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DRAFT 2

Report

SPECIALLY DESIGNATED ARCTIC MARINE AREAS

KLIMA- OG FORURENSNINGSDIREKTORATET

REPORT NO./DNV REG NO.: / **17JTM1D-26**
REV DRAFT 1, 2013-04-23

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Date of Current Issue:		Project No.:	PP072994
Revision No.:	DRAFT 1	Organisation Unit:	Environment and Energy Efficiency
DNV Reg. No.:	17JTM1D-26	Report No.:	

Summary:

---To be included in the final version of the report---

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- ☐ Unrestricted distribution (internal and external)
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- ☐ Limited distribution within DNV after 3 years
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- ☐ Secret

Keywords

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
Draft 1	16-05-13		M. Eide	-	-
Draft 1b	03-06-13	Minor updates based on feedback from co-leads	M. Eide	-	-
Draft 1c	04-06-13	AIS data corrected	M. Eide	-	-
Draft 2		Major updates	M. Eide		

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1 EXECUTIVE SUMMARY

---To be included in the final version of the report---

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 expectations to increasing 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.

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 Climate and Pollution Agency (Klif) has retained DNV to carry out this study.

The first part of the objective, to explore the need for environmental protection from the threat posed by international shipping activities, is addressed in two analytical steps in this report (Section 0). Step 1 is to assess the vulnerability of the high seas area of the Arctic Ocean. This will be a summary of the relevant findings of the PAME II(C) report /1/. Step 2 is to assess the degree to which the vulnerability of the 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.

The second part of the objective, to make recommendations as appropriate regarding 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). 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 (e.g., 2009 *Guidelines for Ships Operating in Polar Waters*), as well as ongoing initiatives to protect the area, e.g., the 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 shows and overview of the key analytical steps in this report, as outlined above.

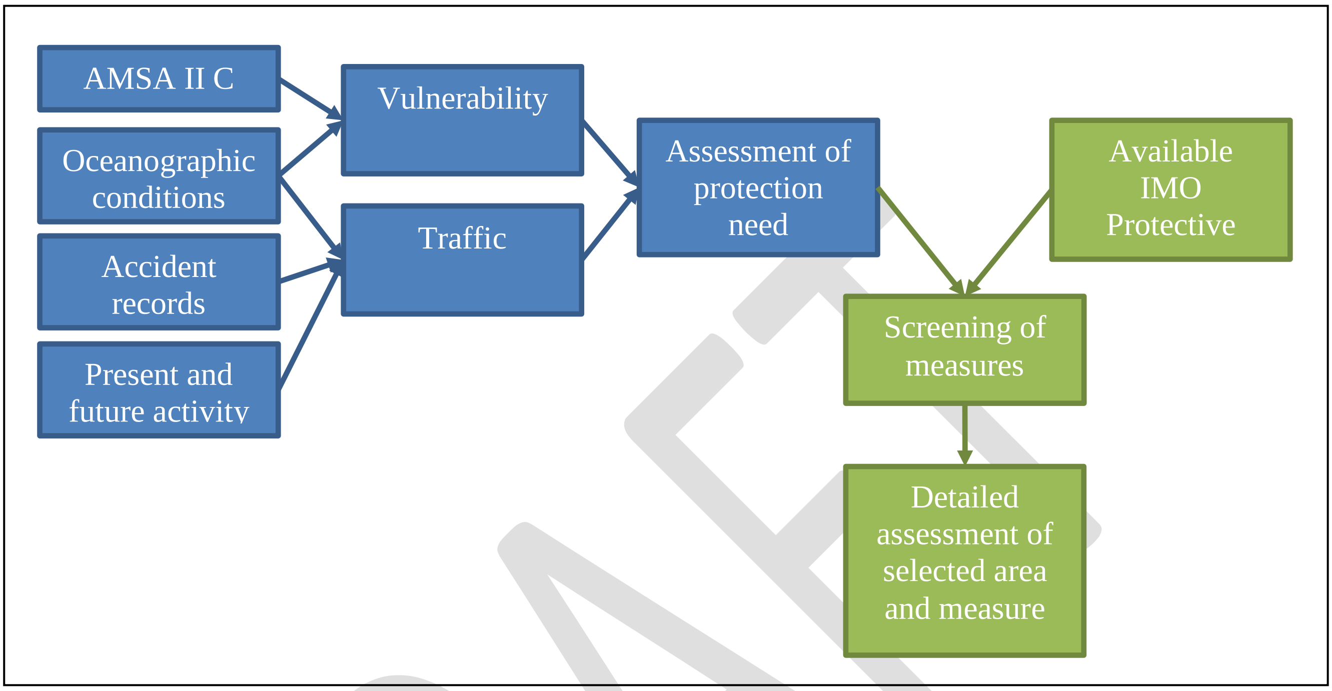

Figure 1: Overview of key analytical steps.

2.1 Definition of the Arctic high seas

Under the UN Convention on the Law of the Sea (UNCLOS) Article 86, the Arctic high seas are areas of the Arctic Ocean beyond national jurisdiction, i.e. "part 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). Under UNCLOS and customary international law, coastal States have certain sovereign rights, duties, and jurisdiction in their territorial seas, EEZ's. These maritime zones are measured from the territorial sea baselines. UNCLOS sets forth the rules on setting such baselines.
Where baselines may be validly set has been contentious. For purposes of this study, Arctic States' claimed baselines are used.[1]

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).

[1] The definitions are used without prejudice to the position of DNV or any PAME member government on the consistency of such claimed baselines with applicable international law.

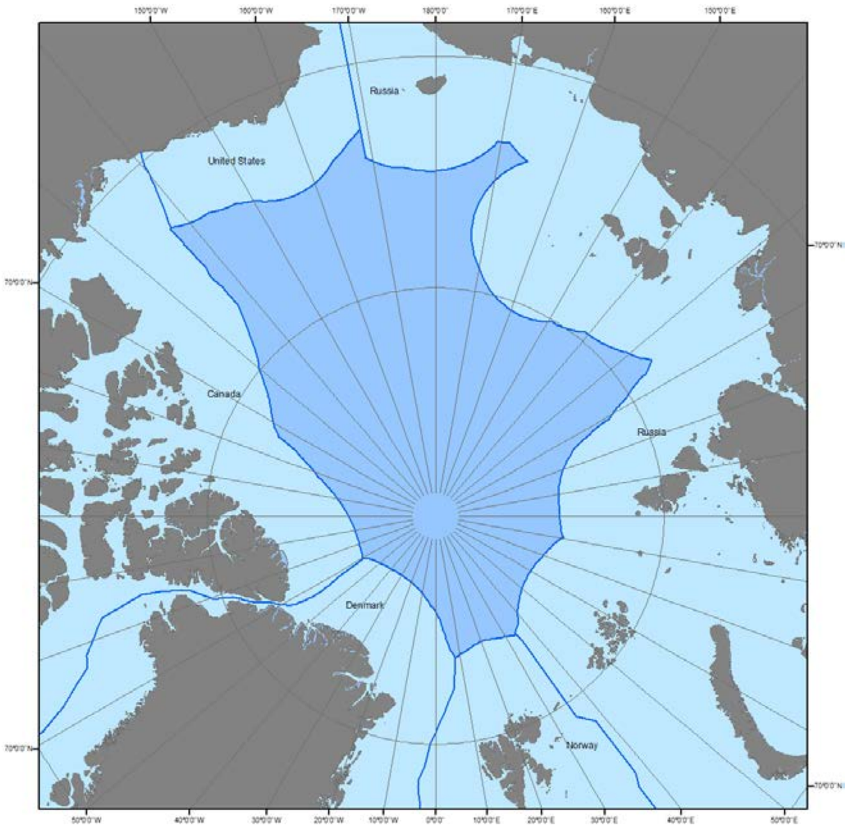

Figure 2 The Arctic High Seas (Source; DNV using data from http://www.marineregions.org per 12. December 2012).

3 PART I: THE NEED FOR PROTECTION

3.1 Shipping traffic in the Arctic High Seas

3.1.1 Current traffic

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'. The passenger vessels 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 in the area (ca. 9 months) (Table 2). The total distance sailed was 30,072 nm (Table 3). Activity shows a marked peak in the summer months, with no activity in November through May (Figure 3).

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	**0**	**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	**0**	**894**	**10 105**	**19 073**	**30 072**

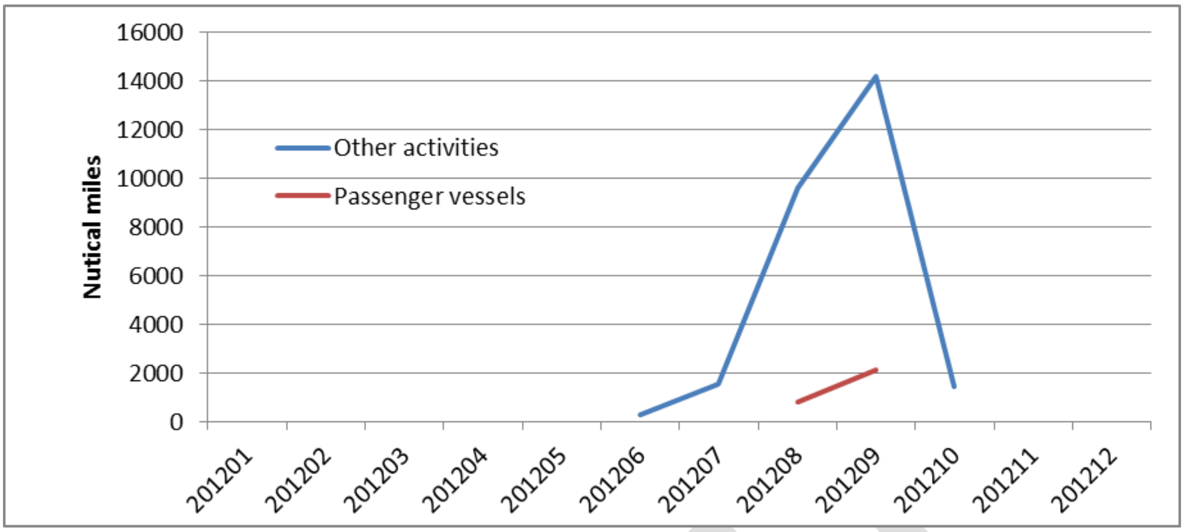

Figure 3: Distance sailed (nautical miles) in the Arctic High seas, per month in 2012

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.

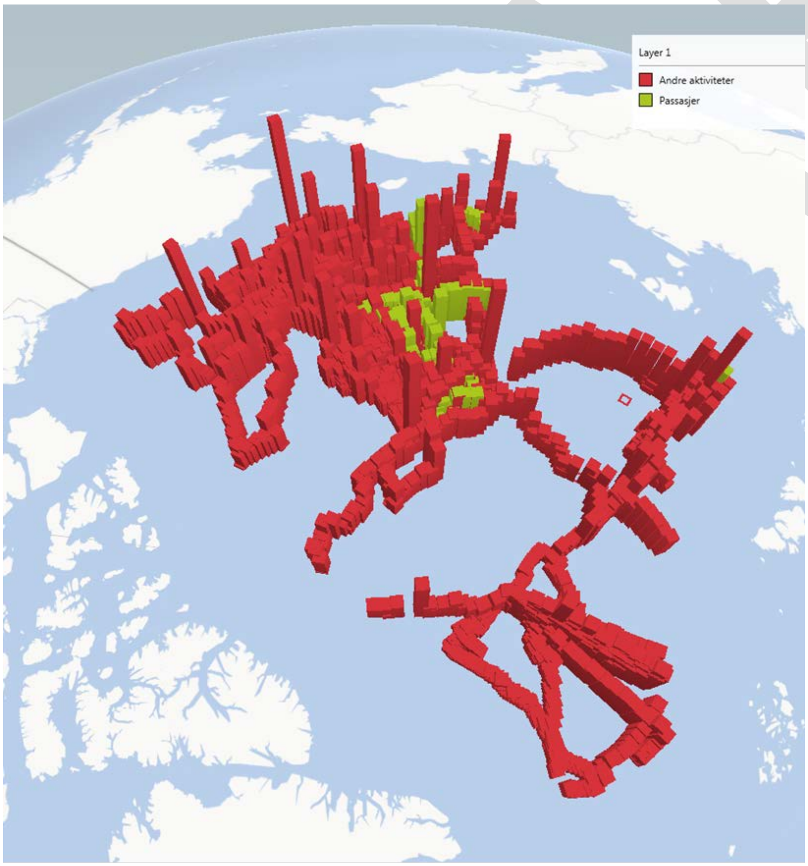

Figure 4: Geographical traffic distribution on the Arctic High seas in 2012. (Distance sailed (nm) per 1°x1° grid cell).

3.1.2 Future traffic

Current traffic in the Arctic Ocean High Seas is limited to research and tourism activity. There is no registered AIS activity from cargo vessels or from fishing vessels, or from oil and gas offshore exploration. Future activity will likely entail a continuation or increase in research and tourism activity as well as potentially significant new cargo ship activity.

Because of the seabed properties of the Arctic Ocean High Seas future activity related to oil and gas offshore exploration or extraction 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.

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 peripheral land masses will likely follow routes outside the Arctic Ocean High Seas.

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. 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 found in the literature. The scenarios will be used to assess the threat from shipping in the Arctic Ocean High Seas.

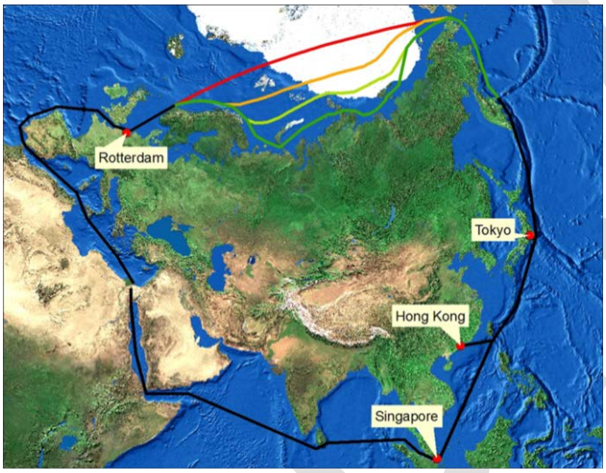

Figure 5: Possible Arctic transit routes vs. the Suez Canal route offers up to 40% reduced travel distance.

3.1.2.1 Review of published studies

This section provides an overview of available literature on future Arctic shipping activity, and discusses in particular the possible traffic in the Arctic High Seas. Broadly speaking, two types of studies have been identified; Some studies makes assessment on the ice cover, the navigation season and the accessibility for different ship types, without making explicit estimates for 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). A few studies explicitly assess the potential for future traffic volumes (Paxian et al., 2010; Corbett et al., 2010; Peters et al. 2011).

3.1.2.1.1 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 8 shows that there is a large spread of hindcasts and future trajectories.

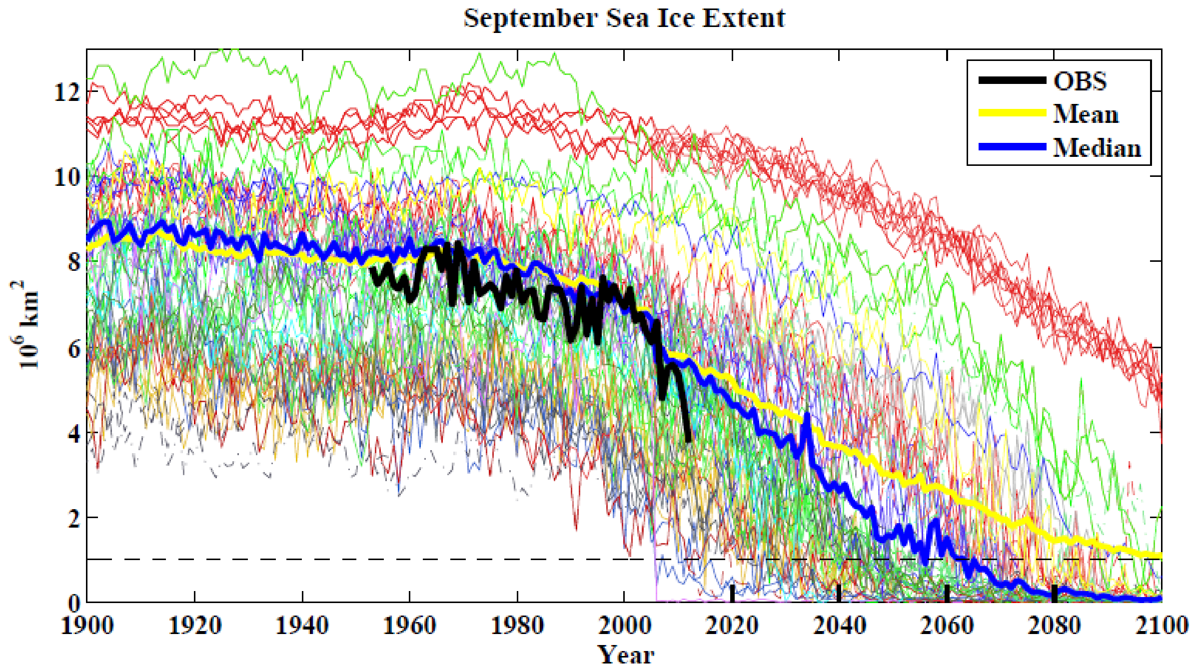

Figure 6: Simulated September sea ice extent based on 89 ensemble members from 36 CMIP5 models under the RCP8.5 (high) emissions scenario. Each thin colored line represents one ensemble member from the model. The thick yellow line is the arithmetic mean of all ensemble members and the blue line is their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

One set of projections estimate 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 of 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.

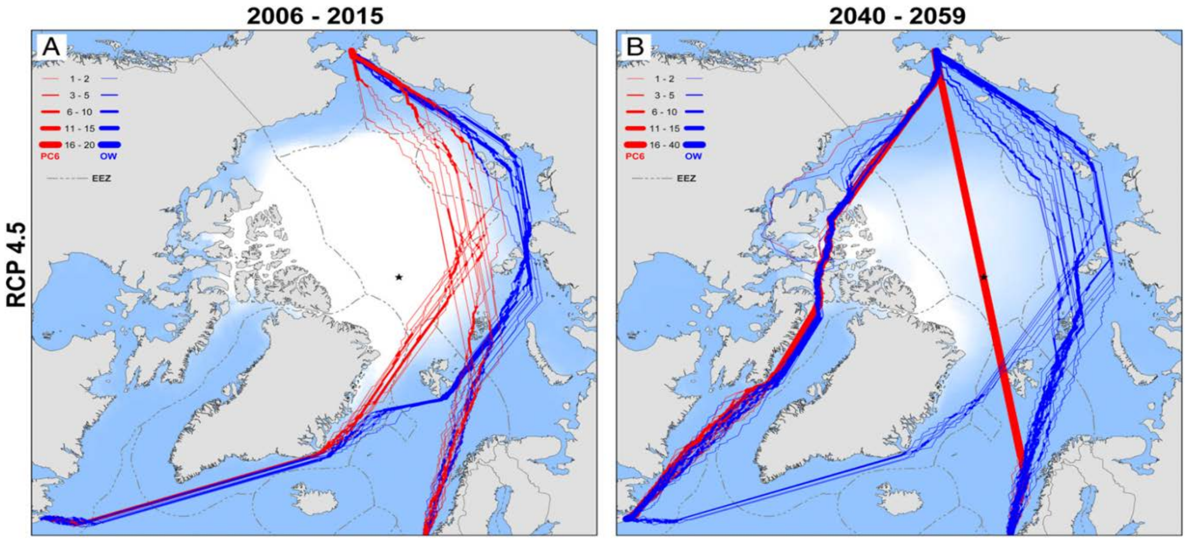

Figure 7: ATAM-derived optimal September navigation routes for hypothetical ships seeking to cross the Arctic Ocean between the North Atlantic and the Pacific (Bering Strait) during historical baseline conditions (consecutive years 1979– 2005) as driven by ensemble-average GCM projections of sea ice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

3.1.2.1.2 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).

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 increasing 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 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

Peters et al. (2011) presents 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) find 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 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.

Paxian et al. (2010) give a range of 0.73–1.28 Mt 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 CO2 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 CO2 emissions from Arctic container traffic in 2030 are 4.8 and 7.7 Mt CO2 for a "business as usual" and high growth scenario, respectively, and for 2050 they estimate 12 and 26 Mt CO2. 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) indicating 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 ship performance and economic costs of shipping, their estimate of 960 transits can be used as a high bound for the traffic.

3.1.2.2 Scenarios for future Arctic Ocean High Seas shipping activity

The above review of the available 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 forecasting 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), 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).

We chose to concentrate on the year 2030. This is 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. 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. In sum, 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 that 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 relating 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.

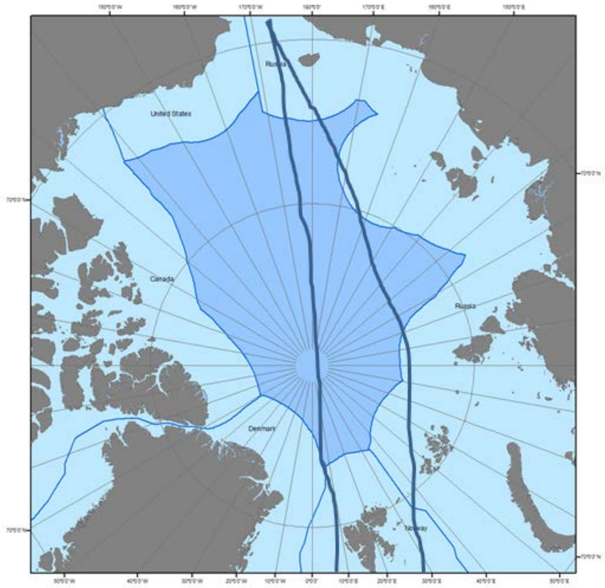

Figure 8: Assumed transit routes across the Arctic High Seas, showing the route across the Pole, as well as a Peripheral route. The assumed routes are used in Table 4 to calculate transit duration times.

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[2]. 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).

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

[2] 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)

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.

Table 4: Activity[3] and accumulated time in the Arctic High Seas (AHS) under the different scenarios.

Scenario	Activity Type	Number of transits	Distance within AHS[4]	Speed	Time in AHS per transit	Accumulated time in AHS		
			(nm[5])	(knots)	(hours)	(hours)	(years)	
Low	Research/Tourism	-	-	-	-	13140	1.5	1.5
	Transit - Pole	-	-	-	-	-	-	
	Transit - Periphery	-	-	-	-	-	-	
Medium	Research/Tourism	-	-	-	-	17520	2	6.5
	Transit - Pole	30	1200	8	150	4500	0.5	
	Transit - Periphery	450	620	8	78	34875	4.0	
High	Research/Tourism	-	-	-	-	26280	3	14.8
	Transit - Pole	400	1200	8	150	60000	6.8	
	Transit - Periphery	560	620	8	78	43400	5.0	

3 In 2012, 46 commercial ships made the passage. Petroleum products constituted the largest cargo group. http://barentsobserver.com/en/arctic/2012/11/46-vessels-through-northern-sea-route-23-11
4 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
5 1 kilometer = 0.54 nautical miles

3.2 Risk of accidents in the Arctic High Seas

3.2.1 Historic record of accidents

The following section describes the analysis of available existing information on shipping accidents and incidents 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.

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, Denmark (Greenland). 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

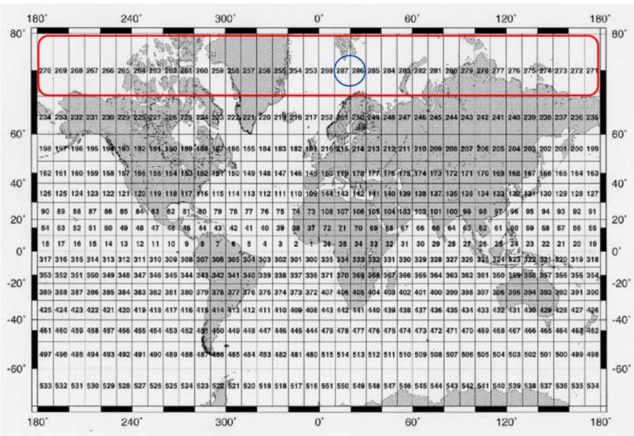

Figure 9: Area of analysis in the IHS database.

The IHS Fairplay contains worldwide occurred 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[6]. The data from the squares covering the area north of 70 degrees (marked with read in Figure 9) have been analyzed. The Marsden squares are allocated a number from 1 to 288 and from 300 to 551, plus an extension of the sequence to 936 in higher latitudes.

We first identify only accidents with environmental consequences (reported oil spill) have been considered. 5 such incidents are found, see Table 5. We find that all the accidents occurred within Marsden squares 287 and 286 (marked in blue in Figure 9). We further find that no reported accidents above of 80 degrees north (squares from 253 – 288) are reported, regardless of consequence category.

Thus, we find that no accidents have been reported for the Arctic High Seas from this dataset.

[6] 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.

Table 5: Accidents with reported oil spill north of 70 degrees from 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/incidents in the database of the Transportation Safety Board of Canada from 2001 to 2010 have been analyzed in this study. No distinction is 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.

We find that a total of 66 accidents or incidents have been reported in the 10 year period analyzed. However, we find that no accidents have been reported for the Arctic High Seas from this dataset.

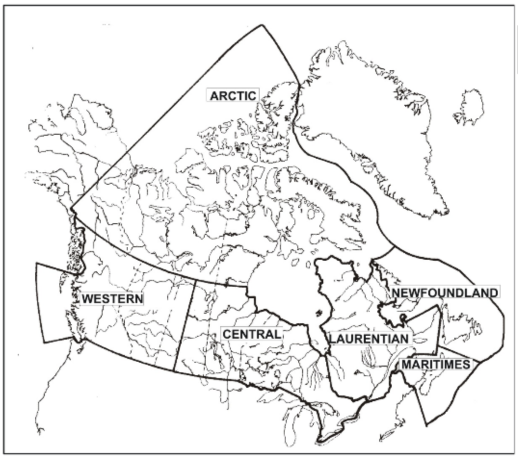

Figure 10: Area of analysis in the Canadian database.

3.2.1.3 Danish Maritime Authority – Greenland waters

All accidents/incidents in Greenlandic waters from 2000 to 2006 have been analyzed based on the data from the Danish Maritime Authority. We find a total of 38 accidents reported. No groundings were reported on the Greenlandic east cost only 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) occurred in Norwegian territorial waters and of Norwegian nationality vessels trading worldwide. All reported accidents / incidents reported north of 66 degrees (Arctic Circle) have been analyzed in this study, covering the period from 1981 to 2011. A total of 2390 accidents have been reported (Table 6). However the northernmost accident reported is located just north of Svalbard, well outside the bounds of the High Seas (marked on the map in Figure 11).

Table 6: Number of accidents per accident category, from Norwegian Maritime Directorate, 1981-2011.

Accident category	Number of accidents
Ships sunk / total loss	480
Total loss (not sunk)	43
Vessel seriously injured	500
Vessel injured	1367
Total	**2390**

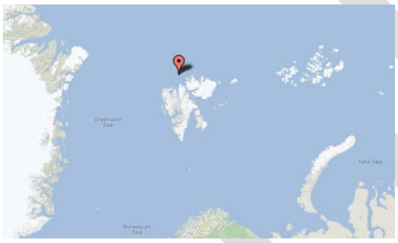

Figure 11: Northernmost accident recorded in the Norwegian database.

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 flag vessels. Still, no accidents were found for the Arctic High Seas.

---A qualitative analysis of accidents in the arctic will be included in the final version of the report---

3.2.2 Inferring a future Arctic High Seas risk picture from the Global accident rates.

Considering the years 1990 to 2012, totaling 1 108 295 ship years, a total of 21 033 serious accidents and total losses were recorded, giving 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) gives a frequency of 148 accidents per 10 000 ship years.

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

Table 7: Frequency of Incidents, all cargo ships, incl. passenger (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

Only 2% or 408 incidents of the reported accidents also reported pollution. This gives a pollution incident frequency of 3.7 per 10 000 ship years. 125 of the pollution incidents were related to the W/S category, giving a frequency of 2.6 pollution incidents per 10 000 ship years when excluding W/S accidents.

Apart from W/S incidents, the pollution incidents are dominated by the collision category (Table 8). Appendix B contains statistics specific for Bulk, Tank and Container ships.

Table 8: Frequency of pollution Incidents, all cargo ships, incl. passenger (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 above finding relating to global accident frequencies with the scenarios for future traffic volume described in Section 3.1.2.2, it is possible to obtain a crude indication of the expected accident rate in the Arctic High Seas.

Table 9 shows the annual frequency of accidents and pollutions incidents in the High Seas in the various scenarios for 2030. Return periods for the accidents are also given. 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 only every few hundred years in all scenarios.

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	Pollution incidents	Return period serious accidents	Return period pollution
	(ship years)	(per year)	(per year)	(years)	(years)
Low	1.5	0.022	0.0004	45	2564
Medium	6.5	0.09	0.0017	10	592
High	14.8	0.22	0.0038	5	260

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 low (Psarros et al. 2010) perhaps by a factor 2 or more. Also, it is recognized that Arctic conditions might be considered as more hostile than global averages, 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.

3.3 Natural Properties of the Arctic High Seas

Like other areas on Earth there are a number of factors influencing the Arctic climate. The different factors influence and 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 main factors influencing the Arctic climate is: Latitude and sunlight, Pressure, Temperature, Geography, Wind, Humidity, Clouds and Precipitation.

As the Arctic climate is greatly influenced by surrounding area, the effects of El Nino/La Nina and the North Atlantic Oscillation (NAO) is also present in the Arctic. The Arctic Oscillation (AO) is the dominant pattern of non-seasonal sea-level pressure variations North of 20th North latitude 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. When the AO index is negative the zonal winds are weaker and greater movement of polar air in to the middle latitudes is experienced.

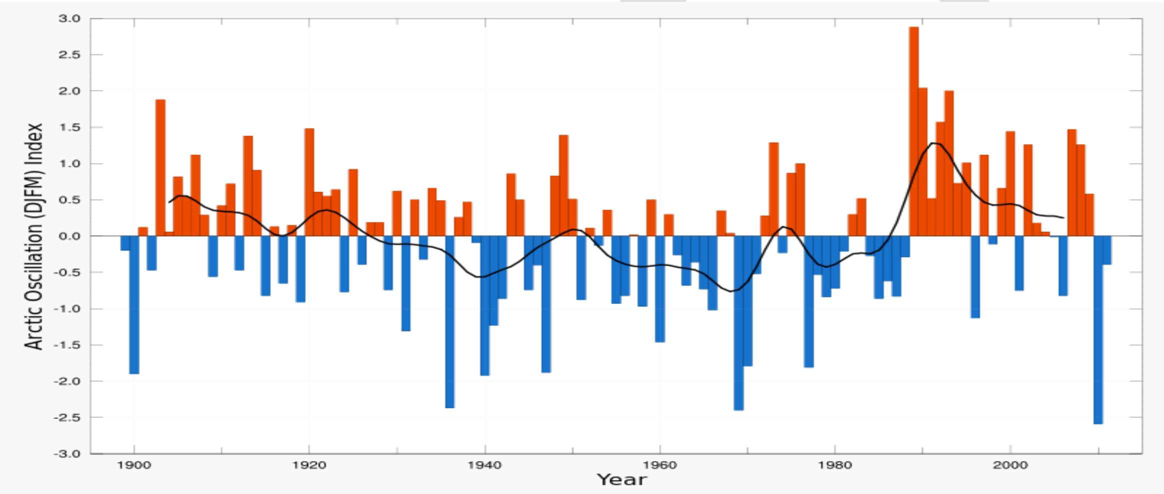

Figure 12 Arctic Oscillation, Source: www.wikipedia.org

A very noticeable feature of the Arctic Ocean is the ice cover. This reduced the exchange of energy between ocean and atmosphere by about 100 times. The sea ice also reduces the penetration of sunlight needed for the photosynthetic processes.

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

3.3.1 Bathymetry

The Arctic Ocean is an ocean mostly enclosed by land. The only entries 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. Several factors make it different from the adjoining North Atlantic and Pacific Ocean. 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.

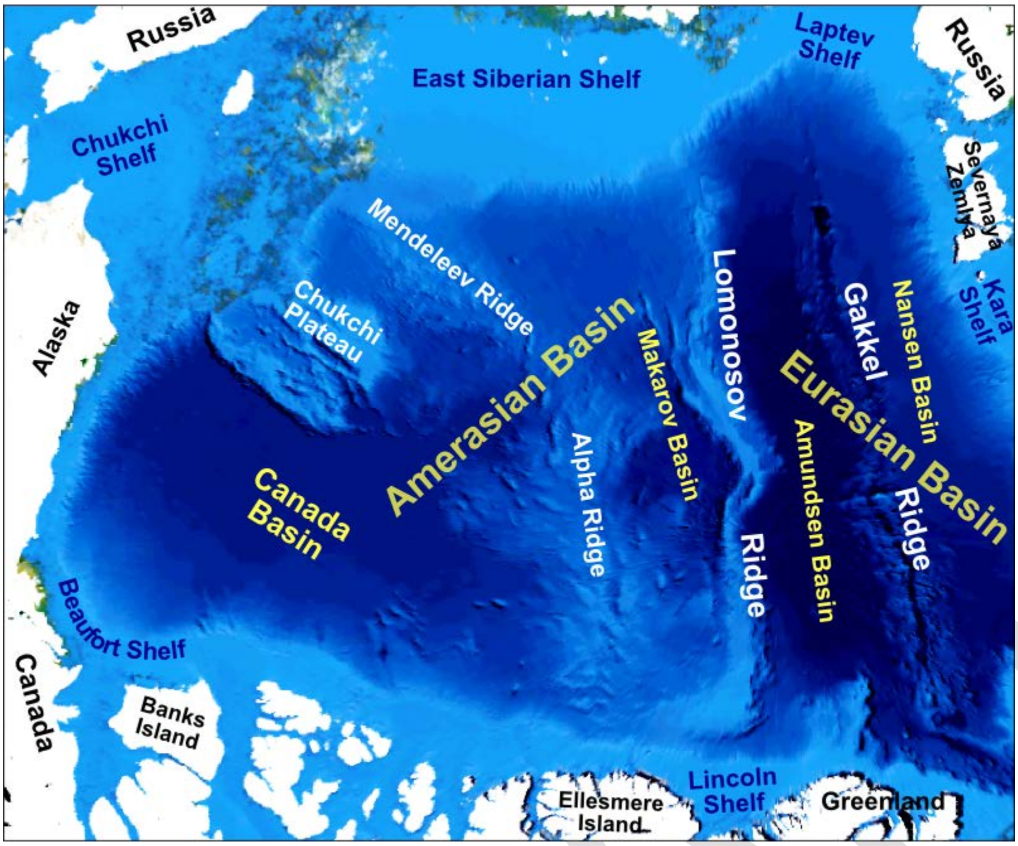

Figure 13 The Arctic bathymetry, Source: http://upload.wikimedia.org/wikipedia/commons/d/d4/Arctic_Ocean_bathymetric_features.png

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 is the deepest abyssal plain with depth up to 4400 meter. Together with the Nansen Basin it is summarized as 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. The main gateways are (Figure 14):

- **Bering Strait** (between the American continent and Siberia) – the flux is however limited due to the shallow water depth caused by the Chukchi Shelf. It is mainly cold Arctic water exiting through the strait.

- **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, 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 Golf Stream.
- **Russian Rivers –** Russian rivers contributes to a large inflow of freshwater during the spring/summer months. This contributes to generating 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 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.

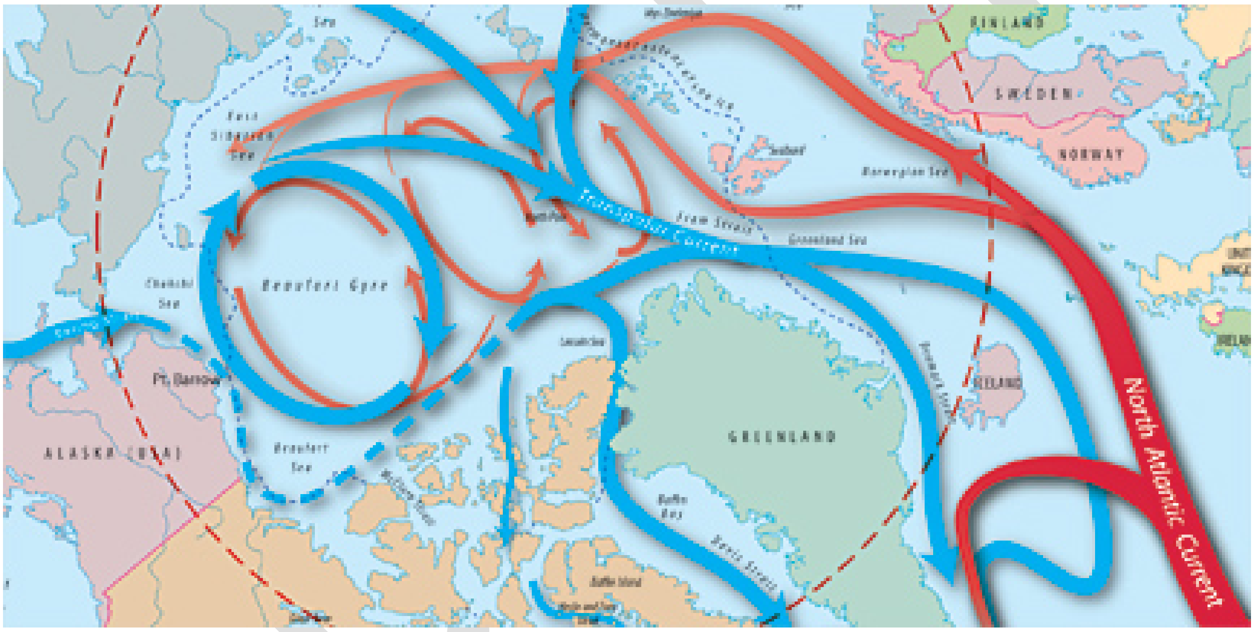

Figure 14 Arctic Ocean Currents, Source: Woods Hole Oceanographic Institution

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 rivers.

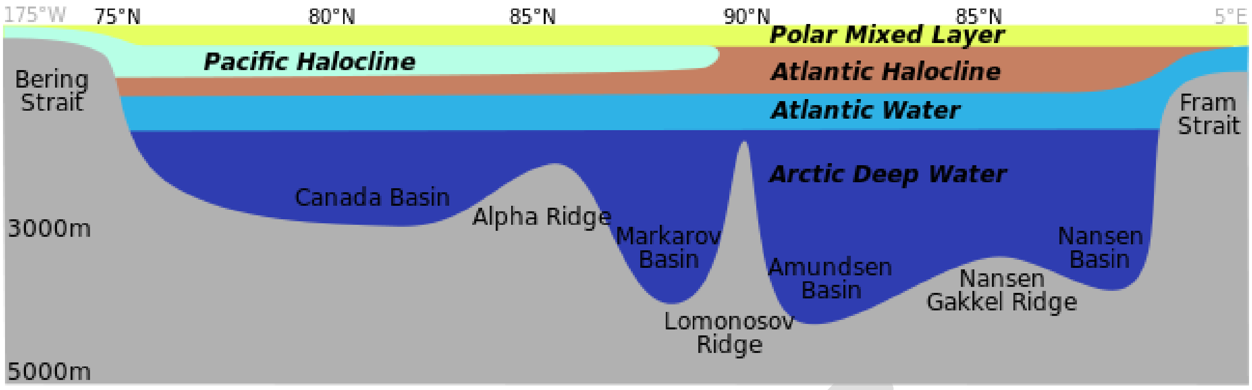

Figure 15 Water masses in the Arctic Ocean, Source: www.wikipedia.org

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 remains relatively constant throughout the whole profile. It is also interesting to note the high temperatures experienced in the Greenland Sea. This is due to the large inflow of warm water from the North Atlantic Current. The temperature is however rapidly decreasing as one move further North or West.

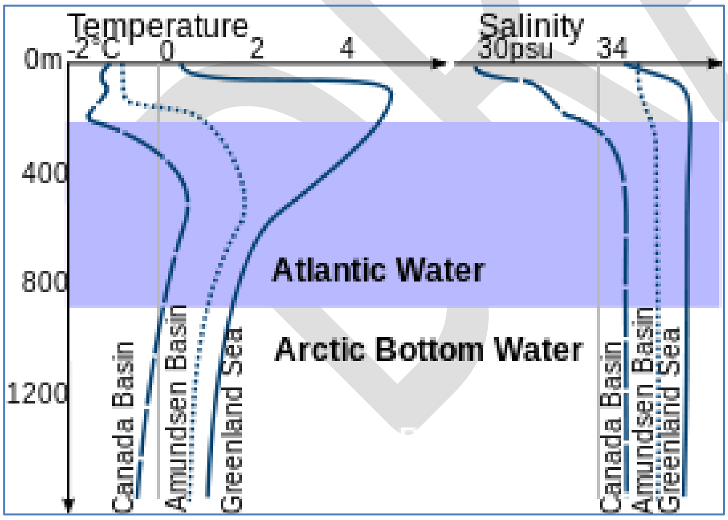

Figure 16 Temperature and Salinity profiles, Source: www.wikipedia.org

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 counter clockwise direction around the perimeter defined by the land and bathymetry of the ocean. This is know as the Beaufort Gyre. When the gyre weakens, volumes of fresh water originating 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 essential for the global oceans overturning, maintaining the earth's climate.

3.3.2.2 Surface Temperature and Wind

The mean surface temperature in the Arctic is highly variable both with regards to location and season. Despite the Arctic Ocean being located on the North Pole, it 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. 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. This is clearly evident in the climatologies measured at the Russian drifting stations NP7-8 and Centrale, see Figure 17.

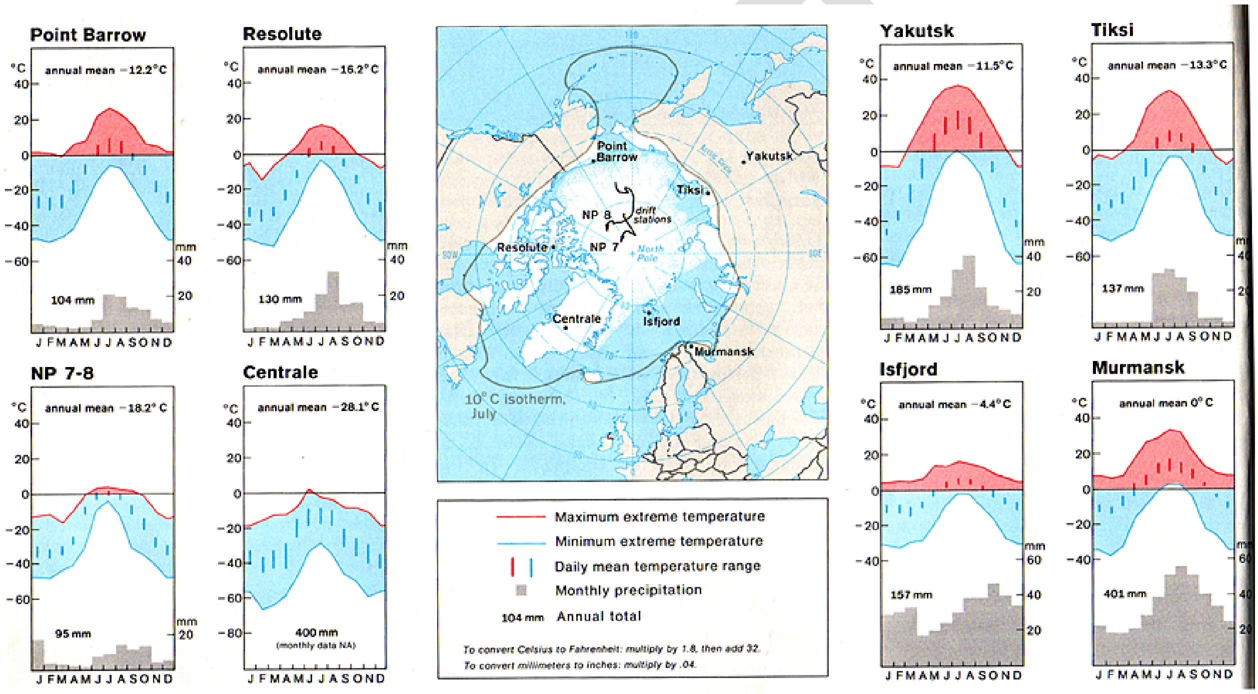

Figure 17 Monthly climatologies, Source: www.wikipedia.org

The temperature variability during the winter months is relatively low for the ice covered arctic basin. The variability is mainly due to clouds. As there is no sunlight the thermal radiation emitted by the atmosphere is the main source of energy. See Figure 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.

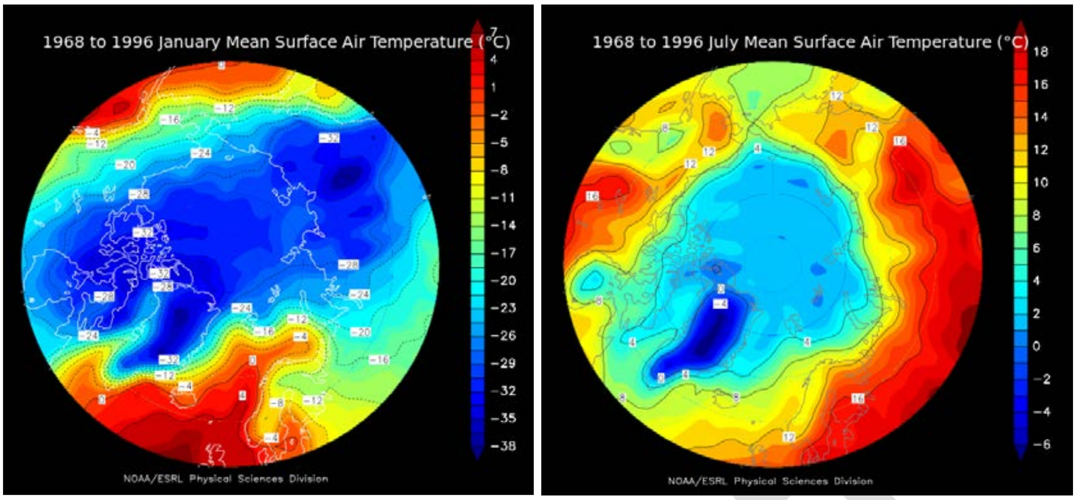

Figure 18 Average surface temperature in January and July, Source: NOAA

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.

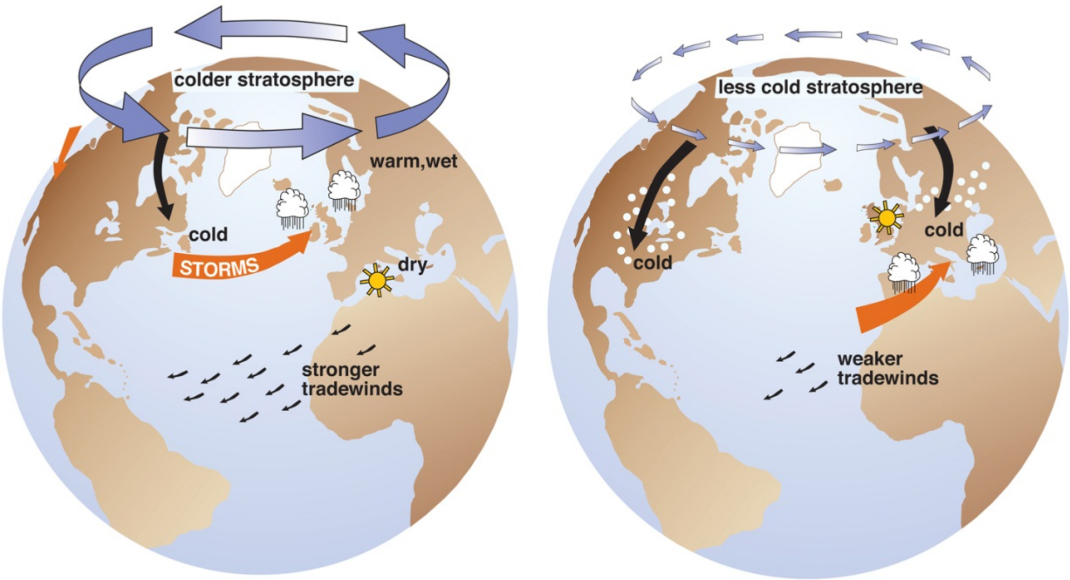

Figure 19 Effect of AO on the wind patterns, Source J. Wallace, University of Washington

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 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.

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 Arctic High Seas is a sea area removed from land and shallow waters, and its dominating oceanographic feature is the sea ice. Sea ice is frozen sea water floating on the surface of the ocean.

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 for 2012/13. Although there is significant yearly variation, the March ice extent covers the entire Arctic High Seas, while the September ice covers most of the Arctic High Seas, although significant areas close to the Bering Strait can be ice free. Importantly, while the Arctic High Seas are ice covered in March, most of the ice is first-year ice. The sea ice is typically described either as first-year ice or multi-year ice. Multi-year ice is ice which has survived (at least) one summer, and is generally thicker and more difficult to navigate for ships.

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 ocean circulation.

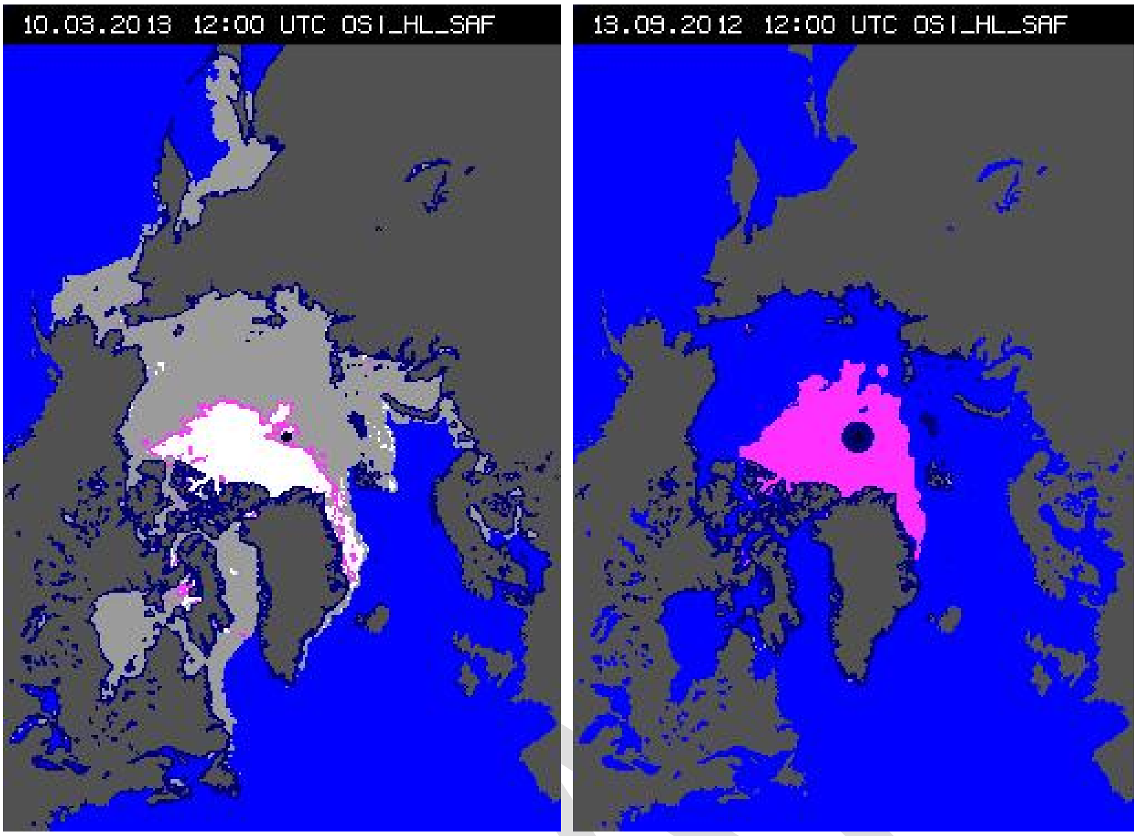

Figure 20: Left: First year (gray) and multi-year sea ice (white) in March 2013. For the Arctic Ocean high seas, the multi-year ice is largely concentrated on the North American side of the pole, north of Greenland, and the Canadian archipelago. Right; Sea ice extent in September 2012. Source: [http://osisaf.met.no/p/ice/index.html#type.](http://osisaf.met.no/p/ice/index.html#type)

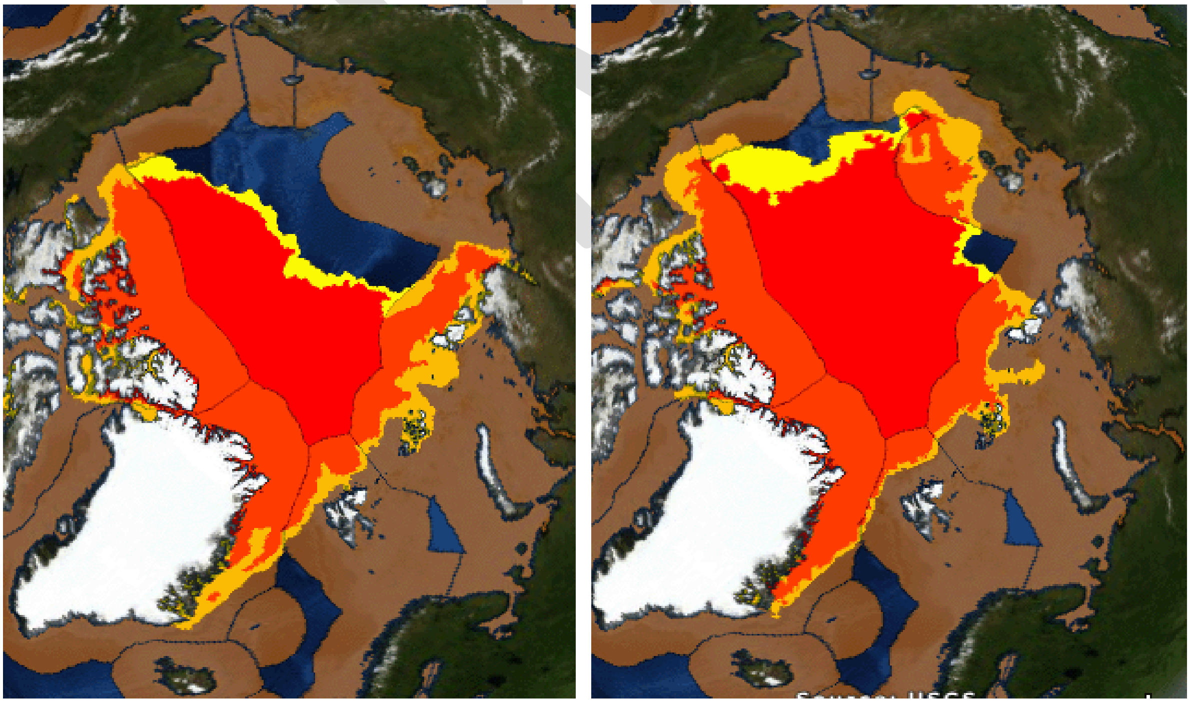

Figure 21: Maximum sea ice retreat and areas of open ocean beyond EEZs in the Arctic Ocean for 2007 (left) and 2011 (right). The sea ice data used to represent the summer minimum extents for 2007 and for 2011 are the U.S.

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).

3.3.3.1 Sea Ice Strength

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. As a result we a highly variable ice thickness over the Arctic Ocean, Figure 22.

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

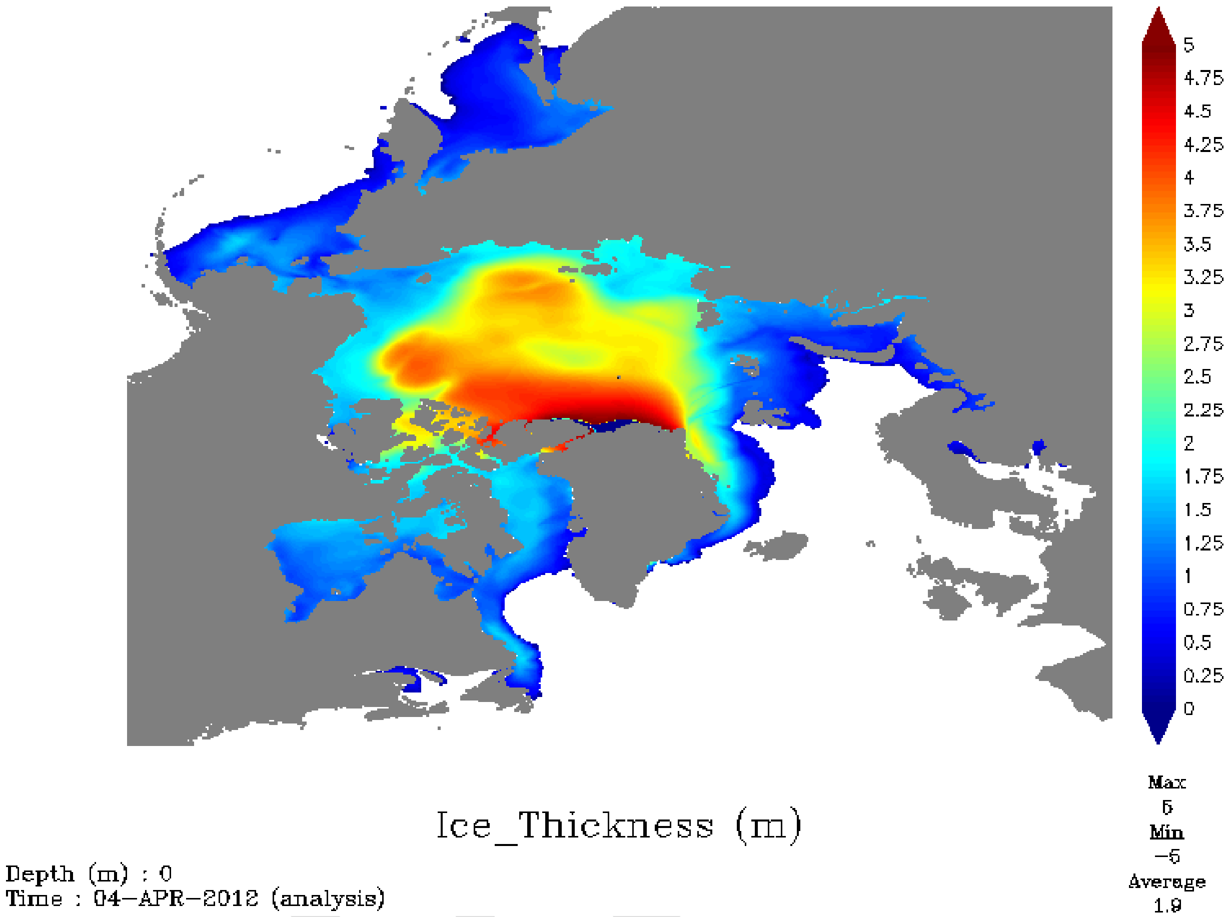

Figure 22 Ice thickness, Source: http://www.mercator-ocean.fr

3.3.3.2 Ice properties relevant for vessel operation

There are additional resistance elements relevant for operation in ice covered waters, compared to open water operation. The strength of the ice is dependent on the following features:

1. Thickness of ice pack
2. Ice salinity
3. Ice temperature

As the above mentioned parameters are highly variable, dependable of area, season and local weather, the properties of the ice pack can be regarded as dynamic. Large variations in the resistance elements can be experienced over dimensions like area and season.

Figure 23 KV Svalbard in rubble fields and ice ridges, Source: Christian Petrich, Coldtech

Ice pressure and the snow cover on top of the ice will generate friction between the ice and the vessel hull, see Figure 23. This is not directly related to ice strength. For vessel operators it is however often difficult to distinguish between the different resistant elements affecting the vessel performance.

3.3.4 The Arctic Ocean of the future

Over the last few decades the Arctic Ocean has experienced profound changes. During the summers seasons the average area covered by sea ice has shrunk (Figure 24), the amount of multiyear ice present is less and the ice thickness has been reduced.

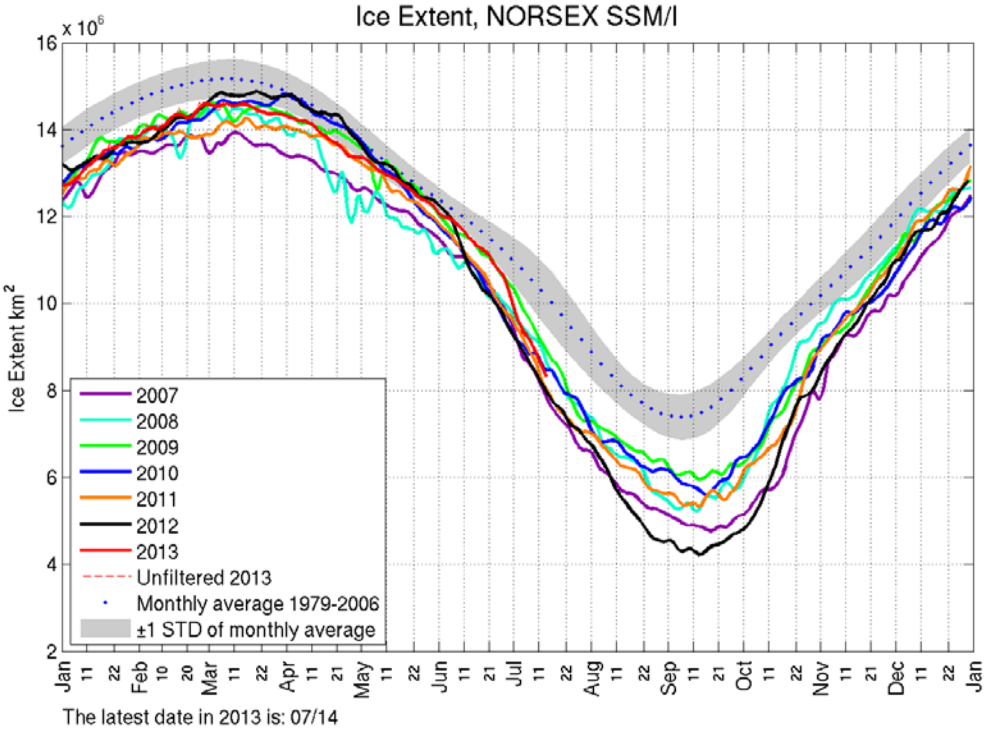

Figure 24 Arctic Sea ice extent, Source: www.arctic-roos.org

Recent science is indicating early signs of acidification and the freshwater storage in the Arctic Ocean is displaying considerable variability. There has also been observed a tendency of different/new patterns with regards to the surface air temperature and pressure fields.

It is however important to note that as the seasonal variability has increased there is still severe conditions to be experienced during the winter months, with extreme sub-zero temperatures and high ice concentrations.

As industrial activities is moving North it has also become clear that the need for more and updated metocean understanding and data is required for defining design criteria's, development and calibration of models and development of reliable weather forecasts.

This is essential from both an operational perspective, on a day to day basis, and in the design phase. Currently there are very few records representing extreme events. To design infrastructure purposely build for the Arctic, reliable statistical data describing the extreme events is essential. As the extreme events are rare, they are usually are 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.

3.3.5 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.

It is important to note that the AMSA II C report /1/ 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 25. 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[7] 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.

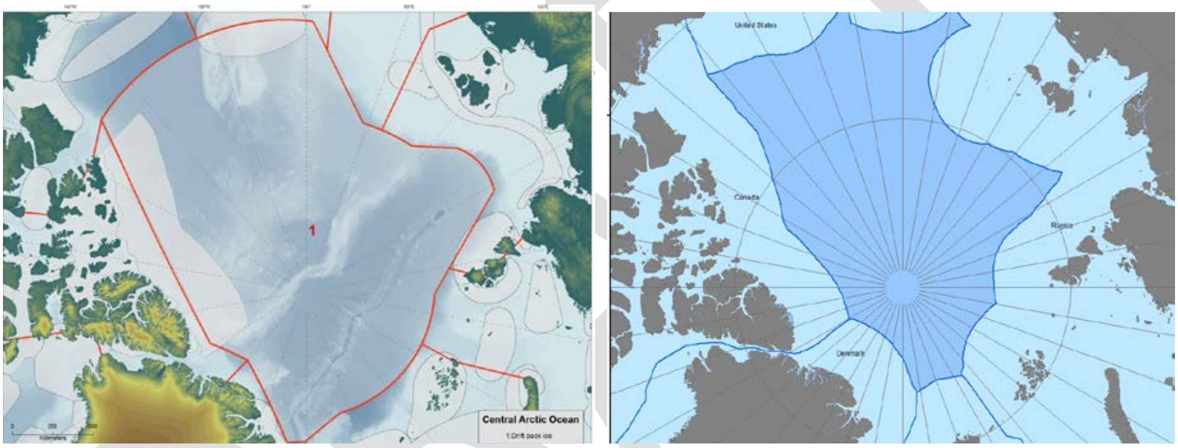

Figure 25: Left: The Central Arctic Ocean LME (From AMSA II C report /1/, their Figure 12), compared to the Arctic Ocean High Seas (Right).

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, ringed seals, and 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.

[7] 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.

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. It seems clear that this region is a core area of higher ecological significance than the other portion (toward the Eurasian side) of the Central Arctic Ocean. The area could be roughly divided by the 0-180 degree longitude through the North Pole, with the western (American) side being of higher significance than the eastern (Eurasian side). However, this distinction is uncertain and the AMSA II(C) considers that the whole area should be regarded as being of heightened significance. The pack ice of the Central Arctic Ocean ecosystem may therefore be considered a threatened habitat in light of climate change. However, it is noted that significant parts of these areas fall outside the Arctic High Seas.

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.

Importantly, the AMSA II C report finds that the endemic fauna associated with the drifting pack ice is sensitive to potential oil spills, although 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 little concern due to the low density of animals and the very wide distribution of the ice communities.

Table 10 summarizes the status for the species[8] 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 3.1.2.2).

[8] The selection of species is based on the Bridging Workshop in Iceland, June 2013.

Table 10: Expected overlap with future shipping activity for selected species found in the Arctic High Seas.

Species	*Area and season*	*Sensitivity*	*Overlap with shipping activity*	*Comment*
Amphipod	Location and seasonality is the same as the ice cover. This means year-round presence in the areas of multi-year ice and seasonal concentrations under 1st year ice, from it forms in the fall, throughout the winter and until ice melts in spring.	Oil spill.	**Moderate.** Transiting ships will go through first year ice on the Eurasian side, but will tend to avoid areas of multi-year ice. Tourism and other activity may seek out multiyear ice.	The critical aspect is the multi-year ice which is diminishing and causing the densities of species to increase. This implies that an accidental oil spill has a larger potential to damage a large part of the population[9].
Polar Bear	Polar bears from several subpopulations[10] use the peripheral areas of the pack ice of the Central Arctic Ocean as part of their summer feeding habitat. Polar bears occur at very low densities here.	Oil spill (disturbance/noise/ship strikes).	**Moderate.** A critical aspect is the retreating ice edge during summer. This is likely to be impacted by shipping.	With diminishing ice, the area may become more important for polar bears as a refuge but a large part of the area is over the deepest waters of the Arctic Ocean and biological productivity is thought to be low[11].
Ivory Gull	Ivory Gull breeds on Arctic coasts and cliffs. It also winters from October through June in the Bering Sea and Chukchi Seas[12]. Ivory gull and Ross's gull also the Central Arctic for foraging during the post-breeding period in late summer and fall[13].	Oil spill.	**Limited.** Present only during winter, when no shipping activity is expected.	Concentrations likely low.

[9] To illustrate the possible extent of an oil spill, consider the Deepwater Horizon accident. The spill volume was approx. 780 000 m^3 (or 660 000 tons or the full loading capacity of two VLCCs), and covered 1 500 km^2. This area is 0.04% of the September 2012 Arctic sea ice extent of 3.61 million km^2. (http://en.wikipedia.org/wiki/Volume_and_extent_of_the_Deepwater_Horizon_oil_spill; http://nsidc.org/arcticseaicenews/2012/10/)

[10] The Arctic Basin subpopulation 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.

[11] http://pbsg.npolar.no/en/status/populations/arctic-basin.html

[12] http://en.wikipedia.org/wiki/Ivory_Gull#Distribution_and_habitat

[13] AMSA II C

Table 10: Expected overlap with future shipping activity for selected species found in the Arctic High Seas.

Species	*Area and season*	*Sensitivity*	*Overlap with shipping activity*	*Comment*
Polar Cod	The fast ice environment is some places breeding habitat for polar cod that spawn in winter under the ice[14]. The spawning season extends from late November to early February in the Beaufort Sea, from end of December to February in Russian waters[15].	Oil and other pollutants in the water.	**Very limited.** The critical spawning season occurs in winter months when shipping is limited or non-existing.	Adjacent waters may be more important.
Bowhead whale	Bowhead occurs with 4 recognized populations (Okhotsk Sea, Bering Sea, Eastern Canada-West Greenland, and Spitsbergen stocks). No concentrations of significance are found within the Arctic High Seas.[16]	Ship strikes) (disturbanc e/noise)	**Very Limited.** Only stray individuals expected in the area.	Adjacent waters may be more important.

3.4 Summary on Part I

This section has presented data on three main topics; a) the traffic volumes in the Arctic Ocean High Seas, present and future, b) the level of accident risk, as indicated by accident statistics and c) the vulnerability of the species found in the Area.

Two results should be highlighted. Firstly, that the risk level in the area is not high. Table 9 shows that, even for the High Scenario, the traffic volume for 2030 in the High Seas is only 15 ship-years per annum, with an expected pollution accident every 260 years. Seen in relation to the size of the area, this is not a high number. Secondly, that the vulnerability of the area is not high. Table 10 shows that that only Amphipods and Polar bears have an exposure towards the expected traffic. They are vulnerable to oil spills, primarily in the multi-year ice in summer months.

[14] AMSA II C
[15] http://www.fao.org/fishery/species/2233/en
[16] http://www.nmfs.noaa.gov/pr/pdfs/rangemaps/bowheadwhale.pdf

4 PART II: ASSESSMENT OF MEASURES

4.1 Protective measures available

ANNEX A provides an overview of the protective measures available to the IMO for application in the Arctic Ocean High Seas.

---A brief summary of the appendix will be included in this section in the final version of the report---

4.2 Screening of applicability and effect

Table 11: *Overview of Measures under the IMO, including comments regarding their applicability in the Arctic Ocean High Seas in terms of a) targeting the needs for protection as evident from section 3, and b) fulfilling the formal criteria as outlined in Appendix A. The color coding is indicative of the applicability, in descending order of applicability; green, yellow, orange.*

I. PSSA				Criteria 1 (ecological) Fulfilled, ref AMSA II C report, their table 17.
				Criteria 2 (vulnerability to shipping) Questionable. Very low activity. Very low densities…
				Criteria 3 (associative protective measure- APM) - Need to specify which threat to mitigate… - Section 3.4 multiyear ice, Amphipods and polar bears.
II. Other (APMs)	A. Nav. Aids	i. Routing systems	1. Areas to be avoided	Applicable i.a. “where there is the possibility that unacceptable damage to the environment could result from a casualty”
			2. No anchoring	Not relevant – no anchoring needs
			3. Traffic separation	Maybe- but very low traffic
			4-9 Recommended track or similar	Maybe – alternative to 1?
		ii. Ship reporting systems		Maybe (not previously done in International waters?) (Need to establish administrative entity?)
	B. Discharge restrictions	i. Special areas (SA)	Annex I (oil)	Criteria 1: Ice and Gyre may concentrate pollution, but very large area, few ships and no other contributing sources make concentrations low? Criteria 2: ecological conditions: maybe – same reasoning as for PSSA? Criteria 3: is the traffic large enough so that other IMO regulations are insufficient? Covered in the Draft Polar Code, Chapter 15 Environmental protection. Will not be pursued further in this report.
			Annex II (noxious liquid)	
			Annex IV (sewage)	
			Annex V (garbage)	
		ii. Emission control areas (ECA –Annex VI)	NOx	Low traffic means low emissions. Little or no exposure to humans.
			SOx	

4.3 Detailed assessment of one or more regions within the Arctic Ocean

Based on the screening in the previous section is it suggested to pursue the application of a PSSA, with associated APMs such as Areas to be avoided or Recommended track, targeting areas of multiyear ice, with the aim to protect amphipods and polar bears.

---To be included in the final version of the report---

5 CONCLUSIONS AND RECOMMENDATIONS

---To be included in the final version of the report---

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APPENDIX A: IMO MEASURES FOR AREA-BASED PROTECTION (PAME II-2012)

(From PAME II-2012 meeting - IMO measures by USA Norway, Finland, Canada, Russia, Denmark & Sweden)

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).[17]

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. 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.[18] In 2005, the IMO

[17] 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.
[18] 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).

Assembly adopted the *Revised Guidelines for the Identification and Designation of PSSAs* (*Revised PSSA Guidelines*).[19] 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.[20]

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.[21]

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.[22] 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. 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."[23] 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,[24] 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

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[19] *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*].
[20] *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)).
[21] *See id.* at 1.2.
[22] 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.
[23] 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.
[24] 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.

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.

II. Other IMO Measures (or Associated Protective Measures)

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—without a PSSA application—and, when doing so, must present such measure(s) to the appropriate IMO bodies for approval and/or amendment. Available measures fall into two general categories: (A) Navigational Aids (ships' routeing systems and ship reporting systems); and (B) Discharge Restrictions (special areas and emission control areas). The following sections describe each of these categories.

A. Navigational Aids

i. 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.[25] 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 environment."[26] The *General Provisions on Ships' Routeing*[27] 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.[28] In general, ATBAs should be established only in places where:

[25] *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].
[26] *Id.* ch. V, reg. 10, para. 1.
[27] *General Provisions on Ships' Routeing*, *adopted* Nov. 20, 1985, IMO Resolution A.572(14), as amended [hereinafter *Ships' Routeing*].
[28] *Id.* at 2.1.13.

- 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."[29]

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.[30] 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").[31]

4. *Recommended Track*

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."[32]

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."[33]

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

[29] *See id.* at 2.1.14; *see also id.* at 5.6 (providing guidance on the planning of No-Anchoring Areas).
[30] *See id.* at 2.1.3, 6.8-6.11.
[31] *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].
[32] *Ships' Routeing*, *supra* note 11, at 2.1.10.
[33] *Id.* at 2.1.8.

provisions of Rule 10(d), as amended, of the *International Regulations for Preventing Collisions as Sea, 1972* [COLREGS]."[34]

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."[35]

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."[36]

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."[37]

ii. 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.[38] 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 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.[39] The IMO *SRS Guidelines* set forth guidelines for voluntary systems as well as the criteria for the development of mandatory systems[40] for "all ships, certain categories of ships or ships carrying certain cargoes."[41]

B. Discharge Restrictions

[34] *Id.* at 2.1.7 (emphasis added).
[35] *Id.* at 2.1.6.
[36] *Id.* at 2.1.12.
[37] *Id.* at 2.1.11.
[38] JULIAN ROBERTS, MARINE ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION: THE APPLICATION AND FUTURE DEVELOPMENT OF THE IMO'S PARTICULARLY SENSITIVE SEA AREA CONCEPT 129 (2007).
[39] *See* SOLAS, *supra* note 8, ch. V, reg. 11.
[40] *See Guidelines and Criteria for Ship Reporting Systems*, *adopted* Dec. 9 1994, IMO Resolution MSC.43(64) [hereinafter *SRS Guidelines*].
[41] SOLAS, *supra* note 9, ch. V, reg. 11, para. 1.

i. Special Areas

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 IV (sewage), and Annex V (garbage).[42] 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."[43]

In 2002, the IMO Assembly adopted the *Guidelines for the Designation of Special Areas under MARPOL 73/78* (*Special Area Guidelines*),[44] 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.

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[42] *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*].
[43] *Id.* at 2.1.
[44] *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.

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.[45] 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 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."[46]

ii. <u>Emission Control Areas</u>

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.[47] 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[48] as well as a significantly lower cap for ships operating within a designated ECA.[49] 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.[50] "The formal amendment procedure applicable to proposals for the designation of ECAs is set out in article 16 of MARPOL 73/78."[51] To date, the IMO has agreed to four proposals submitted pursuant to this provision, establishing two Sulfur Emission Control Areas in

[45] *Id*. at 3.1.
[46] *Id*. at 3.4; *see also* MARPOL 73/78, *supra* note 14, art. 16.
[47] *See* MARPOL 73/78, *supra* note 14, annex VI, reg. 2, para. 8.
[48] 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.
[49] 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.*
[50] MARPOL 73/78, *supra* note 14, annex VI, app. III, para. 2.2.
[51] *Id*. para. 4.3.

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.[52,53]

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.

[52] *North American emission control area comes into effect on 1 August 2012,* http://www.imo.org/MediaCentre/PressBriefings/Pages/28-eca.aspx.
[53] 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.

APPENDIX B: GLOBAL ACCIDENT FREQUENCIES PER SHIP TYPE

Vessel category A1 (tank)

Considering tanker vessels in isolation (Table 12), we find that an accident rate of 136 accidents per 10 000 ship years, or 108 when removing Wrecked/Stranded 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 average. The distribution of incidents with pollution on the different accident categories (Table 13) resemble the cargo fleet average, although more incidents are related to collisions, and fewer related to Wrecked/Stranded.

Table 12: 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 13: 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 14) we find that an accident rate of 217 accidents per 10 000 ship years, or 159 when removing Wrecked/Stranded 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 15) on the different accident categories resemble the cargo fleet average, although more incidents are related to Wrecked/Stranded, and fewer related to collisions.

Table 14: 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 15: 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 16) show an accident rate of 222 accidents per 10 000 ship years, or 182 when removing Wrecked/Stranded 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 17) on the different accident categories resembles the cargo fleet average, although more incidents are related to contact.

Table 16: 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 17: 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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