NORWEGIAN MARITIME DIRECTORATE

PAME –Snap Shot Analysis of Maritime Activities in the Arctic

Revision No. 01

REPORT NO. 2000-3220

Table of Contents

1 CONCLUSIVE SUMMARY

1.1 Scope of the Snap shot analysis

The objective of the work is to provide a report encompassing elements such as:

"outline a draft snapshot analysis of shipping activities in the Arctic including future trends
Identify and prioritize the environmental problems related to current and potential shipping activities in the Arctic.

In order to prepare PAME discussions on shipping in the Arctic, the consultant shall also:

Identify and assess the adequacy of current measures for addressing the problems identified and identify the possible gaps
Consider appropriate measures to fill the gaps identified and provide recommended actions."

The snap shot analysis is produced by Det Norske Veritas (DNV) on behalf of the Norwegian Maritime Directorate and the Norwegian Ministry of Environment.

1.2 Background

Based on the conclusions of previous work, it has been found that sufficient information is not readily available with regard to present and future shipping activities neither in the Arctic nor in relation to associated potential effects to the marine environment. This is partly the result of lacking compatibility in data on current shipping. It is also a result of limited knowledge on the future expansion of shipping associated with the Northern Sea Route, oil and gas developments, specially in Norway (offshore in the Barents Sea) and in Russia (land based and offshore and mining). These activities are however expected to increase and hereby increasing the shipping activity in the region.

The conceptual design of a data reporting and sharing system for the Arctic region, including identification of relevant data and data sources, routines for data exchange and technical solution for analysis of data selected was outlined in 1996. Prior to a decision on the type of data system and level of details needed, a snap shot analysis on present status of the impact from the maritime activities to the marine ecosystems of the Arctic environment was carried out.

The following is a documentation of the snap shot analysis of the maritime activities in the Arctic.

1.3 Maritime activity

Major navigation routes and ports in the Arctic are given in figure 1.1.

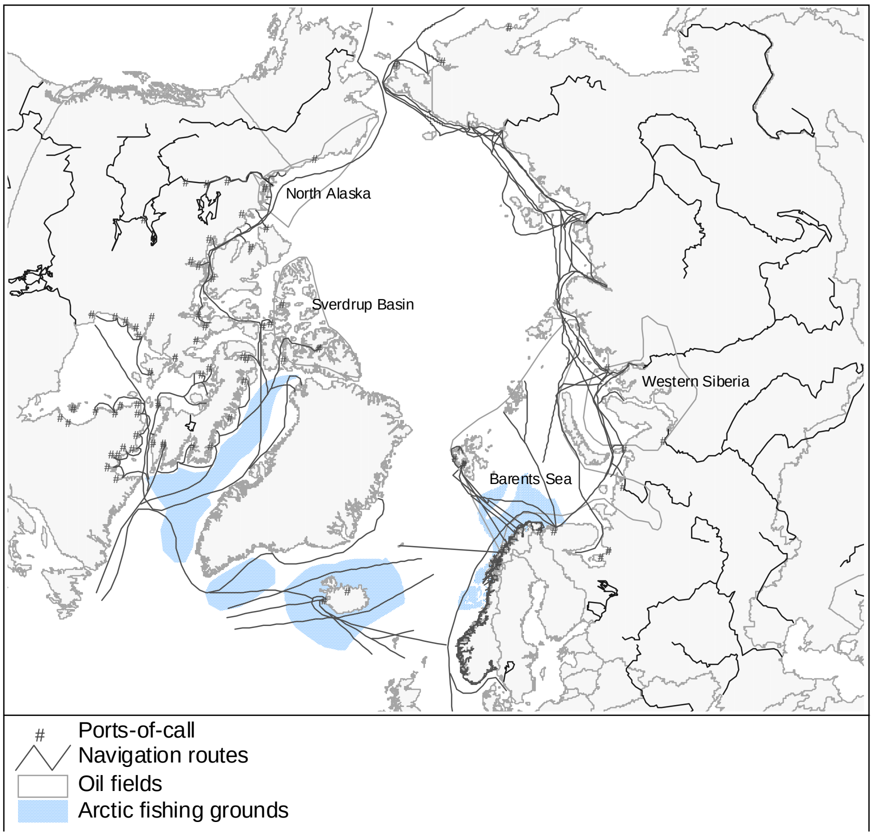


Figure 1.1. Major ports and navigation routes in the Arctic, sources TC (1995), PAME (1996), INSROP (1998) and PAME questionnaire 2000. Geographical reference of fishing grounds have not been made available for USA and Russia.

The maritime activity in the Arctic consists of:

- transport of general cargo and bulk (wet and dry) cargo, containers (assumed to increase in the future)
- fisheries (assumed to remain stable)
- tourism, including whale watching, cruise vessels / passenger vessels (assumed to increase in the future)
- research and other vessels (assumed to remain stable)
- transport of vessels for scrapping (assumed to increase in the future)
- icebreakers and tugs (assumed to increase)

A major part of the maritime activities are related to general and bulk cargo, containers and fisheries.

1.4 Data Input and Parameters

Specified data input from the Arctic countries, quite clearly show that for the region as a whole, detailed and consistent data of requested parameters are not available. However, individual countries have data at various levels of details available, although not easily accessible.

A snap shot analysis has been performed for selected types of vessels and associated environmental impact. Figures are presented for dry cargo, wet cargo, general cargo, fishing vessels and icebreakers/ tugs.

The data sets made available for the snap shot analysis provide general information on trade and operational pattern. The estimates are empirically achieved. The following parameters are included:

geographical vessels densities
annual operation hours
number of vessels by ship type
number of crew / passengers per vessel type and size
distribution of vessels in size groups
number and length of voyages

Identified relevant and adequate parameters for addressing the potential environmental impact of the maritime activity are given in table 1.1.

Table 1.1. Proposed adequate parameters for assessing and analysing the possible environmental impact of maritime activities.

Parameter	Comments	Priority
Ship type	It is necessary to differentiate by ship type due to different operational patterns. Ship types represent different discharges and risks.	1
Number of Travels per ship size category	An analysis should differentiate by ship size categories due to different operational patterns. Number of vessels and Sum DWT or GT in each size category addresses the volume bias.	1
No of vessels per ship size category		1
Sum DWT or GT per ship size category		1
Number of Crew/Passengers	Number of crew and passengers give input to analysis of volume of sewage, garbage and wastes of shipping operations.	1
Number of Port Hours	Number of Port Hours and Operating Hours per size category addresses the operation pattern of the fleet and hereby affect analysis of operational impacts.	1
Number of Operating Hours		1
Number of vessels per hull/bottom type	The measure on hull / bottom type will give input to analysis of possible accidental risk.	2
Number of vessel per age class	Age class differentiation will give input to engine efficiency and hereby calculations on emissions to air. The measure also gives input to analysis of future scrapping frequency and possible accidental risk.	2

Table 1.2 presents aggregation of data received and collected for the analysis. Details on the data are given in appendix 4.

Table 1.2 Arctic fleet numbers used in the modelling.

Type	Number of vessels		
	All	<5000 DWT	>5000 DWT
WC	189	163	26
DC	552	309	243
FV	3394	3383	11
IC/TUG	48*	22*	26*
Sum	4183	3877	306

* for icebreakers and tugs the figures are in GT.

1.5 Results from the Snap Shot Analysis

Impacts from long-term regular discharges from maritime activities are of major environmental concern. The conclusions from previous work indicate that at present the impacts in the Arctic generated by “normal” operational discharges of oil, sewage and other wastes are low. However, long-term effects of chronic low level contaminants are not fully researched on Arctic species. A precautionary approach should be adopted and until research can prove low or no effect due to regular discharges from shipping activities, these activities should be assessed and controlled. The expected increase in shipping activity in the Arctic addresses also the need for measures and control with respect to operational discharges.

Presently severe acute marine pollution due to accidental events is not often reported for the Arctic region. However, the potential risk of accidents increases with frequency of voyages and assessments indicate increased risk of accidents in ice-infected areas. The expected increase in maritime activities in the Arctic region implies increased risk of accidents. The need for ensuring sufficient vessel standards is stressed. Further more contingency planning are recommended evaluated and assessed.

In the following a summary of the results of estimates of emissions to air, TBT emissions and produced waste and sewage is presented.

The numbers used are presented in appendix 4 where table 14.8 –14.10 presents the aggregated data sets. It should be noted that the results are highly affected by parameters as:

- number of operating days
- operational profile
- number of vessels

Inaccuracy related to the produced figures for these parameters will affect the quality of the results of the estimates. As an example the data for Russia can illustrate this. For Russia the INSROP data sets have been used as data input. The reason for this is that these data sets are new and produced through substantial work. The INSROP data sets indicate that Russia holds a major part of the total Arctic fleet (ref. table 14.9 and 14.10). However, the size of the Russian Arctic fleet produced by INSROP diverges largely to the figures produced by PAME in 1996. If the data sets of PAME (1996) had been used for Russia the total figures on estimated environmental impact would have been quit different. It should also be noted that data on the USA share of the Arctic fleet is not provided for the analysis. Hence the figures produced are expected to be underestimated.

1.5.1 Emissions to air

The estimates of emissions to air show that of merchant traffic, dry cargo is the most significant contributor. Dry cargo carriers are dominating by number as well as by emissions. However, compared with the global marine consumption the Arctic consumption is only approximately 1 %.

Fishing vessels contribute to a major part of the consumption of fuel and hereby represent a considerable input to emissions to air. A main reason for this fact is due to the operational profile of fishing vessels. This is also expected due to a large number of vessels with a high number of operation hours. Some of the larger fishing vessels also consume considerable volume fuel due to a higher operational profile (especially factory vessel). It should be noted that many smaller fishing vessels (< 30 meters) are operating on seasonal basis. However, in the calculations all fishing vessels are considered operating on annual terms. The bias in estimated emissions to air with respect to fishing vessels is also due to this fact.

Due to the variable level of detail in statistics (number of vessels, type and size distribution) and the lack of statistics for some regions the estimated values presented should be handled with some caution.

The environmental impact of emissions to air for some emission components (NO_x, SO_x) will depend upon the existing background concentrations in the area. An area experiencing low background levels (low traffic density) might be more vulnerable for an increased “load” than identical increase in an already polluted area (Isaksen, IPCC 1999). Hence, assessments looking at increased traffic density in such low load areas will require a more detailed and advanced approach.

1.5.2 Leakage of TBT

Emitted TBT to the seas of the Arctic is estimated to be in the range of 2-4 ton/year. The emission of TBT world wide is estimated to be in the range of 750-1500 ton/year (2 – 4 g/cm^2/day) and the total wetted area about $148 \cdot 10^6$ m^2 (DNV 1999). The main contribution vessel categories are oil tankers, bulk carriers and general cargo vessels. By comparing the Arctic and world wide emission of TBT, the Arctic contribution is only about 0.3 %, and dry cargo vessels are the dominating category. The results include only wet-, dry cargo, icebreaker/tug and fishing vessels, and the estimated TBT emission may therefore be too low. However, use of TBT on smaller vessels has been banned since 1990 (this ban is not global, but widely accepted). In addition Arctic vessels may use paints with a lower leaching rate due to colder water, and a leaching rate of 2 g/cm^2/day is likely.

1.5.3 Waste, sewage and garbage

Estimates of produced waste, sewage and garbage indicate volumes of 1000 – 100000 m^3/year depending upon what type of wastes that are considered. It should be emphasised that the figures represent potentially produced amounts and do not reflect what is discharged or what is actually delivered ashore. In addition, the large fraction of small fishing vessels may give a too high contribution.

Table7.1. Estimated generated waste in the Arctic, based on fleet statistics for 1998.

Type	Sludge (m^3/year)	Bilge (m^3/year)	Sewage (ton/year)	Garbage (m^3/year)	Solid oil waste (ton/year)	Waste oil (m^3/year)
ICEBR./TUG	4219	2930	7617	114	41	352
WC	2495	5938	15762	236	175	1490
DC	20168	46579	82463	1256	818	4574
FV	16196	35904	179890	2684	2949	16002
SUM	*26882*	*55446*	*105842*	*1607*	*1033*	*6415*

IC/Tug-Icebreaker / Tugs
WC-Wet cargo
DG- Dry cargo
FV-Fishing vessels

1.6 Risk operations

Table 1.3 presents maritime operations expected to have a significant impact on the marine environment.

Risk reducing measures can be found in amending IMO instruments and in the development of new instruments. National or local measures can also be a recommended strategy regarding some issues of concern. A process of analysing existing and possible new risk reducing measures is recommended. It is also recommended to co-operate with EPPR or other appropriate working groups.

Table 1.3 Maritime operations expected to have significant impact on the marine environment. Priorities for discussing PAME response actions are indicated by the numbers: 1: actions should be considered by PAME or 2: actions are not recommended at present

Regular events					
Activity/Operations	Issues of concern	PAME Priority		Reasoning	PAME response
		Present	Future		
1. Onboard production of oily wastes, sewage and garbage	Shortage of reception facilities Illegal discharges to sea Onboard incineration	1	1	Present: Long operation periods at sea imply waste storage problems. Potential impact related to onboard generated pollutants. Future: Long operation periods at sea imply waste storage problems. Potential impact related to onboard generated pollutants.	Observe implementation of MARPOL Annexes encourage enter into force all MARPOL Annexes.
2. Discharge of ballast water of foreign origin	Risk of reduction in biodiversity	2	1	Present: low amount of foreign ballast water discharge. Potential impact related to onboard generated pollutants. Future: expected higher volumes of ballast water discharged due to increased tanker activity. Potential impact related to onboard generated pollutants.	In light of the IMO developments identify the need for Arctic measures on ballast water.
3. Release of TBT from anti-fouling paints	Risk of reduction in biodiversity	2	2	Present: small amounts of large vessels (> 25 m) hence low TBT input to the environment. Future: expected ban in use of TBT as an anti-fouling agent in 2003 (phased out 2008).	PAME should observe IMO developments and encourage implementation of international measures on TBT
4. Cruises / Passenger vessels	Disturbance of vulnerable resources	2	1	Present: Ongoing activity is at an acceptable level Potential impact related to onboard generated pollutants. Future: Increased activity is of concern. Potential impact related to onboard generated pollutants.	Analyse existing and possible risk reducing measures. Develop joint PAME/CAFF policy.

Table 1.3 cont.

Accidental events					
Activity/Operations	Issues of concern	PAME Priority		Reasoning	PAME response
		Present	Future		
5. Loading and unloading activities	Increased risk of discharges of oil and bilge water	1	1	Present: Complex operations involving human element, technical solutions on board and loading and unloading facilities Future: Complex operations involving human element, technical solutions on board and loading and unloading facilities	Analyse existing and possible risk reducing measures. Develop joint PAME/EPPR policy.
6. Tanker traffic –Field Terminal –Terminal Export / Import	Transport of oil products having high potential impact in accidents	1	1	Present: The impact of one accident occurring is high. Future: The impact and consequence of one accident occurring is high. Increasing activity.	Analyse existing and possible risk reducing measures. Encourage implementations of the Polar Guidelines. Develop joint PAME/EPPR policy
7. Heavy bunker oil as cargo and fuel	Heavy bunker oil has very high potential impact if discharged	1	1	Present: Heavy bunker oil is at present used on most types of vessels, i.e. incidents can occur in all parts of the Arctic where shipping activity takes place. The impact of one accident occurring is very high. Future: The expected increase in shipping activity strengthens the reasoning given above.	Analyse existing and possible risk reducing measures Encourage implementations of the Polar Guidelines. Develop joint PAME/EPPR policy
8. Operation in areas of high ice concentration	Increased accidental risk, hence increased risk of pollution	1	1	Present: More complex operation regime than open sea operations. Future: More complex operation regime than open sea operations.	Analyse existing and possible risk reducing measures. Encourage implementations of the Polar Guidelines. Develop joint PAME/EPPR policy
9. Tugging / Towing	Increased accidental risk	2	1	Present: Low frequency of tugging/towing at present. Future: The activity is expected to increase in the future.	Analyse existing and possible risk reducing measures. Encourage implementations of the Polar Guidelines. Develop joint PAME/EPPR policy
10. Cruises / Passenger vessels	Increased accidental risk in near ice or near shore operation	2	1	Present: Low frequency of cruises / Passenger at present. Future: The activity is expected to increase in the future.	Analyse existing and possible risk reducing measures. Encourage implementations of the Polar Guidelines. Develop joint PAME/EPPR policy

2 INTRODUCTION

PAME has identified 6 general areas of concern with respect to pollution contribution in the Arctic environment. In addition, 4 main activities are identified giving rise to input of pollution. These are given in table 2.1.

Table 2.1. General pollutants and activities giving rise to these in the Arctic region (PAME 1996).

General pollutants in the Arctic	Activities giving rise to pollution in the Arctic
1. Persistent organic pollutants (POPs)	• Land-based activities
2. Radionuclides	• Dumping of wastes at sea
3. Heavy metals	• Offshore oil and gas activities
4. Oil	• Shipping activities
5. Acidification	
6. Noise	

Pollution sources both within and outside the Arctic area is to be considered by PAME. It has also been agreed to focus on chronic pollution, as acute pollution is considered by the Working Group on Emergency Prevention, Preparedness and Response (EPPR). However, concerns related to acute pollution will in this context be considered by PAME, among others issues related to risk for acute discharges. The work should be guided by the precautionary approach.

General description of the Arctic is given in appendix 1.

2.1 Previous work on shipping in the Arctic within PAME

Based on the conclusions of previous work, it has been found that there is not detailed information with regard to present and future shipping activities or in relation to associated potential effects to the marine environment in the Arctic. This is partly due to lacking compatibility in data on current shipping. It is also a result of limited knowledge on the future expansion of shipping associated with the Northern Sea Route (NSR), oil and gas developments specially in Norway (offshore in the Barents Sea) and in Russia (land based and offshore). These activities are however, expected to increase the shipping activity in the Arctic.

Recommendations from PAME in March 1996 were that all Arctic countries should jointly develop a co-ordinated information system for collection and sharing of data on shipping activities and the environmental impacts thereof. An assessment of the potential of current activities and future increase in shipping activities due to the issues of concern given above should be undertaken. The assessment should include collection of information on current activities and possible future activities.

As lead country Norway developed a conceptual design of a data reporting and sharing system, including identification of relevant data and data sources, routines for data exchange and technical solution for analysis of data selected. The system; the PAME Data Collection and Sharing System (PDCSS), is described in the DNV-report No: 96-3719 (DNV 1996). Priorities were made for data relevant for assessments of potential impacts in the interface between the given maritime activities and the Arctic environment in the long and short term, and thereby being able to provide background for rationale and environmental management strategies.

Based on this work a standardised set of data formats for information relevant to the PDCSS was proposed. The report concluded that the proposed level of reporting in the PDCSS was too high and ambitious.

This conclusion has lead to the decision on performing a snap shot analysis of the shipping activity in the Arctic.

2.2 Objective of the Snap shot analysis

The objective of the work is to provide a report encompassing elements such as:

"outline a draft snapshot analysis of shipping activities in the Arctic including future trends

Identify and prioritize the environmental problems related to current and potential shipping activities in the Arctic.

In order to prepare PAME discussions on shipping in the Arctic, the consultant shall also:

Identify and assess the adequacy of current measures for addressing the problems identified and identify the possible gaps

Consider appropriate measures to fill the gaps identified and provide recommended actions."

2.3 Description of Contents of the PAME snap shot analysis

The snap shot analysis provides density estimates of status of the shipping activities in the Arctic. Furthermore the snap shot aim to identify environmental impacts/problems related to present and expected future shipping in the region outlining further steps necessary to be taken.

The information used in the snap shot analysis is based on general knowledge of the maritime activities in the Arctic and detailed input on the Arctic maritime activities from the Arctic countries.

The decision on type of information to be included in the analysis is based on the mandate of PAME, possible impact factors and recommendations provided by PAME in previous works.

Table 2.1 presents different shipping operations and type of information related to these operations.

Table 2.1. Maritime activities and type of information proposed for the snap shot analysis.

Identified cases	Relevant information types
• Tankers engaged in onshore and offshore	Number of vessels grouped by ship type, to be

oil and gas activities • General cargo transport • Bulk • Transport of vessel for scrapping • Cruise vessels / Passenger vessels • Container vessels • Icebreakers • Fisheries • Research and other vessels	defined and given in questionnaire. • Main trades or fishing areas; internal waters and international waters • Length of each trade (nautical miles), to be calculated based on input on geographical extent of trades. • Number of travels per trade and ship type (or operating hours for fishing vessel) • Number of vessel in age groups and trade • Number of vessels having, single, double hull/bottom and ice protection. • Number of passengers

2.3.1 Calculations to be performed

The following calculations are performed based on the data collected. Together with the data sets provided, general empirical assumptions are adopted when required.

- Emissions to air (CO_2, NOx, SO_x, VOC (resulting from emission during travel, ventilation of oil tanks and evaporation during handling))
- Noise
- Leakage of anti-fouling agents (TBT)
- Volume of sewage
- Volume of garbage
- Volume of oily wastes

2.4 Methodologies and data used

The data sets used are based on input from the Arctic countries (questionnaire) and general global statistics. Input from the Arctic countries is based on a questionnaire previously distributed and reports produced by PAME. Global statistics are retrieved from databases managed by larger institutions such as Fairplay, Lloyds, National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmosphere Administration. Further details on and quality of the data is given in chapter 4.

The methodology used for emissions to air was developed by Corbett (1999) and further modified by DNV.

Methodologies used for estimating leakage of TBT, waste, garbage and sewage are developed by DNV using standard relations between shipping activity and related parameters.

The methods and adopted relations are all documented. DNV can be consulted for details.

The calculations are performed to indicate the level of potential impact to the environment.

3 SNAP SHOT ANALYSIS; INPUT DATA

3.1 Input data sources

Each PAME member has been requested to provide detailed information for the snap shot analysis (see questionnaire in appendix 3). The data were to be used together with international statistics for the purpose of giving sufficient level of detail for analysing the maritime activities in the Arctic.

The level of detail requested in the questionnaire is looked upon as essential to be able to perform acceptable and qualified calculations in order to enable a detailed and comprehensive analysis.

The questionnaire was produced with relatively satisfactory response where 3 out of 8 countries replied. In addition other data sets were used to support the data.

The following sources are used in the analysis:

The 1995 questionnaire on shipping activities in Canadian Arctic (TC 1995). Parts of the information have been given to PAME in previous assessments.
International statistics received by Lloyds World Fleet Statistics, Fairplay Ship Data Base, The Comprehensive Ocean-Atmosphere Data Set (COADS) and other major reports relating to environmental issues and shipping operations are used in the study. For details the list of references should be consulted.
The International Northern Sea Route Programme (Løvås & Brude 1999) is a comprehensive multi-national and multi-disciplinary research programme with the purpose of investigating the possibilities for commercial navigation along the Northern Sea Route (NSR) and adjacent waters. The work is comprehensive and gives a detailed information on the environmental impact of shipping, navigation and related activities on the NSR. The results of the programme have been used to support more general statistics and information on the Arctic maritime activities along the NSR.
Data received from Finland, Iceland, Canada, Denmark and Norway based on the 2000 questionnaire.
Statistics Norway

The PAME assessment of 1996 (PAME 1996) encompasses general information of maritime activity and provides less detail on trade and operation patterns. The PAME assessment on Canadian activities produced in 1995 is detailed with respect to type of vessels and size. However, details on trade and operational patterns are not given.

The COADS Standard 1a, from the National Centre for Atmospheric Research (NCAR) and the National Oceanic and Atmosphere Administration (NOAA), provides a source for information on global vessel densities. The COADS database has registered the number of ship observations on a 2º latitude and 2º longitude (2x2) resolution. Based on the number of observations, within each grid location, an estimation of the traffic density of marine vessels can be obtained. The data is given on monthly level and starts in the late 1980`s. COADS is the most extensive collection of surface marine data available for the world ocean. However, it should be noted that it only covers approximately 10% of the world fleet in number (Corbett et al 1999). The data is used to estimate the geographical distribution of maritime activities and their possible impact thereof in the Arctic. It should be noted that smaller fishing vessels are probably not included in the data set.

Equally the Lloyds Fleet Statistics and Fairplay data base on port statistics is used to outline the relative share of activity based on vessel registered in ports. The Fairplay database encompasses vessels > 190 GT, leaving smaller vessels (expected to be mostly fishing vessels and inland waterway vessels) out of the database.
The statistics from the Statistics Norway encompass data for the country and is regarded as satisfying. The Arctic share has been calculated based on the total figures.

The INSROP work is expected to be the most comprehensive data set available for Russia on maritime activity along the Northern Sea Route. This data set has been used exclusively for the Russian part of the analysis.

Input given by the Arctic countries through the questionnaires is considered to be representative for the Arctic maritime activities and hence appropriate for the purpose of the snap shot analysis.

3.2 Data Input used

Table 3.1 presents aggregation of data received and collected for the analysis. Details on the data are given in appendix 4. Figures are presented for dry cargo, wet cargo, general cargo, fishing vessels and icebreakers/ tugs. It should be noted that statistics on shipping on inland waterways are not fully included in the study

Table 3.1 Arctic fleet numbers used in the modelling.

Type	Number of vessels		
	All	<5000 DWT	>5000 DWT
WC	189	163	26
DC	552	309	243
FV	3394	3383	11
IC/TUG	48	22	26
Sum	4183	3877	306

The fishing fleet is largest by number. However a large part of the fishing vessels are small vessel, of about 25-100 GT with a low activity level compared to the larger vessels. The merchant activities must be considered relatively low in the Arctic.

3.3 Discussions on data quality

The complete available data sets give information at an acceptable unified and standardised level. Together with the data sets provided, general empirical assumptions are made on parameters when not available in the data sets as among others:
vessels densities (geographical)
annual operation hours
number of vessels by ship type
number of crew / passengers per vessel type and size

distribution of vessels in size groups
number and length of voyages

The analysis has been performed for selected types of vessels and environmental impact. To extent possible the data sets has been divided into size groups of vessels. The data sets provided encompass statistics over a period several years, varying between countries considered. An assumption has been made that this period is representative for the present maritime activities in the Arctic and that the activities have not changed substantially.
For some countries the statistics have not been made available at the same level of detail. Norway, Iceland, Denmark, Canada, Sweden and Finland, the two latter with low level of maritime activity, are expected to have the same level of detail with respect to fisheries. Merchant traffic is overall at the same level of for Norway, Canada and perhaps Russia. Due to the variations in level of detail, the figures given should be looked upon as estimates and used accordingly.
In a collection effort as carried out in this work, (level of details and time schedule) data can be expected to be at this general and overall level. If more detailed data is requested a major collection and aggregation effort is required.

4 SHIPPING IN THE ARCTIC

4.1 Introduction

Because the Arctic is an ocean surrounded by land, it is not surprising that waterways were the first means of transport. Northern natives plied the rivers and lakes in canoes and kayaks, and southerners coming into the area arrived in larger ships either across the seas or down the rivers. The phase of exploration known as the expansion of Europe, beginning in the 15th century, included a search for water routes around the northern end of the continents of the Northern Hemisphere: the Northwest and Northeast Passages. Neither route was discovered for another three centuries, but both are in use today for at least part of, and occasionally along the whole of, their lengths.

The greatest use of water transport is in Russia. The sea route called the Northern Sea Route, carries the largest volume of traffic of any Arctic seaway. Serviced by about 20 icebreakers of more than 10,000 shaft horsepower--some of them nuclear-powered--a fleet of ice-strengthened freighters carries cargoes of several million tons annually to and from the ports of Murmansk and Vladivostok. The shallowness of the water obliges the use of relatively small ships of up to 20,000 tons dead weight. The major constraint is sea ice, which determines the length of the season. This is as little as two and a half months at some points, but at the western end year-round navigation is possible as far as the Yenisey River. Strenuous efforts have been made to extend the season, if possible to the point at which it will be year-round over the whole length. The present route serves ports at the mouth of the major rivers, the principal freight being general cargo and fuel into the north and ore and timber out of it. There is also extensive use of the rivers themselves: all the major and many of the minor rivers carry large fleets of barges, tugs, and hydrofoils (www.britannica.com).

While Russia carries the most traffic, both by sea and by inland waterway, the medium is exploited in other areas too. There is traffic between Greenland and Denmark, and in North America both Canada and the United States use sea routes to supply settlements and industrial sites in the Canadian archipelago and Alaska. About 90% of goods transported into Alaska is by waterborn transport (Kunnskapsforlaget 1995). The Northwest Passage as such is however little used (www.britannica.com).

4.2 Shipping activities in the Arctic

Shipping is one of the activities identified as contributors to pollution in the Arctic and thereby of concern of PAME. Description of the shipping activity in the Arctic is among others documented in the report from the Working Group on the Protection of the Arctic Marine Environment of March 1996 (PAME 1996), detailed for Canada in TC (1995) and in several reports produced under the International Northern Sea Route Programme (INSROP).

Major navigation routes and ports in the Arctic are given in figure 4.1.

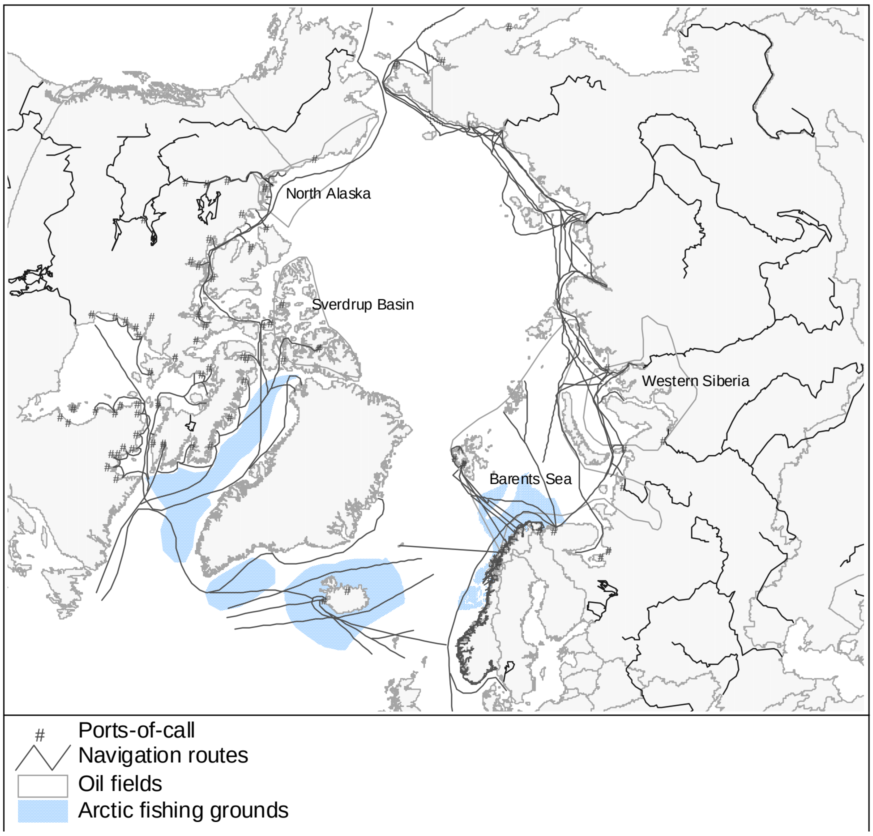


Figure 4.1. Major ports and navigation routes in the Arctic, sources TC (1995), PAME (1996), INSROP (1998) and PAME questionnaire 2000. Geographical reference of fishing grounds has not been made available for USA and Russia.

The maritime activity in the Arctic consists of:

transport of general and bulk (wet and dry) cargo and containers (assumed to increase in the future)
fisheries (assumed to remain stable)
tourism, including whale watching, cruise vessels / passenger vessels (assumed to increase in the future)
research and other vessels (assumed to remain stable)
transport of vessels for scrapping (assumed to increase in the future)
icebreakers and tugs (assumed to increase due to overall increase in maritime traffic)

Figure 4.2. The view from the bridge of the CCGS Louis S St. Laurant near Resolute Bay, Ninuvit. Provided by Transport Canada.

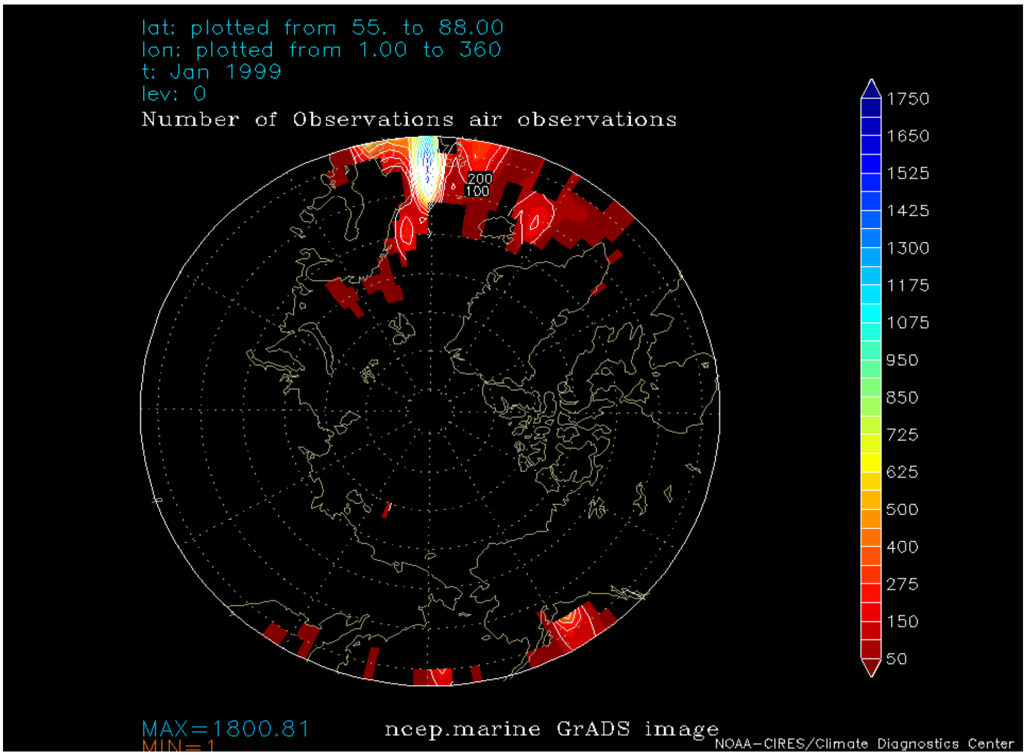
4.3 Seasonal variations

Seasonal variations in the shipping activities in the Arctic region are mainly caused by prevailing ice conditions. In the most exposed areas, the shipping activity is regulated, i.e. in Canada by permissible seasons according to the zone/date table of the Arctic Shipping Pollution Prevention Regulations (TC 1995). However, operating experience has shown that ice and weather conditions are very variable from year to year and within season. Which has driven the development of the Canadian Arctic Ice Regime Shipping System (TC 1996).

In many cases the use of icebreaker escort is necessary or instructed. A major part of maritime activities in ice-infected areas of Arctic Canada is performed in the period June – October. The same is the case for the NSR where dense drifting ice and solid ice cover the whole region in November – April with a freezing phase of August/September - May (Brude et al 1998 and Mikhailichenko & Ushakov 1992).

In areas of less or no ice coverage the shipping activity is of a more regular pattern and changes are mainly due to activities as fisheries (depending upon resource distribution and seasonal variations) and tourism/cruises (summer activity).

Example of vessel densities in January and August are presented in Figure 4.3a and b based on COADS. It should be noted that the COADS data sets are not expected to encompass smaller fishing vessels.



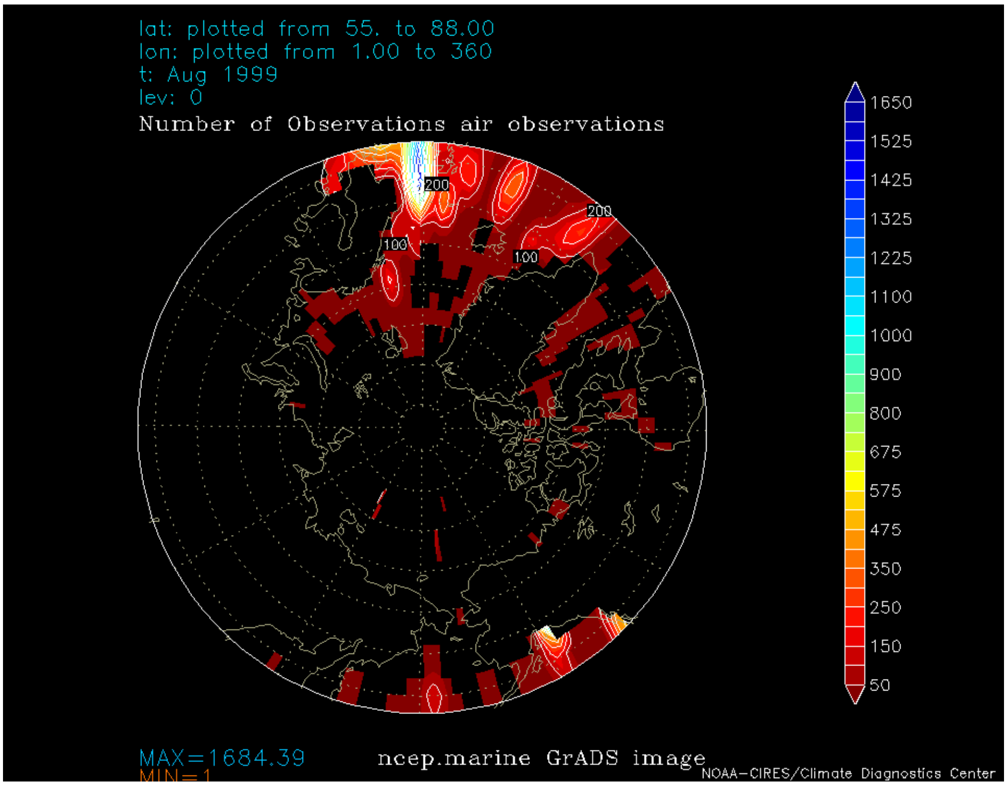


Figure 4.3 a (top) and b (bottom). Example of vessel densities based on air observations for January (a) and August (b) 1999. Data source Comprehensive Ocean-Atmosphere Data Set (COADS) - http://www.cdc.noaa.gov/cgi-bin/DataAccess.pl.

4.4 Import and Export in the Arctic

Shipping in the Arctic is mainly engaged in transporting goods into, within or out of the region. International transit in the Arctic is carried out in lesser extent if at all.

Most sea borne import in the region is that of transport of goods to industry and human settlements by larger cargo and bulk cargo to the major ports. Smaller cargo vessels carry out further distribution. It should be noted that transport also takes place on land and inland waterways.

Export is mainly related to transport of unrefined products from the petroleum industry (oil and gas), fisheries and mining / forestry industry. Transport of these products is performed in and out of the Arctic regions of all Arctic countries. USA and Norway have together with Canada a major portion of this export.

Export from Iceland and Greenland is mostly related to fish-products and to some extent products from the mining industry to Denmark (Greenland).

The Northern Sea Route (from Novaja Zemlja to the Bering Strait) was officially opened for international transit trading in 1991. However, presently commercial utilisation by non-Russian vessels has been insignificant. The distance advantage of using the NSR for transcontinental transport between the Pacific and the Atlantic is in many cases obvious and has been demonstrated by Russian activities. It remains however, to establish this as a stable and safe route on an annual basis. Improvements and optimisations of economical, logistical and technical aspects are necessary to make the NSR economically feasible for international traffic (Brude et al. 1998). The present status of NSR and results of the INSROP programme hence indicates that the use of the NSR for transit shipping operations is not yet proved capable (INSROP 1999).

The data presented by COADS provides data on geographical distribution of vessels densities indicating areas of export/import routes. The data shows a clear bias of activity in the northern part of the east Atlantic, between Norway and Greenland, as illustrated in figure 4.4. The figure presents the monthly mean of vessel densities in the period of January 1991 – April 2000. It should be noted that the COADS data sets are not expected comprised of fishing vessels.

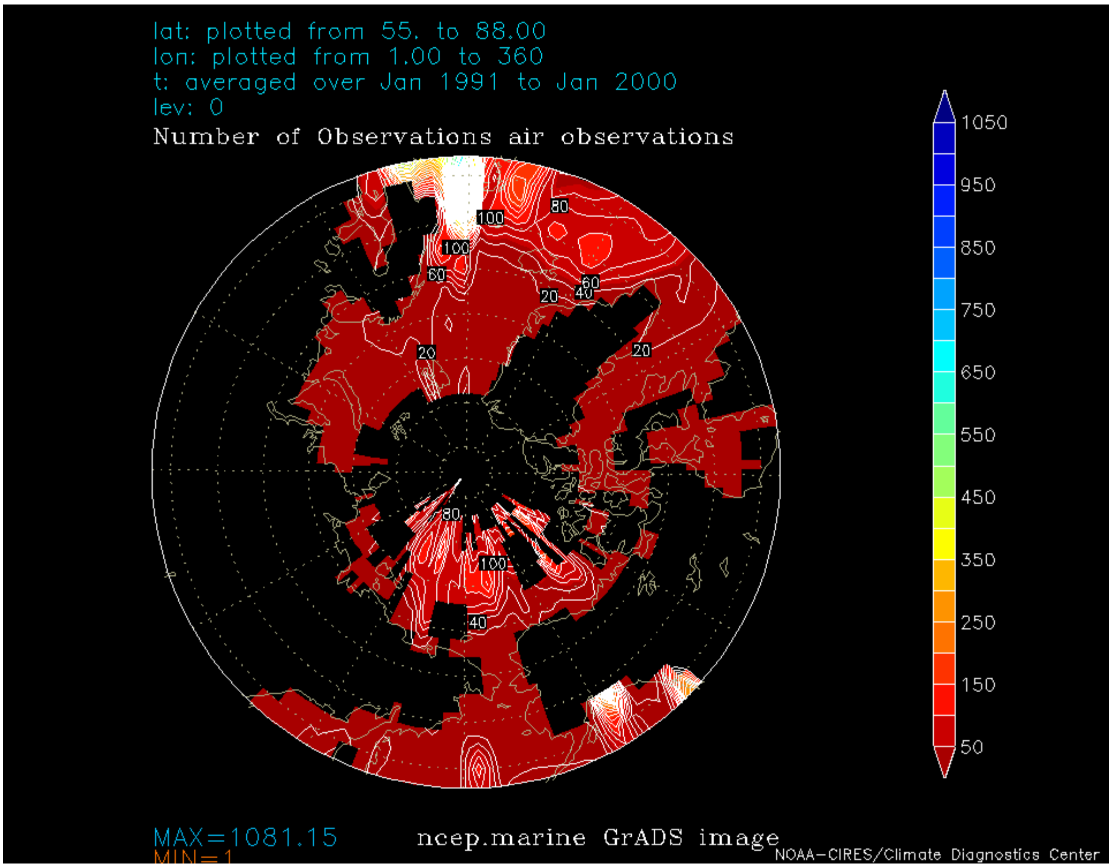


Figure 4.4. Example of merchant vessel densities based on air observations for the period January 1991 – **January 2000. Data source Comprehensive Ocean-Atmosphere Data Set (COADS) -** http://www.cdc.noaa.gov/cgi-bin/DataAccess.pl**.**

4.4.1 Expected future trends

Increase in the economical activity in the Arctic is expected to increase the shipping traffic in the area. New mining activities are expected in the Canadian Arctic, i. e. the development in the Izok Lake site that will require two new ice classes ships and a small port infrastructure. The volumes of transported ore/zinc at the other mines in Canada are expected to increase into this century. Several oil companies have operated in the area and movements to and from the Arctic are limited to the open water season (TC 1995). At present all petroleum activities in the Canadian Arctic is finalised. Future production schemes are not outlined.

Although the use of the NSR for international transit shipping operations is not expected in the near future, this route should not be underestimated. Northern Russia holds rich reserves of petroleum hydrocarbon, coal, minerals and timber. Significant effort is put on improving these economically important sectors and plans for development and export have been raised (Brude et al 1998). It is expected that the sea born export of petroleum products (oil and gas) from Russia will increase in the future. This is mainly expected from the larger oil fields in western Russia (Pechora and Yamal) and central Siberia via the larger rivers of Ob and Yenisey. The sea born export from these areas is expected to increase by 3-4 times by the end of the last century. (EPPR 1997 in Brude et al 1998). Tanker transport from northern Russia is by the Norwegian Trade Council expected to increase to an extent that it equals the amount of petroleum product shuttled in Norwegian waters in the near future (Johannessen 1999).

Export of petroleum products is also expected to increase from the Norwegian section of the Arctic; the Norwegian Sea and the Barents Sea. Production start is yet to be decided, however initiation is expected in the period 2005-2010. Shipping activity is expected increased due to shuttling, contingency support (standby supply vessels) and supply of goods to the fields. To what extent the products will be transported by vessels is yet to be decided, however, a combination of pipelines and vessels are expected.

Traffic to and from Greenland has not changed substantially during the last years and is expected to remain stable. Oil drilling has started outside Nuuk, on the Fylla bank, hence increasing the traffic in the area. Presently this is the only field at stake and other fields are not indicated in the near future.

4.5 General cargo traffic

Larger general cargo and bulk cargo vessels carry goods to the major ports in the Arctic while smaller cargo vessels are used for further maritime distribution.

Major cargo traffic is carried out in Canada. The transport in Canadian Arctic is often divided into eastern Arctic (Hudson Bay and Baffin Bay) and western Arctic (Beaufort Sea) shipping activity of which the eastern encompass by far the largest amount of cargo transported. Data on traffic in Canada based on the period of 1986 – 1991 is presented in TC (1995). A major part of the cargo transported is ore from the mining industry (more than 50% of total cargo volume). Transport of petroleum, oil and lubricants amounts to about 30 % of total volume transported in the period. The remaining 20 % are transport of dry cargo (TC 1995). Canada does not have the infrastructure to handle on shore loading of container traffic. However, container traffic takes place although by direct unloading to smaller vessels for further distribution.

Major transport to and from the Greenland sea areas is comprised of bulk cargo and container vessels. The import of the shipping activity to Greenland serves about 30000 inhabitants (mainly along the west coast) represented by general cargo from Denmark.

4.5.1 Expected future trends

The cargo transport in the Arctic is expected to increase due to increased petroleum and mining activities and the need for future supplies for these industries.

In Russia, requirements in relation to local distribution depend on future human settlements and aggregations of such. These processes depend upon the future economical situation in Russia. In the period of 1991 – 1995 a general decrease in maritime activities were observed along the Russian coast, however the situation has been stable since then (Ivanov et al 1998).

In Canada the major increase is expected in the eastern part of the region.

4.6 Fisheries

Fisheries are mainly undertaken in the ice-free areas of the North East Atlantic, the Barents Sea, Bering Sea and the Baffin Bay and along the continental shelf. These areas contribute to a considerable amount of the total global fisheries, supplying more than 10% to the market. Major nations are Iceland, USA, Russia and Norway. The activity is dependent upon the availability and distribution of resources and shows large seasonal variations on a local scale.

Fisheries in Russia are mainly located to the western part of the Kara Sea and rivers and estuaries and are insignificant on a global scale. This is due to sparse and difficult access to the fish resources east of the Kara Sea. The catch is consumed locally and future long-range transport is not likely (Brude et al 1998).

A major part of the fishing fleet consists of smaller vessels (less than 30 metres) mainly active in near shore areas. Data on such fisheries are often not included in general statistics, but are known to contribute to a substantial part of emissions to air. The larger vessels (larger than 30 metres) are mainly used in open water and are often included in national and international statistics.

The fisheries represent an important part of the livelihood of the indigenous people of Russia, Greenland and Canada. The relationship between these interests should be recognised and future trends and impact on the fisheries in these areas should be elaborated.

4.6.1 Expected future trends

The fishing activity in the future is expected to be stable and located to the same areas as present. This is related to availability of fish stocks and the general natural variation as such. The fishing activity and the fleet structure are a consequence of how the activity is regulated nationally and internationally. At present, information available does not support a future increase nor decrease in the pattern.

4.7 Tourism; Cruise and Passenger vessels

Tourism/Cruises is a relatively new industry in the Arctic and have steadily increased the last 10 years. The activity is mainly located near the shore / ice edge with the aim at presenting dramatic, “untouched” natural resources and the ultimate experience. Among others are the Barents Sea and the Lancaster Sound, Baffin Bay, Hudson Bay and the west coast of Greenland are popular areas (TC 1995). To a smaller extent the east coast of Greenland and the sea areas towards Iceland are used for this purpose.

The use of heavy nuclear powered icebreakers for tourism purposes (e.g. to the North Pole) is among others performed in the Russian sector of the Arctic.

The tourism activity along the Norwegian north west coast and towards Svalbard is also increasing. Larger cruise vessels are operating in the area, about 20 vessels annually.

The activity takes place in the open water season mainly the months of June, July and August.

4.7.1 Expected future trends

Tourism in general is an increasing business among others due to increased availability of targets, increased free time and improved economical status. The activity is expected to increase in all parts of the Arctic in the future.

4.8 Tugs, Research and Icebreakers

Towing is used in transport of cargo, fuel to the local communities and industry by barges and tugging of vessels for scrapping. At present the latter is not a major activity, however the activity is assumed to increase, among others due to the scrapping of military vessels in Russia. The experience in long distance towing varies and has in several cases resulted in losses, e.g. the *Murmansk* and *Boiky* outside the northern coast of Norway.

In the Canadian Arctic towing operations are almost exclusively limited to tugs towing barges loaded with fuel and supplies destine for remote communities. There are two distinct areas of operation, CT1 in the eastern Arctic, Hudson Strait and Hudson Bay and CT3, up the Mackenzie River and down through Amundsen Gulf, Queen Maud Gulf and Rae Strait. While some of these barge operations may take place in the proximity to sea ice, Transport Canada's *Tanker Barge Guidelines* are used by the various commercial companies which among other factors, prohibits the carriage of petroleum products in the barge's forward wing tanks.

Furthermore tugs are used for supporting other traffic when needed, e.g. port and oil terminal manoeuvring.

All Arctic countries perform some level of research activities to some extent in the Arctic. Vessels used for research purposes are mainly active in the "open sea" period. The activity is relatively small and does not amount to any volume compared to other maritime traffic.

The use of icebreakers is in some cases necessary or required by state. The Russian and Canadian Arctic are supported by icebreaker in seasons and periods of heavy ice conditions.

4.8.1 Expected future trends

At present towing of vessels for scrapping is not a major activity, however the number is assumed to increase, among others due to the scrapping of military vessels in Russia.

The operations of research vessels are often difficult to predict but the activity is not expected to increase substantially in the future. A trend is seen in on the development of combined icebreaker and research vessels to support the increased scientific and public focus on the Arctic environment.

The operation of icebreaker activity is linked to the general operations and the hull structure of the vessels. The icebreaker activity will vary with climatic changes or as commercial shipping activity dictates.

5 CALCULATIONS OF EMISSIONS TO AIR

5.1 Global geographical distribution of marine emissions

In order to quantify the air pollution from marine engines, in terms of exhaust discharge within geographical regions, it is instructive to use a geographical emission model. Such models are based on vessel traffic density within a number of selected pollution areas.

The calculation methodology is described in detail in IMO (2000). Table 5.1. presents the input data for the calculations (presented in table 5.2), separated by regions. It is evident that there are a smaller number of areas with high traffic density (as shown Figure 5.1). The geographical areas are classified according to traffic density (Table 5.1).

Table 5.1 Estimated traffic density 1996, individual regions. Source: IMO 2000.

Traffic density	Area size (10^6 km^2)	Average number of vessels
Low	255.0	5
Medium	67.6	50
High	17.4	150
Extra high	2.3	450

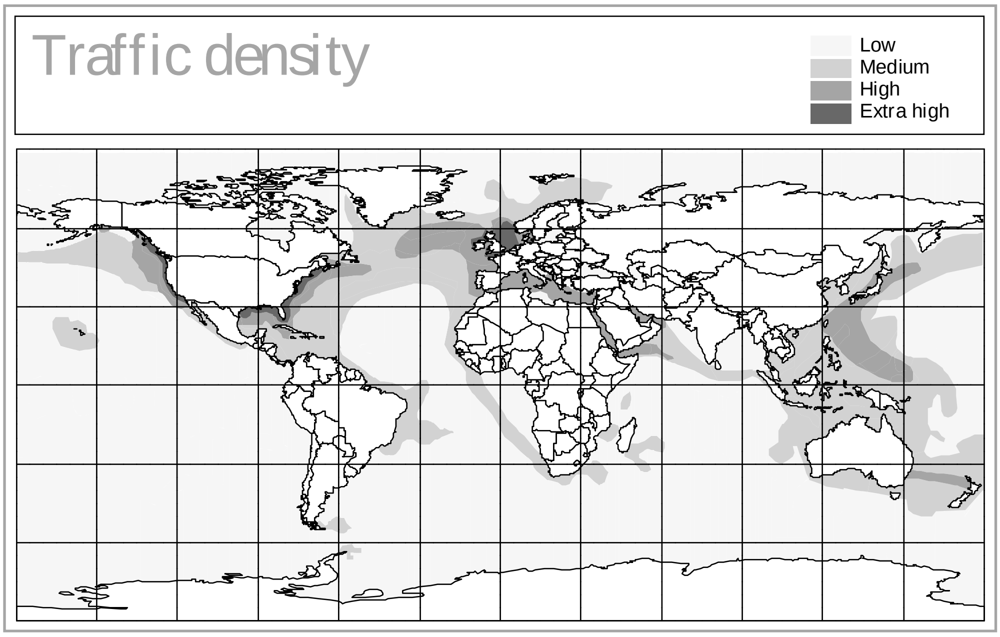


Figure 5.1 Estimated traffic density based on data from 1996. Source: IMO (2000).

5.1.1 Results

The estimated annual (1996) concentrations (mg/m^2 y) in the pre-defined regions (Table 5.2) are connected to the colours in Figure 5.1. These results are also in agreement with the investigations of Corbett (1999), who used a more detailed calculation method (higher grid resolution etc).

The results can be used as an estimate of the global distribution of emissions from exhaust gases originating from merchant shipping. However, it should be noted that:

- the calculation method is based on a simple approach
- the COADS data set only covers 10 % of the world fleet and smaller fishing vessels are not expected to be part of the COADS data sets.
- the used traffic density may include some domestic activity near the coast

The environmental impact of emissions to air for some emission components (NO_X, SO_X) will depend upon the existing background concentrations in the area. An area experiencing low background levels (low traffic density) is considered to be more vulnerable for an increased "load" than identical increase in an already polluted area (Isaksen, IPCC 1999). Hence, assessments looking at increased traffic density and its consequential impact in such low load areas will require a more detailed and advanced approach.

Table 5.2. Geographical distribution of the 1996 emissions, connected to colour in Figure 5.1. Source IMO (2000).

Pollution Area	CO_2		NO_X		SO_2		Fraction (%)
	(Mton)	mg/m^{2}y	(Mton)	mg/m^{2}y	(Mton)	mg/m^{2}y	
Low	3.3	13	0.1	0.3	0.04	0.2	0.8
Medium	33.4	494	0.8	12	0.4	7	7.6
High	100.2	5757	2.4	136	1.3	76	22.9
Extra High	300.6	128176	7.1	3018	4.0	1699	68.7
Sum	437.5		10.3		5.8		100.0

Corbett (1999) concludes that nearly 70 % of ship emissions occur within 400 km of land. Oftedal (1996) reported that 74-83 % of the ships was within 200 n. miles of land (based on IMO document: BCH24/inf.28 and MEPC 38/inf.12) at any time. Consequently, the main amount emitted is along the coast:

- In the Northern Hemisphere
- Along the west and east cost of United States
- In northern Europe
- The North Pacific

As seen from the study of IMO (2000), maritime operations in the Arctic region contributes on a global scale to low emissions to air. Smaller areas are however the source of medium contribution (figure 3.3a and b), e.g. Norwegian Sea, North East Atlantic and the Bering Sea area.

5.2 Estimates of emission to air in the Arctic

In order to quantify air pollution from marine engines in terms of exhaust gas emission, it is instructive to use an emission model. Emission models may adopt actual emission factors recorded from onboard measurements, or they can use theoretical factors arrived from the chemical reaction equations. In combination with actual fuel consumption, an emission inventory can be provided.

5.2.1 A statistical emission model approach

A breakdown of the "Arctic fleet" according to ship type, ship size and engine type is made on three levels. Knowing the specific fuel consumption and the emissions factors, the emissions rate for NO_x, SO_2, CO_2, CO and NMVOC, PM, CH_4, N_2O may be calculated by using the method developed by DNV (DNV 1999). The model is based on information from:

- The "Arctic Fleet Statistic" (Questionnaire 2000, PAME 1996, Fairplay 1998, TC 1995).
- Distribution of engine types and relations between installed engine power and DWT (DNV, 1998b).
- Marine emission factors (*Atmospheric Emission Inventory Guidebook 1999* from EMEP/CORINAIR)
- Specific fuel consumption (Harrington 1992, DNV 1998c and Klokk 1994).
- Activity profile (Questionnaire 2000, PAME 1996, Isensee 1994):
- Number of voyages
- Average duration of navigation (days/year)
- Average main engine load

Description and details of the statistical model are presented in an internal DNV report (1999) and by IMO (2000). The calculation covers only emission to air during operating phase.

5.2.2 Results

Based on the input data given and input from the methodology given above the following emissions to air (Table 5.3) have been estimated for the Arctic in the period 1998.

The results include dry cargo (DC), wet cargo (WC), icebreakers/tugs (IC/TUG) and fishing vessels (FV).

Table 5.3 Calculated emissions to air and fuel consumption in the Arctic for 1998 (in Kton)

Type	NO_x	CO	NMVOC	SO_2	CO_2	PM	CH_4	N_2O	Fuel consumption
WC	6.4	0.6	0.2	3.2	276	0.44	0.03	0.01	87
DC	40.1	4.9	1.6	10.6	2101	1.38	0.20	0.05	663
FV	47.6	5.6	1.8	13.9	2412	1.83	0.23	0.06	761
IC/TUG	11.3	1.4	0.5	2.4	610	0.30	0.06	0.02	192
Sum	*105.4*	*12.5*	*4.1*	*30.0*	*5399*	*3.95*	*0.51*	*0.14*	*1703.0*

IC/Tug - Icebreaker / Tugs, WC - Wet cargo, DC - Dry cargo, FV - Fishing vessels

5.2.3 Discussion

The estimates show that of merchant traffic, dry cargo is the most significant contributor. This is supported by other sources e.g. Flugsrud and Haakonsen (1998) who found a similar pattern when combining domestic and international maritime traffic in Norwegian waters. Dry cargo carriers are dominating (merchant traffic) by number as well as by emissions.

Fishing vessels contribute to a major part of the consumption of fuel and hereby represent a considerable input to emissions to air. This may be due to a large number of vessels with a high number of operation hours (Flugsrud and Rypdal 1996). Some of the larger fishing vessels also consume considerable volume of fuel due to a higher operational profile (especially factory vessel). For the Norwegian fishing fleet, it is documented that larger vessels (> 30 metres) consumes about 80% of the total fuel consumption of the fishing fleet. However, in numbers these vessels constitute for less than 20% of the fleet (Johannessen 1999). It should be noted that many smaller fishing vessels (< 30 meters) are operating on seasonal basis and may have been given a too high annual activity level. The bias in estimated emissions to air with respect to fishing vessels is also due to this fact.

Compared with the global marine consumption (IMO 2000), the Arctic consumption is only approximately 1 % (only wet cargo, dry cargo, fishing vessels and icebreakers/tugs).

Due to the variable level of detail in statistics (number of vessels, type and size distribution) and the lack of statistics for some regions the estimated values presented should be handled with some caution.

6 CALCULATIONS OF TBT EMISSION

Vessels are coated with anti-fouling paints containing toxic compounds. Currently used anti-fouling systems contain compounds like copper, TBT (tributyltin) and co-toxicants like zinc and organic compounds such as triazines. After 3-5 years about 80-90 % of these biocides will have leaked out.

6.1 A statistical emission model approach

The DNVs anti-fouling emission model (DNV 1999) estimate the annually emitted amount of TBT from the Arctic fleet (includes wet cargo, dry cargo, icebreakers/tugs and fishing vessels). The model is based on a breakdown of the Arctic fleet, statistical relations between wetted surface and dead-weight for each vessels category and emission equations as:

Emission [kg/year]= Total wetted area of ships [m^2] · Leaching rate [kg/m^2/year]

The model also require the distribution of anti-fouling types (TBT, Copper and others) and the leaching rates. A detailed description of the model is given in the DNV report *Reference values for ship pollution* (DNV 1999).

It is seen from the equation above that the emitting of TBT is depending of the Wetted surface calculated by the vessel dimensions. However, as documented by INSROP (1998) and PAME (1996), the Arctic merchant fleet consists of smaller vessels compared with world merchant fleet (VLCC etc.), followed by in average a lower TBT emission pr. vessel. It should be noted that the use of TBT was banned for vessels smaller than 25 metres in 1990 on more or less global terms.

It is believed that TBT-based anti-fouling paint is used by 70 percent of the world's fleet (Mayell & Swanson 1998). The TBT leaching rate was assumed to be 2 $\mu g/cm^2$/day in a previous work in the North Sea (Isensee et al 1994). IMO has recommend a TBT leaching rate below 4 $\mu g/cm^2$/day (IMO 1998).

A leaching rate of 2 and 4 $\mu g/cm^2$/day was applied in the model and the fraction of TBT based anti-fouling systems was assumed equal to 70 %.

It is assumed in the calculations of TBT that the vessels in the data set (ref. table 14.1) are in the Arctic region on annual basis. In addition the smallest vessels (< 25 metres) are not included in the TBT calculations.

6.2 Results

The modelling results are presented in Table 6.1. The emission of TBT in the Arctic is estimated to be in the range of 2-4 ton/year.

The emission of TBT by merchant fleet world wide is estimated to be in the range of 750-1500 ton/year (2 – 4 $\mu g/cm^2$/day) and the total wetted area about 148×10^6 m^2 (DNV 1999). The main contribution vessel categories are oil tankers, bulk carriers and general cargo vessels. By comparing the Arctic (maritime traffic) and world wide emission of TBT, the Arctic contribution is only about 0.3 %, and dry cargo vessels are the dominating category.

These results include only wet-, dry cargo, icebreaker/tug and fishing vessels, and the estimated TBT emission may therefore be too low. However, use of TBT on smaller vessels has been banned since 1990 (this ban is not global, but widely accepted). In addition Arctic vessels may use paints with a lower leaching rate due to colder water, and a leaching rate of 2 mg/cm^2/day is likely (Table 6.1; 2.1 tons TBT).

Table 6.1 Emitted TBT using the 1998 Arctic fleet statistics.

Vessel type*	TBT fraction	Emitted TBT (tons/year)	
		$7.3\cdot10^{-6}$ (tons/m^2/year) 1)	$14.6\cdot10^{-6}$ (tons/m^2/year) 2)
WC	0.7	0.3	0.6
DC	0.7	1.8	3.6
FV	0.7	1.4	2.9
IC/TUG	0.7	0.1	0.2
Sum		2.1	4.2

1) leaching rate of 2 mg/cm^2/day
2) leaching rate of 4 mg/cm^2/day
*WC-Wet cargo vessels
DC- Dry cargo vessels
FV- Fishing vessel
IC/TUG- Icebreaker/tug vessels

There are no current international rules governing environmental matters with regards to antifouling paint systems. However, some countries have applied legislation to register and reduce the use of organotins in antifouling systems. Within IMO discussions on prohibiting the use of organotin compounds have taken place for a long period of time. In 1999 IMO 21st Assembly due to adopt Resolution on phasing out organotin compounds acting as biocides in antifouling systems was carried out. Prohibition of application of organotin compounds acting as biocides in antifouling systems and hereby enter the resolution into force is expected by 2003. A complete prohibition in the use of organotins in antifouling systems is expected by 2008.

7 CALCULATIONS OF SEWAGE, OILY WASTE AND NOISE

The most important international convention related to control and management of pollution from ships is the International Convention for the Prevention of Pollution from ships 1973, as modified by the Protocol of 1978 relating thereto, also abbreviated MARPOL 73/78. In accordance with MARPOL, those nations that have ratified the convention are obliged to provide for reception facilities for ship waste.

The various annexes of the MARPOL convention enters into force only following the ratification from a sufficient number of nations.

In this report the following MARPOL annexes are of interest:

- Annex I. Oil (Dirty ballast water, oily tank washing, oily bilge water, slops, sludge, fuel residues, waste oil).
- Annex IV. Sewage
- Annex V. Garbage, trash, oily rags, plastic, packing material and dunnage.

Annex IV is not yet in force. For Annex I dirty ballast water and oily tank washing is not mentioned in this chapter.

Detailed description of the different waste types is given in appendix 6.

7.1 Calculation of generated waste

The quantification of waste generated by vessels has been given limited attention. Therefore, statistical data is not readily available and thus it is difficult to aggregate quality data and to draw conclusions on the issue.

In this study data from a survey undertaken in 1977 by the Ship Research Institute of Norway (NSFI) and later on used by DNV in a project for the Norwegian Maritime Directorate (NMD 1994) have been used. Details of data input are given in appendix 4. The methodology considers sources and amounts of waste oil from ship operations. Temporary models are developed from the waste generation from; separation of fuel oil, lubricating oil and bilge water. Each type of waste generation is particularly considered with relation to the factors that influence the generation.

The Ship Research Institute of Norway (NSFI) undertook a survey on the quantities of oily waste from ships calling at Norwegian ports. The produced amounts were used to calculate expected amounts of waste to 142 Norwegian ports based on information that was gathered from the ports.

The figures that are given for sludge, oily bilge water, lubricating oil and solid wastes (NMD 1994) are given for different types and sizes of ships and given as litres/24 hour. The numbers are connected to the ship size and are not connected to influence factors such as fuel oil quality, type of separator and type of engine. The figures are then combined with the data of ship traffic in the Arctic and the produced amount of sludge, bilge, sewage, garbage, solid oily waste and waste oil from the actual vessels are calculated. Hence the numbers do not describe what is legally discharged.

The numbers that are given for sewage (black and grey water) are given for different types of ships, different sizes of ships and given as litres/24 hour. The numbers take into consideration the number of crew and passengers, differences in the production of sewage from conventional and vacuum systems and parts of vessels that have vacuum/conventional systems. The calculations are based on figures for potential produced amounts of sewage. The numbers do not take into account that in over-sea traffic about 80 % of the ships have sewage treatment plants. Vessels with sewage treatment plants produce 2 litres sludge/p.e./24 hour (NMD 1994). The numbers are then combined with the data of ship traffic in the PAME-area and the produced amount of sewage from the actual vessels are calculated. Hence the numbers do not describe what is legally discharged.

The amount of garbage produced on a vessel is a function of the number of persons (crew and passengers) on board and is usually reported in kg/man/24 hour. The NMD study (NMD 1994) suggested a garbage rate, r_g= 1.5 kg/man/24 hour for cargo vessels and for passenger vessels, r_g= 2.1 kg/man/24 hour.

These figures are combined with figures of passengers/crew and gives produced amount of waste from different types of vessels. The figures are then combined with the data of ship traffic in the Arctic and the produced amount of garbage from the actual vessels are calculated. Hence, the numbers do not describe what is legally discharged.

The calculations cover only production of sludge, bilge, sewage, garbage, solid oily waste and waste oil during operating phase.

7.2 Results

The results from the calculations are given in Table 7.1. It should be emphasised that the given numbers are potentially produced amounts and do not reflect what is discharged or what is actually delivered onshore. Fishing vessels contribute a major part of waste generated. However, the large fraction of small fishing vessels may give a too high contribution.

Table7.1. Estimated generated waste in the Arctic, based on fleet statistics for 1998.

Type	Sludge (m^3/year)	Bilge (m^3/year)	Solid oil waste (ton/year)	Waste oil (m^3/year)	Sewage (ton/year)	Garbage (m^3/year)
ICEBR./TUG	4219	2930	41	352	7617	114
WC	2495	5938	175	1490	15762	236
DC	20168	46579	818	4574	82463	1256
FV	16196	35904	2949	16002	179890	2684
SUM	*43078*	*91351*	*3983*	*22418*	*285732*	*4290*

IC/Tug-Icebreaker / Tugs
WC-Wet cargo
DC- Dry cargo
FV-Fishing vessels

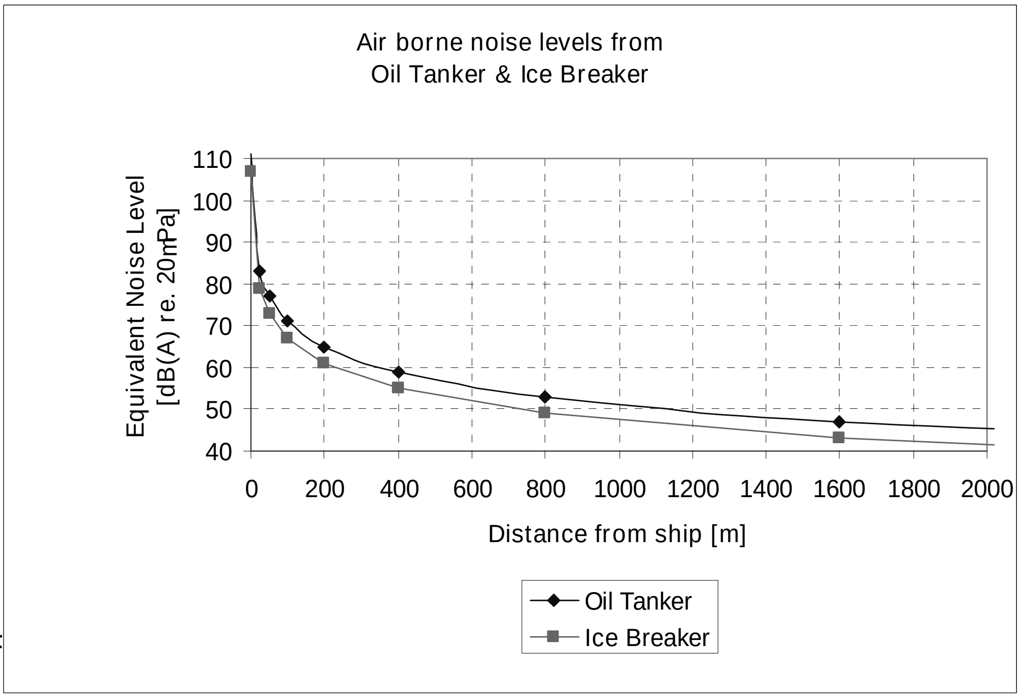
7.3 Airborne and waterborne noise

Airborne and waterborne noise is predicted for icebreakers/research vessels and Tankers (represents cargo transport). The prediction is based on empirical and statistical data measured on similar but not necessary identical vessels. Tankers of about 100 000 DTW and conventional research vessels and seismic vessels are used in the prediction.

The prediction is meant as a rough estimation of the noise levels in air and water.

7.3.1 Airborne Noise

Airborne noise plotted as a function of the distance from the vessel is shown in figure 7.1 for icebreaker and tankers.



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The main noise sources onboard the vessels are expected to be:

- Exhaust outlets
- Fans (inlets/outlets)

Noise from these sources is general at frequency of 1000 - 2000 Hz. The predicted noise levels from the icebreakers do not include noise from the ice breaking process.

7.3.2 Waterborne noise

Ships in open water produce noise that increases with increasing speed. Monitoring of an ice-breaker and smaller boats operating around drilling sites showed almost the same magnitude of sound pressure levels. Icebreakers produce much noise that is dominated by the cavitation noise produced by the propellers. The noise from the machinery and by the impact of the ship with the ice cover contributes little to the total noise at some distance from the vessel. The source strength is highest at the lowest frequencies (below 100 Hz) and can be detected up to a distance of 55 km in open water and up to 33 km in fast ice (Severinsen & Hansson).

Predicted waterborne noise levels from icebreakers and tankers is shown in figure 7.2:

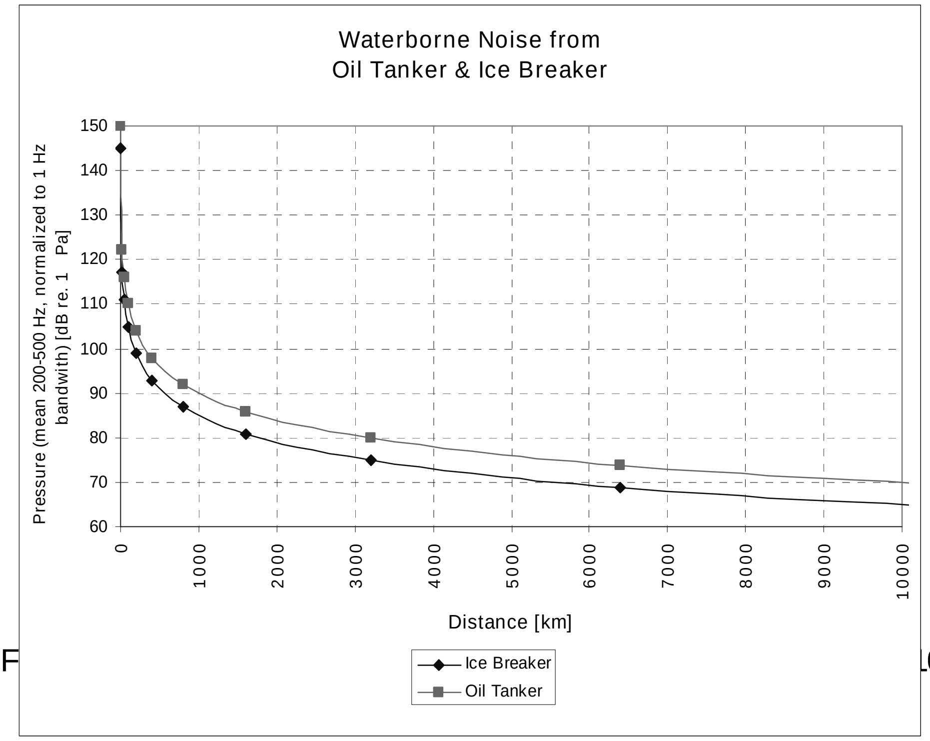
The main noise sources for the waterborne noise are expected to be:

- propeller
- engines mounted directly on the hull

Noise from these sources is general at low frequency of 100 – 200 Hz As for the airborne noise, noise from the ice breaking process is not included in the prediction for waterborne noise.

Comparing the predicted noise levels to the industrial limit of acceptable noise in Norway (50 dB(A)) the minimum distance from the vessels to the emission point is:

- icebreaker: 750 m
- tanker: 1200 m



F [illegible] 10 000 m)

Threshold of hearing for cod and herring is shown in figure 7.3.

The figure shows that the herring can hear the sound in the water much better than the cod.

Comparing the noise levels in figures 7.2 with the threshold for hearing for the fishes herring and cod in figure 7.3, the following is found:

- Max. distance the cod could hear the Ice Breaker: 35 m
- Max. distance the cod could hear the Oil Tanker: 70 m
- Max. distance the herring could hear the Ice Breaker: 3 000 m
- Max. distance the herring could hear the Oil Tanker: 6 000 m

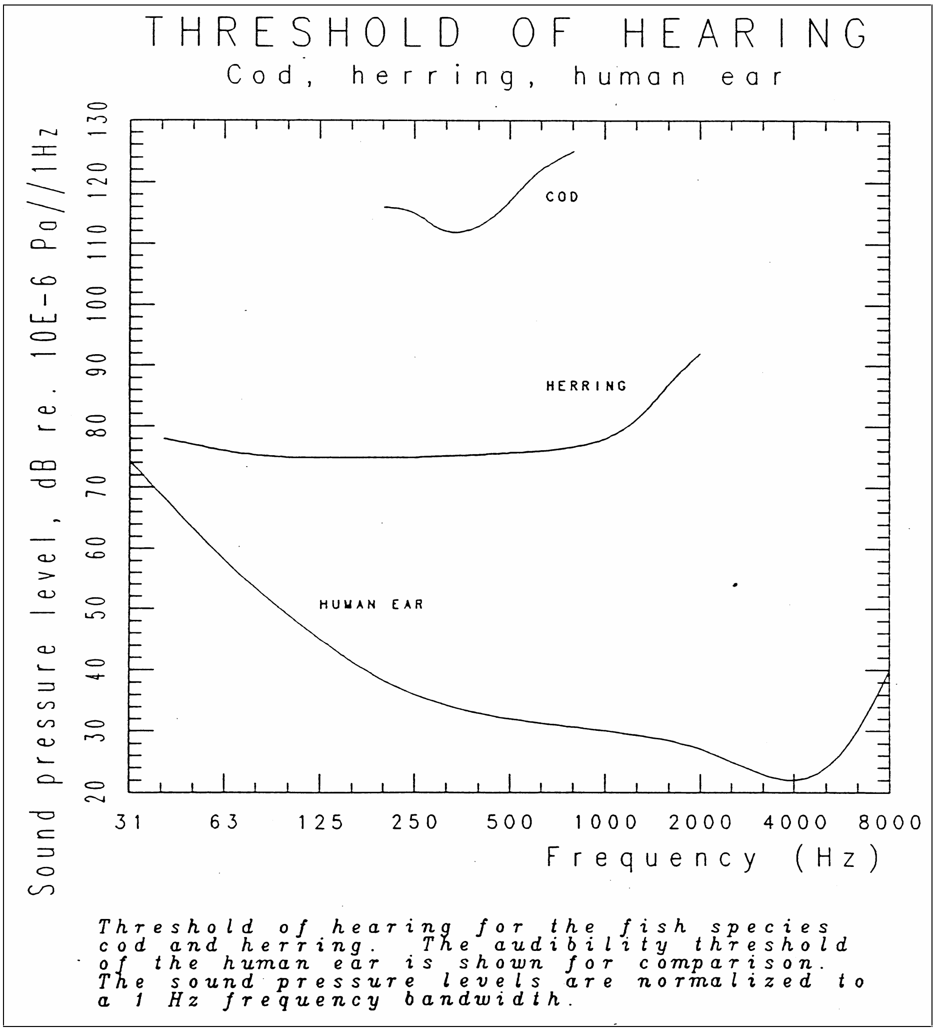


Figure 7.3: Threshold of hearing of cod, herring and human ear. Source: Enger & Andersen 1967.

Marine mammals (whales and seals) can hear as well as human beings in air. In water they can hear better than the carnivores on land, and they have a very good directional hearing. For each species there is a range of frequencies where hearing threshold is low. Below and above this range the hearing threshold increase with decreasing or increasing frequency. The sensitivity at low frequencies is especially interesting, because it is in this frequency range most industrial noise is found. In many whales the sensitivity seems to decline rapidly first above 120 kHz. Some seal species are known to detect frequencies under water from 1 to 180 kHz. The effect of different kinds of noise shows great variance between species. Some species react powerfully, while others do not react at all. This is exemplified by the problem the fishermen have with keeping seals away from their fishing nets (Severinsen & Hansson 1990).

The effect of this noise on marine mammals is not fully understood. Reported effects of ships in open water to marine mammals are few. Sometimes whales may approach a vessel and surfing the front wave of the vessel. In other occasions they may abandon an area when a vessel is arriving. There are indications that marine mammals get habituated to industrial noise. It should be noted however, that long term impact is yet to be monitored and fully understood. Precaution should therefore be taken when impacting undisturbed areas (Severinsen & Hansson 1990).

8 CONCERNS RELATED TO MARITIME ACTIVITIES

The seas of the Arctic are exposed to significant regular discharges from local sources both directly and via the large rivers, as well as long range transport of contaminants via the atmosphere and ocean currents. This is outlined in more details in appendix 1.

8.1 Accidents in the Arctic

A detailed study has been performed in Canada (TC 1995) related to accidents in 1990. It should be noted that fisheries, research vessels, icebreakers and oil and gas industry support vessels are not included in the study. The accidental risk was documented to be 5 times higher in the heavily ice-infected regions, of which approximately 50% of this increase were due to non-ice damage. The main causes were due to human error (55%), equipment/structure (12%) and unknown (13%). In general it was concluded that the risk of accidents was higher in heavily ice-infected areas of the Arctic than in other areas.

Work performed in Norway including Svalbard (Johannessen 1999) shows that accidents are evenly distributed along the coastal areas. In areas of little or no ice the accidental rate is not expected to be higher than in other areas. Grounding, collisions and fire/explosion amounted to about 75 % of the incidents. Fishing vessels is by far the largest group and constituted to about 40% of the incidents and dry bulk about 25%.

Certain parts of the Arctic have regions of inadequate hydrographic information. Hence it is assumed that the risks of accidents in heavily ice-infected areas are higher than in other areas. The causes may however, not exclusively be due to ice damage.

Figure 8.1. This Type D Bulk Carrier was damaged by ice in Hudson Strait. Provided by Transport Canada.

8.2 Environmental Impact of shipping activities

Maritime activities may interact with the environment in several ways. Impacts from the shipping activity can be divided into regular operations and accidental events.

8.2.1 Regular operations

The regular operations are a point source of long-term and low level exposure.

Operational discharges from shipping are generated by operations on board (oil, chemicals, sewage and garbage) or during cargo operations (oil, chemicals, vapour and dust). Other forms of discharges are caused by emissions to air (CO_2, NOx, SO_2, VOC, and particulars).

Release of TBT from anti-fouling paints is known to have impact on several marine organisms.

Noise and physical disturbance are other impact factors generated by frequent navigation in ice-infected areas (Brude et al 1998).

Oily wastes, sewage and garbage are to be discharged onshore according to local and international legislation. The number of offshore facilities for wastes handling and the respectively low capacity in the Arctic result in an increase in onboard incineration giving input to the emission to air. It is also experienced that due to lack of facilities sewage, garbage and oily wastes are known dumped offshore.

Transfer of living organisms (aquatic plants, animals and pathogens) via ballast water has been known to occur since the beginning of the 20th century. The extent of this transfer has since then increased with growing maritime activity and larger and faster ships. Carlton (1985) has given a comprehensive review of ballast water history. Undesirable spreading of exotic organisms has been described as the biggest threat to biodiversity and as the next big pollution challenge for the shipping industry causing irreversible processes effecting human health and industrial activities as well as the ecological balance of the seas. In several cases the introduction of non-indigenous species have caused great economic consequences, and there is an increasing realisation of the ecological costs of biological invasions in the irretrievable loss of native biodiversity. Along with growing concern on these effects, there has been an increasing amount of research related to the dispersal of organisms and transfer via ballast water during the last decades.

Conclusion

Impacts from long-term regular discharges from maritime activities are of environmental concern. The conclusions from previous works indicate that at present the impact in the Arctic of regular legal operational discharges of oil, sewage and other wastes is low. However, long-term effects of chronic low level contaminants are not fully researched and understood on Arctic ecosystems. A precautionary approach should be adopted and until research can prove acceptable effect due to regular discharges from shipping activities, these should be assessed and controlled. The expected increase in shipping activity in the Arctic suggests also the need for measures and control with respect to operational discharges. Addressing this concern PAME should follow the AMAP work on impacts of pollutants in the marine Arctic.

8.2.2 Accidental events

Discharges caused by accidental events are mainly caused by collisions, groundings or fires. Discharges will mainly be related to smaller amounts of cargo and bunker, but can also cause a major environmental impact. In addition the rescue operations during an accident may cause impact to the environment.

Significant environmental impacts to the Arctic marine environment can be expected from larger accidental discharges of oil and/or chemicals. A number of sensitive areas and resources are identified in the Arctic and are regarded as vulnerable due to their ecological features. Accidental discharges in areas of breeding, spawning and major feeding areas can have serious long-term effects, particularly given the low reproduction rates and the strategy of energy storage in fatty tissue that is common in Arctic species.

Presently severe acute marine pollution due to accidental events is not often reported for the Arctic region (Brude et al 1998). However, the risk of accidents to occur rises with the frequency of voyages. The Canadian assessment (TC 1995) show increased risk of accidents in ice-infected areas (up to 5 times). The expected increase in maritime activities in the Arctic region may therefore imply an increased risk of accidents. The need for ensuring sufficient vessel standards is stressed. Further more, contingency planning should be evaluated and assessed.

8.3 Environmental resources at risk

In comparison with most other areas of the world, the Arctic remains a “clean” environment. However, for some pollutants, combinations of different factors give rise to concern in certain ecosystems and for some human populations. These circumstances sometimes occur on a local scale, but in some cases may be regional or circumpolar in extent.

A set of Valued Ecosystem Components (VEC) and vulnerable components in the Arctic have been defined and assessed by INSROP (1998) and TC (1995). The geographical areas not encompassed by these sources (Greenland, Iceland, western Barents Sea and Alaska) are comparable ecologically to these sources and the combination of these sources is not expected to exclude any potential VECs.

The environmental sources consist of ice-edge communities, seabirds, marine mammals, fish resources and several marine organisms and ecosystems. These components are assessed and found to be vulnerable to normal shipping operations both in open water and in ice-affected areas (ice breaking operations). Equally these resources are at risk in accidents.

The EPPR (Working Group on Emergency Prevention, Preparedness and Response) working group of the Arctic Council will produce a report on “Circumpolar Map of Resources at Risk from Oil Spills in the Arctic”. The intention of the project to produce a series of maps covering the circumpolar area that highlight the areas of highest risk of an oil spill and those areas where sensitive natural resources or subsistence communities exist. In so doing, the project aims to highlight a limited number of “conflict areas” where the high risk of oil spills and very sensitive resources overlap. To achieve the overall goal of this project, a circumpolar Arctic database will be developed from contributions of the eight Arctic nations containing four categories of information: (1) major potential sources of oil spills, (2) important biological resources at risk in case of a spill (3) subsistence human communities living in the Arctic, and (4) protected areas. The project will gather and synthesise existing data, and compile and maintain them in a GIS-database, with a separate application interface that can be used to output maps as needed. It is emphasised that this project is circumpolar in scope, concentrating on the elements of the data that are considered to be of broad interest in an international context (guidelines for the working definition of “international” are found both below and in the supporting documentation). Because of this large-scale (circumpolar) focus, the data coverage is not intended to be exhaustive at local or national levels. For further details the EPPR or Michael Carroll at Akvaplan-niva, Norway can be consulted.

Defined VECs by INSROP (1998) and TC (1995) are listed in appendix 5.

8.4 Maritime operations at risk

Based on general knowledge of the impact of maritime operations on the environment, a list of major high risk operations can be given as in Table 8.1. Each operation is given a priority as “high” or “low” based on a professional scientific perspective.

Table 8.1 Maritime operations expected to have significant impact on the marine environment. Priorities for discussing PAME response actions are indicated by the numbers: 1: actions should be considered by PAME or 2: actions are not recommended at present.

Regular events					
Activity/Operations	Issues of concern	PAME Priority		Reasoning	PAME response
		Present	Future		
1. Onboard production of oily wastes, sewage and garbage	Possible shortage of reception facilities Illegal discharges to sea Onboard incineration	1	1	Present: Long operational periods at sea imply waste storage problems. Potential impact related to onboard generated pollutants. Future: Long operational periods at sea imply waste storage problems. Potential impact related to onboard generated pollutants.	Observe implementation of MARPOL Annexes and encourage ratification of the relevant MARPOL Annexes*.
2. Discharge of ballast water of foreign origin	Risk of reduction in biodiversity by introduction of harmful marine organisms to the Arctic.	2	1	Present: Low amount of foreign ballast water discharge. Potential impact related to onboard generated pollutants. Future: Expected higher volumes of ballast water discharged due to increased tanker and bulk carrier activity. Potential impact related to onboard generated pollutants.	In light of the IMO developments identify the need for Arctic measures on ballast water.
3. Release of TBT by leaching from anti-fouling paints	Risk of reduction in biodiversity	2	2	Present: Small amounts of vessels hence low TBT input to the environment. Future: Expected ban on the use of TBT as an anti-fouling agent in 2003.	PAME should observe IMO developments and encourage implementation of international measures on TBT.
4. Cruises / Passenger vessels	Disturbance of vulnerable resources Reference is made to activity 1 above.	2	1	Present: Ongoing activity is at an acceptable level Potential impact related to onboard generated pollutants. Future: Increased activity is of concern. Potential impact related to onboard generated pollutants.	Analyse existing and possible risk reducing measures. Analyse the need for joint PAME/CAFF policy. Analyse the adequacy of the WWF guidelines on ecotourism with regards to codes of conduct.

* list of ratified MARPOL Annexes are given in appendix.

Table 8.1 cont.

Accidental events					
Activity/Operations	Issues of concern	PAME Priority		Reasoning	PAME response
		Present	Future		
5. Loading and unloading activities in general	Increased risk of discharges of oil, oily water, bilge water and other hazardous substances.	1	1	Present: Complex operations involving human element, technical solutions on board and loading and unloading facilities. Future: Complex operations involving human element, technical solutions on board and loading and unloading facilities.	Analyse existing and possible risk reducing measures. Analyse the need for joint PAME/EPPR policy.
6. Tanker traffic – Production field - Terminal – Terminal - Export	Transport of oil products has high potential impact in case of accidents.	1	1	Present: The impact of an accident occurring is high. Future: The impact of an accident occurring is high. The activity is expected to increase.	Analyse existing and possible risk reducing measures. Encourage implementation of the Polar Guidelines. Analyse the need for joint PAME/EPPR policy.
7. Heavy bunker oil as cargo and fuel	Heavy bunker oil has very high potential impact if discharged to the environment.	1	1	Present: Heavy bunker oil can be used on several types of vessels, i.e. incidents can occur in all parts of the Arctic where shipping activity takes place. The impact of an accident occurring is very high. Future: The expected increase in shipping activity strengthens the reasoning given above.	Analyse existing and possible risk reducing measures. Encourage implementation of the Polar Guidelines. Analyse the need for joint PAME/EPPR policy.
8. Operation in areas of sea ice or glacial ice concentration	Increased risk of accidental impact hence increased risk of pollution.	1	1	Present: More complex operational regime than open sea operations. Future: More complex operational regime than open sea operations.	Analyse existing and possible risk reducing measures including remote sensing technologies. Encourage implementation of the Polar Guidelines. Analyse the need for joint PAME/EPPR policy.
9. Tugging / Towing of vessels	Increased accidental risk	2	1	Present: Low frequency of vessel tugging/towing at present. Future: The activity is expected to increase in the future.	Analyse existing and possible risk reducing measures. Encourage implementation of the Polar Guidelines. Analyse the need for joint PAME/EPPR policy.
10. Cruises / Passenger vessels	Increased accidental risk in near ice or near shore operation.	2	1	Present: Low frequency of risk operations of cruises / passenger vessels at present. Future: The activity is expected to increase in the future hence increased risk.	Analyse existing and possible risk reducing measures. Encourage implementation of the Polar Guidelines. Analyse the need for joint PAME/EPPR policy.

8.4.1 Operational events

Onboard production of oily wastes, sewage and garbage

Operation in the Arctic is often an operation with long periods at sea before coming into port. Hence there might be waste storage problems onboard. The occurrence of port reception facilities and infrastructure for handling oily wastes, sewage and garbage is not fully understood. In some cases wastes are incinerated onboard solving the waste problem, leading to emissions to air. However, the IMO standards on incinerators should be followed. To secure the full implementation of MARPOL Annexes entered into force is an ongoing task that will use the problems occurring. In addition the Arctic states should contribute to enter into force the MARPOL Annexes IV and VI.

The amount of waste, sewage and garbage produced is relatively high. The onshore facilities are not fully understood in the Arctic. Unless these products are transported to facilities that exists in the Arctic region or outside the Arctic these products are incinerated on board and hereby contributing to the emissions to air. The amount of waste, sewage and garbage from cruise and passenger vessels is very high compared to other vessel traffic. It should however, be noted that many vessels used for these purposes normally hold very high standards and are often "optimised" with respect to environmental aspects.

At present the cruise operations are limited in the Arctic. However, the expected increase in cruise operations in the Arctic places this activity as of major concern with a low operational impact compared to other operational activities in the region.

Discharge of ballast water of foreign origin

Introduction of harmful marine species is of concern. Presently the amount of foreign ballast water is low. However, an increase in the traffic is expected to increase the amount of foreign ballast water introduced in the region.

Canada will be introducing guidelines for the exchange of ballast water in the fall of 2000. There have been two ballast water exchange areas designated, one at the entrance to Lancaster Sound and the other at the entrance to Hudson Strait.

IMO is presently working a global instrument on ballast water. The target date for finalising the work within the Marine Environment Committee is 2003. The PAME response at present should therefore be to observe the IMO developments prior to taking actions on ballast water management.

Release of TBT from anti fouling paints

The release of anti-fouling paints has proven to have adverse impact on the marine environment. The expected IMO ban in use of TBT (in 2003) will reduce this impact in the future hence the use of TBT is given a low PAME priority. However, PAME should observe IMO developments and encourage implementation of international measures on anti-fouling paints.

Cruises / Passenger vessels

Tourism by cruise vessels might disturb the vulnerable resources in their operation. Further documentation will be included using information from other working groups and other sources like WWF, EPPR, INSROP and CAFF

8.4.2 Accidental events

Loading and unloading activities

Loading and unloading operations particularly related to oil and fuelling operations are known to have a higher risk of discharges. This is due to the human element, technical solutions on board and loading and unloading facilities. Port safety procedures do to some cases reflect the risk involved.

General increase in maritime activity will increase such operations. Long-term low level contamination is of major concern environmentally and the operations are proposed to have a high PAME priority.

Tanker traffic (Production field – Terminal and Terminal - Export)

Tanker traffic in the Arctic is expected to increase due to the higher volumes of petroleum activity. An economic growth in Arctic region will require more refined oil products. There is also an expected increase of the volume of unrefined products being shipped southwards from both the Russian and Norwegian Arctic areas. The tanker traffic also includes the introduction of shuttle tankers transporting petroleum products from the production sites to terminals. Tanker traffic itself is not expected to have a higher rate of accidents than other traffic, however, the potentially high environmental impact of a tanker accident with an oil spill addresses the need for precaution related to this activity.

Transfer operations of oil from production sites or oil terminals and their further export are given a high impact potential. Presence of tankers with double hull is expected to be higher in the future. All classed tankers delivered after mid 1990s have double hull / double bottom.

Heavy bunker oil as cargo and fuel

The use of heavy bunker as fuel or transported as cargo is expected to increase with an increase of industrial activity. The traffic in itself is not expected to have a higher rate of accidents than other traffic. However, the potential high environmental impact of an accident with a spill of heavy bunker addresses the need for precautions related to this activity. The environmental impact of heavy bunker is observed in several incidents and is lately addressed in the IMO as a follow up of the Nachocta and Erika accidents.

Operation in areas of sea ice or glacial ice concentration

Areas of high ice concentrations have been identified as having a higher risk of accidents although those mechanisms have not been fully outlined. An increase in maritime activity is expected to involve such operations, unless regulations / voluntary procedures (i.e. Polar Guidelines) are established. This type of operation has a high impact potential.

Tugging / Towing of vessels

Towing of vessels for scrapping is regarded as a high risk operation that can result in grounding. Presently the towing activity extends from northwest Russia in a southwesterly direction to foreign destinations outside the Arctic. Towing is expected to increase as the age of the Arctic fleet increases. Experience in large distance towing operations of vessels varies and has caused great concern due to several grounding casualties (e.g. the grounding of the Murmansk and the Boiky outside the northern coast of Norway.) The direct environmental impact of such an incident depends upon where and when it occurs and the content of the tow. This operation is at present considered as one of low impact due to low activity.

In the Canadian Arctic tugging and towing operations are almost exclusively limited to tugs towing barges loaded with fuel and supplies destine for remote communities. Experience with this activity shows that there are at present not significant reason for environmental concern.

Cruises / Passenger vessels

Cruises in the Arctic take place in light ice or open water seasons, mainly in June - August. The general accidental risk imposed by hull / ice interaction is therefor low. In many cases tour operators place their ships near the ice-edge or shoreline in order to give their passengers a natural experience. These same areas are important for the ecosystem and many vulnerable resources are aggregated in high concentrations during the spring and summer months (feeding, nursing). The long term effects of the presence of vessels in these areas are not fully understood. At present there are relatively few cruise operations in the Arctic compared to more temperate regions. However, the expected growth of the tourism industry in the Arctic places this activity as one of major concern.

8.4.3 Risk reducing measures

Risk reducing measures can be found in existing IMO instruments and in their present and future amendments, and in the development of new IMO instruments. In addition national, bilateral and multinational measures can be a recommended strategy regarding some issues of concern. A PAME process of analysing existing and possible new risk reducing measures is recommended. It is also recommended that PAME co-operate with EPPR or other appropriate working groups within the Arctic co-operation in the further process of analysing possible measures on shipping activities in the Arctic.

9 ADEQUATE MEASURES

9.1 Adequate Measures

As part of questionnaire produced for PAME in 1997 (DNV 1997) a set of key measures were identified. At the PAME meeting in Halifax, 1997 it was concluded that the number and detail of measures where too comprehensive and the costs related to collecting such data would be very high. It was recommended to perform a snap shot analysis based on a smaller number of measures at a lower level of detail.

In 2000 a questionnaire was presented for the purpose of performing the snap shot analysis. Table 10.1 presents the measures identified and proposed as relevant for performing accurate and detailed snap shot analysis on the possible environmental impact of maritime activities in the Arctic. Each of the measures was requested given on trade level where the trades were to be specified by each country. These measures are not only applicable for analysis in the Arctic but in general terms for a defined geographical area.

Table 9.1. Proposed adequate measures for assessing and analysing the possible environmental impact of maritime activities. The "priority" indicates what measures that should have the highest priority when collecting data.

Measure	Comments	Priority
Ship type	It is necessary to differentiate by ship type due to different operational patterns.	1
Number of Travels per ship size category	An analysis should differentiate by ship size categories due to different operational patterns. Number of vessels and Sum DWT or GT in each size category addresses the volume bias.	1
No of vessels per ship size category		1
Sum DWT or GT per ship size category		1
Number of Crew/Passengers per ship size category	Number of crew and passengers give input to analysis of volume of sewage, garbage and wastes of shipping operations.	1
Number of Port Hours per ship size category	Number of Port Hours and Operating Hours per size category addresses the operation pattern of the fleet and hereby affects analysis of operational impacts.	1
Number of Operating Hours per ship size category		1
Number of vessels per hull type per ship size category	The measure on hull type will give input to analysis of possible accidental risk.	2
Number of vessel per age class per ship size category	Age class differentiation will give input to engine efficiency and hereby calculations on emissions to air. The measure will also give input to analysis of future scrapping frequency and possible accidental risk.	2

9.2 Availability of Adequate measures

In the present work sources of international shipping statistics are identified and information collected. Based on the feedback from the Arctic countries, it can be concluded that for the Arctic region as a whole consistent data of the measures listed in table 9.1 is not available. However, individual countries have several of the listed measures available, although not easily accessible.

At present, major efforts are required for the collection of data whenever an analysis is requested. An optional methodology for future trend assessments is outlined for this purpose using overall and general statistics were relationships between relevant and adequate measures as given in table 9.1 are established empirically.

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11 APPENDIX 1 - GENERAL BACKGROUND OF THE ARCTIC

11.1 Definition of the Arctic

The Arctic refers to the northernmost part of the world and encompasses the land and sea areas around the North Pole, figure 11.1.

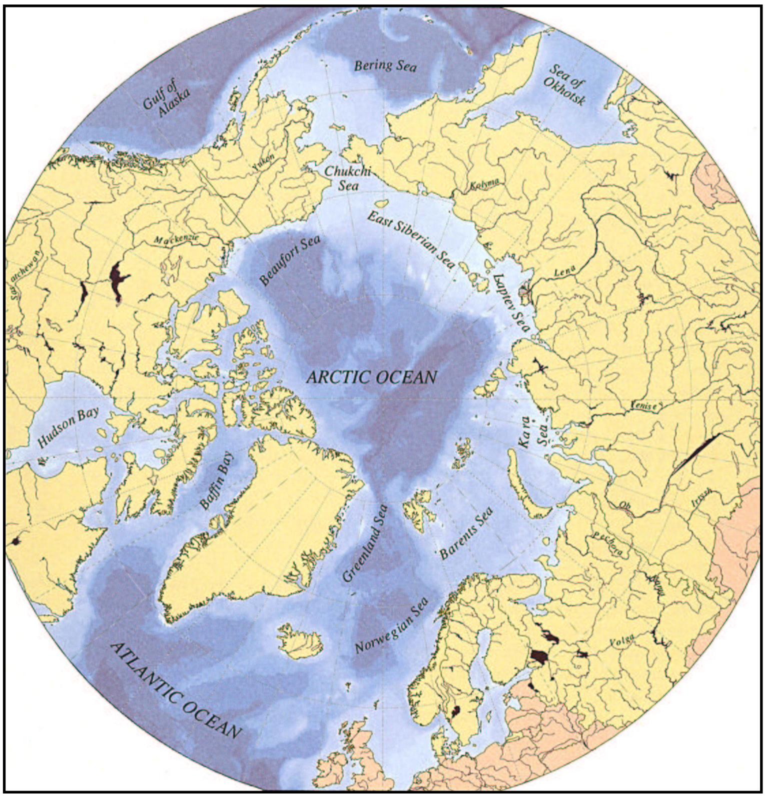

Figure 11.1. The Arctic region, source PAME (1996).

A larger part is comprised by the Arctic Ocean and is covered by ice. The marine boundary of the Arctic is formed when the water of the Arctic Ocean, cool and dilute from melting ice, meets warmer, saltier water from the southern oceans. In the Canadian Arctic Archipelago, this belt is at approximately 63°N and swings north between Baffin Island and the coast of west Greenland. Off the east coast of Greenland, the marine boundary lies at approximately 65°N. In the European Arctic, the marine boundary is much farther north, pushed to about 80°N to the west of Svalbard by the warming effect of the North Atlantic Current. At the other entrance into the Arctic, warm Pacific water flows through the Bering Strait to meet Arctic Ocean water at about 72°N, forming a boundary that stretches from Wrangel Island in the west to Amundsen Gulf in the east.

11.2 Arctic Marine Environment

The Arctic marine environment has been fully described and detailed in several works performed by scientific institutions and organisation as well as by CAFF, PAME, AMAP and INSROP and should be well known. A detailed description of the Arctic marine environment will not be given in this report and for further detail the foras indicated above should be consulted. An outline of the physical and ecological characteristics of the Arctic marine environment is given in the table below.

Table 11.1. General physical and ecological characteristics of the Arctic.

Physical characteristics	Ecological characteristics
• Stable deep water with slow exchange with other water masses. • Water system dominated by two major gyres. • Major riverine run-off. • Less saline coastal water • Sea formation in major parts of the area comprises about 30% of the world total sea ice. • The ice coverage plays a critical role in regulating the world climate. • The ice coverage is dynamic over long periods of time (years) with a marginal ice front important to the ecosystems of the Arctic.	• Simple food chains; rapid transfer of pollution in the food chain. • Simple food chains; high vulnerability to impact on key species • Fat as energy storage; accumulation of fat-soluble contaminants in primary producers. • Fat as energy storage; accumulation of fat-soluble contaminants to toxic levels in higher organisms. • Concentration of organisms in limited areas; high vulnerability to acute pollution in such areas • The animals live long ad produce few offspring; over-exploitation or pollution can give long lasting impairment • Large, undisturbed areas necessary to meet demands for food, breeding and shelter. • Short growing seasons • Low temperature and few organisms reduce degradation of pollutants

11.3 Indigenous people in the Arctic

The indigenous people have developed within ethnic groups, over a major part of the Arctic region and in sparsely populated areas their rural populations constitute about 100 % of the population. However, their average portion of the total population of the North is low. For the Russian part of the Arctic indigenous people constitute about 1,5 % of total population.

Indigenous people of the North and their culture are characterised by a close and dependent relationship to the environment. Distinctly different subsistence cultures have been developed dependent upon the natural conditions. Only in Russia a number of 30 official recognised indigenous people are settled (Yefimenko et al. 1999). Most of the groups live across two or several vegetation zones and have developed diverse cultures i.e. taiga / tundra culture and coastal/inland culture. The coastal cultures are dependent on areas with significant sea mammal resources as walrus and various seals. Reindeer breeding is the most characteristic and distinguished occupation of the minorities of the North and is closely connected to their ethnic identity. Game hunting and fisheries in rivers, estuaries and in close coastal areas are also important occupations of the indigenous people (Brude at al 1998).

Considering human impact and the increase of such in the northern areas (among others the Northern Sea Route) involve assessment and precaution related to the environment, the indigenous people dependent upon it and the territories that can be affected.

For further information the following can be accessed:

www.raipon.org

http://www.grida.no/caff/indig.htm

11.4 Industrial activities in the Arctic

Historically, natural resource exploitation has been limited to fishing, hunting, mining and herding of reindeer. However, hydroelectric power has been developed followed by oil and gas exploitation resulting in infrastructure developments comprising pipelines, roads and electronic power lines. The shipping activities in the Arctic are expected to increase, mainly due to the increase in oil and gas exploitation both on land and offshore.

11.5 Sources of contamination within or in close proximity of the Arctic

Knowledge of sources of contamination of the Arctic is improving and in some cases the information is quantified. The pattern that is emerging is of two major types of source - sources remote from the Arctic and sources found within the Arctic (AMAP Assessments).

- PCBs from decommissioned DEW (Distant Early Warning) Line sites in Canada, and dioxins/furans from smelters in Norway are examples of identified sources of POPs within the Arctic; other such sources probably exist but are presently unknown.
- Two-thirds of heavy metals in air in the High Arctic originate from industrial activities on the Kola Peninsula, the Norilsk industrial complex, the Urals (outside the Arctic) and the Pechora Basin.
- At point sources such as mine sites, heavy metals may exceed local background concentrations at distances up to 30 km from the site.
- Mineralization of geological formations provides significant, non-anthropogenic local inputs of heavy metals.
- Industrial activities in northwestern Russia, including the Kola Peninsula, and at Norilsk are the dominant sources of sulfur north of 60°N.
- Severe local and regional problems have occurred recently, associated with the exploration, development, and transportation of oil and gas.
- With the exception of catastrophic releases of oil, concentrations of hydrocarbons associated with anthropogenic inputs have been relatively low in the Arctic.

- Local sources of radionuclides, such as dumped nuclear waste, nuclear storage sites, accidents and past explosions, have led to local radioactive contamination.
- There exists a high concentration of radioactive sources in northwestern Russia. These sources represent a potential for release of considerable quantities of radionuclides.

11.6 Contaminant pathways

The Arctic is a focus for major atmospheric, riverine, and marine pathways, which result in the long-range transport of contaminants into and within the Arctic. The Arctic is, therefore, a potential contaminant storage reservoir and/or sink. Various processes remove these contaminants from the atmosphere, oceans and rivers and make them available to plants and animals. Food chains are the major biological pathways for selective uptake, transfer, and sometimes magnification of contaminants by Arctic plants and animals, many of which are subsequently consumed by Arctic peoples (AMAP Assessments).

- Strong south to north air flows, particularly over west Eurasia in winter, transport contaminants, e.g., sulfur and nitrogen compounds, POPs, and radionuclides, from lower latitudes. Special mechanisms selectively favour the accumulation of PCBs and certain pesticides in the Arctic.
- Arctic rivers are a significant pathway for contaminant transport to the Arctic, often associated with extreme seasonal fluctuations due to freeze-up and meltwater flushing characteristics. Suspended solids carry high levels of PCB and DDT in the Ob and Yenisey river deltas, as do sediments in the Indigirka and Pechora rivers. Sedimentation processes play a critical role in depositing particles in estuaries, deltas, and Arctic coastal shelves. These riverine pathways lead to local and regional dispersal of radionuclides, some heavy metals, and oil.
- Ocean waters are a major storage reservoir and transport medium for water soluble POPs. Sea ice may be important in transporting POPs and other contaminants from coastal sediments during the winter, and from deposition from the atmosphere, with subsequent redistribution during ice melt.
- Long distance marine transport of radionuclides from previous mid-latitude releases resulted in accumulations in Arctic sediments. Radionuclides from current releases from spent fuel storage and wastes dumped at sea, tend to remain local, although low-active liquid wastes dumped previously in the Arctic marine environment have been distributed more widely.

In marine, freshwater and terrestrial ecosystems, contaminants are selectively taken up by micro-organisms and higher plants from water, sediment and soils. Consumption by herbivores and carnivores results in the transfer of contaminants, and in some cases increased concentrations (biomagnification), within the food webs. Food web structure and length of the food chain, therefore, significantly influence the transfer and redistribution of contaminants within the Arctic.

Freshwater and marine ecosystems contain higher levels of POPs than terrestrial ecosystems due to longer and more complex food webs. Biomagnification of POPs is especially significant in food webs dominated by organisms with high fat contents. Many upper trophic level carnivores are long-lived and may transfer POPs to offspring during extended gestation and lactation.

In several marine mammals, geographical differences in contamination, e.g., cadmium and mercury contamination, may be explained by differences in geology, diet, and growth processes related to temperature. Biomagnification of metals is often very selective, e.g., there is no indication that lead, and selenium, levels increase in higher trophic levels although cadmium and mercury clearly do.
Some species and/or their prey contain large metal and POP burdens from wintering at lower latitudes and deliver these to the Arctic on their return in the summer.
Terrestrial and freshwater ecosystems contain higher levels of those radionuclides that are important in relation to human exposure, than do marine ecosystems.
The combination of long-range transport processes, climate conditions and physical, chemical and biological properties results in the accumulation of some contaminants in traditional foods at levels often exceeding those in foods from outside of the Arctic.

For further details on the Arctic documents produced by AMAP should be consulted (http://www.grida.no/amap).

12 APPENDIX 2- EXISTING LEGAL AND OTHER INSTRUMENTS RELATING TO SHIPPING ACTIVITIES IN THE ARCTIC

The following table presents major international instruments encompassing shipping activities in the Arctic, with respect to both pollution and safety issues.

Other international overall instruments may also control and affect shipping activities. Of these are conventions as Convention on Biological Diversity, Bonn Convention, World Heritage Convention, Ramsar Convention etc.

Table 12.1. International instruments controlling the shipping activities in the Arctic as of June 2000Input given by the PAME secretariat.

International Agreements	Adopted	Entry into force	Comments
Biological Diversity	1992	1993	2) Canada (X), Denmark (X), Finland (X), Iceland (X), Norway (X), Russia (X), Sweden (X)
Civil Liability Convention (CLC)	29-Nov-69	19-Jun-75	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X)
CLC Protocol 92	27-Nov-92	30-May-96	1) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Sweden (X)
Polar Guidelines **			2) Group of Arctic countries developing these IMO Guidelines
COLREG Convention 72	20-Oct-72	15-Jul-77	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
ESPOO Convention	1991	not yet	2) Canada (X), Finland (X), Norway (X) , Sweden (X)
FUND Convention	18-Dec-71	16-Oct-78	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X)
Fund Protocol 1976	19-Nov-76	22-Nov-94	1) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X)
Fund Protocol 1992	27-Nov-92	30-May-96	1) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Sweden (X)
GPA (Global non-binding framework developed in response to Agenda 21)	1995	not applicable	2) GPA adopted by all Arctic Countries
HNS Convention 96	03-May-96	not yet	1)
Limitation of	19-Nov-	01-Dec-	2) Denmark (X), Finland (X) , Norway

liability for Maritime Claims	76	86	(X) , Sweden (X)
LOAD LINES Protocol 88	11-Nov-88	3-feb-00	1) , Denmark (X), Norway (X) , Sweden (X), USA (X)
London Convention 72 (LC72)	13-Nov-72	30-Aug-75	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
London Protocol 96	07-Nov-96	not yet	1) Canada (X) , Denmark (X) , Norway (X)
MARPOL 73/78 (Annex I/II)	17-feb-78	02-Oct-83	2) Compulsory; Canada (X) , , Iceland (X), Norway (X)Denmark (X) , Finland (X) , Russia (X), Sweden (X), USA (X)

MARPOL 73/78 (Annex III)	17-feb-78	01-Jul-92	2) Optional; Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
MARPOL 73/78 (Annex IV)	17-feb-78	not yet	2)Optional-being revised , Denmark (X) , Finland (X) , Russia (X), Sweden (X)
MARPOL 73/78 (Annex V)	17-feb-78	31-Dec-88	2) Optional , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
MARPOL Protocol 97 (Annex VI)	26-sep-97	not yet	1) Norway (X) , Sweden (X)
Nuclear Safety Convention *	17-Jun-94	24-Oct-96	5) Canada (X), Denmark (A), Finland (A) , Iceland (S), Norway (X) , Russia (A), Sweden (X), USA (X)
OPRC Convention 90	30-Nov-90	13-May-95	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Sweden (X), USA (X)
OSPAR 3)	22-sep-92	25-mar-98	4) Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Sweden (X)
Protection and Use of Transboundary Water Courses	1992		2) Denmark (X) , Finland (X), Norway (X) , Russia (X), Sweden (X),
RAMSAR	1971	1975	2) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
SOLAS Protocol 88	11-Nov-88	03-feb-00	1) , Denmark (X) , Finland (X) ,Norway (X) , Sweden (X), USA (X)
STCW Convention 78	7-Jul-78	28-apr-84	1) Canada (X) , Denmark (X) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X), USA (X)
STCW-F Convention 95	7-Jul-95	1-feb-97	1) , Denmark (X) , Finland (X) , Russia (X),
UNCLOS	10-Dec-82	16-Nov-94	5) Canada (S) , Denmark (S) , Finland (X) , Iceland (X), Norway (X) , Russia (X), Sweden (X)
UNCLOS - Agreement related to implementation of Part XI	10-Dec-82	28-Jul-96	5) Finland (X) , Iceland (X), Norway (X), Russia (X), Sweden (X)
UN-ECE LRTAP	13-Nov-79	16-mar-83	2) Canada (X), Denmark (X), Finland (X), Iceland (X), Norway (X), Russia (X), Sweden (X), USA (X)
(a)Protocol on Long-term Financing	28-sep-84	1988	5) Canada (X), Denmark (X), Finland (X), Norway (X), Russia (X), Sweden (X), USA (X)
(b)Protocol on the Reduction of Sulphur Emissions	08-Jul-85	1987	5) Canada (X), Denmark (X), Finland (X), Norway (X), Russia (X), Sweden (X)
(c)Protocol	31-Oct-	1988	5) Canada (X), Denmark (X), Finland

concerning the Control of Emissions of NOx	88		(X), Norway (X), Russia (X), Sweden (X), USA (X)
(d)Protocol on the Control of Emissions of VOCs	18-Nov-91	29-sep-97	5) Canada (S), Denmark (X), Finland (X), Norway (X), Sweden (X), USA (S)
(e)Protocol on the Further Reduction of Sulphur Emissions	14-Jun-94	05-Aug-98	5) Canada (X), Denmark (X), Finland (X), Norway (X), Russia (S), Sweden (X)
(f) Protocol on Heavy Metals	24-Jun-98	not yet	5) Canada (X), Denmark (S), Finland (S), Iceland (S), Norway (X), Sweden (X), USA (S)
(g) Protocol on Persistent Organic Pollutants	24-Jun-98	not yet	5) Canada (X), Denmark (S), Finland (S) , Iceland (S), Norway (X), Sweden (X), USA (S)
(h) Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	01-Dec-99	not yet	5) Canada (S), Denmark (S), Finland (S) ,Iceland (N), Norway (S), Sweden (S), USA (S)

13 APPENDIX 3 - QUESTIONNAIRE

Below is the questionnaire distributed in February 2000 presented.

13.1 Bulk and Tankers

Questionnaire No.	QI	Comments
Year:		
Vessel case:	Bulk	
Trade No.:		
Country:		

Size category in DWT	Number of Vessels	Sum DWT per size category	Number of Travels	Number of Crew	Number of Port Hours	Number of Operating Hours
< 5 000						
5 000 - 50 000						
> 50 000						
All categories						
Quality						

Questionnaire No.	QI	Comments
Year:	0	
Vessel case:	Bulk	
Trade No.:		

Size category in DWT	Number of vessels per hull type			Number of vessel per ageclass		
	Single hull	Double hull	Ice-protection	< 5 years	5-20 years	> 20 years
< 5 000						
5 000 - 50 000						
> 50 000						
All categories						
Quality						

13.2 General cargo and Container vessels

Questionnaire No.	QII	Comments
Year:	0	
Vessel case:	General cargo	
Trade No.:		
Country:	0	

Size category in DWT	Number of Vessels	Sum DWT per size cat	Number of Travels	Number of Crew	Number of Port Hours	Number of of Operating Hours
< 100						
100 - 20 000						
> 20 000						
All categories						
Quality						

Questionnaire No.	QII	Comments
Year:	0	
Vessel case:	General cargo	
Trade No.:		

Size category in DWT	Number of vessel per ageclass		
	< 5 years	5-20 years	> 20 years
< 100			
100 - 20 000			
> 20 000			
All categories			
Quality			

13.3 Cruise vessels, Passenger vessels and Fishing vessels

Questionnaire No.	QIII	Comments
Year:	0	
Vessel case:	Passenger Vess	
Trade No.:		
Country:	0	

Size category in GT	Number of Vessels	Sum GT per size cat	Number of Travels	Number of Crew/Passengers	Number of Port Hours	Number of of Operating Hours
< 100						
100 - 1 000						
> 1 000						
All categories						
Quality						

Questionnaire No.	QIII	Comments
Year:	0	
Vessel case:	Passenger Vess	
Trade No.:		

Size category in GT	Number of vessel per ageclass		
	< 5 years	5-20 years	> 20 years
< 100			
100 - 1 000			
> 1 000			
All categories			
Quality			

13.4 Icebreakers/Tugs and Other vessels

Questionnaire No.	QV	Comments
Year:	0	
Vessel case:	Ice-Breaker/Tug	
Trade No.:		
Country:	0	

Size category in DWT	Number of Vessels	Sum DWT per size cat	Number of Travels	Number of Crew	Number of Port Hours	Number of of Operating Hours
< 50						
50 - 100						
> 100						
All categories						
Quality						

Questionnaire No.	QV	Comments
Year:	0	
Vessel case:	Ice-Breaker/Tug	
Trade No.:		

Size category in DWT	Number of vessel per ageclass			No. Nuclear Power
	< 5 years	5-20 years	> 20 years	
< 50				
50 - 100				
> 100				
All categories				
Quality				

13.5 Tugging

Questionnaire No.	QVII	Comments
Year:	0	
Vessel case:	Tugging	
Trade No.:		
Country:	0	

Size category in DWT	Total Number of Vessels Towed	Number of vessels towed, by vessel case					
		Tankers	General Cargo	Bulk Carriers	Container Vessels	Cruise /Passenger Vessels	Fishing Vessels
< 100							
100 - 1 000							
1 000 - 20 000							
20 000 - 50 000							
> 50 000							
All categories							
Quality							

14 APPENDIX 4 – INPUT TO THE MODELLING

In the following, the Arctic fleet is presented country specific including annual operating profile based on several data sources and assumptions. The country specific information is aggregated, and used as an input to the modelling (to sea and air).

The main statistical data sources has been:
PAME (1996)
TC (1995)
Fairplay (1998)
Questionnaires 2000
Statistics Norway

Empirically country specific data is collected through:
Arctic fleet statistics
Operating profile
Number and characteristic of ships in Arctic ports based on the Fairplay database

14.1 General

The data input is based on the questionnaire 2000 and other sources (indicated above). Only the data set for Canada fully complies with recommended level of detail (questionnaire of 2000). The other Arctic countries are presented by figures at a lower level of detail. Consequently the calculation methods have been adjusted in accordance to data available.

The following operating profile was presented in PAME 1996:

- Average duration of a voyage in the western part of the arctic:
  - 5 days in summer
  - 10 days in winter
- Average duration of a voyage in the eastern part of the arctic:
  - 8 days in summer
  - 16 days in winter

Based on this a typical duration of a voyage is estimated to 10 days in the Arctic region. The fleet statistic is made using vessel categories, separated in “small” vessel < 5000 DWT and “large” vessel > 5000 DWT.

Based on fleet statistic (Lloyds 1996, Fairplay 1998, Løvås & Brude 1999), it is assumed that a typical “small” Wet and Dry cargo vessel (< 5000 DWT) has an average DWT of 2500, and similarly “large” vessel (> 5000 DWT) 12000 DWT.

14.1.1 Russia

Information for Russia on fleet statistics (1993/1994) of cargo vessels and icebreakers is based on data presented for the Northern Sea Route by INSROP (Løvås & Brude 1999, INSROP GIS -Software and database). The duration of navigation (days/year) is estimated to 120 days, based on ice condition, some of the vessels included may also travel on other sea routes and on information provided from PAME (1996). Aggregation of the data set is given in table 14.1.

The numbers of fishing vessels are based on input from Fairplay 1998 (table 14.10.), and the duration of navigation (days/year) is estimated from Norwegian statistics (fishing vessel).

Compared with the reported number of vessel by PAME 1996, the INSROP fleet database seems to include a larger number of cargo vessels.

Table 14.1. Russian Arctic Fleet numbers.

Type	<5000 DWT			>5000 DWT		
	N	ADWT	Days	N	ADWT	Days
Wet cargo	12	2654	120	17	13951	120
Dry cargo*	166	3606	120	212	10742	120
Icebreaker**	-	-	-	26	6600***	120
Fishing	186	1200	180	11	6100	250
Sum	364			266		-

* General cargo, Bulk, Container, Ro-Ro Cargo, Ro-Ro Cargo/Gen. Cargo
** Not included: 7 nuclear powered, Included: 1 Research/Icebreaker and 1 Passenger/Icebreaking
*** In gross tonnage
N-number of ships
ADWT-average dead weight
Days- annual number of operating days, estimated based one Norwegian statistics.

14.1.2 Canada

Canada has supplied the project with a fully Questionnaire 2000 for1997 and 1998. Only the 1998 data has been used in the analysis. Aggregation of the data set is given below.

Table 14.2. Canada Arctic Fleet numbers 1998.

Type		<5000 DWT			>5000 DWT		
		N	ADWT	Hours	N	ADWT	Hours
Wet cargo		6	3078	2112	7	17491	3954
Dry cargo	Bulk	-	-	-	17	33787	6822
	Gen. C.	-	-	-	5	5935	1200
Icebreaker/Tug	Iceb./Tug	5	2630	12372	-	-	-
	Tug	5	686*	4218	-	-	-
Fishing		3	1429*	2490	-	-	-
Other vessel		2	615	6768	3	2213	6072
Cruise vessel		-	-	-	6	9489*	2400
Sum		21			38		

* In Gross tonnage
N-number of ships
Gen. C- General Cargo
ADWT-average dead weight
Hours- annual number of operating hours

14.1.3 Finland

Finland has delivered data according to the Questionnaire 2000. Figures are presented in table 14.3. As seen, the maritime activity of Finland is low in the Arctic region.

Table 14.3. Finnish Arctic Fleet numbers.

Vessels types	Number of vessels		ADWT		No. of Voyage	Sea days
	>5000 DWT	<5000 DWT	>5000 DWT	<5000 DWT		
Wet cargo vessels	-	-	-	-	-	
Dry cargo vessels	5	-	17677	-	10	100
TOTAL	5					

- No registrations
Sea days – annual number of operating days
ADWT-average dead weight

14.1.4 Denmark

Denmark has given input to the Questionnaire 2000 based on a national survey of 1999. The aggregated figures are given in table 14.4.

Table 14.4. Danish Arctic Fleet by numbers (National Survey 1999). The figures refer to 1998.

Vessels types	Number of vessels		ADWT		Days**)	
	>5000 DWT	<5000 DWT	>5000 DWT	<5000 DWT	>5000 DWT	<5000 DWT
Wet cargo vessels	0	2	-	1892	-	234
Dry cargo vessels	3	13	8310	1346	235	235
Fishing vessels	0	649*)	-	**)	-	200
Cruise/Passenger	6	4	16103	1669	-	-
Sum	9	668				

- No registrations
ADWT-average dead weight
Days- annual number of operating days, estimated based one Norwegian statistics.
*) Foreign Flag: 191; Danish Flag: 458
**) Estimated from Norwegian Statistics (fishing vessel).

14.1.5 Iceland

Iceland has given input to the Questionnaire 2000 on figures for 1998. The aggregated figures are given in table 14.5.

Table 14.5. Arctic Fleet by numbers for Iceland, 1998.

Type	<5000 GT		
	N	AGT	Days[1)]
Wet cargo	7	544	234
Dry cargo (**)	4	3737	235
Icebreaker/Tug	-	-	-
Fishing	790	235	200
Other vessel	155	194	-

Cruise vessel*	19	400	-
Sum	975		-

[1)] Based on Norwegian Statistics
* In dead weight
(**) Only general cargo
N-number of ships
AGT-average gross tonnage
H- operating hours

Table 14.7 Icelandic Arctic vessels (Fairplay 1998).

	No. of vessels	No. of vessels >5000 DWT	No. of vessels <5000 DWT	Avg. weight >5000 DWT	Avg. weight <5000 DWT
Wet cargo vessels	1	-	1	-	2500
Dry cargo vessels	17	1	16	12400	800
Cruise/Passenger vessels	1	-	1	-	450
Fishing vessels	47	-	47	-	600
Sum	66	1	65		

- No registrations

14.1.6 Norway

Information on maritime activities in the Arctic part of Norway, is based on figures from several sources. The number of vessels or days in operation by national sea traffic is estimated by combining Norwegian fleet statistic and number of calls. The method is recently developed by DNV (Mjelde & Endresen 2000), and it is modified according to scope of this project.

In this study the following steps are used to estimate fuel consumption and emissions from national and international sea traffic:

1) A breakdown of the Norwegian fleet by vessel type and size (Norwegian Maritime Directorate 2000), only vessels with a length greater than 10 meters are included.
2) Calculation of time in operation for each vessel type and size category, using detailed operational profile for each vessel type and size category (Statistics Norway 2000 & Flugsrud & Rypdal 1996).
3) Calculation of time in operation for each vessel type and size category in a port region (geographical link), based on detailed port of call statistics (vessel type and size classes, Norwegian Environmental Department 1994).
4) Aggregation of the time in operation or number of vessels in the Arctic region (including ports from Bodø and north), on vessel type and size category. Then applying the individual operation profile for the vessel category and size category to convert to annual number of active vessels.
5) Based on 4), calculation of the national fuel consumption and emissions to air using the statistical emission model.
6) Including the fuel and emission contribution from international sea traffic, using data collected from Statistics Norway (from Bodø and north, Flugsrud 2000). Only the fuel and emission contributions from: wet cargo, dry/general cargo, fishing and tugs vessels are included.

The ore cargo traffic to/from Narvik is separated due to the significance of the tonnage used (about 100 000 DWT) and its contribution is included in the national inventory. Based on 200 calls (PAME 1996) and assuming 1 day travelling time in and out of the Vestfjorden/Ofotfjorden area the number of navigation days are estimated. Aggregated figures are given in table 14.6.

Table 14.6. Norwegian Arctic Fleet numbers.

Vessel	Number of vessel in each size category (GT) and operating profile (days)									
type	<300	Days	3-499	Days	5-999	Days	>1000	Days	>5000	Days
Dry	84	180	16	235	12	235	9	235	1	235
Wet	130	180	2	234	2	234	0	234	2	234
Fishing	1554	160	45	240	62	270	66	280	-	285
Iceb./Tug*	12	160	-		-		-		-	

Days- annual number of operating days
* Only Tug vessel

The traffic in the Svalbard region is separated from the Norwegian statistic, and based on 1998 data (Statistics Norway 1999). The figures are given in table 14.7.

Table 14.7 Svalbard Arctic Fleet numbers.

Vessels types	Number of vessels	ADWT	Number of voyages	Duration of a voyage (days)	Annual navigation time (days)
Wet cargo	2	2500 2)	8	10	80
Dry cargo	5	3000 3)	39	10	390
Fishing 1)	28	600 4)	28	10	280
Research 1)	11	-	11		
Cruise 1)	31		31		

- No registrations
ADWT-average dead weight
1) Estimated size category
2) Based on fleet statistic (Lloyds 1996, Fairplay 1998, Løvås & Brude 1999), it is assumed that a typical “small” Wet and Dry cargo vessel (< 5000 DWT) has an average DWT of 2500.
3) Based on cargo volume transported, and number of calls into Gamlekai and Kullkai in Longyearbyen.
4) Based on table 14.9.

14.1.7 Sweden

Input of statistics for Sweden is based on PAME (1996). The activity is low represented by 4-research voyages per 10 year.

14.1.8 USA

Figures on the maritime activities in the Arctic region of USA have not been produced for the snap shot analysis. The only available statistics is given in PAME (1996) encompassing figures on number of port of calls.

14.2 Aggregated data sets

Table 14.8 and 14.9 presents the aggregated numbers of vessels by vessel type and by country respectively. Table 14.10 presents aggregated figures on fuel consumption for each country. These numbers are the basic input to the estimates of environmental impact.

Table 14.8 Aggregated numbers of vessels.

Type	Number of vessels		
	All	<5000 DWT	>5000 DWT
WC	189	163	26
DC	552	309	243
FV	3394	3383	11
IC/TUG	48*	22*	26*
Sum	4183	3877	306

* for icebreakers and tugs the figures are in GT.

Table 14.9 Number of vessels by country.

Country	Number of vessel		
	<5000 DWT	>5000 DWT	Sum
Russia	390	240	630
Canada	19	29	48
Finland	0	5	5
Denmark	664	3	667
Iceland	801	0	801
Norway	1994	3	1997
Svalbard	35	0	35
Sum	3903	280	4183

Table 14.10 Fuel consumption by country (in Kton).

Country	Fuel consumption (Kton)				
	WC	DC	FV	IC/TUG	Sum
Russia	39	536	172	171	918
Canada	3	11	1	12	27
Finland	0	2	0	0	2
Denmark	2	17	106	0	125
Iceland	4	5	196	0	204
Norway	39	90	286	9	423
Svalbard	0	3	1	0	4
Sum	87	663	761	192	1703

15 APPENDIX 5 – VALUABLE ECOSYSTEM COMPONENTS VECS - OF THE ARCTIC

Table 15.1 presents Valued Ecosystem Components (VEC) and vulnerable components in the Arctic. Sources Brude et al (1998) and TC (1995). For details the sources and underlying documents should be consulted.

Components	Components
Water-land border zone • Shoreline features • Substrate – topography • Inundated reverine areas, also including polynyas • Ice Edge Communities	Birds, including breeding / non-breeding distribution of: • Brünnichs guillemot • Black guillemot • Ivory gull • Ross gull • Kittiwake • Black-legged kittiwake • Thick-billed Murre • Common eider • King eider • Stellers eider • Spectacled eider • White-fronted goose • Barnacle goose • Brent goose, incl. dark bellied Brent goose • Bean goose • Emperor goose • Long-tailed duck • Waders, feeding and resting areas • Loons • Northern fulmar • Old squaw eider
Invertebrates, including distribution of: • Benthic, Sampling and monitoring stations • Benthic Sediment features • Biocenosis • Benthic Species name and number (more than 2000 different taxa) • Plankton	
Marine, Estuarine and Anadromous Fish, including distribution of: • Scorpion fish (25 taxa) • Salmonids (17 taxa) • Gadoids (16 taxa) • Whitefish (6 taxa)	
Marine mammals, including distribution, abundance, migrations, feeding and breeding areas of: • Polar Bear • Walrus • Bearded seal • Ringed seal • Harp seal • White whale • Gray whale • Bowhead whale • Narwhal • Arctic fox	

16 APPENDIX 6 – GENERAL DESCRIPTION OF WASTE AND GARBAGE FROM MARITIME ACTIVITIES

16.1 Sludge

From bunker tanks, fuel oil is transferred to a service tank and through an oil separator before being transferred into a day tank. The residue from the separator, or sludge, is a semi-compact mass, which is either automatically flushed off the separator at periods and pumped into a holding tank or scraped off manually and stored in barrels. To be in accordance with MARPOL Annex I, the dumping of sludge into the sea is not allowed.

16.2 Oily bilge water

Machinery space bilge water accumulates in the bilge of engine room compartments in all types of ships. The composition of this waste is mainly oil and water from minor leaks in various engine room components, and water from the lubricating oil separator.

When engine room bilge are emptied, a bilge pump transfers the oily bilge water to a separator. The oily component is pumped into the holding tank, while the separated water can be pumped overboard through the ppm monitor. Normally, the holding tank will be the same for sludge from the fuel oil separator, and oily residue from bilge water. Hence, as the sludge extracted from the bilge water may contain metals and washing agents the sludge from the fuel oil separation contains pure oil.

16.3 Waste lubricating oil

The lubricating oil causes two types of waste:

sludge from separation of used lubricating oil
used lubrication oils

Lubricating oil is continuously being drawn from the engine sump through a lubricating oil separator to extract water and particles from the oil. Normally, the same holding tank as for other sludge residue is used for the particles/sludge from the lubricating oil. Hence, the sludge extracted from the lubricating oil may contain metals while the sludge from the fuel oil separation contains pure oil.

16.4 Solid oily waste

Solid oily waste is rags, gaskets, tubes etc. that are covered with different types of oil like lubrication oil, hydraulic oil or fuel oil. In addition deposits in bunkers oil tanks consists of a mixture of oil and sand/soil /rust.

16.5 Sewage

Many vessels have a common system for sewage (black-water) and grey-water.

Sewage (black-water) originates from toilets and urinals. Other liquid that is mixed with the mentioned should also be considered as sewage.
Grey-water originates from kitchen, laundry, bath, showers etc.

Some ships have conventional systems while other ships have vacuum systems where the difference is mainly related to the amount of water used. Some ships also have sewage treatment plants. These can be of various types as biological treatment or chemical treatment. Some vessels are fitted with a holding tank arrangement.

In general the sewage may be discharged outside 12 nm from land if the ship has no system for treatment of the sewage. If the sewage is collected in a tank the sewage may not be discharged directly but should be discharged in a moderate rate while the ship is keeping a constant speed of at least 4 knots.

16.6 Garbage

Garbage is e.g. plastic, paper, metal, wood. Except for plastics, garbage can legally be dumped at sea provided that the distance from nearest shoreline is above certain limits summarised in the Guidelines to MARPOL Annex V. Within special areas, dumping of other waste categories is also restricted. For new, ocean going vessels, especially for ships that create large amounts of garbage (such as cruise ships), incinerators are becoming a standard piece of equipment. It is also possible to install incinerators on older ships, but such an installation is costly, and there is no requirement for such installations in MARPOL.