

Accident type	Severity	Frequency
Foundered	Serious accident	-
	Total loss	-
Fire/Explosion	Serious accident	-
	Total loss	-
Collision	Serious accident	1.3
	Total loss	0.1
Contact	Serious accident	1.0
	Total loss	-
Wrecked/Stranded	Serious accident	0.7
	Total loss	0.4
Hull/Machinery damage	Serious accident	0.3
	Total loss	-
Sum		4.0

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