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ARCOP FINAL REPORT

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DELIVERABLE SUMMARY SHEET

Short Description
Deliverable summarizes the work and findings during the whole project

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Executive Summary

During the ARCOP 57 research reports were published. All reports from the ARCOP project have been published on the ARCOP web-site www.ARCOP.fi.

Work package 1 "The Ice Information System" was actually started at the beginning of 2005. The research part of this work package was performed jointly with IRIS (Ice Ridging Information for Decision Making in Shipping Operations) -project, which is an separate EU-funded project coordinated by Helsinki University of Technology (HUT). It intended to develop methods to acquire online ice information and create accurate ice condition forecasts in short time span. KMY was participating in this project and the results from IRIS were applied to the ARCOP thus the co-operation with IRIS was close. The IRIS project proceeded well and the project provided ARCOP the basic data required as planned. Within ARCOP the learning from IRIS were compared to the experience within the Russian Arctic. The potential of the enhanced ice information system was demonstrated by economic analyses in the NSR conditions. The review of the current infrastructure in the area resulted into recommendations for the future development of the alternatives for the ice information system. All the three reports within Work Package 1 were completed before the end of the ARCOP project.

Work Package 2 covered a large number of topics varying from international law to rules and fees applicable in the Russian Arctic. Within international law, the regime in force in the Russian Arctic is in line with UNCLOS Article 234 and thus the situation regarding commercial shipping is more or less clear. It was also considered that the UNCLOS Article 76 dealing with the extended exclusive economic zones does not really affect the commercial shipping since the sailing in the central Arctic Ocean means in any case passing through areas covered by the Article 234.

There are a number local issues related to the dispute zones and possible PSSA areas. From the point of view of commercial shipping the dispute zones are not a problem. But the potential PSSA areas may cause need for longer voyages and affect the economics of the transportation. However it seems that within the oil industry these additional cost have considered acceptable if they are properly justified by environmental reasoning.

Within the WTO and GATS there are a number of issues that are not clear today. But since the whole GATS regime covering shipping is still open, this cannot be a specific problem for the Arctic. There is one issue, which is interesting for the Arctic shipping community and this is the question of icebreaker services. In some countries this considered as a service that should be open for competition within WTO. In Russia as well as in Sweden this is considered to be part of the infrastructure that the coastal state provides. Probably the solution to this question will be seen only when the large-scale transportation is in place and we can see if the coastal states are able provide the required service.

The question of ice rules caused a lot of discussion during the ARCOP workshops. And it seems that system of rules is not consistent. When dealing the hull strength The IMO recommendations refer to Polar Classes. But these Polar Classes in fact do not exist since IACS has not published their Unified Requirements. And as far is the propulsion power is concerned the Unified Requirements do not say anything about that. Among the national authorities like in Finland and Russia there are and obviously will be requirement for minimum power. This puts the ship owners and ship designers in a difficult situation since there is no generally approved basis for the requirements. So a lot of work needs still to be done within this sector.

The issue of fees seems also to be a difficult one. Generally it is considered that the current level of fees, for instance 16 dollars per ton of oil cargo, is far too high. The problem is that the fees are set based on the current cargo flow, which is less than 2 million tons per year. If the cargo flow will increase 40 million tons or more per year the fees should decrease to a level of 1 dollar per ton. This would be in line with fees collected in Finland. The other issue is that the system to define the fee level in Artic Russia is not transparent as it is in Finland. We actually do not know how the money collected as fees is used. It was also criticized that the fee systems do not encourage the use of higher technology. A simple calculation shows that a more expensive vessel, which needs less icebreaker assistance, is not beneficial for the ship owner since he in any case is forced to pay for the service he does not need. Hopefully this issue is also reconsidered in the future.

Work Package 3 "Integrated Transportation System" was the actual core of the ARCOP project. Here we looked at the different elements that are needed from tankers and icebreakers to loading system, traffic management and crew training. And of course we looked at the economics of the transportation. The scenario for which the development work was done was selected to be realistic, but not yet commercially in operation. The task was to transport 330.000 barrels per day oil production from Varanday in North West Russia to Rotterdam in Europe. As tankers we used two different operational modes; independent and assisted. As icebreakers we had three alternative designs each capable to assist the tankers up to 120.000 tdw. The route alternatives used were either direct transportation to Rotterdam or shuttle service to Murmansk and transhipment there to open water tankers to Rotterdam. The result was that assuming a fee level of 1.2 Euro per ton, we can achieve a cost level of 12 Euros per ton. This can be considered feasible if we compare it with the pipeline costs for similar routes that are approx. 20 euros per ton. What is important to notice is that the difference between the best and worst alternative is some 100%. This means that with the optimisation you can achieve a saving of more than 100 million Euros per year. Over the lifetime of the project this is over 2,5 billion Euros.

The work with the VTMIS system showed that there are a number of information services that can be combined in the system in the Arctic. In future especially the ice information should be part of the VTMIS system.

The lack of crew training was an issue that came quite strongly out of the work that was done within ARCOP. Although many international codes including IMO recognise the issue, there is no international standard or not even service available. The need for trained crews for ice operations is increasing. The need for crewmembers to be trained in the coming few years is more than 3000. The question is also strongly related to the issue of safety.

Within Work Package 4 "Environmental Issues" we at first looked at the risk levels of the Arctic marine transportation. With the scenarios that were created it seems that the risk levels are quite low when compared to the experience from other sea areas. It must however be admitted that there is not existing experience from the large-scale transportation in the Arctic conditions. The experience on ice damages is mainly based on Baltic conditions. This is an issue that needs to be studied more thoroughly in the future.

The second issue studied was the oil drift after the accident. The several scenarios produced showed that depending on the accident location either high capacity or quick response time is important. This means that the response strategy must take both these into account. What was satisfactory was that the different simulation methods gave consistent results and thus at least the experts are confident that the methods are reliable.

The third issue was the actual oil spill counter measures. Knowing that the use of in-situ burning and the use of dispersants are efficient, but their use may be limited to other reasons, we concentrated on bioremediation and mechanical oil recovery. In bioremediation the problem still exists that the type of bacteria available today are not efficient in temperatures below freezing. This means that the development of more specific PAH-degrading cold adapted bacteria needs to be continued. Within the mechanical oil spill recovery several options were studied. It seems that none of them is proven in large-scale oil spill. There are efficient methods like the LAMOR Arctic Skimmer, but they have been designed for limited size of oil spills and need further development.

The original idea within ARCOP was to arrange a large-scale validation voyage with a large size tanker up to the Russian Arctic. Unfortunately no commercial cargo was available for a large tanker by the time the voyage was planned. What was done instead was that the Russian participants in the project analysed some of the ongoing activities in areas that can be considered relevant. The current cargo operations at the Varandey terminal show that the downtime estimates that were used in the ARCOP economic analyses were quite close to those that are experienced today. Also the time that is needed to perform the customs and other administrative formalities were on realistic level.

The analyses related to the operation of icebreakers with large tankers were done from the experience in the Baltic. This analyses shows that at least in Baltic conditions one icebreaker is often enough to assist one large tanker through the ice. Thus the assumption that was used in the ARCOP calculations may be slightly pessimistic.

During the project 8 workshops have been arranged. The workshops gathered 401 specialists representing 89 different organisations from 12 different countries during the whole project.

The web-site has been in active use for close to three years and the there has been some 250.000 successful requests from the site by the end of 2005. The web-site will remain in operation for two years after the project has ended.

The workshops were an efficient tool to bring together the different interest groups from industry, science and authorities. And although ARCOP was a EU-project, the workshops brought a circumpolar dimension into the work.

In general ARCOP managed to achieve most of the strategic objectives:

- The Workshops formed a continuous discussion forum between EU and Russia with some circumpolar dimension towards the end. The discussion was open and the participation was wide both among the industry, science community and governmental bodies. At the end there was several requests to continue the activity beyond ARCOP.
- The review of the legal aspects resulted in common understanding of the legal status of the Artic sea routes. The analysis of the WTO/GATS raised a number of issues that need to be taken in consideration, as the GATS regime for shipping will be developed.
- The research within the rules, regulations and requirements brought some clarity to the consistency to the regulatory basis of the Arctic Shipping in Russia. But it also brought up the fact that the current IMO and IACS regulations are not fully satisfactory.
- The economic analysis of the transportation showed how the different factors like technology, fees, efficiency of the border formalities and the way of operating the icebreakers, influence the overall economics. The result serve as valuable input those who plan the related activities in practice.
- The studies on environmental issues gave a clear warning that readiness for accidents must be further developed and the all the safety related factors have to be taken seriously.
- The work between the EU and Russian researchers was fruitful in creating understanding between the cultures. This understanding helped in develop-

ing common recommendations on a number of topics and will help in future

ARCOP was considered to be a part of the EU-Russia Energy dialogue. The results of the project will be if help when developing the energy transportation policies from Arctic Russia to Europe

Contents

1. WP1 Ice Information for Arctic Route Selection

One of the main targets of ARCOP/WP1 was to give recommendations for the concept design of future ice information system for the Northern Sea Route (NSR). The basis for this work was started by the state-of-the-art reviews presented in the first deliverables of this Work Package.

Long experience of Arctic navigation in Russia has proved the importance of ice information and other hydro-meteorological support providing safety and efficiency of sea operations. The currently available ice information system is based on combined processing and analysis of non-homogeneous information from satellites, ground-based observations, autonomous drifting buoys and polar stations as well as icebreakers and ships. In the present system ice mapping is performed using the information on ice regime, historical databases and ice models. Ice information is analysed by skilled ice experts with the use of modern hardware and special special software. The system has a module for analysis and forecasting of ice and hydro-meteorological conditions. Stochastic and hydrodynamic models for prediction of ice cover distribution from 1-7 days up to 3-6 months have been developed and are in current use and a numerical model for the evaluation of ice routing has also been developed.

Specific problems of a wide practical implementation of the elaborated information support technologies in the Arctic Seas were encountered during the last decade due to a reduction in the number of ice information users. Though there are no actively operating Russian meteorological satellites at present, today's ice information acquisition for the NSR area is based on satellites.

On the request of users, detailed ice charts with ice symbols as well as the other hydro-meteorological information can be made available both on the entire NSR and on any local region. One of the most promising and on-demand technologies at the nearest time will be a technology and presentation formats for operational ice and meteorological information that will provide their simultaneous depiction together with navigation information. The use of satellite images received on-board icebreaker or ship in near-real time in addition to the ice chart, provides detailed and very useful information on ice conditions. According to Russian experts the currently available Russian ice information system could be considered as a basis for the future NSR ice information system.

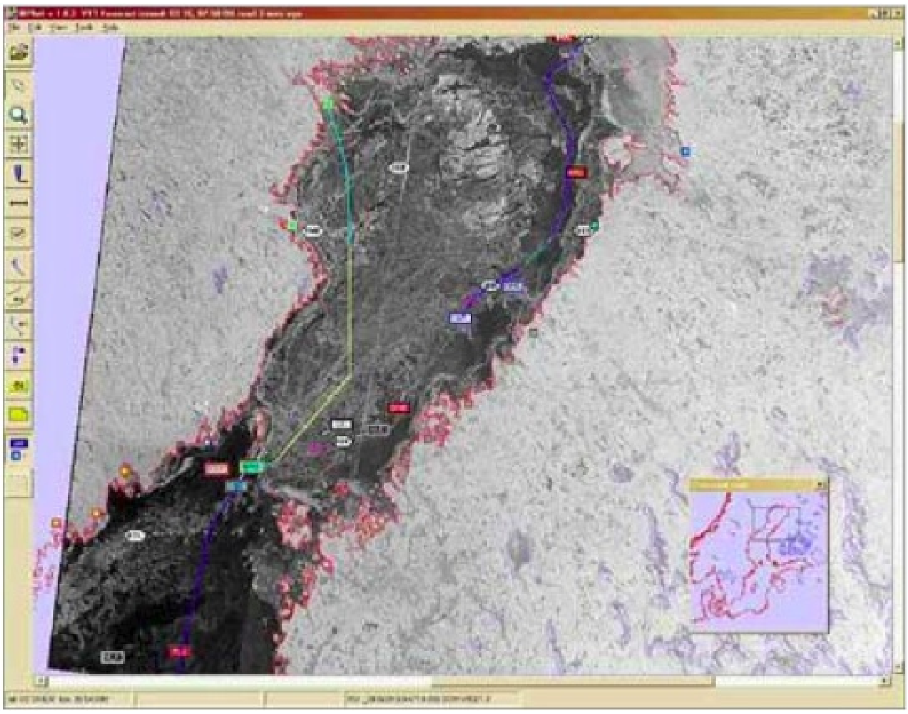
In addition to reliable and full information of ice conditions that supports the decision-making in shipping and navigation through the Arctic seas it is absolutely necessary to have also up-to-date information about depths, locations of hazards and navigation conditions. A continuous information field about the actual hydro-meteorological conditions is also needed. Short-term and periodic meteorological forecasts are needed to prepare ice forecasts. Financial resources are needed for maintaining an up-to-date level of navigation and hydrographic support.

Information about the quantity and quality of ships in the Arctic region as well as information about the tasks which are carried out by these ships is needed to help the administration in its efforts to ensure the safety, e.g. when planning assistance operations or in the case of an emergency.

Modern ice information systems are to a large extent based on satellite data and numerical modelling, supported by in situ observations from ships, aircraft and other available data. Particularly on large and regional scale, satellite data are playing an increasingly important role. This is mainly because wide swath SAR data have been adopted by many national ice services in their regional ice charting services. On global scale, passive microwave data is the work horse, supplemented by scatterometer, infrared radiometer and optical data.

On local scale, where tactical information is needed for ice navigation and other marine operations, the most important information comes from the ships, aircraft/helicopters, and possibly from ice buoys. High-resolution satellite data is part of the input data, but the usefulness of the satellite images depends very much on delivery in near real time. SAR images can be delivered to ships with a 2 – 4 hours delay, provided that the SAR images have been ordered for the area where they are needed.

The current SAR systems require pre-ordering, and this is a limiting factor for



Screenshot from the routing system software

providing high-resolution, narrow-swath SAR images in areas which are not pre-defined. In tactical ice navigation it is necessary to have a flexible ordering system where users can order data with one day. For fixed installations, such as platforms, pipelines and terminals, high-resolution SAR can be pre-ordered for example for every third day. But users need data coverage every day, and this is not feasible with the present SAR systems.

New SAR systems can provide very high resolution SAR images, with pixel size of about 3 m, and a swath width between 10 and 40 km. Also polarimetric capability of the new SAR systems will increase the possibility to classify ice types and ice features. Such data will be very useful to map details in the ice cover such as ridges, leads, floe size on local scale, although the data will not be available every day. High-resolution optical images can be used as a supplement to SAR, but there are limitation due to clouds and darkness. Even if the data can be obtained every day, useful information can only be obtained during daylight and cloud free conditions.

To support information provided by satellites, it is common to use data from ships and coastal stations, where direct observations and ship radar data are the most important. Aircraft surveys include visual observations, vertical video recording and Side-Looking Radar. Recently, use of scanning laser and GPS has been demonstrated as useful tools to measure the surface topography of sea ice, especially ridges. Helicopter surveys using laser and electromagnetic induction provide data on ridges as well as thickness. Group penetrating radar is used for measuring thickness on local scale. For tactical information, it is particular useful to collect ridge and thickness data because the satellite data do not provide any quantitative estimates of these parameters.

Ice modelling is used to provide forecasts on global and regional scale, but the quality of ice forecasts needs improvement in particular on regional and local scales. The most commonly used plastic-viscous ice rheology is applicable on scales of 10 km and upward, but on local scale it is necessary to apply discrete element modelling or similar approached where individual ridges and floes are simulated. Ice forecasting also depends heavily on atmospheric forcing fields. In most polar regions, the atmospheric forecasts are not satisfactory on local scale. In order to improve the ice forecasts, improvements are needed both in the atmospheric forcing fields and in the oceanographical models, which are coupled to the ice models.

An ice information system for decision making in shipping operations has been developed in the EU funded IRIS-project. This kind of system, which has recently been validated in the Baltic Sea during application test voyages in winter 2005, makes it possible to use onboard route optimisation in the navigation through ice covered waters. By combining remote sensing data, other reliable sources of relevant information, validated ice models and efficient high-tech information technology, it can provide the operators with the most up-to-date important information related to the environmental conditions and forecasts that should always be taken into account when the operative work is planned and carried out.

Further development and supply of new versatile information products and services, serving the various needs of the operations in the NSR area, seems to offer good possibilities for commercial actors, too, if the availability, format and terms of the use (of the basic ice information) as well as the responsibilities of each product/service provider can be agreed on a solid and transparent basis.

The final recommendations concerning the concept design of the future ice information system for the NSR are as follows:

- The future ice information system for the Northern Sea Route must deliver sufficient data of the prevailing ice conditions and other relevant environmental conditions to the users
- Reliable forecasts of ice conditions and other relevant environmental conditions should be included in the information produced and delivered to the users. These forecasts should have a time span ranging from 3 hours to several days.
- The accuracy of the information and data delivered by the ice information system should be known. Minimum requirements for the accuracy of the information should be established.
- The future ice information system must be reliable. In order to achieve this requirement the system should be constructed of redundant components of excellent quality.
- The operation of all the components of the system as well as the whole system should be verified and validated according to the principles applied to other safety-critical systems.
- In order to ensure continuous operation of the ice information system, built-in redundancy should be applied in the design. The system should not be critical to any single failure
- The present ice information system can be used as the basis for building the future ice information system
- However, possibilities for commercially based products and services should be guaranteed to ensure continuos development of ice information that serves the various needs of different users and user groups.

For this purpose

- The availability, format and terms of the use (of the basic ice information / source information) as well as the responsibilities of each data/product/service provider should be agreed on a solid and transparent basis.

Thus, the design of the NSR ice information system can be based on the existing ice information system, provided that it can be operated, maintained and developed on a firm basis. Basic data and ice information produced by this infrastructural part of the ice information system can then be used further, e.g by commercial (or other) service providers to serve the special needs of the various ice information users. The benefits of such kind of ice information system, that can be used to guarantee a safe voyage for a merchant ship, but can also be used to optimise the route of a ship, are obvious.

Appendix WP1

ViewIce – An Example of an End User Tool for Route Optimisation in Ice Covered Waters

Robin Berglund, Technical Research Centre of Finland

End users need tools for their decision support when making route planning in ice-covered waters. An example of such a tool intended for on-board use is ViewIce, developed by VTT. The history of ViewIce goes back to almost a decade ago. The first version of ViewIce was developed by VTT in 1998.

ViewIce was originally intended for display and analysis of satellite images and ice charts. Many features have been developed for the Swedish and Finnish icebreakers in a software called IBPlott, which has several common software modules with ViewIce. IBPlott is now in operational use on the icebreakers, ViewIce is for merchant ships. ViewIce also serves as a prototype application platform in research projects

ViewIce functionality

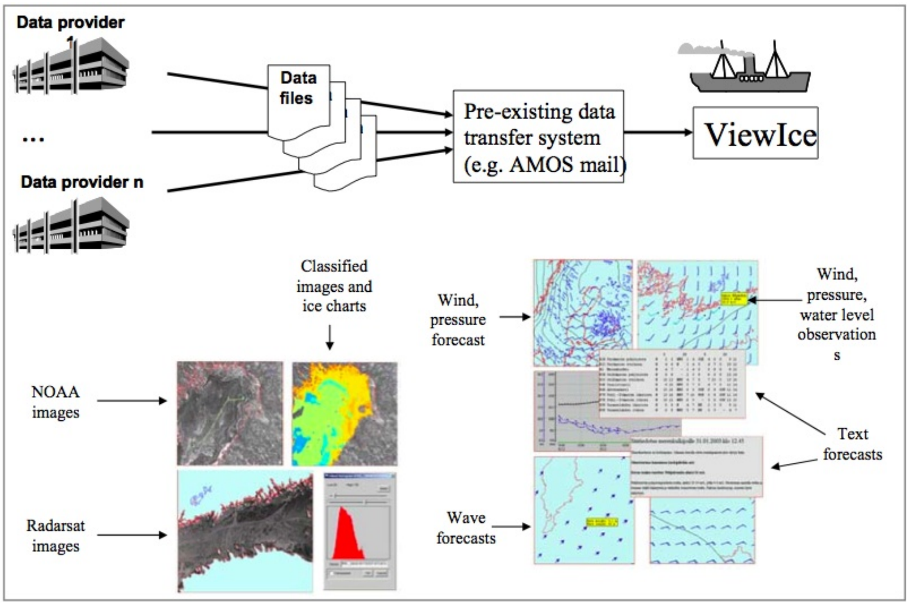
The main functionalities of ViewIce are to display:

- geocoded satellite images (both optical and SAR)

- weather forecasts
- wave forecasts
- coastal station observations (water level, wind ..)
- ice chart information as selectable overlays.

The forecasts can be studied at selected times on the map or as a time series at any given point. The attributes can also be shown along a planned route.

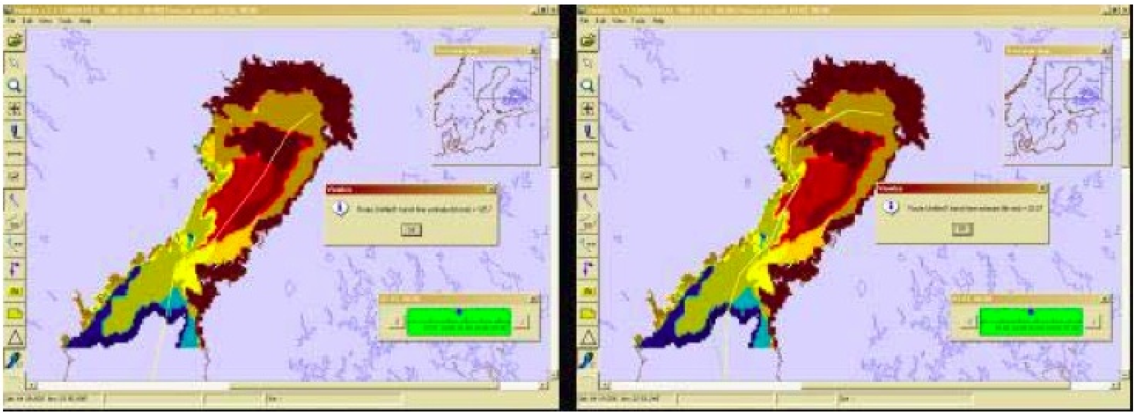
Data flow from providers to endusers:



ViewIce in IRIS

ViewIce has been used as the end-user tool in the EU-funded IRIS project (EVK3-CT-2002-00083). In IRIS, ViewIce was used to integrate an ice resistance model with ice model data to calculate the transit time estimate along any user drawn route. The ice resistance model is ship specific, and may use either design models or resistance models based on simulations. This was developed further by implementing an optimisation algorithm, which tries to minimise the total transit time by varying the waypoints along the route taking into account that the ice situation is dynamic, i.e. the situation changes as a function of time.

In 2005, ViewIce was used in application tests onboard the vessels m/v Bothniaborg, m/t Sotka and r/v Aranda navigating in the Bay of Bothnia.



Route optimisation based on ice model results.

In the figures above, level ice thickness of the bay of Bothnia, is visualised. To the left, ViewIce has calculated an estimate of the transit time of a route going through the ice field. To the right, ViewIce has calculated a route, which has the shortest (estimated) transit time, which is significantly shorter than the original route alternative (32 h vs. 132 h). Calculation is done on board. The optimisation algorithm takes into account the dynamically changing environmental conditions along the route.

Discussion

The optimisation basis in IRIS is the transit time of a vessel. It is assumed that the ship uses full power. The simulation utilizes a cer tain model for the resistance of the ship when going through ice. It is also taking into account the characteristics of the ship. Ice variables are level ice thickness, ridge thickness and ice concentration. Also model tests and formulas based on model tests can be used.

The program is designed to be used only by the project group. For the mapping and the images, cer tain projections are assumed. The metadata of complete images contains the parameters and geological information on where to place the satellite images.

The model takes into account the changes in ice conditions, although in the workshop demonstration case the changes were not large.

Conclusions

On board route optimisation is possible to perform but reliable results require accurate ice models, accurate ship resistance models and efficient telecommunications possibilities for transfer of the ice model parameters to the ship in near real time.

In ViewIce the project group has demonstrated that this kind of information could be utilised by the end-user in a useful way to make route selection in ice covered waters easier and more reliable.

In Baltic conditions the route optimisation saves approximately 20% in the sailing time. Similar or even higher figures can be expected in Arctic ice navigation.

2. WP2 Administrative Measures for the Marine Transportation in the Arctic Russia

2.1 The Legal Status of the NSR

2.1.1 Legal Status of the NSR and Westover

Russia appears to be extending its NSR regime, based upon UNCLOS Article 234, ice-covered areas, westward to Kolguev Island in the Pechora Sea. There are certain elements of consistency in the common interpretation of existing law and behaviour of the large Arctic littoral States, Russia, Canada and the U.S. surrounding this regime. These elements seem to have put in action the process of formation of a specific customary international law with respect to the passage of vessels, including State vessels, through the Arctic area in general and its international straits in particular. This means that Russia enjoys substantial support from the large Arctic littoral States, the U.S. and Canada, for its legal regime regulating Arctic navigation. Especially the regime governing commercial vessels appears to stand strong. The present navigational provisions probably will remain the same for some time into the future, despite developments under the complicated UNCLOS Article 76 defining the continental shelf.

Under UNCLOS Article 234 coastal States have the obligation to adopt and enforce non-discriminatory environmental provisions. The main thrust of the Russian provisions is based upon environmental protection and safety, thereby seemingly implying that all vessels including Russian are encompassed. The principles are stated under Article 2 of the 1990 Rules[1] to be to regulate navigation free from

[1] 'Regulations for Navigation on the Seaways of the Northern Sea Route', in accordance with the U.S.S.R. Council of Ministers Decision No. 565 of 1 June 1990 and approved by the U.S.S.R. Minister of Merchant Marine, 14 September 1990 (1990 Rules). Russian text published in Izveshcheniya Moreplavatelyam (Notices to Mariners), No. 29, 18 June 1991; English translation published in Guide to Navigating Through the Northern Sea Route (St. Petersburg: Head Department of Navigation and Oceanography, Russian Ministry of Defence, 1996), pp. 81–4.

discrimination for navigational safety and to prevent, reduce and control marine pollution caused by the presence of ice. All vessels including State regardless of nationality are subject under Articles 1.4. and 2, and the implication of the supporting legislation is the same.

However concerning 'fees for services rendered', set forth in Article 8.4. of the 1990 Rules, there may be questionable compliance with the requirement of non-discrimination. Article 8.4. requires vessels navigating the NSR to pay for services rendered by the Marine Operation Headquarters (MOH) and the Northern Sea Route Administration (NSRA) in accordance with the adopted rates. Apart from the question of non-discrimination the issue remains whether fees themselves fall outside the scope of 'due regard to navigation' under Article 234. As noted, it may be questioned whether the current Russian fee rate, of $3.33 per ton to $73.02 per ton depending upon cargo, is required of the Russian vessels. This raises the issue whether non-discrimination is meant only to be among foreign vessels of different nationalities, or also between foreign vessels and Russian vessels. The better view appears to be upon analysis that related to Article 234, both Russian and foreign vessels are probably encompassed, especially since that is what seems stated explicitly in the 1990 Rules.[2] Thus, the fees, if justified under Article 234, must apply to all vessels, and the previous and likely current Russian practice on this point is contrary.

It is difficult to examine specific Arctic State practice on this issue, which may be contrary, since it is only Russia, which appears to have a blanket fee structure. Passage rights under both the Canadian and the U.S. legislation are not dependent upon the payment of fees.[3] The Russian authorities indicate a possible relaxation under Articles 8.1.–.3. of the 1990 Rules of initial 'control of navigation', if the vessels and captains are familiar, however the issue of fees has not been mentioned.[4]

The study of the State practice with respect to passage through NSR nevertheless demonstrates that due to the region's strategically sensitive geographical

[2]See R. D. Brubaker, The Russian Arctic Straits – International Straits of the World, pp. 55, 80 and 84.

[3]See Y. Ivanov, A. Ushakov and A. Yakovlev, 'Russian Administration of the Northern Sea Route – Central or Regional?', INSROP Working Paper No. 106, (1998), IV.2.5., 19-20.

[4]A. Ushakov, 'Interview', 24 February 1994, Moscow. A. Ushakov is Deputy Director of the NSRA. Flag State was not indicated to play any role.

situation, there is a continuous risk for disputes and may need practical solutions for preventing and resolving potential disputes. This may likely be extrapolated to the Barents Sea.

Norway is considering measures for the Barents Sea under international law of the sea to include,

- extended limit of territorial sea (20 nautical miles (nm) is possible);
- vessel traffic service (VTS);
- traffic separation schemes (TSS) including position of traffic separation scheme, automatic identification system (AIS) including distribution and coverage through stations;[5]
- tow vessels at strategic locations;
- electronic chart display and information system (ECDIS);
- implementation of routing regime;
- contingency management and planning regime including environmental risk analysis and oil spill contingency assessment;
- places of refuge and beaching;
- measures related to loading and unloading of cargo;
- control of emissions to air;
- management of oily wastes, sewage and garbage including reception facilities; and;
- ballast water management.

A Barents Sea management plan from Norway is expected in 2006.

The establishment of a PSSA is also being considered by the Norwegian government. 'Appropriate associated measures' looking cumulatively at the 10 PSSA's already designated include areas to be avoided, areas for compulsory pilotage,

[5]Norway and Russia are working to establish the Barents Vessel Traffic and Information System (VTMIS). This will be based on the exchange of AIS data between the authorities, with the traffic control centres in Vardø and Murmansk playing central roles. Norwegian authorities have also engaged in dialogue with tank vessels in international traffic in the Russian Barents Region, and the vast majority now volunteer information demanded. An AIS is now installed in all tank vessels, which makes it possible for Norwegian authorities to track them when they are set in motion. Information is also provided on cargoes carried. Norwegian authorities desire notification of hazardous cargoes two days previous to the vessels entering the Norwegian Exclusive Economic Zone.

prohibition of discharges including ballast water, prohibition of dumping of most other wastes, installation of reception facilities, no anchoring, and enhancement of surveillance and monitoring capacities for illegal discharges. Norway could follow suit.

Currently the Norwegian Military's Command in Northern Norway, (Landsdelkommando Nord-Norge (LDKN)) tracks vessel movements on radar along the Norwegian coast and notes in 2005 that flags freighting hydrocarbon products from Russia through the Barents Sea are chiefly from Liberia, Marshall Islands, GBR Isle of Man, Russia, Cyprus, Bahamas, Norway NIS, Sweden, Finland and GBR Gibraltar in that order.[6] The main cargoes are crude oil, and main ports are Murmansk and Rotterdam by a large margin. The tracks indicate that most vessels hug the Norwegian territorial sea 12 nm. boundary or cross it on the way to the Netherlands. This would indicate clearly in terms of protecting biodiversity the need for sealanes 20 nm. or more seawards or particularly sensitive sea areas (PSSA's) extending seawards 50 nm.[7]

At the same time, problems with a Barents Sea PSSA as outlined by Det Norske Veritas (DNV) north of Finnmark down to Lofoten about 50 nm. out to sea may include discrimination issues, both against Russian oil and gas tankers on the way to Europe and possibly Norwegian fishing vessels. All vessels in international shipping are subject to the measures taken by Norway. If Russia becomes a member of the World Trade Organisation (WTO) which may happen early in 2006, and oil is freighted solely on Russian tankers, it may be questioned whether these are discriminated under General Agreement in Trade in Services (GATS) by being required to sail 50 nm. to sea to Europe?[8] Although not a problem currently since Russia is only one of 15 flags, albeit the fourth largest, it seems uncertain the effect reflagging of Russian owned vessels to a new Russian international register will have. Will this cause the tankers navigating the Barents Sea to be predominantly Russian? One Russian diplomat indicates that the reasons be-

[6] See http://www.mil.no/sjo/start/article.jhtml?articleID=102534. Information obtained from Landsdelkommando Nord-Norge (LDKN), 6 September 2005. The latter four are equal in number of navigations.

[7] See Figure 6. See Sections 5.2. and 6.2. for PSSA's.

[8] See http://www.wto.org/english/tratop_e/serv_e/gats_factfiction_e.htm. It appears only Russian oil tankers are permitted under the current production sharing agreements Russia has with Norway. The EU production sharing agreements allow other flags, which would seem to allow other flags vessels in the Barents Sea traffic should EU States be involved in this oil production.

hind this relate to expedite taxation as well as facilitate the tracking of tanker ownership in case of accidents for liability purposes.[9] Fishing vessels though not technically regulated under the PSSA regime which governs international shipping, have in practice been strictly regulated or excluded in approximately 67% of the Australian Great Barrier Reef Marine Park - PSSA, and roughly 50%, looking at large trawlers, of the Florida Keys Sanctuary Area - PSSA.[10] What is to guarantee that Norway or other States may not establish a coincident 'Marine Park' - PSSA, containing 10 marine zones with 10 differentiated activities? A legal representative for particularly trawler organisations may with reason be concerned, and Norwegian fishery interests generally fear unnecessary regulation of fisheries.[11] Issues surrounding the Convention on Ballast Water need addressing as well for tankers returning to Murmansk and loading ballast water with possible alien species. Parties undertake to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.

Many weighty policy arguments exist as well, possibly weighing against a Norwegian PSSA, outlined in the expert report 'Mot Nord',[12] as well as the recent Government White Paper, St.meld.nr.30.[13] These include untraditional bilateral co-operative agreements between Norway and Russia.[14] A Barents Sea management plan is expected developed by Norway by 2006, covering specific activities and dealing with the interactions between the hydrocarbon, fisheries, transport, biology and security interests.[15] Due to the balance attempting to be achieved

[9] Y. Petrenko, First Secretary, Embassy of the Russian Federation, Oslo, Norway, 'Interview', 7 September, 2005.

[10] The large ATBA in the Florida Keys applies to all vessels but only over 50 meters, and U.S. trawlers in the area are generally shorter. Many Norwegian trawlers on the other hand are over 50 meters would be excluded.

[11] P.J. Schei, Director, FNI, 'Interview', 28 June 2005.

[12] 'Mot nord! Utfordringer og muligheter i nordområdene', (To the north! Challenges and possibilities in the northern areas) NOU 2003:32, pp. 25-6. This is an independent expert group's report and proposals published by the Norwegian Foreign Ministry. Translation by author. See http://odin.dep.no/ud/norsk/publ/utredninger/NOU/032001-020003/dok-bn.html.

[13] See http://odin.dep.no/fkd/norsk/dok/publ/stmeld/047001-040002/dok-bn.html.

[14] Norway has under the Cold War been fearful of entering bilateral agreements in most areas with the more powerful Soviet Union/Russia. Fishery administration has been the chief exception.

[15] The prospect of transport of nuclear spent fuel from Japan along the Northern Sea Route to the U.K. and France and reprocessed fuel back again has also been discussed, implicating both the Barents Sea and Western European Waters. See generally Steven G. Sawhill and Claes L. Ragner, 'Shipping nuclear cargo via the Northern Sea Route', Polar Record, Vol. 38, (204),

by Norway in the Barents Sea, the legal controversy at all levels regarding PSSA designation,[16] current boundary delimitation negotiations with Russia, security concerns in relation to the U.S. and the EU. and NATO, the influence Norwegian shipping, oil and gas, and fishing interests carry, the weight good relations with Russia carries, possible discrimination of Russian tankers sailing 50 nm. to sea, the sensitivity bilateralism with Russia entails, a thin population base in the district Finnmark on the Russian border, as well as the present controversy over Sámi property rights in Finnmark under International Labour Organisation Convention 169,[17] the Norwegian government may well decide not to proceed with PSSA designation. It may decide to achieve much the same through quicker and less controversial measures under SOLAS and other relevant IMO treaties.[18] Enforcement under SOLAS would also seem easier to facilitate due to the vessel identification systems.

On the background of the international developments noted authorities of the International Oil Pollution Compensation Funds (IOPC Funds) associated with the IMO 1992 Protocols to the International Convention on Civil Liability for Oil Pollution Damage (CLC Protocol) and International Convention on the Establishment of an International Fund for Oil Pollution Damage, (Fund Protocol)[19] have in prac-

January 2002.

[16]PSSA designation is particularly sensitive for Russia in the Baltic Sea and sensitive for Norwegian fishing interests in the Barents Sea, the former because of a belief of breach of law of the sea rights of vessel passage and the latter because of a fear of unnecessary regulation of fisheries.

[17]See http://www.ilo.org/.

[18]A routing system can encompass mandatory sealanes, traffic separation systems and sailing rules in and out of a definite zone, recommended sealanes, deepwater lanes and precautionary areas, the latter which vessels must navigate with special care and through which recommended sealanes can be established. Areas to be avoided (ATBA) can also be established, where because of a particular danger or a particular sensitive ecological or environmental condition all vessel traffic or a certain type of vessels are forbidden to sail. A routing system can consist of several different of the above in combination. Mandatory or recommended vessel reporting systems are also allowed subject to application to the IMO. As part of this an automatic vessel identification (AIS) system of oil tankers is allowed, making reporting and a reporting scheme superfluous.

[19]International Convention on Civil Liability for Oil Pollution Damage, 29 November 1969, (CLC), New Directions, Vol. II, (1973), p. 602; International Convention on the Establishment of an International Fund for Oil Pollution Damage 18 December 1971, (Fund Convention), New Directions, Vol. II, (1973), p. 611. Protocol of 1992 to Amend the CLC, in force 1996 with 91 State parties, 1 June 2003. Protocol of 1992 to Amend the Fund Convention, in force 1996 with 85 State parties, 1 June 2003. See www.imo.org. See also Gauci, G., 'Limitation of liability in maritime law: an anachronism?' Marine Policy, Vol. 19, No. 1, (1995), 73. See ibid. generally 65-74 for further arguments against limitation of liability.

tice acknowledged the necessity to meet more demanding clean-up standards in areas associated with important wildlife values and/or tourism. From this one expert believes,

While oil spill damage in ecologically sensitive PSSA's has so far not been an issue for the 1992 Fund Executive Committee... the committee is likely to take a more generous view of reasonableness in order to meet stringent environmental reinstatement costs. Were that to be the case the preventive environmental rationale of marine protected areas would at least prompt a sympathetic realignment in the economic compensation system for oil pollution damage, although the high biodiversity value of such areas is likely to expose more acutely the absence of recompense for eco-system damage per se.[20]

However, a strong European reaction to the oil tanker accidents with regards to liability for damage from pollution occurred and may perhaps be extrapolated to other areas of international environmental law. Viewed globally, the extension under the UNCLOS Part XII of coastal and port State jurisdiction with MARPOL 73/78 probably has not had much impact on pollution prevention, reduction and control. Various problems have been noted. Though practice may have become somewhat 'greener' in the last years, it is unlikely that dramatic changes have occurred. Therefore the unilateral developments currently taking place in Europe as well as North America should not be underestimated.

The 1999 Erika incident caused much turbulence in the liability and compensation regime governing oil pollution and was the first tanker pollution incident in which the European Commission (EC) has taken a strong role in proposing changes in the international IMO regime. These proposals revolve around increasing available compensation for damage available through, the limitation rights, channelling of liability and a third tier fund, and some experts believe that these may pose a serious threat to the existence of the international liability and compensation regime.[21] The EC argues first that limitation rights are too protective that should be broken only in cases of 'gross negligence'. This argument finds support from

[20] Mason, M., 'Civil liability evolving,' 7.

[21] See Wu, C., 'Liability and Compensation for Oil Pollution Damage: Some Current Threats to the International Convention System,' Spill Science & Technology Bulletin, Vol. 7, Nos. 1-2, 109-11 from which the following is obtained.

the U.S. OPA 1990[22] which marks a significant move and increase away from the limits of liability provided for in the IMO, 1992 Protocol to the CLC.[23] Counter arguments include that the right of limitations would be rendered very vulnerable, the determination of the existence of fault or privity (knowledge) often delays the compensation process, and with more serious consequences, different interpretation of 'actual fault or privity' by national courts would lead to disparities in compensation. It is also argued that the limits under the 1992 Protocols were planned raised by 50.37% by late 2003, unless 25% of State parties objected.

The EC argues secondly that by channelling, liability is imposed in a manner that may not adequately reflect the responsibilities of the parties. Counter arguments include that holding multiple parties responsible encourages litigation, thus slowing down the compensation process and wasting money on transactional costs. Such is argued to damage the negotiated balance under the 1992 Protocols, including the prompt and certain compensation to claimants, set against a financially manageable regime with predictable insurance requirements for liability parties. The current level of coverage of $1 billion is argued by the IMO to be possible because of the reassurance given to underwriters by the limitation rights. If the $1 billion were called upon, there is a real risk it would cease to be available, even at increased cost.

Concerning the third issue, a third tier fund, counter arguments include that a European third tier fund paid for by cargo owners would upset the balance achieved by the 1992 Protocols between ship-owners and oil companies, and consequently undermine the regime. Financial sharing the last 10 years has been approximately 50/50 between oil companies and ship-owners, with the former rarely involved but paying substantial contribution in the large spill clean-ups through the IOPC Funds.[24] If forced to contribute to a new purely European oil company-financed fund, European oil companies could put pressure on national governments to move out of the 1992 Fund Protocol, or even move themselves out of European States or pursue re-structuring to allow smaller companies to import

[22] United States Oil Pollution Act of 1990 (OPA 1990), 33 United States Code (USC) 2701, Public Law 101–380, August l8, l990.

[23] See www.imo.org. See also Gauci, G., 'Limitation of liability in maritime law: an anachronism?' Marine Policy, Vol. 19, No. 1, (1995), 73. See ibid. generally 65-74 for further arguments against limitation of liability.

[24] See www.imo.org.

smaller amounts below the threshold for Fund contributions.[25]

Developments surrounding liability coverage for pollution damage associated with oil transport thus should be carefully followed both under the IMO 1992 CLC and Fund Protocols, and also the evolving EU base, including any interrelation between the two. Some turbulence will likely continue due to the European dissatisfaction. The area of law is crucial, both seen in a remedial perspective, as well as a preventative perspective.

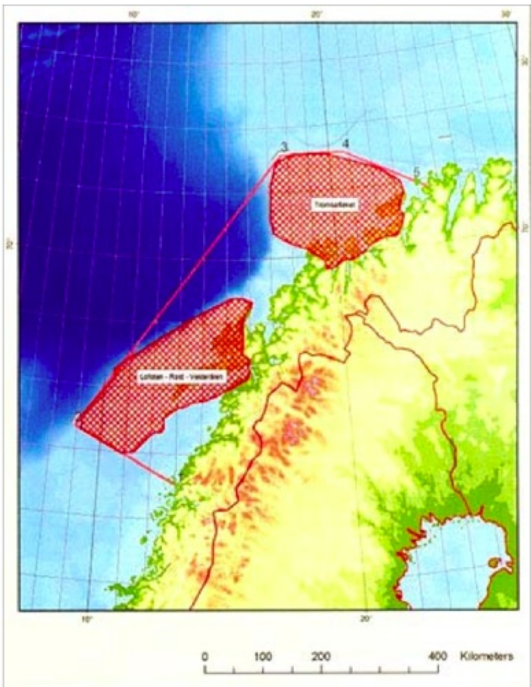
Finally, general statements have been made should current claims by the Arctic littoral States to the Arctic continental shelf be recognised, there will remain two small doughnut holes in the Arctic Ocean, with all countries having extended their regulatory regimes out past 200 nm. This is somewhat misleading, since the continental shelf regime under 1982 United Nations Law of the Sea Convention (LOSC)[26] Part VI is separate, from the navigational regimes represented by LOSC Parts II (territorial sea and contiguous zone), III (international straits), V (exclusive economic zone, including fisheries) and VII (high seas).[27] Also thus far it is only Russia which has made an official submission to the Commission for the Continental Shelf's Outer Limit (CLCS) related to the Arctic, though Denmark and Norway reportedly are in the process of drafting submissions. Though certainly interrelated, these regimes have been functioning separately for at least 10 years, and most longer under other treaties and customary international law. This means in practice that not only will the present navigational provisions probably remain the same for some time into the future, despite developments under the complicated LOSC Article 76 defining the continental shelf, at the maximum out to 350 nm. from the baselines, but also that any navigation associated with developing the continental shelf, will remain subject to the international and national provisions already in place. Separation is as well noted in LOSC Article 78. This, as

[25]Gold, E., Gard Handbook on P&I Insurance, 5th Edition, (Arendal, Assuranceforeningen Gard-gjensidig, 2002), p. 414, notes the EU has already set the basis for an environmental liability regime for Europe to make polluters strictly liable for environmental damage they cause, which appears to take the EU towards a more U.S. oriented compensation and liability regime. This consequently has serious implications for existing IMO international regimes.

[26]1982 United Nations Convention on the Law of the Sea (LOSC). United Nations Treaty Series (UNTS), reprinted in International Legal Materials (ILM), Vol. 21, (1982), p. 1261. The LOSC came into force 16 November 1994. For the IMO regime see generally http://www.imo.org/.

[27]LOSC Parts XI (the Area) and XII (Marine Environmental Protection) will also have application, as will the 1994 Agreement on the Implementation of Part XI of the 1982 Law of the Sea Convention, ILM, Vol. 33, 1309 (1994).

will be seen below, is already extensive for 85% of the Arctic exclusive economic zones, and these marine areas must be crossed by vessels in order to reach the continental shelves lying under the high seas areas. What can be imagined should future navigation increase for any reason, including developments on the Arctic shelf, may be even greater navigational regulation in the Arctic exclusive economic zones, including particularly by Norway and Denmark/Greenland.



Area proposed designated as PSSA in northern Norwegian Sea and the Barents Sea, indicated by a red line. Areas given in red hachure are of high environmental vulnerability. Sectors indicated in grey are suggested Traffic Separation Scheme. Obtained from Figure 10.1., Det Norske Veritas, Report No. 2002-1621, p. 112. Please note that distances appear in kilometre (km.). 1 nm. equals 1.852 km. Thus, 100 km. on the chart equals approximately 54 nm.

2.1.2 EU Law – Trends and Extraterritoriality

EU Trends

Several trends will be noted in EU law in addition to those under civil liability for oil pollution damage noted previously. Then extraterritoriality will be addressed. Related to oil and LNG tankers trafficking the NSR and westover, issues to be dealt with originally included clarification of WTO/GATS and EU requirements for competition, the establishment of a treatment-no-less-favourable regime under GATS, and trade in services under GATS. The Russian Federation is applicant Member State for 10 years and not yet party to the WTO.[28] It was determined underway that the WTO/GATS regime would have relevance in the long term, but less so currently. It appears in spite of probable Russian membership in WTO within the next years, the GATS regime governing shipping is still under formation. Thus, EU law will be specific focuses of this speech. However, since Russia is working towards that accession take place in 2006, an overview of the WTO/GATS regime will be given in the final paper, together with Russian views regarding WTO/GATS membership.

Criminal Sanctions

Related to criminal sanctions, the EC and the European Parliament (EP) are drafting what appears to be moving beyond what the IMO has been attempting to do, due to differences in implementation by States of MARPOL 73/78, particularly related to the imposition of sanctions for discharges of polluting substances.[29] The scope is increased holding not only the ship-owner or master of the ship criminally liable, but also cargo owner, the classification society or other involved persons. This is applicable in all maritime zones for infringements in accordance with international law, committed with intent, recklessly and or by serious negligence.

[28]The Working Party on Russian accession was established on 16 June 1993. For the status of the negotiations. See http://www.wto.org/english/thewto_e/acc_e/a1_russie_e.htm

[29]See Brussels, 28 Feb. 2005, Doc. No. 6614/05, MAR 24, ENV 29, CODEC 100; and Brussels, 17 Feb 2005, Doc. No. 6408/1/05 REV 1, MAR 21, ENV 73, DROIPEN 11, CODEC 93. Italics added.

PSSA's

Similarly, Western European Waters were designated 'in principle' at MEPC 49 as a PSSA.[30] MEPC 52 agreed to the final designation of this PSSA[31] In the October 2004 IMO/MEPC meeting Western European Waters were finally designated, with a new mandatory yet free vessel reporting system as an 'associated protective measure' under SOLAS Regulation V/11 which will enter into force in June 2005.[32] NAV had approved a mandatory ship reporting system, which was proposed by Belgium, France, Ireland, Portugal, Spain and the U.K. to serve as an 'appropriate protective measure' for this large marine area. Other APM's already in place and adopted by the IMO include traffic separation schemes, deep-water routes, areas to be avoided, routing measures, mandatory ship reporting systems, and coastal vessel traffic services (VTS).[33] This PSSA covers the Western coasts of the United Kingdom, Ireland, Belgium, France, Spain and Portugal, from the Shetland Islands in the North to Cape S. Vicente in the South, and the English Channel and its approaches.[34] Sensitive areas include a very high species diversity of both macro-fauna and flora, including seabirds. Offshore waters of Ireland contain some of the richest fishing grounds in Europe. Various specially protected areas (SPA's) already exist off the coasts of Ireland, Belgium, Spain and Portugal. Off the coasts of Belgium lie areas known for fishing, and off France areas known for great biodiversity and biological wealth. Spain and Portugal enjoy coastlines with areas containing species of fauna and flora with a high degree of endemicity. The marine and shore environment of the Belgian, French, Irish, Portuguese, Spanish and U.K. coasts, the English Channel and its approaches are thus particularly vulnerable to the risks of vessel transport. This

[30] See J. Roberts, M. Tsamenyi, T. Workman, and L. Johnson, 'The Western European PSSA proposal: a "politically sensitive sea area"', Marine Policy, Vol. 29, Nr. 5, 2005, 431.

[31] See http://imo.amsa.gov.au/public/resolution-titles/res-mepc.html (subscription) and www.uscg.mil/hq/g-m/mso/docs/MEPC_52_Delegation_Report.doc.

[32] See MEPC 52/24 p. 47 citing MEPC121(52) and SOLAS Regulation V/11. See MEPC 52/24/Add.1, Annex 10, (Annex 3) for specifics regarding the new mandatory ship reporting system for the Western European PSSA. Detailed descriptions of the characteristics of the maritime traffic, the transport of harmful substances, and the threats from disasters, including a description of the meteorological, oceanographic and geographical conditions is found in MEPC 49/8/1 and MEPC 49/8/1 add.1 and MEPC 49/8/1 Corr.1.

[33] See MEPC 52/24/Add.1, Annex 10, (Annex 2) for specifics areas and measures.

[34] See MEPC 52/24/Add.1, Annex 10 for the following description. See MEPC 49/8/1 for detailed descriptions of the ecological, socio-economic and cultural, scientific and educational criteria of this area.

area is one of the most international significant sea routes due to the number of ships and quantities of dangerous or polluting goods transport. 25% of the world commercial traffic converge on the English Channel, on the way to the industrial areas and harbours of northern Europe. additionally significant cross channel commercial traffic exists between Ireland and the U.K., between Ireland, the U.K. and the European mainland, and North European traffic bound for Western Atlantic ports. Because of the size of the PSSA and the location and the EU coastal States, future environmental and safety measures concerning international shipping should be watched. This area will undoubtedly be of importance in defining the PSSA regime, including in relation to the Barents Sea.

Vessel and Port Security

Along the same lines, the International Ship and Port Facility Security Code (ISPS) as was adopted in the IMO with amendments in SOLAS to increase security and measures against terrorism on board vessels and in ports.[35] The EU adopted Provisions 725/2004 implementing the IMO provisions, but expanding the scope and requirements for vessels and port terminals, and through this, parts of domestic traffic are also encompassed. A new EU Directive may be adopted in 2005 that expands the scope, especially with respect to facilities that handle large quantities of dangerous and polluting cargoes, located near populations centres. Norway is implementing these provisions, both for vessels and ports at a substantial cost, to hold a standard with Norway's most important trade partners.

Competency

Although the European Court of Justice stated already in 1964 that the European Community represents a hybrid conglomerate situated somewhere between a State and an intergovernmental organisation, much controversy still affects the field of the Community's role as an actor under international law.[36] In particular,

[35]See http://www.ilo.org/ilolex/english/convdisp1.htm

[36]A. Proelß, University of Tübingen, Speech – 'EC Competence in Respect of Shipping: Is the Community Bound to Obligations Arising from IMO Conventions?' University of Oslo, 23

problems arise in case the Community's member States accede to a multilateral convention dealing with a subject for which they subsequently transfer competence to the Community. This may be demonstrated by referring to the case of the IMO. Whereas all member States of the Community are IMO members, the European Community itself may at present neither become a member to the IMO since membership is restricted to States, nor may it accede to the conventions negotiated within the organisation. According to Article 80 of the European Community Treaty, however, the Community holds internal and external competence in respect of shipping. Therefore, the Community's member States are bound to the obligations deriving (directly or indirectly) from their membership to the IMO as well as to the shipping standards enacted by the Community. The question of which obligations enjoy primacy in case of conflicting obligations deriving from international law on the one hand and from European law on the other is still being answered.

These developments might be followed closely, particularly with respect to the growing EU legislation, as well as the U.S. OPA 1990[37] and related legislation. Should a PSSA in the Barents Sea not be designated, the protective measures and implementation of such taken by the EU, the U.S. and perhaps Canada could be modelled by Norway, or other States, for example with similar or slightly less strict provisions in order to achieve less resistance from adversarial interests such as shipping. It remains to be seen how these developments will affect the Barents Sea, however, the EU and U.S. coastal environmental regimes may likely have an effect on the hydrocarbon vessel traffic in the Barents Sea, including port entry requirements in both of these federations for vessels carrying Russian hydrocarbons.

The territorial scope of European Union shipping services acquis – with a special emphasis on free trade in Russian arctic oil and gas shipping services

As the proposal for an international competition law[38] is deadlocked,[39] unilater-

November, 2005.

[37]United States Oil Pollution Act of 1990 (OPA 1990), 33 United States Code (USC) 2701, Public Law 101–380, August l8, l990.

[38]See WTO Doc. WT/WGTCP/2 of December 8th 1998, Doc. WT/WGTCP/3 of October 11th 1999 and Doc. WT/WGTCP/4 of November 30th 2000.

[39]Harry First. The Vitamins Case: Cartel Prosecutions and The Coming of International Competition Law, 68 Antitrust Legal Journal (2001) p. 711 ff., at 727-33 which still is the US-position

alism seems the most plausible alternative for efficient regulation of intra State activities. The hypothesis is that solutions emanating from an extensive extraterritorial reach of the European Union shipping services acquis, are sufficient in the case of the EU-Russia transportation trade.

The aim of this project is to display the EU-Russia oil and gas transportation market lie under the legal regime of the EU trade in shipping services, irrespective of the citizenship or location of the subject addressed. In casu, what is the territorial scope of the 1986 Maritime Service Regulation (No 4055/86), the 1986 Maritime Competition Regulation (No 4056/86) and the1979 Liner Conferences Regulation (No 954/79)?

No attention is directed to the material law of trade in shipping services.[40] Nor is discussion addressed to the national States' option to refrain from compelling legislation, which leave it open to trade partners inside and outside Russia to opt for the EU maritime regulations. Freedom of contract demands a national declaratory prescription policy,[41] which is the codified solution for trade in goods but not yet for trade in services.[42]

Zero tolerance for double standards: The international law frame

As justified i.a. by the International Court of Justice (ICJ) the unilateralist approach ratione terrae and ratione personae should be balanced against international law.[43] Thus, focus is upon the international law 'effects doctrine',[44] the

under the ongoing Doha-round, see Kerrin M. Vautier. International Approaches to Competition Law: Government Cooperation for Business Competition in Yang-Ching Chao & al. International and Comparative Competition Law and Politics (2001) p. 199.

[40]See however the Commission of the European Communities. White paper on the review of Regulation 4056/86, applying the EC competition rules to maritime transport COM (2004) 675 final of October 13th 2004.

[41]An option that reaches back to 13 January 1987; The Soviet Union legislation on equity joint enterprises to be formed with partners from Western countries on the territory of the Soviet Union, See W.E. Butler, Joint ventures and the Soviet Arctic, Marine Policy, March 1990, 175.

[42]See the 1980 Vienna U.N. Convention on International Contracts on Trade in Goods.

[43]See i.a. U.K. v Norway (Fisheries Case) ICJR 1951, 116, at 132; 'Although it is true that the act of delimitation is necessarily a unilateral act, because only the coastal State is competent to undertake it, the validity of the delimitation with regard to other States depends upon international law'.

[44]This concept is also called the principle of objective territoriality. This doctrine relies on unilateral actions to what are observed as conflicts of law issues. As made clear by the ECJ in

notion of comity among States and the ban on double standards, which imply the principle of reciprocity, often called the golden rule among nations. The reciprocity requirement makes national States' actions unlawful if identical actions in the hands of other States are opposed by that State. The EU cannot carry out results that receive its condemnation elsewhere.

The EU condemned U.S. extraterritorial provisions

The litmus test of the EU comprehension of illegal implementation of the 'effects doctrine' is the EU position concerning the 1996 Blocking Statute (No 2271/96) to the U.S. extraterritorial legislation over what has been called 'a most questionable example of USA's imperialistic behaviour in international jurisdictional conflicts'. Due to the zero double-standards principle, this position should also curb the EU's extraterritorial jurisdiction. Characterizing the U.S. extra-territorial position as statutes that 'violate international law', the international societies of States will request that the EU itself follow identical requirements under international law.

The EU envisages that four instances of extra-territorial application violate international law, all four or which originate in the U.S.[45] Thus the legal consequences of these provisions are claimed 'null and void' vis-à-vis EU subjects:

> No person referred to in Article 11 shall comply, whether directly or through a subsidiary or other intermediary person, actively or by deliberate omission, with any requirement or prohibition, including requests of foreign courts, based on or resulting, directly or indirectly, from the laws specified in the Annex or from actions based thereon or resulting there from (1996 The Blocking Statute Article 5 – italics added)

The non-compliance order also relates to U.S. justification or public decisions:

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the Ahlström-case 'the Community's jurisdiction to apply its competition rules to such conduct [abroad] is covered by the territoriality principle as universally recognized in public international law.' ECR (1988) p. 5193, at paragraph 18.

[45]See respectively National Defence Authorization Act for Fiscal Year 1993, Title XVII Cuban Democracy Act 1992, sections 1704 and 1706, Cuban Liberty and Democratic Solidarity Act of 1996 and Iran and Libya Sanctions Act of 1996. Code of Federal Regulations, Chapter V Part 515 - Cuban Assets Control Regulations, subpart B (Prohibitions), E (Licenses, Authorizations and Statements of Licensing Policy) and G (Penalties).

> No judgment of a court or tribunal and no decision of an administrative authority located outside the Community giving effect, directly or indirectly, to the laws specified in the Annex or to actions based thereon or resulting there from, shall be recognized or be enforceable in any manner (Article 4).

In all cases referred to in the Annex to the 1996 The Blocking Statute,[46] the EU subjects affected should engage in international trade or the movement of capital and related commercial activities between the Community and third countries. The persons affected according to EU's interpretation, are EU legal subjects defined as:

1. any natural person being a resident in the Community and a national of a Member State,
2. any legal person incorporated within the Community,
3. any natural or legal person of the Member States established outside the Community or shipping companies established outside the Community and controlled by nationals of a Member State, if their vessels are registered in that Member State in accordance with its legislation
4. any other natural person being a resident in the Community, unless that person is in the country of which he is a national,
5. any other natural person within the Community, including its territorial waters and air space and in any aircraft or on any vessel under the jurisdiction or control of a Member State, acting in a professional capacity (1996 regulation Article 11 and 1986 regulation Article 1 (2)).

As indicated, this listing includes natural and juridical persons. It covers persons that are residents, incorporated, or present within the EU. Being a resident in the EU means, being legally established in the EU for a period of at least six months within the 12 month period immediately prior to the date on which, under this Regulation, an obligation arises or a right is exercised.[47] According to the golden rule of international law, the EU cannot condemn an U.S. position and likewise follow identical practice vis-à-vis foreign legal subjects abroad.

[46] Council Regulation (EC) No 2271/96 of 22 November 1996, Official Journal L 309, 29/11/1996 p. 1 - 6.

[47] 1996 Regulation note 4.

The extraterritorial reach of the Liners Conferences provisions[48]

An issue of interest is whether the headquarters or founding place of Liners Conferences are relevant for the application of that provision. Should shipping services – irrespective of the State for incorporation of the Liners Conferences or the nationality of the ship – subsume under the EU shipping trade acquis? As regards the active subject – the offender – it should be stated that it is sufficient that his dominant position 'may affect trade between Member States'. It is sufficient that the position held have a possibility for the negative implications on the trade.

As with the Article 81 discussion, the effects are manifest within the EU, but there is no matching claim in relation to the location of the active part, the offender. Thus we experience also here unlimited competency jurisdiction ratione terrae, a discretionary power that the Council may use according to the 1986 Maritime Shipping Regulation Article 7.

Article 82 is triggered by the presence of a dominant position. Whether it is caused by, unfair purchase or selling prices or competition, production quotas, market limitations, market discrimination or other dominating draws, is of minor interest, as the list mentioned is only illustrative. The remaining question is to figure out whether agencies fully take advantage of the competencies.

The analysis of the specific Conferences[49] indicates, that the EU trade in shipping services provisions is designated to the Liners Conferences, without respect to the nationality of the conference members and irrespective of the location of the conferences' headquarters as long as internal effects are apparent in the EU shipping trade market. Conferences having its main office or place of incorporation outside the EU are included. So is also a foreign ship that operates under a Liners Conference, whether or not that ship is owned by non-EU citizens or flies a

[48]The Liners Conferences system is now threatened. A liberalization drive towards trade in services is under way. For consideration in the European Parliament is currently the Draft Directive on Services in general (September 12-17, 2005), See Financial Times, September 12th 2005 p. 15: Ian Byatt: 'Europe's Directive on Services must not be diluted'. Further liberalization provisions are advertised.

[49]The most important Conferences are the Trans-Atlantic Agreement (TAA) of 31 August 1992, Associated Central West Africa Lines (Cewal), Continent West Africa Conference (Cowac), United Kingdom West Africa Lines Joint Service (Ukwal) and Mediterranean West Africa Conference (Mewac).

foreign flag. In this respect the EU is in the same position as the heavily criticized position of the U.S. as indicated in the 1996 Blocking Statue.

Thus from this it is seen that the EU – under the Liners Conferences Regimes – fully practices the 'effects doctrine'. Charter parties negotiated and signed in Russia outside such conferences by Russian inhabitants taking Russian petroleum to destinations in EU, escape however these provisions, because no Liners Conferences apply to the Russian harbours that ship Arctic petroleum. Amending the TAA Liners Conferences so as to affect the northern and eastern part of Russia would however incorporate Russia oil and gas charter parties, and thus bring members of this trade under the auspices of the EU Treaty Articles 81 and 82, as implemented in 1986 Maritime Service Regulation.

Applying the EU legislation to such shipments requires a bilateral EU-Russia agreement justifying principles of the 1986 Regulation. A model here could be the European Economic Area Agreement (EEA) which requires the associated members of the Union – Iceland, Lichtenstein and Norway, to fully implement the EU inner market acquis. In this respect, the EU is close to the U.S. in its broad application of the 'effects doctrine'.

The 1986 Trade in Shipping Services Provisions

Leaving the area of Liners Conferences it is found that ships registered abroad are excluded from the freedom to provide services according to the 1986 Maritime Service Regulation Article 1 (2) if the owner is not a national of a Member State. For example, a ship incorporated in Russia is under the EU acquis as long as the ship-owner is a citizen of one of the EU Member States. This is not without modification; a shipping company incorporated outside the EU is still under the EU shipping acquis if it is controlled by nationals of a Member State even though these ships are not registered in the EU.

This being a starting point, the picture is not at all clear, taking case law into consideration. The 1988 Ahlström Case was related to concerted practices between undertakings established in non-member countries that affected selling prices to purchasers established in the Community.[50] The foreign sellers claimed that the Commission by imposing fines on them infringed the home countries' sovereignty and thus breached the principle of international comity.[51]

Even more extensive use of the EU competition acquis is illustrated by the Gencor Case. Here Gencor Ltd., a company incorporated under South African law, established in Johannesburg was, by its purchase of an English company, Lonrho Plc ('Lonrho'), thereby created an illegal dominant position (EC Regulation No 4064/89). The company applied for the annulment of Commission Decision 97/26/EC of 24 April 1996, declaring an amalgamation to be incompatible with the common market and the functioning of the EEA Agreement.[52]

It was stated that the Regulation No 4064/89,

. . . does not require, in order for a concentration to be regarded as having a Community dimension and, accordingly, for it to fall within the scope of that Regulation, that the undertakings in question must be established within the Community or that the production activities covered by the concentration must be carried out in Community territory.

The application of this regulation,

. . . is justified under public international law when it is foreseeable that a proposed concentration between undertakings established outside the Community will have an immediate and substantial effect within the Community.[53]

. . . as regards the consistency of that approach with public international law, the German Government states that both the conflict rule contained in the Regulation and its application in the present case fulfil the criteria arising from the 'effects doctrine', otherwise known as the principle of objective territoriality. The achievement by each of the two undertakings involved in the concentration of a turnover within the Community of at least ECU 250 million constitutes a sufficient connecting factor. Furthermore, the facts referred to by the Commission in its analysis of the impact of the concentration on the EEA confirm that the extraterritorial applic-

[50] A. Ahlström Osakeyhtiö and others v Commission, Judgment of the Court of 27 September 1988, Joined cases 89, 104, 114, 116, 117 and 125 to 129/85 [1988] ECR p. 5193.

[51] L.C. paragraph 8.

[52] The EU Commission Case No IV/M.619 - Gencor/Lonrho, OJ 1997 L 11, p. 30.

[53] Case T-102/96 Gencor Ltd v EU Commission [1999] paragraph 2-3.

ation of the Regulation is consistent with international law.[54]

Thus the 'effects doctrine' is no remote wish but a firm characteristic indicating the EU legal position.[55] The EU Commission Competition Directorate draws similar conclusions during the latest years. Here it is sufficient to mention the merger between foreign companies such as Boeing/McDonald Douglas,[56] Exxon/Mobile,[57] General Electrics/Honeywell[58] and AT&T.[59] The EU jurisdiction to the amalgamation were in all cases acknowledged by the involved companies.

2.2 Rules and Regulations to be Followed on Different Parts of the NSR

2.2.1 Operational Regulations

As detailed in ArcOp Deliverable 2.2.1 "Report on current regulations and practices and impact of IMO Guidelines" the following Russian statutory documents regulates the traffic on the Northern Sea Route (NSR):

- “Guide for Navigation through the Northern Sea Route”
- “Regulations for Navigation on the Seaways of the Northern Sea Route”
- “Regulations for Icebreaker-Assisted Pilotage of Vessels on the NSR”
- “Requirements for Design, Equipment and Supply of Vessels Navigating the NSR”

For Arctic ice-covered waters it is further essential to consider the International Maritime Organisation's (IMO) publication:

[54]Op.cit. paragraph 74.

[55]The Court of First Instance (CFI) in the 1999 Gencor Case T-102/96, [1999] ECR 753 paragraph 74 confirms this. However as Richard Whish, Competition Law (4th ed. 2000) at p. 399-400 states we still fail to find any ECJ explicit confirmation of the 'effects doctrine' as such.

[56]1997.

[57]1999.

[58]2001.

[59]Financial Times September 29 2004. The legal issue that was decided against the Commission was of a procedural character, blocking the commission from taking a stand if the merger is reversed, which was here the case.

- “Guidelines for Ships Operating in Arctic Ice-Covered Waters”

The “Guide for Navigation through the Northern Sea Route” is a comprehensive document, embracing both sea area descriptions, practice for ice navigation and requirements for design, equipment and outfitting of vessels navigating the NSR. The guide is founded on the long experience gained by the Russian Polar seafarers, and has been proven since it was published in 1995.

The IMO publication “Guidelines for Ships Operating in Arctic Ice-Covered Waters” was adopted in 2002, and harmonizes national requirements relating to the standards of the navigational and communication facilities, hull structure, equipment, and manning of vessels operating in ice. The IMO guidelines are compatible with the Northern Sea Route Administration requirements, as shown in ArcOp Deliverable 2.2.1.

2.2.2 Ice Class Rules

Operational regulations for navigating in ice-covered sea areas are complemented by ice class rules. These fundamentally provide a safe level of protection for ships in ice covered seas. Ice class rules principally cover the strengthening of hull structure between waterlines (called the icebelt) to resist the force imparted by the ice, strengthening of propeller and shaft to account for forces resulting from ice piece impacts and increased rudder strength for high loads when backing in ice.

Today many Classification Societies have their own ice class rules. In addition to these, there are a number of rules and requirements from the National Authorities, such as those of the Northern Sea Route Administration, the Finnish and Swedish Maritime Administrations, and those of the Canadian Coast Guard. These National Administration requirements may be overlapping or be integrated/referenced within those of the Classification Societies ice class rules.

There are two main groups for ice class rules:

1. Requirements for navigation in first-year ice.

2. Requirements for navigation in multi-year ice.

The Finnish-Swedish Ice Class Rules (FSICR) has been established as the de-facto rules for first-year ice. They having been developed over many years and also have a proven service experience. The FSICR have been developed with regard to the icebreaker assistance available in the Baltic and the need for continuity of trade during winter.

The International Association of Classification Societies (IACS) has over the past ten years managed a continued effort to develop a set of harmonized rules. These rules are mainly applicable to navigation in multi-year ice. The introduction of the IACS Polar Ship rules will be a significant step in the rule harmonization process, and with a continued effort a comprehensive set of compatible rules and regulations may be developed and improved to provide additional transparency. The IACS Polar Ship rules have been developed in parallel and compliment the IMO's "Guidelines for Ships Operating in Arctic Ice Covered Waters". The IACS Polar Ship Rules will be adopted by all IACS member Classification Societies.

For the Russian Arctic it is essential to consider the Russian Maritime Register of Shipping (RMRS) ice class rules, which are currently stipulated in the "Guide for Navigation through the Northern Sea Route". These rules have a long service experience for ships operating in the Russian Arctic.

In most instances the National Administrations currently determine the equivalency between ice class rules of different Classification Societies. However, the equivalency is difficult to determine, due to variations in ship arrangements, construction, operation, etc. Nevertheless, a method commonly used is the relationship of the principal scantlings. This method was investigated in ArcOp Deliverable 2.2.2 for three ships, a small, medium and large tanker, which could feasibly operate in the Varanday region. Since the NSR regulations are currently given for RMRS ice class, the impact of the introduction of the IACS Polar Ship rules was reviewed by comparing the likely change in existing ship's design when applying RMRS ice class rules and IACS Polar Ship rules. The study is based around the ice classes suitable for this region and the principal hull structure requirements for both rule sets.

The results from the hull structure study suggest that the IACS and RMRS rules both provide a measure of safety, however there is some differentiation in the requirements, see example Table 1 illustrating the midship icebelt shell structure weight, in tonnes, as given by ArcOp Deliverable 2.2.2. It should be noted that the differences shown in Table 1 may vary with the design of the hull form and hull structure. The selection of the ice class needs therefore to be considered jointly with the operational scenario of the vessel.

Midship icebelt steel weight, in tonnes (Source: ArcOp Deliverable 2.2.2)

	IACS				**RMRS**		
Vessel	**PC3**	**PC4**	**PC5**	**PC6**	**LU6**	**LU5**	**LU4**
Small	144	122	93	78	118	91	64
Medium	1237	1043	806	622	1134	862	657
Large	1494	1295	991	756	1460	1162	821

2.2.3 Operational Aspects

A further consideration in the selection of ice class, in addition to the ice class variables, i.e. the design based on ice thickness, is that the RMRS also currently provides tables equating regions in the Russian Arctic to the ice class. These tables give an indication of the allowable seasons that navigation to the different parts of the NSR maybe possible with a certain ice class, and whether the navigation, depending on the ship's ice class, can be independent or need to be supported by an icebreaker.

An important factor to consider in the choice of ice class is the hull design and the engine power which will determine the ship's capability to break ice. The FSICR engine power requirement is based on icebreaker assistance, and as such operating in a channel made by the icebreaker. The ship will therefore not require icebreaking capability, and may benefit from a reduced power requirement because of this. However, operation in the Russian Arctic may necessitate the capability to break ice and an increased engine power to provide sufficient force. Moreover, the vessel speed is an important factor. Since vessel speed may be a requirement by the owner and may increase in a channel, this could lead to increasing ice impact force. Currently the IACS Polar Class rules have no requirements for the engine power, which necessitate thoughtfulness in the design of the vessel. The engine power and ship design will also reflect in the ships ability to manoeuvre and within ice this also relates to the ability to follow leads.

Today the practise is that the vessels may have in addition to the ice class a document called "Ice Certificate" (or Ice Passport). This document is prepared by a competent organisation and it gives the safe limits for the vessel's operation. These limits are defined by the capability of the vessel to move in different ice conditions and by capability of the hull structure to withstand the ice loads at different speeds in different ice conditions.

2.2.4 Future Developments of the Rules

In the future the "Guide for Navigation through the Northern Sea Route" will still remain in force. However, the introduction of the IACS Polar Ship Rules will necessitate that the guide is renewed in the near future to include references to the PC classes. The renewed guide will also contain requirements for ship's propulsion power which may be fulfilled by the relevant Classification Society formula (e.g. RMRS), by verified service experience, or by the formula to be presented in the guide.

The IACS Polar Class rules will be implemented into all IACS member Classification Societies, including the RMRS rules, as soon as they come into force. In addition to this, RMRS and other Classification Societies may also contain requirements for the propulsion power, defined either by equations presented in the rules or through ice model testing.

2.2.5 Recommendations

Many challenges are present for vessels to survive in the harsh environment of the Russian Arctic. However by selecting an appropriate ice class and compliance with National Administrative regulations these will ensure safe navigation in this region. The intended operation of vessel, icebreaker assistance and operational scenario should always be used to gain the appropriate ice class and application of the suitable regulations, to enable the marine transportation to operate efficiently and safely.

At present vessels navigating in the NSR, must be ice strengthened to the NSR Administration's satisfaction, and for now it is recommended to consult with the NSR Administration for establishing the limitations in navigation. For individual vessels of classification outside the RMRS ice class rules, a certificate can be obtained to describe the ship's ice suitability.

The development of the Arctic region is already incipient and several ship projects are currently planned. Also for these ships it is recommended to consult with the NSR Administration to find an ice strengthening that is suitable for the intended operation. It should be noted that these ships can already be designed according to the harmonized IACS Polar Ship rules, and that they can receive a statement of compliance, in order to smoothen the transition, when the IACS Polar Ship Rules are later implemented.

For harmonization principles it is the aim of the IACS Polar Ship rules to replace the current rules for navigation in multi year ice. Developing equivalence tables between various different rules and the coming IACS Polar Ship rules could cause an undesirable lengthening of the harmonization process. However to some extent it may be necessary to compare the old ice classes to the new harmonized ice classes, in order to assign a new harmonized ice class to ships already in service or coming into service prior to the completion of the IACS Polar Ship rules. One example of such a comparison is shown in Annex 1.

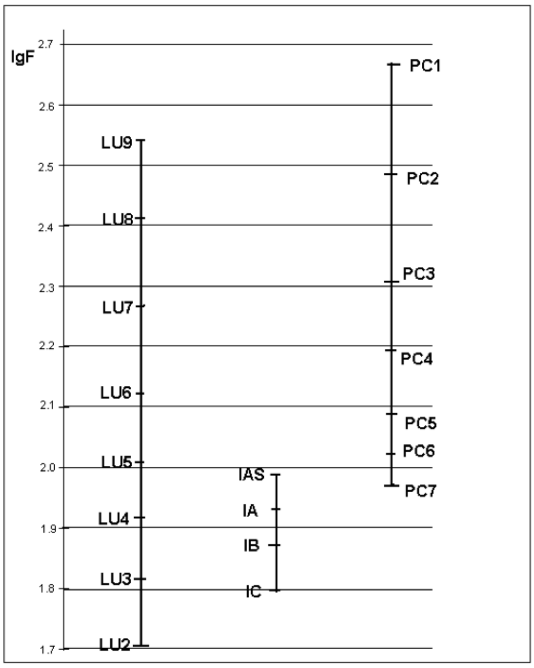
The goal for the future should be to finalize the IACS Polar Class rules. Currently this is awaiting the completion of the machinery requirements, which partly depends on the Finnish/Swedish Administrations, and their contribution. It is expected that these will be completed within 1-2 years.

In the long run it is in the European shipping's interest to have as few national / regional enforced restrictions as possible, and consequently strong influence should be used to implement international rules to all Arctic and Antarctic areas. This will minimise the cost of obtaining and maintaining an ice class, and maximise the flexibility for operation in the Polar Regions and calling into ports in any region with a minimum of bureaucracy.

2.2.6 Annex 1: Ice Classes Based on Structural Strength and Weight of Side Structures

Source: Russian Maritime Register of Shipping (RMRS)
Designations:

- LU2 to LU9 denote ice classes in accordance with the RMRS ice class rules
- 1C to 1AS denote the ice classes in accordance with the Finnish-Swedish ice classes
- PC1 to PC7 denote the ice classes in accordance with the draft IACS Polar Ship Rules 2004
- F is an area consisting of a cross-section of transverse framing and shell plating within one span. Note, this is considered a generalized characteristic of ice belt strength.



Example of relative ice classes (Source: RMRS)

2.3 Immigration and Custom Procedures on the Way In and Out of Russian Territory

The European Union constantly improves its normative-legal base including customs procedures (affairs). According to the available information, the basic priorities of EU policy in the field of development of customs procedures are:

- to change a role of customs bodies (authorities) in collecting customs duties;
- to increase the responsibility of customs bodies in regard to regulation of foreign trade;
- to accelerate the introduction of electronic data processing with a view to simplify and speed up the passage of commodity flow across customs borders;
- to support participants of foreign trade activities on the part of customs bodies with a view to provide their fair competition at the world market;
- to intensify struggle against swindle and to prevent participation of organized crime in any customs activities.

In general, basic directions of development of customs procedures which can be taken as a pattern for development of domestic Russian counterparts are set out in a specially developed purpose-oriented program of EU the main task of which consists in increasing effectiveness of functioning of the home market, and in creating uniform conditions in all territory of the European communities.

2.3.1 Working programs of development and integration EU Experience

"Program - 2000".
The most important part in development of normative and legislative base of integration process of EU customs procedures plays the adoption and further evolution of "Program-2000" jointly developed and adopted by the European Parliament and by the Council of Europe (Resolution 210/97/EU of December, 19, 1996).

The high priority measures determined by this program include:

- Providing uniform application of the EU legislation (communitarian legislation);
- Developing general approach to the protection of interests of the European Community citizens and the participants in foreign trade activities operating within its territory;
- Preventing wrongful acts, swindle and illegal commodity turnover;
- Increasing effectiveness of national customs bodies operations; development of cooperation between customs bodies of Statesmembers of EU, and also between national customs bodies and the Commission of the European Union.

Originally the program was intended for a period of 5 years (since January 1996 till December 2000). However in 2000 the legal operation of the program was prolonged till December, 31, 2002 (Resolution 105/2000/EC). Computerization of the transit system on the territory of the European community was determined as an additional priority.

"Program - 2007".
In 2002 the then current out-of-date programs urgently required fundamental improvements. "Program - 2007" is a result of such improvements (Resolution 253/2003/EC). The program is intended for a period since January 1, 2003 to December 31, 2007. Its primary goal is to speed up computerization of customs bodies and to rationalize their operations.

"Program - 2007" takes into account the expansion of EU due to the East Europe and Baltic States, emphasize the necessity to provide a set of practical measures by means of which new members of the Union could undertake obligations following from communitarian law of the Community.

The program emphasizes the necessity of strengthening cooperation in struggle against swindle and in actions directed on reduction in expenditure of the companies engaged in foreign-economic activity.

With a view to accelerating an integration process in the field of customs law "Program - 2007" provides coordinating actions in realization of the primary goals of Community's home market and increasing interaction of customs bodies to such an extent that it would be possible to achieve identical results in all territory of the European Union.

The program links a necessity of further development of customs law with a role of EU in the world economy. In connection with process of globalization it is necessary, in particular, to provide high competitiveness of the goods produced in the territory of the Union, and also to provide protection of financial interests of the Community.

Further details of the basic priorities are shown in item 4 of Resolution 253/2003/EC. Some of them are as follows:

- cutting down expenses connected with the duties provided for by the communitarian customs legislation and performed by the participants of external economic activities.
- Improving the system of standardization and simplification of customs operations and procedures;
- improving coordination and cooperation between the laboratories which are carrying out tests for the customs purposes; the result of the improvement is to be a uniform tariff classification to be used in the territory of all European Union;
- supporting creation and putting into operation of an electronic system for carrying out operations related to customs clearance of cargoes;
- rendering support to new EU members in formalization of their legislation in conformity with the communitarian norms of legislation;
- rendering support to the third States in modernization of their customs services and procedures on the basis of the European experience;
- developing a system of training courses which meet the requirements of the provisions of the present program.

As is obvious from the foregoing, EU pays great attention to simplification of the system of moving goods across external borders, including cutting expenses of the participants of external economic activity. No doubt that the above measures promote an increase of turnover in export and import sectors of production, which finally should increase economic competitiveness of the European Union.

Neapolitan convention.
The Neapolitan convention developed in 1997 plays an important role in regulation of methods of interaction of customs bodies. The convention is directed to improve mechanisms of cooperation of customs bodies in revealing and preventing infringements of the customs legislation, and also in prosecuting and punishing similar infringements at a national and commonwealth level.

Provisions of the Convention do not contradict and do not replace the provisions of the communitarian legislation applicable to cooperation of judicial bodies in criminal-legal sphere, as well as any other provisions of the communitarian law creating more favorable conditions for cooperation in the above mentioned area.

According to the Convention, the States-members of EU should create a coordinating center which would collect all necessary information, and would take applications for rendering multilateral (or bilateral) aid within the framework of the Convention provisions.

In his application the applicant is obliged to specify all necessary information concerning inquiry: applicant's personal file and his power, requested restraint, motivation of the requested restraint, involved standards of law and a brief list of the facts concerning the given case.

As a rule, cooperation between customs administrations is carried out with a view to investigation, prevention or liquidation of illicit turnover of such goods as drugs, explosive and toxic substances, nuclear materials and materials which can be used for manufacture nuclear, biological or chemical weapons, and also the goods representing a special cultural value.

Besides the above-mentioned the interaction of customs administrations is directed to prevent illicit traffic of taxable goods, which lawbreakers try to transport without payment of any taxes thus rendering a substantial damage to national budgets and to the budget of EU.

The Court of EU is assigned to control the observance of the Convention provisions. The Court is authorized to resolve disputes between separate States-members of the Union, and between these States and the Commission of EU in regard to interpretation or application of the Convention provisions.

2.3.2 EU experience in overcoming difficulties of transitional period

Expansion of EU in May, 2004 when the East Europe and Baltic States joined EU, made these States, on the one hand, to formalize their legislation in conformity with the standards of the European law, and, on the other hand, resulted in increase of duties assigned to the customs bodies of the European Union.

To make the process of integration more successful, provision is made for a transition period after which the standards of communitarian customs legislation begin to be applied uniformly in the territory of all new members of the Commonwealth.

Since May of the last year the customs bodies of the States joined EU have started to work in the customs regime of the Union. State borders of new members of EU automatically have become the borders of the European Community, and the principle of duty-free transportation of goods has started to operate in their territory.

The provisions of EU constituent treaties and all statutory acts developed by the Commonwealth on the basis of these treaties (for example, the Customs code of EU) shall be applied to the new members of EU. From the same date the normative-legal acts of EU (including constituent treaties) shall be applied with allowance for the provisions provided by the Agreements of accession. So, the amendments shall be introduced to item 205 (2) of the Treaty on the European Community (the item assigns a "weight" to voices in the Council of EU by qualified majority of voices during decision-making procedure.

The Agreement of accession provides a number of transitive measures aimed at promotion of goods turnover between old and new States-members, and also between the new States-members and the third States. Since it is impossible to predict obstacles which can potentially arise during transitional period, the Agreement of accession contains a set of provisions allowing one to make exceptions to the standards of the European legislation for a terminable period (items 37-42 of the Agreement of accession).

From the moment of joining EU all protective measures effective on the territory of the European Union in regard to the third States are to be applied to new States-members (for example, antidumping measures),. At the same time one shall stop to carry out measures of a similar character used by the new States-members in regard to the third States before the new States accede to EU.

Protocol 4, section 5 of the Agreement of accession contains a list of transitive measures in the area of the law of customs which shall come into operation from the moment of entry of the given State to EU. Among them the most important are the following measures (principles):

- In the interests of increasing commodity turnover of transactions the fulfillment of which began before a State joined EU and will come to an end after the joining of the State, are regulated by former standards of the national law;
- A number of transactions having relation to a period prior to joining EU (for example, re-import) and completed after the State joins EU, are similarly regulated by the former legislation of the corresponding State.

It is necessary to pay attention to the fact that the provisions of the Protocol provide for application of the above principles exclusively to particular customs procedures or regimes. In all other cases the communitarian legislation shall be applied to the goods.

Special attention shall be paid to control practical application of a principle of duty-free movement of goods within the territory of EU (having already enlarged number of members) with regard to the production which was released in the duty-free turnover within new State-members after joining the Union.

2.3.3 Influence of EU integration process on the development of Russia

In connection with the increase in number of members of the Community there were a number of difficulties caused by crusted economic and political relations between new members of EU and the third States which used a preferential status as to their production.

Under conditions of consolidation of strategic interests of most industrially developed countries of Europe the third countries faced the necessity of changing the terms of trade with the States entered EU. Our country was most touchy upon this circumstance especially taking into account historically developed close trade and economic relations with the East Europe and Baltic States. The reduction of trade turnover and ousting Russian goods from the markets of Central and East Europe are predicted to take place.

The Russian party in the course of negotiations indicated a number of the most important problems the solution of which would allow the party to avoid those potential economic losses which could be caused by joining of the former Soviet and current Russian economic partners to the European Union.

Among the above problems one should mention the extension of the Agreement on partnership and cooperation between EU and the Russian Federation to all countries entering the Union, settlement of the problem of transit of cargoes to the Kaliningrad area, and achievement of an agreement on restriction of subsidizing the agriculture of the joined States.

The Agreement on partnership and cooperation (APC) concluded in June, 1994 and put in force on December, 1 1997 provides for the Most Favored Nation Treatment, similar conditions for the similar goods of the parties, freedom of transit and remission of import duties for temporarily imported goods. At the same time the APC stipulates for an opportunity of taking protective measures the validity of which Russia can contest only after joining the WTO as a full member.

Automatic extension of APC to the new EU-jointed States means an application of the Most Favored Nation Treatment in trade with regard to Russia. It concerns both tariff policy and procedural questions, with all members of the European Community being obliged to observe the favorable treatment.

As to the nomenclature of the export-import goods experts predict an increase in export to Russia of agricultural production from the new States-members of EU since a number of enterprises cannot sell their production in the territory of the Union because of nonconformance of their goods to the current European standards.

Since May, 2004 the EU-jointed States of the East Europe and Baltic are obliged to carry out all antidumping procedures directed against Russian interests in this community. The application of protective measures by EU means that the Russian suppliers will lose about 250 million euro per year, it is expected, that in the future due to extension of EU this sum will increase.

Summing up, one can make the following conclusion. Intensive development of the European integration dictates the necessity of modernization of legal base, including customs legislation. At the same time special attention should be given to parity increase in competitiveness of the European Union as economic association on the one hand, and of Russia on the other hand; the above increase will be produced by simplification (on the part of both EU and Russia) of the formal procedures connected to export and import.

2.3.4 Experience of interaction between customs services of EU and Russia

A meeting of the first vice-president of the State Customs Committee of Russia Leonid Lozbenko with Folker Undorf, Chairman of the Board of the European Business Club (EBC), took place in January of the last year. The questions of application of the new Customs code of the Russian Federation were discussed at the meeting.

Leonid Lozbenko informed the participants on essential simplification of formalities relating to foreign trade activities in Russia in connection with changes made in the customs legislation and reduction of customs supervision on the territory of Russia. He emphasized, that the «intervention of customs authorities in the foreign trade process should be minimized and based on the logic of mutual interest of the State and participants of the foreign economic activities. This is important for Europeans because after 10 States joined the European Union on May, 1, 2004 more than 50 percent of commodity turnover of the Russian Federation will fall on the enlarged European Union.

In this connection Leonid Lozbenko pointed out that the program of development of interaction of customs services of the European Union (EU) and Russia had been developed and was now being carried out. In May basic work on transition of the Russian customs service to a form of the Uniform administrative document of EU was completed for the purpose of using this form as cargo customs declaration, and adapting the Russian system of customs transit to requirements of the General transit procedure of the European Union.

EBC initiatives and projects in Russia were submitted at the meeting and the ways of development of interaction of the State Customs Committee of Russia with the EBC Committee for transport and customs were discussed. EBC representatives pointed out that the European business community had grounds for optimism about the new Customs code of Russia, and noted some positive prospects of functioning of "hot line" used for cooperation of the Russian customs service with business.

An example of such fruitful and mutually advantageous cooperation was a program in compliance with which the European Union invested about 16 million euro in improvement of the infrastructure and equipment of customs check points of the Northwest of Russia.

Of this sum about 8 million euro was allocated to modernize the infrastructure of the check point "Chernyshevskoye" on the border between the Kaliningrad area and Lithuania, about 6 million euro was intended for the point "Suoperya" on the border between Finland and Russia and 2 million euro - for the point "Brusnichnoye", also on the Finland border.

The works under the project at the check points should come to an end by the middle of 2005. There was a positive experience in this relation: in 2002 within the framework of the program of the European Community on modernization of customs check points the check points "Svetlogorsk" (Leningrad oblast) and "Sala" (Murmansk oblast) in the Northwest of Russia were provided with relevant equipment.

2.3.5 Strategy and basic directions of development of cooperation between the State customs committee of the Russian Federation and the Commission of the European Communities

The main legal base of development strategy of cooperation between the State Customs Committee of the Russian Federation (the State Customs Committee of Russia) and the Commission of the European Communities (CEC) in the customs area is the Agreement on Partnership and Cooperation between the Russian Federation and the European Communities of 1994 (APC) and Protocol 2 to it "On mutual administrative assistance for the purpose of adequate application of the customs legislation".

The strategy takes into account the provisions of working documents on implementation of the Joint working program of APC in relation to customs and trans-boundary cooperation, and also the decisions and recommendations adopted by the Committee for RF – EU cooperation and Subcommittee for customs and trans-boundary cooperation.

The development strategy of relations between the Russian Federation and European Union in the intermediate-term outlook (2000-2010) the basic provisions of which were set out in the Decree of the State Customs Committee of the Russian Federation # 01-99/586 of May, 15 2000, corresponds to the general direction of strategic partnership between Russia and the European Community.

Initial preconditions of development of relations between Russia and the European Union in the customs area are to create favorable conditions for mutually beneficial trade between Russia and its European partners and to ensure protection of society from illicit conveyance of goods across the border.

Influence of customs tariff policy of Russia on development of trade and economic processes in the all-European space is recognized by the European communities. This factor, in particular, determines an objective interest of the European Community in customs cooperation with Russia.

At the beginning of its work the State Customs Committee of Russia aimed at creating a multipurpose, competitive, effectively controlled customs service comparable to the most modern models of customs houses of the world.

The concept of the customs legislation harmonized with the legislation of the European Community was taken as a basis for changing customs procedures. Such approach during transition of Russia to overt market economy ensured an introduction into customs practice of concepts and rules accepted in the world customs environment, and contributed to an interest of the Commission of the European communities in giving practical assistance to the Russian customs service in the field of modernization.

The further development of customs service of Russia under conditions of changes occurring in the world community, that is, useful increase in volumes of goods moved across borders owing to the process of trade globalization, implementation of mass computer information technologies, alongside with increase of the role of customs as a tool regulating trade and economic relations – all demand new approaches to customs affairs (procedures).

The current work is directed, first of all, to modification of the existing customs legislation on the basis of a new concept of the project of the Customs code of the Russian Federation which takes into account the provisions of the International Convention on the Simplification and Harmonization of Customs Procedures, approved by the World Customs Organization in a revised edition of 2004.

Planned accession of Russia to this basic international customs convention predetermines the necessity for the Russian customs service to resolve complex technological problems, which can be promoted in long-term outlook by experience and assistance of the European Union.

In the long-term outlook the Development strategy of cooperation between the State Customs Committee of Russia and CEC in the customs area is being built on this base.

In the intermediate-term outlook the basic purposes of the international customs cooperation as far as CEC is concerned, are determined by strategic directions of developments of the Russian customs service as follows:

- Simplification and acceleration of customs procedures;

- Maximum use of modern information technologies and automated control systems;
- Detection (Revealing) and suppression of economic crimes and customs offences, with the control over domestic trade in imported articles being included;
- Strengthening of struggle against corruption;
- Development of institution of customs brokers;
- Development of partner relations between customs bodies and business circles;
- Implementation of the program of modernization of customs bodies;

The development strategy of the Russian customs is directed to:

- Intensification of interaction between customs service of Russia, the Commission of the European Communities and customs services of the States-members of the EU participating in implementation of programs and projects of customs cooperation;
- Exchange of professional experience, familiarization with methods of work, basic customs rules and technologies, establishment of working contacts;
- Achievement of information openness and predictability of operating mode (conditions) of the Russian customs houses.

Such cooperation should be focused on those areas of customs affairs (procedures) which require further perfection of methods of work, in particular by implementation of new customs procedures, application of risks management technology including estimation of risks and selective control over analysis of preliminarily received information in an electronic format.

The Strategy is aimed at active participation of all parts of the Russian customs service in the international cooperation. Practical use of programs and projects preliminarily coordinated between the State Customs Committee of Russia and CEC, is provided by departments of the State Customs Committee of Russia, regional customs administrations (departments), and local customs bodies (offices), with the general coordination of work on planning and implementation of such programs and projects carried out by the Agency of the International Customs Cooperation.

Participation of the State Customs Committee of Russia and the Russian customs bodies in actions and programs within the framework of regional customs cooperation of the Council of the Baltic States (CBS) (SGBM), Council of Barents/Euro-Arctic region (CBER) (SBER), Operative committee SGBM, groups TaskForm SBER can promote attraction of additional financial assets of the European Community with a view of developing the Russian customs service.

Priority directions of customs cooperation between the State Customs Committee of Russia and CEC are as follows:

- Improving the Russian customs legislation with allowance for the new Customs code of the Russian Federation and the process of accession of the Russian Federation to the International Convention on the Simplification and Harmonization of Customs Procedures (Kyoto Convention), 1999;
- Strengthening interaction between competent authorities of CEC and customs services of the States-members of EU in struggle against economic crimes and customs offences;
- Exchanging information on the goods moved for the purposes of customs supervision and improving the system of monitoring customs cost of the goods;
- Implementing control based on the methods of audit of participants in foreign economic relations, developing a network of customs laboratories;
- Analyzing data of foreign trade customs statistics;
- Expanding administrative and technical assistance in lawenforcement activity of customs bodies (struggle against illicit traffic of drugs, weapon, nuclear materials, other dangerous cargoes and high-risk goods, protection of the rights of intellectual property, struggle against laundering of incomes gained by illegal way);
- Speeding-up customs registration and improvement of customs supervision (creation of the centers of customs clearance, preliminary electronic declaring of goods, development of objects of nearcustoms infrastructure, in particular, institute of customs brokers, strengthening of interaction with participants of foreign economic relations, development of technologies of risks management including estimation of risks and selective control, supply with information of persons concerned with respect to customs rules and pro-

cedures);
- Studying new forms of information technologies of customs clearance using databases of participants of foreign economic relations (including technologies of electronic commerce);
- Developing a system of training and improvement of professional skill of the customs staff;
- Expanding trans-boundary cooperation in the Northwest region, including the border with the Baltic States and in the Kaliningrad area, including implementation of investment projects with a view of developing customs infrastructure on boundary check points;
- Strengthening partner relations at the level of local customs bodies within the framework of the program "winning" and strengthening interaction between various services and departments which carry out border control functions, including joint control.

2.3.6 Investment plan

In the light of both the above-stated analysis of last experience and programs of development of customs affairs (procedures and techniques) in EU and previous cooperation of EU and Russia in the field of implementation of concrete projects, and also taking into account strategic interests of Russia in development of trade with EU and other interested parties with reference to a complex of problems connected with the use of the Northern Sea Route for commercial purposes, it is necessary to emphasize the following actual subjects to be dealt with by implementation of target investment programs:

- Counseling assistance of EU experts in the field of customs legislation; Exchange of practical experience between managers of structural units of customs services of EU and Russia;
- Improvement of the system of control over customs valuation;
- Cooperation in development of local customs laboratories;
- Cooperation in development of objects of customs infrastructure;
- Cooperation in creation of a joint information base for the purpose of efficient struggle against economic violations of the law;

Cooperation in the formation of a joint data base for efficient analytical investigation of practical application of current standards and rules used in trans-border transportation.

The amount of financing as well as detailed structure of programs which can be realized in relation to the above subjects shall be preliminarily traded off with the representatives of all parties concerned.

2.4 Liabilities and Insurance Coverage

The principal purpose of ARCOP Sub-Project WP 2.4 during the three-year period 2002-2005 has been to provide an assessment on the availability of adequate and appropriate risk coverage for vessels, especially those carrying potential pollutants and hazardous and noxious substances, navigating the Northern Sea Route and Russian Barents Sea. It is obvious that with-out adequate and appropriate risk coverage such navigation would not be economically or environmentally viable. This report summarizes the ARCOP Sub-Project WP 2.4 findings based on the research work carried out during this period. In addition, the Report also provides an assessment of the marine insurance industry's interest in developing a sustained system of coverage for this type of risk

The starting point for this work were based on some of the questions raised by this aspect of Northern Sea Route navigation that were initially discussed under the International Northern Sea Route Programme (INSROP) during a six-year period, 1993-1998.[60] At that stage it was determined that whilst limited Arctic commercial navigation had been taking place for many years in Russian and, to a lesser extent, Canadian Arctic waters, this trade had not resulted in the establishment of clearly discernable marine insurance market patterns, especially in international marine insurance markets. This was due to the fact that existing shipping services had either been very specialized or very limited. Furthermore, until recent times, the more vigorous Russian Arctic shipping sector had its marine insurance coverage underwritten by a variety of state-sponsored schemes that did not permit or

[60]See: Edgar Gold, John Cantello, and Peter Wright, Shipping and Marine Insurance on the Northern Sea Route: Conclusions 1993-1998 (Oslo: INSROP Working Paper No. 124, 1999)

were not designed to establish clear actuarial records of the various marine risks involved. In other words, the principal international marine insurance markets did not have access to the information for Arctic waters navigation that is normally required before the various marine risks may be covered. This also meant that risk coverage for existing and planned Arctic waters and Russian Barents Sea navigation, would have to be underwritten on a case-by-case basis. This was a very expensive proposition and resulted, in certain instances, in shipowners or charterers covering a large percentage of the risk themselves.

2.4.1 General Features of the Russian Marine Risk Insurance Market

The Russian marine risk insurance market is currently in a formative stage due to a number of specific aspects in the history of the development of Russian insurance. In the former USSR there was no necessity for the development of an advanced insurance system, despite the fact that the USSR was one of the leading shipping countries in the world. A state-owned company was faced with very limited material liability in case of an accident. The value of lost assets was excluded from the balance of the company and its charter capital was simply reduced by the amount lost. In other words, the company would pay only for necessary repairs and there was little need to insure its ships. However, the reconstruction of the Soviet economy after 1990 not only resulted in the increased demand for insurance due to changed relations between companies and the state, but also initiated the availability of a competitive insurance sector resulting from the establishment of a decentralized insurance market.

Before the collapse of the Soviet Union the marine insurance of national operators was basically performed by the Ingosstrakh (Foreign State Insurance) company. The currency share of the insurance portfolio was traditionally reinsured with Lloyd's syndicates and with European companies in England, Switzerland, Germany, France, Sweden and Italy.

The collapse of the USSR and formation of independent states resulted in the division of the previously substantial common national shipping fleet into relatively small shipping companies. According to the regulation of joint-stock companies, the owners of each shipping company have to take responsibility for maintenance, operational conditions, fleet renewal, and insurance. This responsibility was initially undertaken with some state support from the state, which has now been discontinued. Unlike hull and machinery insurance of ships, which is not compulsory, shipowners who operate vessels internationally in the commercial cargo or passenger trade, or for scientific research must also insure any liabilities that arise from such operations.

Since Russia has evolved in to market economy state, a number of large, medium-size and small insurance companies, offering insurance of marine risks, have emerged. As a result, with the abolition of the state insurance market, Russian ship owners now have the ability to choose between the former state monopoly insurer Ingosstrakh and these newly established marine insurance companies. However, due to a lack of confidence in the financial viability of Russian insurance companies, many Russian shipowners have attempted to enter their liability risks directly with foreign liability insurers and mutual protection and indemnity clubs. This practice conflicts with the existing Russian insurance legislation, which obliges shipowners to insure their liability risks (as well as hull and machinery risks) in Russian insurance companies.

The Russian marine insurance market also faced a problem caused by unfair competition amongst Russian insurance companies. In order to obtain the largest most well-funded clients, some insurers offered substantial 'privileges', such as, reduced premium, rates, low franchise levels, and even the partial repayment of insurance premiums. However if a company obtains clients under such terms, it inevitably faced difficulties when reinsuring such risks, as the reinsurer will demand changing the original insurance terms regarding very low premium rates. In such cases, the insurance company will be forced to carry the whole risk itself. This is a very difficult problem as it is unlikely that any Russian insurance company would be capable of satisfying a major claim without reliable reinsurance protection. This will either result in bankruptcy of the insurance company or result in unnecessary prolonged legal proceedings in the hope that inflation will reduce the real loss.

In addition to the financial problems faced by the Russian marine insurance market, there are also some technical and organizational difficulties. The first is the absence of any complete or reliable data and statistics on marine cases handled by Russian insurance companies. Without this type of information any analysis of the current market and trends of its development for the future is virtually possible. Furthermore, there is no institution in Russia, comparable to the Institute of London Underwriters that could combine and unify Russian marine insurers, their practices, tariffs, marine insurance provisions and development. Such a body is needed in order to ensure that Russian marine insurers could provide acceptable hull and machinery and liability coverage for shipowners.

The final problem is that the majority of Russian insurance companies, engaged in marine insurance, neither possesses sufficient experience, nor professionally trained specialists. This is, of course, due the fact that the Russian insurance market is relatively new, as well as the lack of educational institutions offering adequate insurance training and knowledge.

In summary, it can be concluded that the development of the Russian marine insurance market for Russian shipping:

- is now at the stage of early development;
- it is faced with a number of serious problems, that can be solved by various measures that must be taken at the state level, as well as by the marine insurance industry itself.

2.4.2 The Existing Regulatory Legal Base

For insurance of marine risks during transportation of oil cargo along the NSR, with use of nuclear icebreakers and tankers, the following documents form the legal regulatory base of the Russian Federation:

- RF Civil Code, Chapter 48. Insurance.
- The Law of RF On Organizing of Insurance Procedures in RF as of November 27, 1992, No. 4015-1.
- The Code of Merchant Shipping of RF as of 30.04.1999, No. 81-F.L., Chapter XV. Marine Insurance Contract.

- The Federal Law On Use of Nuclear Energy as of 21.11.95 No. 170-F.L.
- Insurance procedures (standard) for civil liability of organizations operating dangerous industrial objects, for causing damage to life, health or property of third parties and to the environment, as a result of an accident at a dangerous industrial object (introduced by the letter of the State Technical Surveillance of the RF as of 23.04.1998 No. 01-17/116 in compliance with the Federal Law as of June 21, 1997 No. 116-F.L. On Industrial Safety of Dangerous Industrial Objects).
- Rules for issuing and checking up of insurance certificates or other financial securities of civil liability for damage caused by oil pollution (introduced by the Order of the Ministry of Transport of the RF as of November, 25, 2002 No. 147 in compliance with Article VII of the International Convention of Civil Liability for Oil Pollution Damage, 1992 and with Articles 323 and 324 of the Code of Merchant Shipping of the RF).
- Rules for ship insurance made public by insurance companies.

2.4.3 The Practice of Insurance Risks Related to the Operation of Icebreaker Fleets

At this stage the escort services of ships operating on the NSR on a round-the-year basis is provided by state-owned nuclear icebreakers, operated by the Murmansk Shipping Company under a contract on trustee management. According to the contract, the company insures against the following possible risks:

- Icebreaker fleet vessels' hulls, engines and equipment (Hull & Machinery ships);
- Civil liability of operating organizations related to the use of nuclear power.

Hull and Machinery Insurance of Ships

The basic coverage requirements for hull and machinery risks for Russian insurers are contained in the Code of Merchant Shipping of the RF. An insurance contract for hull and machinery coverage is usually based on one of the following terms: "Liability for total loss and damage of the ship" – the list of terms almost completely reproduces the terms of the Clauses of the Institute of London Underwriters 280. According to these terms, the following events shall be subject to compensation:

1. the loss by damage as a result of actual or constructive total loss of a ship because of fire, lightning, storm, whirlwind and other natural disasters, shipwreck, grounding of a ship, collision of ships with each other or with some immobile or floating subjects (ice included), or because of capsizing or sinking of a ship and as a result of accidents during loading or discharge or while accepting fuel, after explosion aboard the ship or outside, explosion of boilers, the breakage of shafts, because of a latent defect of hull, machinery and boilers, as a result of carelessness and mistake of the master, engineer or other crew members or the pilot;
2. ship damage loss as a result of measures taken for saving or extinguishing a fire;
3. loss of ship missing;
4. loss, contributions and general average expenses;
5. losses subject to compensation by the owner to that of another ship after collision of ships;
6. all necessary and reasonable expenses on ship salvage, on reducing loss and fixing its volume if it is compensated on the terms of insurance.

On these terms ship damage loss is compensated using franchise, i.e. loss is not subject to compensation if it did not amount to certain per cent of insured sum. Loss caused by damage is compensated without any franchise only when it was caused by a shipwreck, a collision with another ship, grounding, a fire or an explosion on board a ship as well as incase of a general average.

Total loss of a ship is compensated without any deductible. Total loss of a ship means considerable structural failure excluding any technical possibility of its repair, or ship sinking when its recovery is impossible or unreasonable as well as its lifting.

A ship is considered missing when it has not been heard from for 3 months and, if news could be delayed because of hostilities, - during 6 months.

When insurance is carried out on the terms 'Ship damage liability only', the following are subject to compensation:

1. expenses on elimination of damage of a hull, superstructures, (deck) houses, ship spaces, its machinery and boilers – refrigerating installations, mechanisms, equipment, systems, devices and rigging – for the same reasons as in case of insurance 'with total ship loss and damage liability';
2. loss, contributions and expenses in case of general average;
3. all necessary and reasonable expenses on ship salvage, on reducing loss and fixing its volume if this loss is compensated on the terms of insurance.

When insurance is carried out on the terms 'Only with total ship loss, expenses on salvage included', loss caused by actual constructive total loss, by missing ship loss and by all necessary and reasonable expenses on ship savage, on reducing loss and on fixing its volume are compensated if this loss is compensated on the terms of insurance. Insurance on these terms is identical to that in accordance with the Institute of London Underwriters clause 289.

When insurance is provided out on the terms 'With liability only for total ship loss', the actual or total constructive loss or ship missing loss will be compensated. There are no analogies to these terms in the international marine insurance market and are the most limited provisions in terms of insurer's liability.

The losses occurring due to the following factors are not subject to compensation:

1. intentional or gross negligence of an insured, a beneficiary or their representatives;
2. lack of seaworthiness (i.e. unreliability or lack of fitness of ship for sea voyages, absence of necessary outfit and equipment, lack of the necessary number of crew members required and/or their proper qualification, as well as undertaking the voyage without the necessary shipping documents;
3. fair wear and tear of ship, its parts and fittings;
4. any type of hostilities or war events and their consequences, injuries and destruction by mines or torpedoes, bombs and other weapon; pirate activities and civil war, social disturbances and strikes, confiscation, requisition, arrest or elimination of ship at the request of war or civil authorities etc.

The insured sum is agreed under the insurance policy by the parties to the agreement. This sum is based on the standard insurance cost of icebreakers taking into account their technical condition and age. Franchise costs are similarly agreed on. The insurance premium is set by the insurer, depending on the insured sum and insurance tariff with its increasing or decreasing coefficients taking into account the extent of insurance risks that are applicable. In accordance with the planned operation of icebreakers, an insurance contract is concluded for an agreed voyage or time period. The insurance policy is concluded on the basis of a written application of an insured, with full disclosure of the rights and duties of the parties. When an insured accident occurs, the claims procedures between insurer and insured are governed by the rules of insurance and the corresponding marine Codes and are compulsory. If the insured and/or the insured's representative do not fulfil their duties, the insurer has the right to have the policy voided.

Civil Liability Insurance for Operators of Nuclear Powered Ships

Operators of nuclear powered vessels require insurance coverage for civil liability for loss and damage caused by radiation affecting to life, the property of individuals (injured party) during vessel operations. This insurance coverage is effective providing that it:

- it occurs as a result of damage done to the injured party, as a result of a radiation accident that took place on the insured party's vessel or premises using atomic energy during the period of the insurance contract validity;
- there is a cause-and-effect dependence of causing damage to the injured party and the events occurring, while the insured executed permitted activities in the area of atomic energy use;
- is due to an accident that has occurred, i.e. sudden and unforeseen damage or destruction of the atomic energy source.

Damage to life, health and/or the property of several injured parties as a result of one accident shall be considered a single insured accident. Actual damage to life, health or property of individuals, who have not concluded any contract with the insured (according to which they would have fulfilled their duties), as well as damage done to property of legal persons shall be subject to compensation.

The principal insurer and co-insurers shall not be obliged to compensate the loss (damage) done by radiation influence to the injured party in cases of:

- Circumstances of irresistible force (earthquake, hurricane).
- Hostilities, war conflicts, civil war or uprising.
- Intent of the Injured Party (individual).
- Breach of the requirements of the instruction on systems and equipment exploitation by personnel of the insured as well as the breach of regulatory requirements.

In addition, the following shall not be subject to compensation:

- The damage done to the property of individuals and legal persons that was located on the industrial area of the insured, and was designed to ensure the maintenance of institutions involved in atomic energy use.
- Damage to any property owned or managed by the insured party.
- Loss of life or personal injury and of the insured's officials operating the institution involved in atomic energy use.
- Damage to the environment (nature).
- Mental health and morale damages.
- Compensatory damages and loss because of missed benefits.

The territory covered by this insurance policy is that of the RF, including the NSR area.

The insurance agreement also contains the following points:

- The volume of insured sum for all the insured accidents;
- The limits of liability on the risk "Doing damage to the life and health of the Third Parties" (as to one person, in all – as to one insured accident and in all – as to all the insured accidents);

- The limits of liability on the risk "Doing damage to the property of the Third Parties" (as to one individual, in all – as to one insured accident and in all – as to all the insured accidents).
- The following points are agreed to by the parties:
- The insurance premium and the terms of its payment.
- Deductible franchise as to every insured accident.
- The final (concluding) sections of the agreement state:
- The effective period of the policy.
- The rights and duties of the parties.
- The terms of contract termination.
- The terms for claims and litigation.
- Any special terms. Here it is usually pointed out that any co-insurers are jointly responsible to the insured and/or the injured party (the beneficiaries) for the payment of the total liability sum as set out in the policy.

2.4.4 The Practice of Marine Insurance for Oil Cargo Shipping

The analysis of statistical data on accidents with tankers carrying liquid hydrocarbons from Arctic deposits shows that the most important factor for risk assessment relates to ice conditions that result in damage to the hulls of ships. However, during Arctic operation in Arctic of 12 tankers of the Samotlor type (from 1975) and 5 Astrakhan type (from 2000), with the LU5 ice category, indicates that were no oil spills ships' hulls damaged by ice during this period. Although the majority of serious ice damage (up to 70% in 1983) occurred at the eastern part of the NSR, mostly in the East-Siberian and Chukotka seas, the analysis of statistical data for the 28 year period indicates that the number of accidents on the NSR is comparable to the global average. Accident risks for tankers of the LU5 ice category are minimized due to the escort services provided by powerful icebreakers as well as strengthened hulls and increased engine capacities. Such factors need to be taken into consideration in the calculation of insurance tariffs for tankers navigating the NSR.

Insurance of Liability for Oil Pollution Damage

Article 320 of the RF Code of Merchant Shipping establishes the level of financial liability for pollution (US$4,2 million – for ships carrying less than 5,000 tons of oil, and up to US$84 million – for ships carrying more than 5,000 tons). This liability cannot be covered by any single Russian insurance company. As a rule, the limit of insurance payment from a company's own funds does not exceed US$350,000. For this reason the Russian P&I Pool was founded. Currently 13 large insurance companies are members of this pool which is managed by Zeller Associates Gmbh, of Moscow-Hamburg.

The limit of self-retention of the Pool is US$1 million; the maximum coverage limit – US$25 million. These amounts are sufficient for coverage of owners of small and mid-sized ships. The liability of the Russian Pool in excess of its self-retention up to $25 million is secured by a reinsurance contract with three well-known international reinsurance companies: Munich-Re (34%); Hannover-Re (33%), and Alpina (33%). For potential clients who need liability limits exceeding US$25 million, there is the possibility place such limits with these reinsurance companies or in P&I Clubs, operating with fixed rates.

The International Oil Pollution Compensation Fund

The multistage scheme of compensation of damage resulting from oil spillage also includes the International Oil Pollution Compensation Fund (IOPCF). The purpose of this Fund is, firstly, to provide maximum compensation for pollution damage to claimants, and secondly, transfer a part of the costs of compensation from ship owners to the Fund. The Fund is formed from contributions of recipients of oil, transported by sea involving the parties to the 'International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (FUND 1971)' as amended. Russia is also a party to FUND 1971 as declared by the Federal Law as of January 2, 2000. No.26-3.

Under FUND 1971 the general limit of compensation for a single incident amounts up to US$135 million, and the maximum sum of compensation is US$203 million. However, these limits were considered to be insufficient as actual amounts of compensation claims for oil spills from large tankers in the last 15–20 were significantly higher. For example, in the grounding of the very large tanker of Exxon Valdez in March 1989 in Prince William Bay in Alaska some 100,000 ton of oil were spilled. The damage claims exceeded well over US$1 billion. The company paid $1.2 billion in penalties but only the first US$400 million were covered by insurance.

The spill of 19,000 tons of oil from Russian tanker Nakhodka in January 1997 in the Japan Sea was another example. The cleaning of the environment cost US$19 million. The total claimed sum at the beginning of 1999 amounted to US$250 million, but the FUND 1971 convention limit the tanker was only US$180 million.

As a result, it has become evident that not all claims could be covered by existing liability insurance and new discussions to revise the FUND 1971 convention are under way.

International Pools of Mutual Insurance

In response to the inadequacy of existing international oil pollution for catastrophic oil spills a number of international P&I Pools were formed. The majority of Western mutual insurance clubs of mutual insurance currently are united into pools of mutual insurance with the purpose of accessing sufficient financial reserves for covering catastrophic consequences of oil spillages at sea (Catastrophe Reserve Funds). These funds are able to compensate very significant damages – from US$12 million up to US$1.25 billion.

As a result, there are currently two types of oil spill liability insurance for ship owners available:

1. Insurance of risks of oil pollution in Clubs;
2. Insurance of risks of oil pollution in Pools of Mutual Insurance Clubs.

2.5 Fee Policy

2.5.1 Background

Each coastal sea area with harbours have more or less defined water ways which leads to the harbours. In areas with dense archipelago and shallow waters these water ways may be difficult to navigate. To minimize the risks for accidents like groundings, the coastal states map and mark the safe waterways. Usually the waterways also require continuous maintenance due to natural soil transfer or due dredging new and deeper channels for new harbours and larger size of vessels. To cover the costs for constructing and maintaining these water ways coastal states normally collect a fee from those who use these water ways.

In Arctic or other areas which have ice cover the safe and efficient use of the waterways call for additional services. depending on the area and the type of traffic special vessels are needed either to assist the other vessels through the ice conditions or to keep the channels through the ice in such a condition that other vessels get through on their own. This additional work also costs money and this money is collected as icebreaker fees.

The fees that are collected can be defined in a number of ways. Normally the water way fee is defined based on the cargo volume on the waterway and the over all costs of the construction and maintanence work. This can be done either separately for each harbour or as overall cost for the coastal state. The basis for the fee ofr the user would in this case be the cargo volume or the size of the vessel. The icebreaker fees can be based on the actual cost and actual use of the ice breaker assistance or they can also be taken as overall costs and paid by all the traffic that uses the water ways. Also it is possible to vary the fee during winter season and the open water season.

The way that each country defines and collects the fees is part of the country's maritime policy. The only restriction today is that the fees should be of non-discriminatory nature.

Sea areas which are considered as international sea ways and are open for any sailing form a special case. The UNCLOS Article 234 defines the basis for the fees in the following way:

> "Coastal states have right to adopt and enforce non-discriminatory laws and regulations for prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance."

Based on this article it is understood that the coastal states can also collect fees to cover the costs of the safety measures they have adopted to protect the environment.

2.5.2 Fee systems in use in different countries

There are not many countries in the world that really have considerable traffic through the ice-covered waters and who provide the ice breaker service for that traffic. The main players are Russia, Finland, Sweden and Canada. In other countries the ice problems are more occasional or traffic volumes are so low that no special systems have been created.

Russia

General

One of the results of the administrative reform carried out in Russia is a higher status of accepted decisions on tariffs - up to the level of the Government of the Russian Federation.

The Federal Tariff Service which is under the authority of the Government of the Russian Federation was formed in 2004. The Federal Tariff Service estimates icebreaker-assisted services rendered along the NSRand approves icebreaker-fee rate by special Order.

The Board Administration Tariff was organized within the framework of the Federal Tariff Service for the purpose of estimating services of icebreaker-assisted pilotage. The structure of the Board includes representatives of the Ministry of Economic Development and Trade, the Ministry of Transport of the Russian Federation and other ministries.

The Board considers tariff proposals of the Shipowners and Operators of the icebreaking fleet operating on the Seaways of the NSR in view of the fact that the tariffs include costs of maintenance and modernization of icebreakers as well as charges on ice air-reconnaissance flights, hydro-meteorological support and satellite communication.

The Federal Tariff Service proceeding from the consideration of proposed tariffs shall issue Orders 'On tariffs for services of the icebreaking fleet along the NSR'.

Indexation of icebreaker fees

The necessity of indexation of tariffs for services of the icebreaking fleet shall be grounded by the Operator of the icebreaking fleet, that is, by the Murmansk Shipping Company. Within last two years there was no indexation of tariffs for icebreaking services. At the same time in connection with growth of prices for repair, nuclear and organic fuel and reactor equipment the expenses on the icebreaking fleet have considerably increased.

On the basis of the above-stated the tariff of icebreaker fees will be raised, inparticular, for transportation of oil by 12%.

The Government of the Russian Federation is considering the proposals of the oil companies ("Rosneft") planning transportation of oil through the Karaand Barents seas, to finance work on prolongation of the service life of nuclear icebreakers on condition that these means will be compensated in the long run by reduction of the tariff for icebreaking services.

Legal basis of icebreaker fees

The basic normative-legal and normative-technical acts on State regulation of icebreaker fees, except for the Orders issued by the Federal Tariff Service are set forth in "Guide to navigation through the Northern Sea Route". The Guide is issued by the Administration of the NSR and the Hydrographic Enterprise of the Ministry of Transport of the Russian Federation in 1995 n Russian and English.

"Rules for navigation on the Seaways of the Northern Sea Route" state that the Shipowner or the Shipmaster is obliged to confirm in his request for pilotage a guarantee of payment of icebreaker fees (Rule 3.1).

Payment for the services rendered to vessels by the Marine Operations Headquarters and the Administration is made in accordance with the authorized tariffs as established by relevant procedure (Rule 8.4).

"Rules for icebreaker-assisted pilotage on the Northern Sea Route" state that:

- In this case payment shall be made in accordance with the additional tariff and at the submission of the request for pilotage on the NSR(Rule 2.2);
- Pilotage of substandard vessels and also docks, drilling platforms, monobuoys (wharfboats) is carried out under additional special or icebreaker support, with additional charges being paid (Rule 2.5).

"Requirements for design, equipment and supply of vessels navigating the NSR" determine that the Shipmaster having little or no experience of ice navigation on the Seaways of the NSR (not less than 15 day of navigating a ship in ice conditions), is obliged to take onboard an ice pilot and pay for his services.

As a whole the tariff policy provides for the State regulation of icebreaker fees not only on the Northern Sea Route, but also in the northern seas. As volumes of oil export increases the rate of icebreaker fees will be reduced. A scientific basis of the tariff policy shall become the project "Regulations of payment for navigation services on the NSR", developed by CNIIMF.

Finland

(as presented by General Director Markku Mylly from the Finnish Maritime Administration at the ARCOP Worshop 7)

General

The Finnish Maritime Administration is the authority responsible for maritime safety, winter traffic assistance, fairway maintenance, VTS and pilotage, hydrographic charting and the provision of ferry services to the archipelago communities. The Administration ensures that the basic operational conditions for merchant shipping and sea transport are maintained and continually improved, taking into account safety and economic aspects, as well as environmental consequences. The activities aim to ensure safe and efficient merchant shipping, meeting both society's and customers' needs.

The Finnish Maritime Administration purchases, either from the established state enterprises or other companies, the services needed to ensure unhindered shipping. These services include for example icebreaker services, fairway maintenance/buoy tender services, community ferry services.

The Administration also maintains its production related to fairways and nautical charts.

The Finnish Maritime Administration finances its services for merchant shipping by charging its customers fairway dues. It also conducts official and public services which are financed out of the government budget. The Finnish Maritime Administration's annual budget is roughly 105 million euros. The budget is financed via fairway dues, 75 million euros, state budget 25 million euros, other revenues 5 million euros.

Fairway dues in Finland – Background

The objectives of the fairway due system in the 1970's and in the 1980's was to promote good iceclassed vessels navigating to Finland and also to support regular liner traffic.

Up to year 1989 the costs of the icebreaking were partly covered by fairway and towing dues and partly by governmental budget money. The towing fee was abandoned in 1989 due to the fact that collected towing fee was very minimal, abt 2 -8 million FIM, equals to 0,2 – 1,2 million euros and the system to collect towing fees caused more delays and made assisting operations often very difficult.

Fairway dues policy have had and still have several goals, for example in respect to shipping policy, industrial policy and regional policy. The financing policy has also had goals on respect to state budget.

The Ministry of traffic and Communication has accepted certain demands and goals on fairway policy in 1990's and those demands are still valid. Some of the demands were at the time being;

1. Special attention was to be paid on regular liner traffic to Finland and suitable ice classed vessels on that traffic;
2. When adjusting fee levels the foreign trade competitive position and ability had to be taken into consideration;
3. The goal was to lower the fairway dues level;
4. To continue to lower the costs of the administration causing pressure to fairway dues

Act of fairway dues was renewed in Finland in 2002. New fairway dues Act came into force 1st September 2002 and they are collected by the State to cover costs it incurs from the construction, maintenance and care of public fairways used for navigation, and safety devices required by waterborne traffic, and from assistance provided by icebreakers.

Today also the cost of national VTS activities is covered by fairway dues.

Fairway dues are collected by the customs authorities. The National Board of Customs may issue more detailed provisions on the procedure for collecting fairway dues.

Notwithstanding confidentiality provisions, the Finnish Maritime Administration shall provide the customs authorities with the reports, opinions and other material required to apply this Act. The Administration shall also provide the customs authorities with other executive assistance, as needed.

Any party engaged in merchant shipping on a registered Finnish or foreign ship in Finnish waters is liable to pay fairway dues.

No fairway dues need be paid when a ship travels from one foreign port to another through Finnish waters but does not call at a port in Finland.

The ship owner and the party who reports the ship for inward clearance on behalf of the ship owner or represents the ship owner on voyages between Finnish ports are responsible for payment.

Parties liable to pay who do not reside in Finland and all foreign parties liable to pay shall have a representative who does reside in Finland and has been approved by a customs district to assume responsibility for the duties that this Act allots to the party liable to pay and for the consequences of their neglect.

The fairway dues on international traffic are collected as a single payment when a ship arrives in Finland from abroad.

Charging principles

The amount of the single payment is determined on the basis of the ship's net tonnage and ice class.

More detailed provisions on the amount of the single payment and, as needed, their maximum limits are issued by Government decree.

The fairway dues on domestic traffic are collected in the form of an annual payment for each calendar year. The amount of the annual payment is determined on the basis of the ship's net tonnage. More detailed provisions on the amount of the annual payment are issued by Government decree.

Domestic traffic means voyages between Finnish ports, except when during such voyage the ship calls at a foreign port to load or unload cargo or to pick up or leave passengers.

Waiver of payment based on number of payments and increase in dues

When fairway dues have been paid 32 times for a passenger ship registered for at least 120 passengers and 10 times for other ships, the ship's fairway dues for international traffic will be waived for the remainder of the same calendar year, provided that the specifications affecting the amount of the dues do not change in a way that would increase the dues.

Other waivers of payment

No fairway dues are collected on ships that are used solely in inland navigation, or arrive in and depart from Finland via the Saimaa Canal without calling in at a Finnish coastal port or are owned by the State and are not used for commercial purposes; or call at a Finnish port without unloading or loading cargo or passengers because of a compelling need, or solely to receive orders pertaining to the continuation of their voyage, or for repairs or so that the need for repairs to the ship can be assessed.

Half of the amount of fairway dues is collected on a ship referred to in subsections 1 and 2 above when the ship is heading for the Saimaa Canal, both when it is also bringing cargo from abroad to a Finnish coastal port and picking up cargo for port/s abroad from a Finnish coastal port.

Ships that call at a foreign port to pick up more cargo for technical loading or stevedoring reasons during one and the same voyage between loading cargo in Finnish ports are exempt from paying fairway dues twice.

Increase in dues

Fairway dues may be increased if the party liable to pay has:

- provided insufficient or erroneous information for the purpose of fairway dues assessment, or has fully or partially neglected his duty to notify, by up to 30 per cent; or
- deliberately or from gross negligence provided an insufficient, misleading or false notification or other information or document, for the purpose of fairway dues assessment, neglected to submit information for the purpose of fairway dues assessment, or otherwise neglected his duty to notify, and this is likely to have caused insufficient fairway dues to be charged, by up to 50 per cent.
- If, in the light of the potential benefit gained thereby and other material circumstances, the actions referred to in subsection 1, paragraph 2, must be considered aggravated, the fairway dues shall be increased by at least 50 per cent and no more than 100 per cent.

On written request, the Finnish Maritime Administration may grant a reduction on or an exemption from fairway dues, or order the full or partial refund of fairway dues if:

1. this is warranted by the promotion of tourism or coastal or through-traffic, or pressing causes pertaining to the promotion of Finnish foreign trade; or
2. collecting the dues in full would be manifestly unreasonable.

The Ministry of Transport and Communications may assume responsibility for resolving a matter concerning the reduction of or exemption from dues when it involves a significant question of principle.

Main objectives of fairway dues in Finland

As said before the fairway due system has in Finland several objectives;

1. Shipping policy,
2. Maintenance support function or performance,
3. Industrial policy,
4. Traffic policy,
5. Regional policy,
6. State budget policy

Renewal of Fair Way Dues

On November 19th 2004 the Government submitted a proposal (HE 240/2004) to Parliament for the amendment of the Act on Fairway Dues which would have vested the Finnish Maritime Administration with powers to interpret the ice class rules in a more flexible manner.

The proposal was based on a suggestion of a working group appointed by the Ministry of Transport and Communications to prepare a total revision of the Act on Fairway Dues.

In accordance with the Constitutional Law Committee, a Parliament Committee which controls the constitutionality of laws, the fairway due is, from a constitutional point of view, to be considered as a tax and the bill would have given the government authorities too much discretionary power with respect to the size of the tax. Thus the Constitutional Law Committee considered the proposal to be unconstitutional. The proposal was therefore withdrawn on December 14th 2004.

Pursuant to section 28 of the Act on Fairway Dues, the Finnish Maritime Administration may at its discretion, in individual cases, grant a reduction on or an exemption from fairway dues, or order the full or partial refund of fairway dues if this is warranted by the promotion of tourism or coastal or through-traffic, or pressing causes pertaining to the promotion of Finnish foreign trade or if collecting the dues in full would be manifestly unreasonable.

The working group appointed by the Ministry of Transport and Communications continued to work on a total revision of the fairway due legislation and the work was complete at the end of May 2005.

The working group was obliged to take into account the following opinion of the EU in their work;

The Commission is pressing ahead with the infringement proceedings against the discriminatory charges levied on vessels in Finland. The Finnish scheme breaches the European rules on the freedom to provide maritime transport services. In particular, it makes international operations in Finnish waters more difficult and more costly than purely national services. If no satisfactory response is received from the Finnish authorities within two months, the Commission may decide to refer this matter to the Court of Justice.

Although the services provided to vessels are the same, Finnish legislation imposes higher fees for use of waterways on international traffic than on vessels performing cabotage operations between two ports in Finland. The fairway charge is calculated differently in each case. Vessels performing cabotage operations are liable to payment of an annual lump sum calculated on the basis of the net tonnage of the vessels and entitling them to an unlimited number of voyages. No account is taken of their "ice class" for this purpose. By contrast, vessels entering a Finnish port from another country must pay a charge based on both net tonnage and ice class for each of their first 10 or 32 voyages, depending on the type of vessel.

Although the Finnish legislation does not discriminate on grounds of the nationality of the provider of the services, it creates an obstacle to the freedom to provide services since it draws a distinction between international anddomestic traffic, even though the services provided are the same. It therefore hampers operation of the internal market. After having considered these opinions of the European Union the working group made two alternative proposals of which the other one was based on so called ice index and the other one was based on vessels ice class and net tonnage, similar to what is in force today. Both alternatives were sent to comments to the industry and the result of the comment was that the futurefairway due legislation should be based on vessels ice class and net tonnage as it is today.

In this respect the proposed changes to the existing fairway due legislation are minimal. The proposed changes only fulfil the opinion of the EU and revised legislation does have minimal effect on the level of the dues in force today.

Goals of the proposition and essential proposals

1. All rules and regulations concerning ice classification of the vessels are to be withdrawn of the new fairway due legislation and these rules are to be transferred to new legislation which concerns ice classification of vessels and ice breaker assistance,
2. The fairway due is proposed to be simplified so that charges are based on four categories instead of existing six. This means that in the future the categories are; 1 A Super, 1 A, 1 B and 1 C are combined and ice classes II and III are combined. The unit fee to be charged is highest in ice classes II & III and lowest in ice class 1 A Super
3. The unit fee is different for cargo vessels and passenger vessels
4. The fee is charged 10 times/calendar year for cargo vessels and 30 times / calendar year for passenger vessels
5. There is no different fees for domestic and foreign traffic
6. Cruise vessels pay fairway due on each individual call 1,06 €/net tonnage and max. fee as 45000 €/call
7. Fast ferries pay fairway due 30 times/calendar year 6,04 €/net tonnage
8. Export transito vessels are proposed to receive 50% deduction in fairway dues

The proposal is to be handed over to the Finnish Parliament still this autumn and we are expecting to get new legislation in force from the beginning of 2006.

2.5.3 Alternative fee systems to be evaluated

The basis for the fee systems is to cover the costs of the fairway maintenance, the ice breaker investments and operations and the environmental protection measures in place. These costs can be divided between the users of the water ways based on following principles:

1. Each vessels pays the actual cost they cause
2. The cost for ice breaker service is carried by vessels operating during the winter time. During open water season the vessels carry only the cost for fairway maintenance
3. All the costs are carried by all the traffic in the area. The costs are divided evenly on the cargo units.

In each case the measuring unit is cargo ton. This could also be cargo volume since the physical size of a vessel and thus the costs that it creates is more dependent on volume than weight., but since all the assumptions of cargo volumes is in tons, this assumption is made to keep the figures more simple.

2.5.4 Description of the economic evaluation method

The evaluation was made using the selected ARCOP scenario, where 15 million tons of oil per year is transported from Varanday to Rotterdam. The scenario is described more in detail in the ARCOP report D 3.1.3. Ice conditions of an average year were used for this study. The tanker alternatives that have been studied are described in the ARCOP report D 3.2.1 and the icebreaker alternatives in the report D 3.3.1. The computer simulations are described in ARCOP report D 3.5.1. The overall cargo traffic in the area has been taken from the ARCOP report D 2.5.1 a and from the data presented at the ARCOP workshop 6, which has been reported in the report D 6.6.

The basic assumption for the overall traffic in the area is 100 million tons per year. The general water way maintenance costs are evenly distributed on this volume of transported cargo. The sensitivity of the fees on the cargo volume was also studied in the case where the overall cargo volume is only 20 million tons per year.

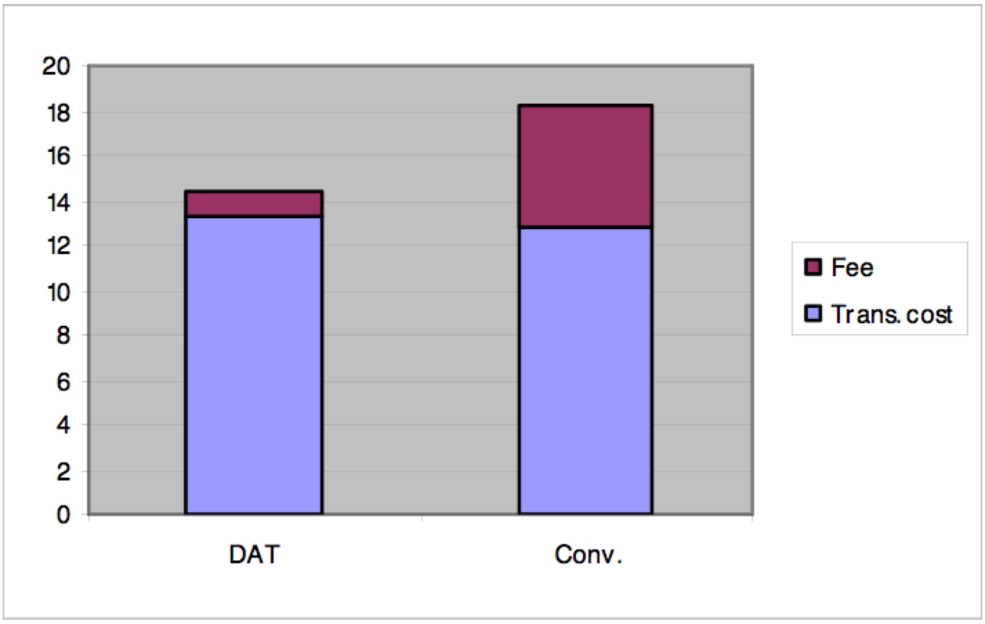
The second assumption was that 50% of the cargo volume is transported during the winter season. The impact of the volume of winter traffic was also studied for the case where winter cargo volume was only 25% of the total volume.

The costs for icebreaking were calculated with two methods. First the actual icebreaker costs covering both investment and operation of the icebreaker were taken from the report D 3.5.2 'Economic calculations'. These were used as actual costs for each transportation alternative. The second method was based on the information on icebreaker costs received at the workshops from representatives of the Russian Ministry of Transport. Based on this information the yearly costs that the Russian government wants to cover with fees is 120 million USD. This is not the actual cost of the icebreaker fleet, but covers the operation and maintenance of the fleet. The actual investment costs are those that are covered by the government as a support to encourage the use of marine transportation in the Arctic. In addition to this icebreaker cost there are the costs of maintaining the waterway infrastructure. Since no data was available on these costs an assumption was made that this is of same value as the costs for icebreaking. This assumption was based on the experience from Finland. Finnish Maritime Administration presented at Workshop 7, ARCOP report D 6.7, that in Finland the fleet of 9 icebreakers create a yearly cost of approx. 30 million euros. At the same time the cost for maintenance of waterways to Finland cost the same amount. The 120 million waterway maintenance cost is evenly distributed over all the traffic in the area. The 120 million USD cost for icebreaking can either be carried by all the traffic in the area, as in Finland or by the traffic that takes place during the winter months. Both alternatives were calculated in this study.

2.5.5 Results

Actual Costs

The simulation was made for the 90.000 tdw tankers running directly from the Varanday to Rotterdam. The required number of tankers was 8 for both independent operation and for assisted operation. In assisted operation 6 conventional icebreakers with 18 MW shaft power were used. The results are shown below.



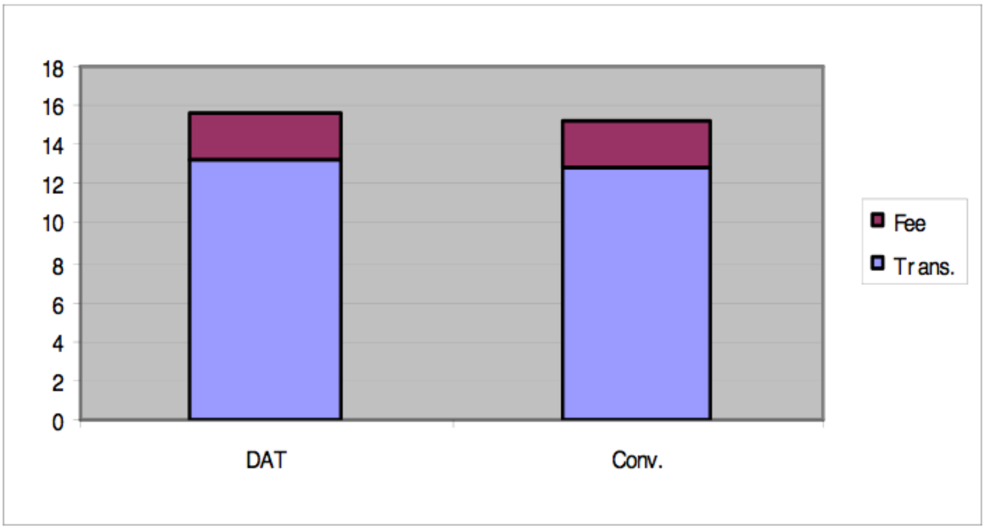
Actual costs

The basic tanker costs for independently operated Double Acting Tankers (DAT) were 13.2 USD per ton and for the conventional assisted vessels 12.8 USD per ton. The difference comes from the somewhat higher investment cost of the DA-tankers.

The waterway costs were assumed to be 120 million USD per year. This cost is divided evenly over all the traffic in the area. If the total cargo volume in the area is 100 miilion tonnes per year, the resulting fee is 1.2 USD per ton. The actual icebreaker costs for the use of 6 18 MW diesel-electric icebreakers are 63.0 million USD per year. This gives additional cost of 4.3 USD ton for the conventional tankers and the overall cost will be 18.3 USD per ton. This is considerably higher than the 14.4 USD per ton for the DA-tankers paying just the basic fee of 1.2 USD per ton.

Even fees for all traffic

In this alternative we assume that the icebreaker service is available to everyone and fees are the same regardless of the usage of icebreakers. The cost to provide this service is 120 million USD per year and this cost is collected from all the traffic in the area. The results of this calculation are shown in figure 2.



Even fees to all traffic

In this case the overall fee that all the traffic have to pay is 2.4 USD per ton. This will result in total cost of 15.6 USD per ton for the the DA-tankers and 15.2 USD per ton for the conventional tankers. In this case it is more feasible for the ship operator to use conventional tankers. The difference is 6 million USD a year and 120 million USD over the lifetime of the fleet. This example shows that the selected fee policy may have impact on the technology development. But this also a safety policy issue. If the coastal state does not want to encourage operations without icebreaker escort, it is justified to collect the costs of icebreakers also from those who do not use them.

Even fees for all the winter traffic

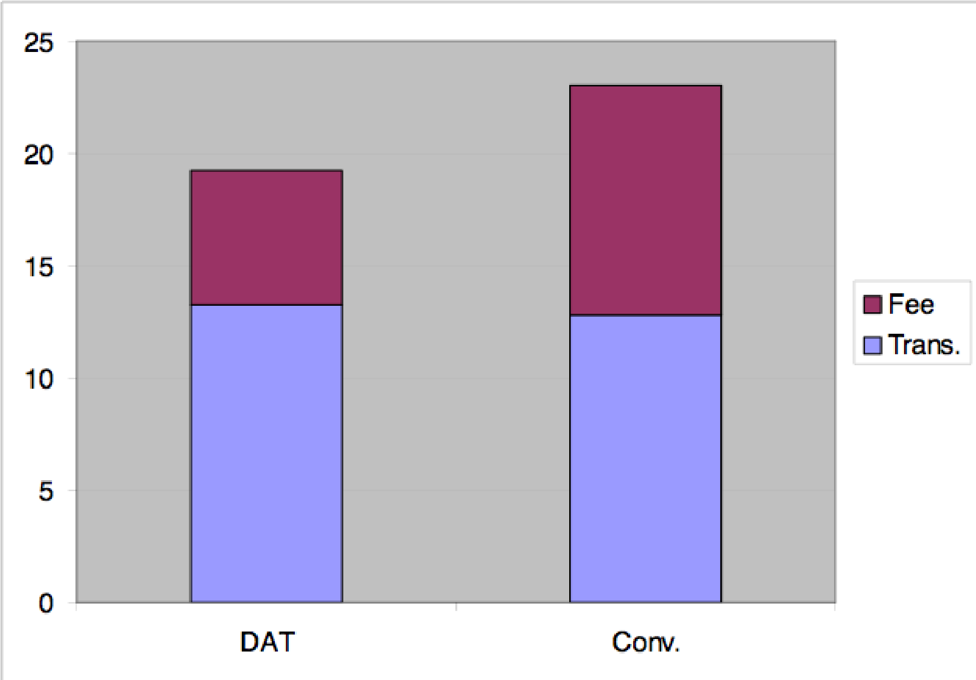
In this alternative we also assume that the icebreaker service is available to everyone and that the fees are not dependent on the use of icebreakers. In this case the traffic during the summer time need not take part in the costs of the icebreakers. If the distribution of cargoes during summer and winter is the same with all the traffic as it is with our scenario, the end result will be same on yearly basis. In our case approx. 45–50% depending on the alternative.

To demonstrate the impact of this system on the economics of the winter carriers, we make the assumption that only 25% of the total transportation volume is carried during the winter time. That means that 25 million tons need to cover the cost of the icebreaker fleet. This will lead to the icebreaker fee of 4.8 USD per ton. The fair way fee will be 1.2 USD per ton. Thus the total fees collected from the scenario transportation will be 54 million USD per year which in average is 3.6 USD per ton.

This 50% higher than in the case where the costs are collected evenly from all the traffic. This is also a policy issue. If the coastal state wants to develop steady taffic volumes throughout the year, it is feasible to collect the costs for winter traffic also from the traffic that takes place during the summer time. This would encourage the operators to invest in transportation systems that guarantee regular service.

Influence of the total cargo volume

The overall cost level here is dependent also on the total volume of the traffic in the area. If we assume that instead 100 million tons the volume would be only 20 million tons, then the figures would be as presented in Figure 3. In both cases the actual costs will be close or above the level of 20 USD per ton. This example shows how sensitive the fees are to the actual cargo volume. Thus it is important that the decisions on the fees are based on realistic estimates of the expected volumes. In case the government wants to encourage the development of the marine transportation in general, the fee level can be set based on future volumes.



2.5.6 Conclusions

The first conclusion that can be made from the calculations is that what ever fee system is selected it should be transparent. There are quite many factors influencing costs that are involved that the government should make it clear where they are aiming at with the fees.

The second conclusion is that the level of fees today is much too high if the traffic volumes grow as the need seems to be. With the current fee level the transporters will look for other means of transpor tation than the marine alternative. The pipeline tariffs from the current oil production sites to Germany var y between 20 and 25 USD per ton, so the current level of icebreaker fees makes that more attractive.

The third conclusion is that the fees should take into consideration the technology achievements. If the shipping company wants to invest in technology that needs less icebreaker ser vice, this investment should be rewarded by lower fees. At the end such development would be beneficial to all.

3. WP3 Integrated Transportation System for Arctic Oil and Gas

3.1 Selection of the Transportation Scenarios

3.1.1 Oil reserves, production profiles and transmission to loading terminal

The oil reserves in the relevant area can be divided to two separate logistical areas according to the existing or planned oil pipeline infrastructure. Both of the areas are presented in the Figure 2.1.1.

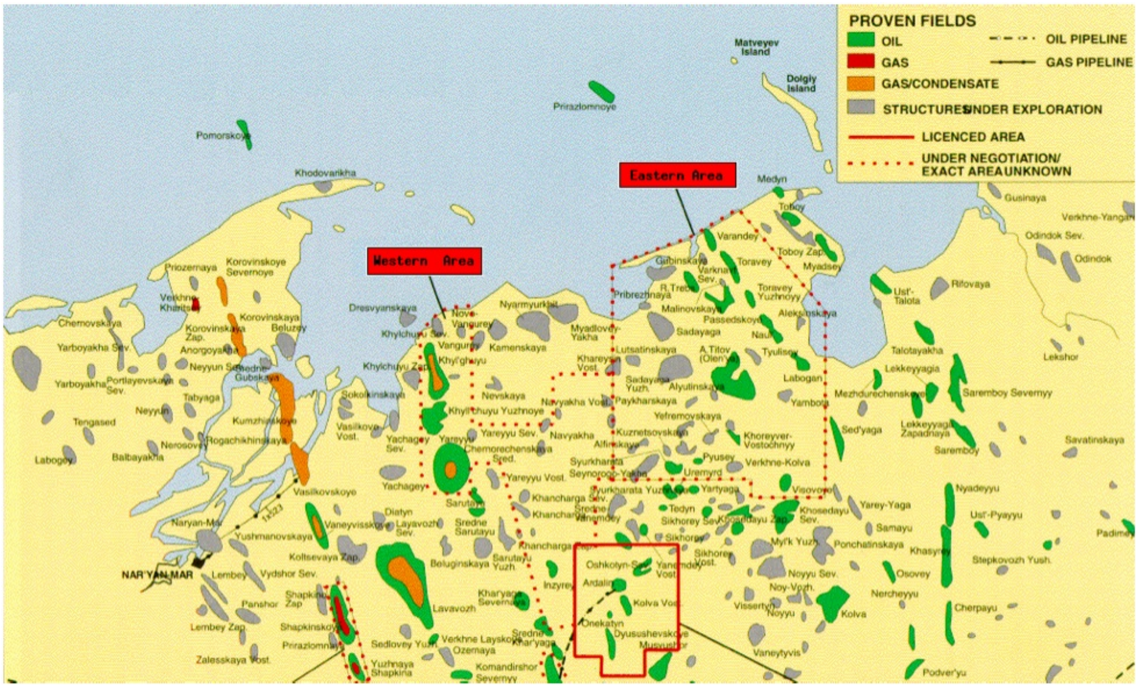


Figure 2.1.1. The Western and Eastern oil production areas.

The sea depth in the coastline near both of the areas is very shallow and the loading terminal must be located far a way from the shoreline. Oil will be transmitted to the terminal by underwater pipelines. The relief of the Pechora Sea is presented in the Appendix 1 and the bathymetry in the considered area is presented in the Figure 2.1.2. The lengths of underwater pipelines for both loading terminal alternatives and for three sizes of the tankers are presented in the Table 2.1.1.

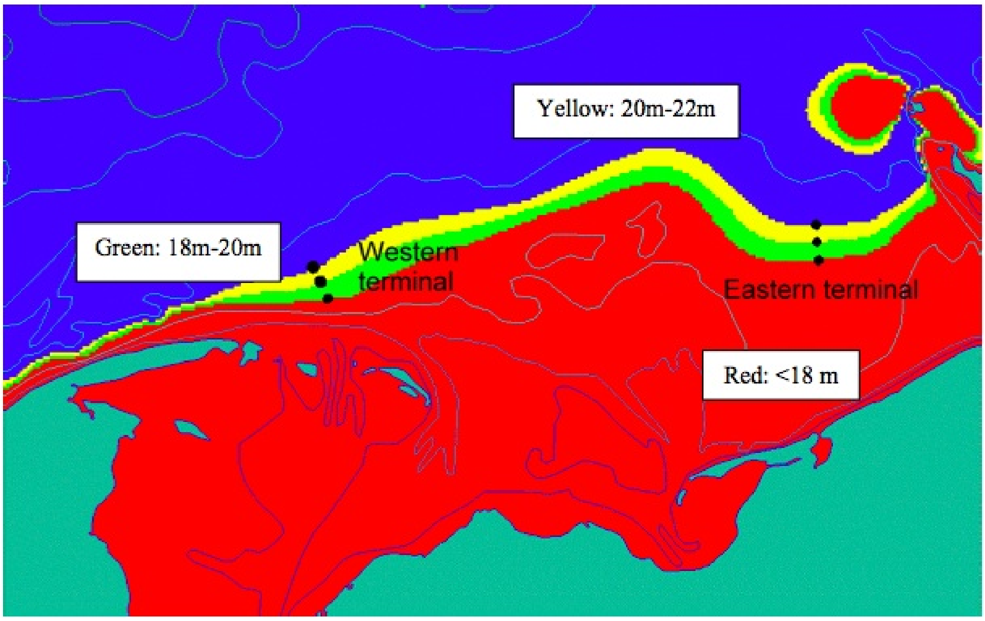


Figure 2.1.2. The bathymetry in the Western and Eastern terminal alternatives.

Table 2.1.1. The length of underwater pipelines in the Western and Eastern area.

Sea depth	Western Area	Eastern Area	Maximum tanker size
18 m	61.7 km	39.1 km	60 000 dwt
20 m	65.6 km	43.0 km	90 000 dwt
22 m	69.0 km	47.6 km	120 000 dwt

The approximated full level of production in the Western area is estimated to be 100 000 bbl/day. Correspondingly the full production level in the Eastern area is estimated to be about 330 000 bbl/day (ref. Figure 2.1.6), which indicates clearly higher production potential for the Eastern Area. Both of the estimations are conservative. In addition, the Eastern Area has existing experience of loading operations. The existing loading facilities are presented in the Figure 2.1.3.

As a sum of the facts mentioned above the Eastern Area seems clearly better for further development at this stage. Therefore the Eastern Area, later Varanday Area, is selected for case used in ARCOP-project.

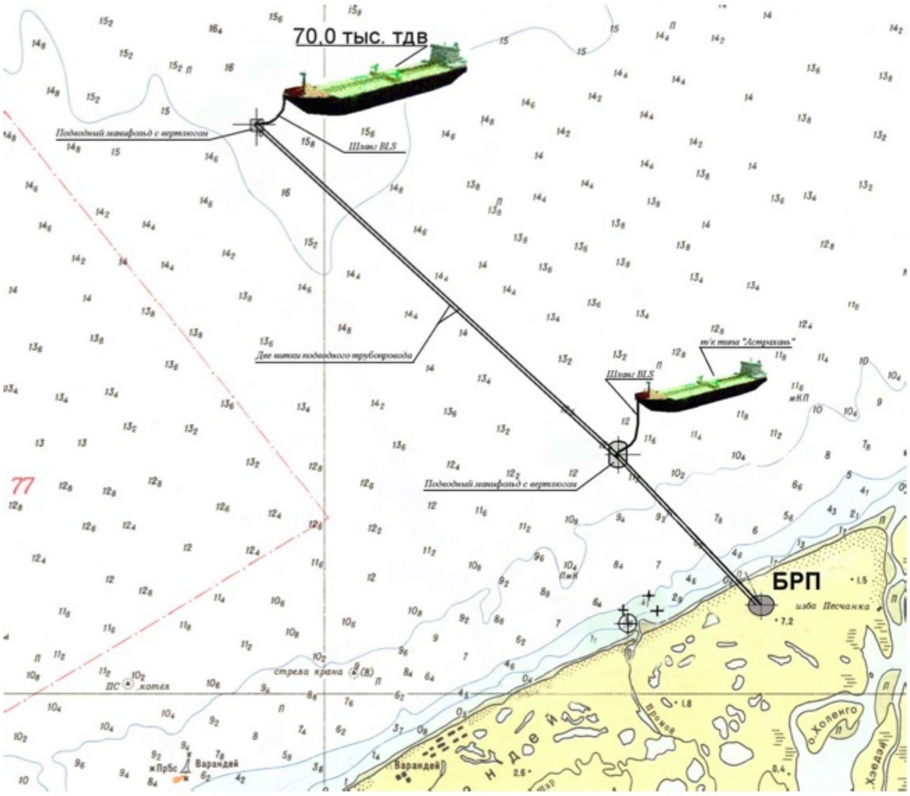


Figure 2.1.3. Existing loading facilities in the Eastern (Varanday) Area.

The Varanday Area with its oil deposits is presented in the Figure 2.1.4. The oil will be transmitted from each oil field to the oil storage area via two separate oil main pipelines. The oil storage area is located to the coastline near Varanday village and every oil field has own pump stations. One oil deposit lies near Varanday. The capacity of oil storages is designed to withstand at least one-week delay in offloading. The maximum estimated production is 330 000 bbl/day (as presented in the Figure 2.1.6). This requires at least 370 000 m^3 storage capacity during maximum production. Oil will be transferred from the oil storages to the loading terminal via underwater pipeline. The principle and components of oil transportation from the deposits to the tanker are presented in the schematic Figure 2.1.5.

The pipelines from the fields to the oil storages will be located above the ground. This kind of construction is preliminary confirmed to be more stable in permafrost conditions than the construction, which is located below the ground. This is due to the heat conduction from the pipe to the ground, which may defrosts the surrounding soil making it unstable.

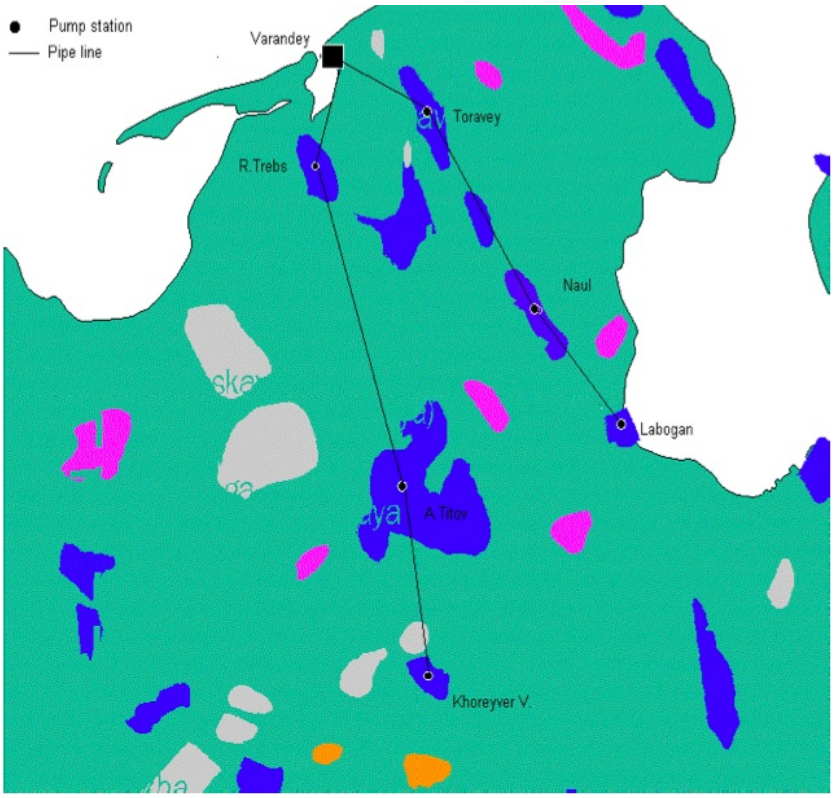


Figure 2.1.4. The oil deposits in the Varanday Area.

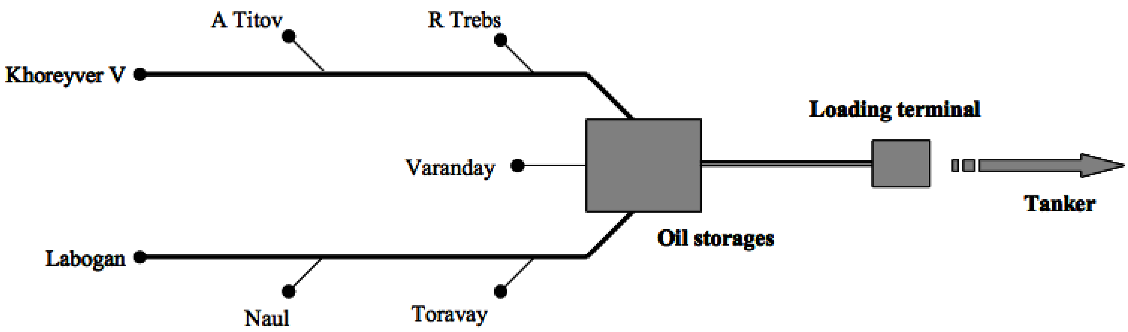


Figure 2.1.5. The components of the oil transportation.

The development of production will be started from the closest deposits to allow the early stage transportation to minimize the capital costs. The rest of the fields and infrastructure will be developed later when positive cash flow for the project has started. The full production level is estimated to reach in six years. Estimated production profile and development sequence is presented in the Figure 2.1.6.

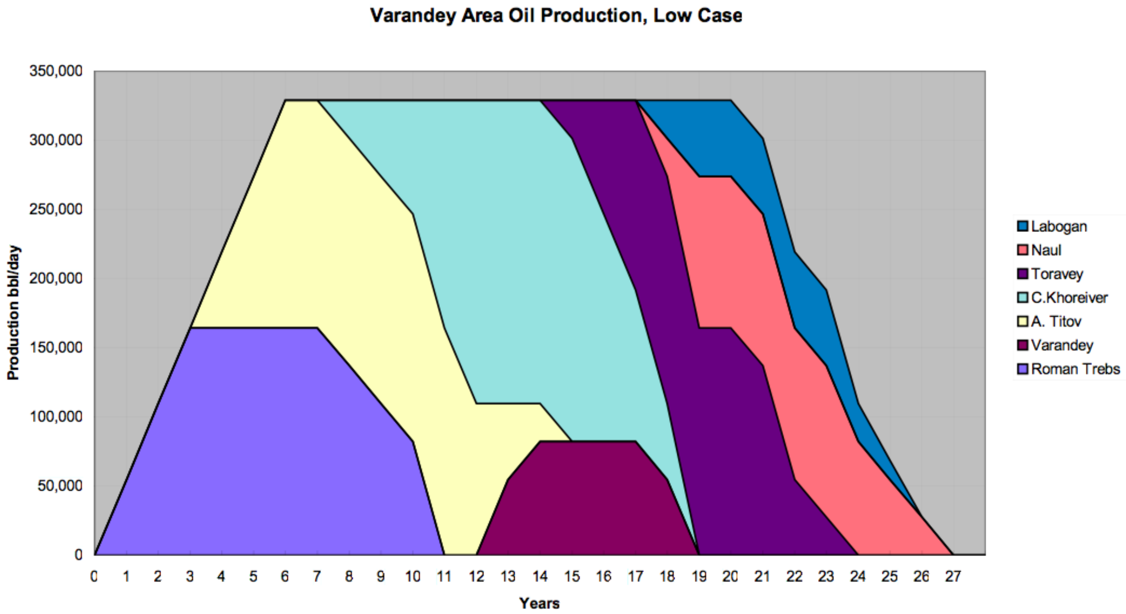


Figure 2.1.6. Estimated production profile from the deposits of Varanday Area. The sequence and the volumes are based on the preliminary assumptions (conservative).

Oil in each deposit is different. Therefore the oil properties at the oil storages are a mix of different oil types depending for example on the stage of production. The oil properties used in ARCOP are presented in the Table 2.1.2. The values are based on the standard characteristics of the Russian Arctic oil blend.

3.1.2 The sea route and tankers

As clarified earlier, the oil will be loaded to the tankers from the loading terminal at the sea. The tankers will carry loaded oil to Murmansk. The loaded volume at the maximum production is assumed to be 330 000 bbl/day (about 44 300 tons/day). The capability of 60 000, 90 000 and 120 000 dwt tankers to manage this volume will be studied in ARCOP: Also the performance of two tanker concepts (conventional and Double-Acting) will be studied. The main parameters of studied tankers

Table 2.1.2. Standard oil characteristics in the Varanday terminal.

Quantity	**Unit**	**Value**
Pour point	Deg.	-10 – -15
Viscosity at -10 deg	cSt.*)	43
Viscosity at 0 deg	cSt.	27
Viscosity at 10 deg	cSt.	18
Viscosity at 40 deg	cSt.	7
Viscosity at 99 deg	cSt.	2
Density at 15 deg	Kg/L	0.8652
Sulphur Content	% Wt	1.24
Water Content	% Vol.	0.147
Water Content	% Wt.	0.170
Sediment Content	% Vol.	0.0039
Sediment Content	% Wt.	0.0090
Hydrogensulphide in liquid	PPM	<1.0
Hydrogensulphide in vapour	PPM	600
Salt Contents	Mg/L	44.0
Salt Contents	Pct	0.0051

*) cSt. (Centistoke) = mm2/s

are presented in the Table 2.2.1.

Table 2.2.1. Main parameters of the selected tankers.

Type	Conventional	Double-Acting	Conventional	Double-Acting	Conventional	Double-Acting
DWT	60000	63000	90000	90000	120000	120000
Length (m)	226.7	212	251.9	230	278.9	280
Breadth (m)	32	34	40	40	44	46
Draft (m)	12.7	13	13.2	14	15.5	15

The tankers will meet a several types of ice and open water conditions during their voyage from the loading terminal to Murmansk (and visa versa). Environmental conditions and route map are clarified in more detail in the next section.

The tankers will be offloaded and oil will be stored in Murmansk. From Murmansk the oil will be loaded to the open water tanker, which will take it to western oil market.

The studies in ARCOP are limited to the logistical leg starting from the oil storage area in Varanday and ending to the offloading in Murmansk.

During the ice season one of the three standard navigation variants at the Murmansk – terminal point route, namely Central, Northern, and Southern (Fig. 2.2.1) will be likely selected (Brovin et al, 1996). The Central navigation variant is the shortest (930 km), but the situations are possible when the unfavourable ice cover distribution does not allow us to consider this route as an optimal variant. The Southern or the coastal navigation variant (958 km) envisages transit to the south of Kolguyev Island and further along the Timansky and Varandey shores using flaw polynyas, which allows sailing predominantly in thin young ice.

The Northern navigation variant (964 km) deviates northward beyond parallel 70° N and is used at the formation of an extensive polynya south of the Novaya Zemlya archipelago.

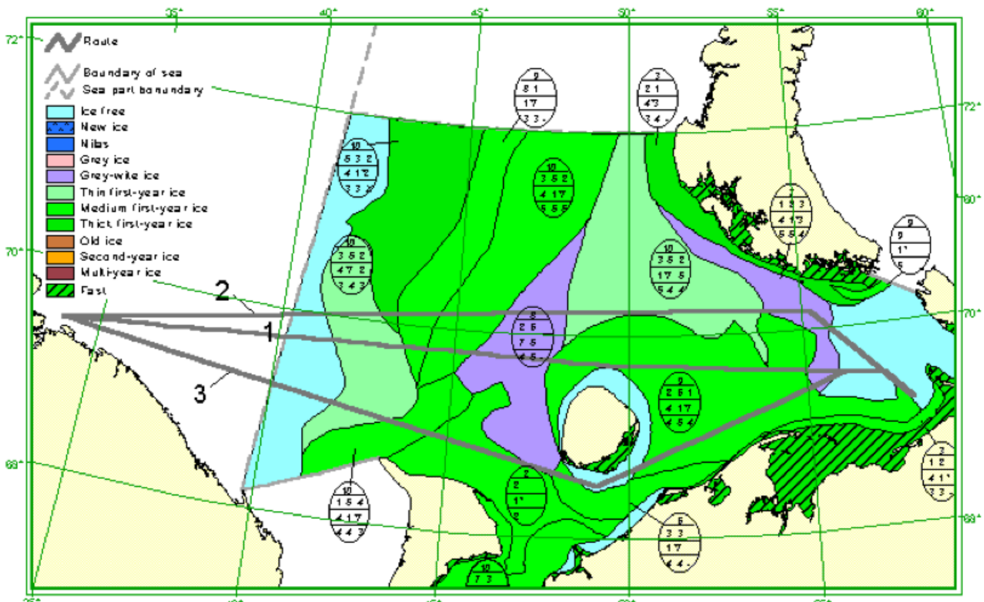


Figure 2.2.1. Location of standard navigation variants in the south-eastern Barents Sea (1 – Central, 2 – Northern, 3 – Southern).

The ice conditions in the figure 2.1.1 presents a hard ice conditions in the Pechora. The ice conditions during hard, average and easy ice conditions (with clarification of denotes in the ice charts) are presented in the Appendix 2.

3.2 Parameters of the Transportation Vessels

3.2.1 Operational principles

Same principles of operation, which are presented below, may apply to vessel types other than tankers when evaluating the differences and consequent pros and cons of 'traditional' icebreaking tanker design versus Double Acting one. However, tankers in the Arctic would probably be crude carriers of large sizes due to the economies of scale. This may be even more important in the Arctic because the costs of the transportation will be much higher than in open water. A large size brings extra problems for navigating in arctic ice, problems that are different for 'traditional' and 'Double Acting' vessels.

3.2.2 Conventional Ice-Bow Tankers

Conventional tankers operating in the Arctic will be provided with an 'ice bow' which may be designed for icebreaking or operation in broken ice. The operation is 'bow ahead', and according to traditional thinking it depends always on icebreaker assistance. A further option is to consider an independent 'conventional' icebreaking tanker that would operate independently as an icebreaker even in 'traditional bow ahead mode'.

Today the breadth of a vessel, that is assisted by icebreakers is normally considered the same or a little larger than that of the escorting icebreaker. This would limit the breadth of the tanker to about 30 meters maximum and the 'size' of the tanker to some 35000 tons deadweight, consequently, because the largest existing icebreakers, the large nuclear icebreaker from the Soviet era, are only around 28 meters wide. This size arctic ice going and icebreaking tankers have not been built yet, so there are few or no references available when the Arctic is considered.

For larger vessels the alternative, which is discussed by experts, is to use two or more icebreakers to assist one large size vessel. Large tankers perform routine ice voyages only in the east part of Gulf of Finland during winter. Some preliminary tests have been done also at Sakhalin Island but not in the Arctic. The only 'real' tanker test voyage so far in the Arctic was the 'Manhattan' experiment in 1969 from US East Coast to the north slope of Alaska via the Northwest Passage.

Winter 2002-03 was a difficult 'ice winter' for navigation in the Gulf of Finland and almost all shipping to the eastern ports was halted because of lack of icebreaker assistance. The two brand new Double Acting tankers of the Finnish oil company Fortum Oil and Gas were the only vessels that could keep the scheduled traffic. In fact they were assisting the other cargo vessels waiting for icebreakers each time they would pass by. All the other vessels in the area, large ice class tankers included, had to wait days and even weeks for icebreakers. The Sakhalin test voyage consisted of escorting an ice strengthened tanker to an ice covered DeKastri terminal with two icebreakers. From the results of the test voyage mixed opinions prevail. The 'Manhattan', a twin screw turbine tanker of 31.6 MW shaft power, 106000 dwt with 273 m length and 44.5 m width was fitted with over ten thousand tons of extra steel constructions in an effective ice bow and inclined double sides. The test voyage was run with altogether 5 icebreakers taking part during the arctic 'summer' in 1969. The test was deemed successful, as the Alaskan oil could have been taken out with icebreaking tankers but instead a decision was made to build the Trans Alaskan Pipeline to export oil.

So the relevant references are few or non-existent when this kind of operation in the Arctic is considered. Experience suggests that an ice-bow tanker will need icebreaker assistance, probably at least two icebreakers per each tanker. A large export volume means a number of large tankers, which fix a double number of icebreakers. Costs of the icebreakers must be included in the economic calculations. The availability and performance of them should be guaranteed; otherwise the transport will stop when facing difficult ice conditions.

An alternative to icebreaker assistance is to design the ice-bow tanker with enough power and performance for independent operation. Depending on the desired route and performance this may require much power to be installed, and in the end the icebreakers may have to be used anyway.

As already mentioned about the propulsion of an arctic tanker, one should choose machinery that is able to maintain the power when the speed of the vessel goes down. The 'normal' machinery option of a large tanker with direct coupled fixed pitch propeller driven by a slow speed diesel engine is the worst selection, because when the propellers rpm and the ship's speed is reduced, power is lost to large extent. A controllable pitch propeller is much better because the loss of the ship's speed, due to ice, can be compensated by reducing the propeller pitch, and the engine can maintain constant rpm and consequently high power.

A characteristic, which may be worth attributing in the 'ice context', is maneuverability. Any vessel will loose steering capability when thick ice surrounds the hull. Tankers with very long vertical sides cannot turn at all and can only go straight ahead in thick ice.

3.2.3 Double Acting Tanker

As for the 'conventional' counterpart, the operation experience from large Double Acting tankers in the Arctic is still missing. In non-arctic ice covered seas the principle has been used successfully since 1990 in the Baltic and Caspian Sea with excellent operational performance and experience.

Unlike the 'ice bow' tanker which is considered to operate with icebreakers assistance although possibility of independent operation may not be totally ruled out, the Double Acting tanker is considered to have a reliable 'independent operation option' readily available. Of course icebreaker assistance can be used also as a supplement or when conditions exceed the design definition.

The Double Acting principle includes providing the tanker with electric propulsion machinery that is an optimal solution for operation in ice. Generators driven usually by diesel engines produce electric power, but turbines may also be used. Electric propeller motors located in azimuthing propeller pods can run equally and without limitations in both directions, which allow the vessel excellent maneuverability and steering both ahead and astern. A 'normal' vessel provided with 'normal arrangement of propeller and rudder' cannot be steered when reversing, and in ice the rudder prohibits astern operation totally anyway.

The Double Acting principle allows the vessel to be designed with a bulbous bow for open water efficiency, because heavy or heaviest ice operation is best done astern. Provided with a bulb the vessel can hardly proceed ahead in ice conditions and is using normally astern operation any time in ice, both in thin and thick ice, in rubbles and ridges. Of course the achieved speed in easy ice conditions will be high in astern operation also, but will decrease when the conditions get more difficult, and finally the vessel will proceed at slow creeping speed in the most difficult ridges or other problematic ice formations. The astern operation does not need ramming if the vessel stops for a while because the ice is destroyed and removed by the propeller. For most cases the power needed for open water speed will be enough to allow for remarkable capability in ice conditions as well, especially when the required open water speed is high.

The regulations have not been defined to recognise the Double Acting principle and may require much higher power for a given ice class. In practice the performance is not equal to the class and the desired performance can be achieved with a lot less power than stipulated by the class of the rule. In this case an exception is needed to gain the specified class.

The bow does not need to be open water one; an efficient ice bow form may be adopted if large profits depend on high speed in thin ice. This may be the case if open water performance is not important, and the vessel seldom operates in open water. This type of Double Acting vessel is normally operating in ice using ahead mode but turns around to use the highest performance of the stern and astern operation mode when the ice conditions grow really bad.

Already mentioned some times above, in the real world selecting between independent and assisted operation may not be a question of performance only. The government and the icebreaker owner are eager to exercise their reign and dominance, maintain cash flow, and even finance the development of the future icebreaker fleet which may make the adoption of independent operation more difficult than it should be.

3.2.4 Examples of future Arctic vessels

Two examples of the designs of Arctic vessels are presented below. First one is the 200 000 m3 LNG vessel proposed for the operations also in the Kara Sea. Kara Sea is in the Eastern side of Novaja Zemlya (see Figure 1), where the ice conditions are typically harder than in the Pechora Sea (Varandey area).

The main parameters for the Arctic LNG vessel are presented in the table below and the general arrangement of this is presented in Figure 2.

Length oa.	328.0 m
Breadth	50.0 m
Depth	23.4 m
Draught	12.0 m
Propeller Power	abt. 35 MW
Double Acting	(with bulbous bow for open water)

This vessel is designed to meet the requirements of trading between the Yamal Peninsula and USA. In addition to the heavy ice conditions in the Kara Sea the vessel must be able to operate in heavy open sea conditions in the Northern Atlantic.

One estimate for the transportation volume of LNG from Yamal is 20 million tons per year. To be able to maintain a steady flow throughout the year, a total of 20 to 22 of vessels of this size are needed in the fleet. This will be one of the major challenges for the European shipbuilding industry in the future.

The second example is the Arctic Container intended to operate in the ice conditions, which can be very severe in certain seasons. The GA-drawing is presented in Figure 3 and the main parameters below.

Length b.p.	153.7 m
Breadth	23.1 m
Depth	14.2 m
Draught (in arctic)	9.0 m
Propeller Power	13.0 MW
Bow designed for effective ice breaking (i.e. 'Ice Bow')	

This vessel is intended to operate independently without assistance from icebreakers between Dudinka and Arkhangelsk in most of the conditions. The design of the vessel was a challenge. The experiences from the ARCDEV voyage were utilized when defining the performance requirements for the ship. The design of the transportation system without icebreakers is dependent on the capability to do efficient ice routing. The experience from ARCDEV gave justification to assume that an efficient routing system exists in the future. In this respect the expectations towards the IRIS project and the WP 1 of ARCOP are quite high.

3.2.5 Tanker alternatives for the ARCOP scenario

The selected crude-oil tankers for further studies in ARCOP are presented in more detail below. As defined in the ARCOP's Design Basis, all of the tankers will be designed to operate in the Barents and Pechora seas. The design service speed of all tankers will be approximately 15 knots.

The propulsion machinery of Conventional Arctic Tankers consists of two low-speed diesel engines coupled to a single screw. The pitch of the propellers will be controllable (CP-propellers).

The machinery of the Double Acting Tankers will be diesel-electric consisting of four diesel engines driving main generators, that feed the propulsion network and one frequency converter controls one azimuthing propeller unit. Propeller will be FP -type.

The GA-drawings are presented at the end of this paper.

Table 3. Main parameters of Conventional Arctic Tanker

Deadweight (t)	60 000	90 000	120 000
Length over all (m)	234.0	260.2	286.8
Length Lpp (m)	225.0	250.0	278.9
Breadth (m)	32.0	40.0	44.0
Draught (m)	12.7	13.5	15.5
Depth to main deck (m)	19.0	21.3	23.5
Propeller Power (MW)	21.0*	23.0*	25.0*
GA-drawing	Figure 4	Figure 6	Figure 8

* Preliminary estimation

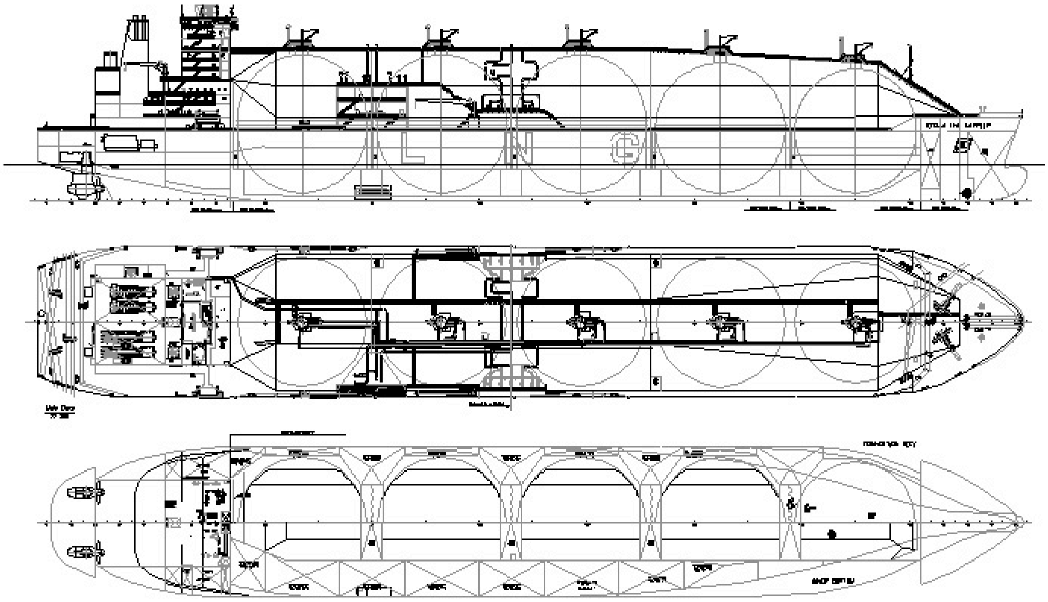


Figure 2. Arctic LNG Tanker

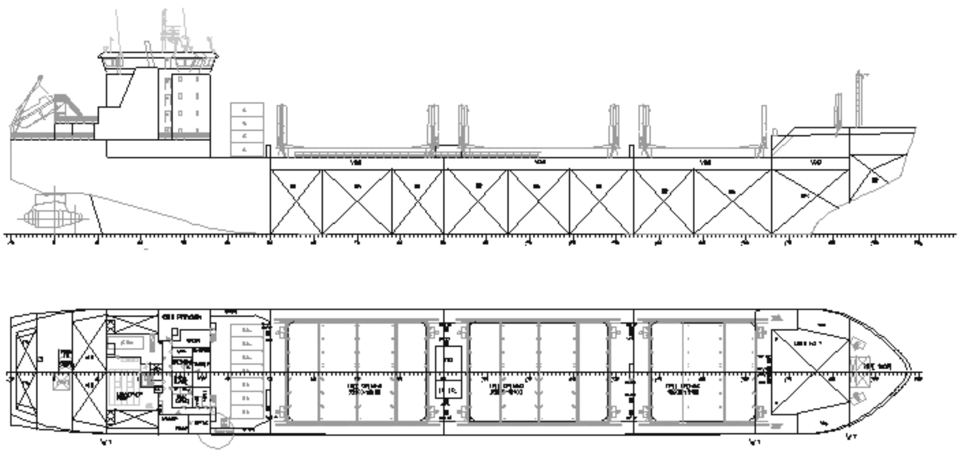


Figure 3. Arctic Container

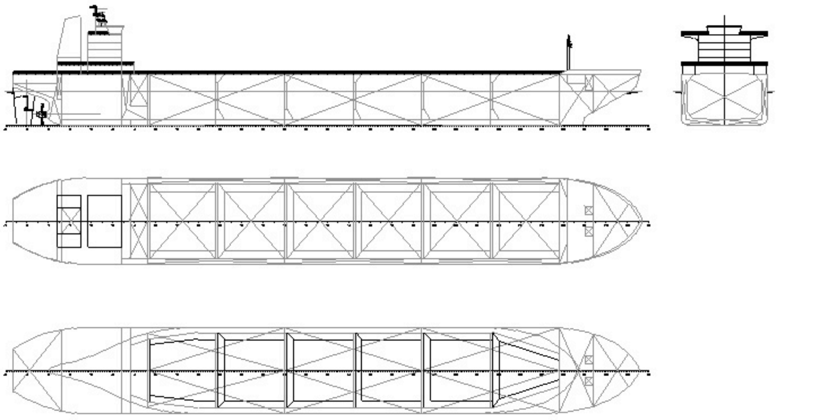


Figure 4. 60 000 dwt Conventional Arctic Tanker.

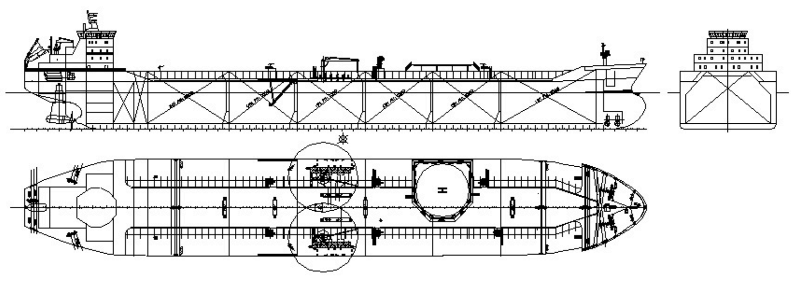


Figure 5. 63 000 dwt Double Acting Tanker.

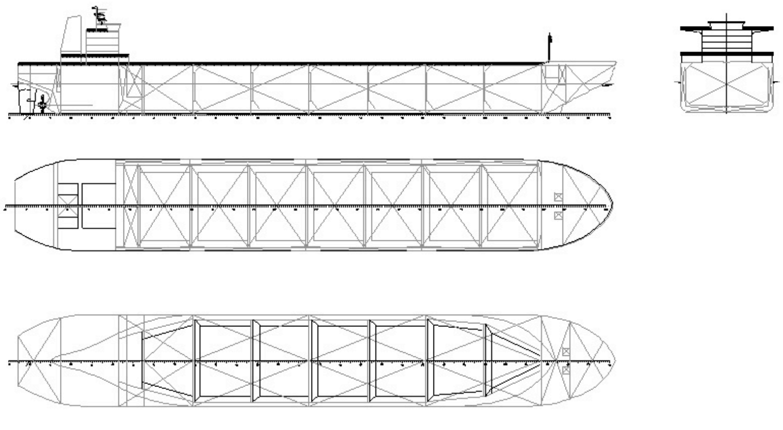


Figure 6. 90 000 dwt Conventional Arctic Tanker.

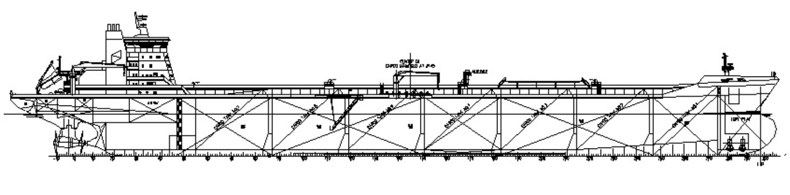


Figure 7. 90 000 Double Acting Tanker

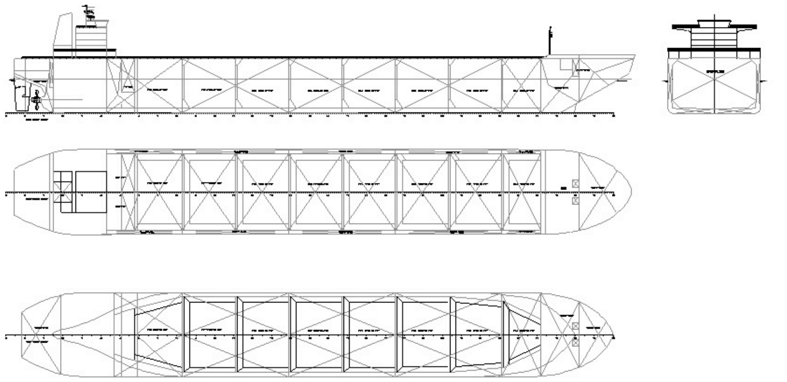


Figure 8. 120 000 dwt Conventional Arctic Tanker

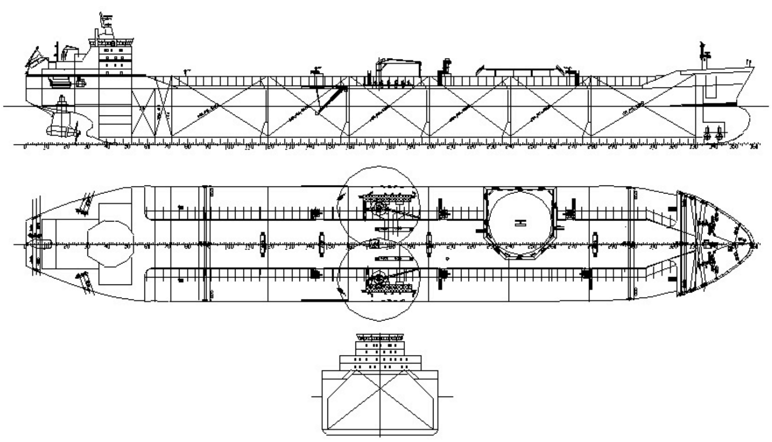


Figure 9. 120 000 dwt Arctic Double Acting Tanker

Table 4. Main parameters of Double Acting Tankers

Deadweight (t)	63 000	90 000	120 000
Length over all (m)	219.5	252.0	289.0
Length Lpp (m)	202.0	228.0	268.0
Breadth (m)	34.0	40.0	46.0
Draught (m)	13.0	14.0	15.0
Depth to main deck (m)	17.0	19.0	22.0
Propeller Power (MW)	14.5*	18.0*	22.0*
GA-drawing	Figure 5	Figure 7	Figure 9

* Preliminary estimation

3.3 Parameters of the Assisting Fleet

3.3.1 Convoy Practice

Brief history of icebreakers

Particular features of the location of Russia characterized by the considerable extent of northern and eastern sea boundaries necessitated the development and construction of the powerful domestic fleet. Rescue tugboat Pilot is considered to be a prototype of the first Russian icebreaker, that is a ship capable of breaking and thus actively surmounting ice cover en route. Owner of the ship was M.O. Britnev, industrialist from Kronstadt, the tugboat being about 26 m long and having a 85 h.p. steam engine. In 1864 the forebody of Pilot was cut off and a stem inclination by 20^o was given thus permitting the ship under the propeller thrust effect crawl over ice and break it down by the proper gravity.

Abroad the construction of icebreakers started in Germany to provide for the reliable operation of the port of Hamburg, as during severe winters the Elbe river was covered with ice. In 1871, after familiarization with the work of Pilot in Kronstadt German engineers built Eisbrecher I for Hamburg. The icebreaker had a specific 'spoon-like' shape of bow proving itself good in relatively thin level ice. A series of three such icebreakers was constructed. This type of icebreakers was later called 'Hamburg' (fig. 2.1).

In 1890 in Sweden, 1200 h.p. icebreaker Murtaja was built for the Central Admin-

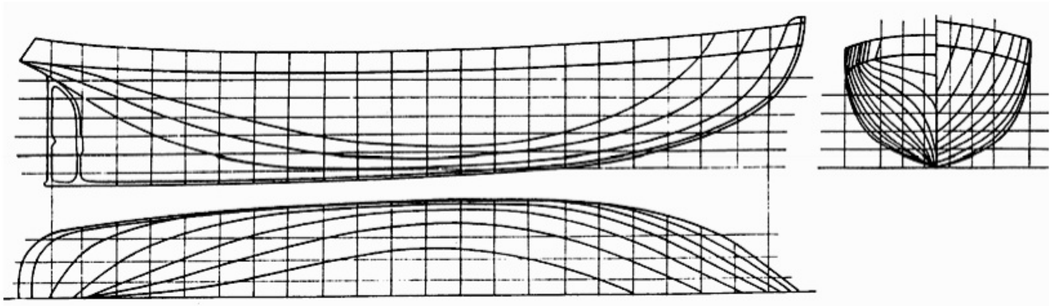


Fig. 2.1. Lines drawing of the Hamburg type icebreaker

istrative Board of the pilot and lighthouse departments of Finland. It was the most powerful sea-going Hamburg type icebreaker of the Russian Empire of that time. Its length was about 48 m, breadth – 11 m.

By the end of the XIX-th century, along with Russia, Germany, Denmark, Norway and Sweden, the USA as well started building icebreakers to be mainly used on the Great Lakes. Icebreakers of the 'American' type were distinguished by the presence of bow propeller. It was found out that the bow propeller improved ship's icebreaking capability due to the effect of the suction of water from under the compact ice and washing away hummocking ice with snow cover. The first icebreaker with a bow propeller named St. Marie was built in 1893 and operated on the Michigan Lake. Totally, by the beginning of the XX-th century about 40 small steam icebreakers were constructed in these countries.

The construction in Russia in 1899 on the initiative of admiral S.O. Makarov of the first polar icebreaker Yermak startered the development of new ideas in the world icebreaker building. Icebreaker Yermak built by the English shipbuilding company Armstrong&Co substantially differs from the predecessors by much greater dimensions and power. In compliance with the original project its overall length was 93 m, breadth – 21.6 m, draft – 7.6 m and displacement – 9 000 t. It was fitted with 4 steam engines of triple expansion with a total horsepower of about 10 000 driving three stern and one bow propellers. The icebreaker was distinguished also by the presence, along with a trim heeling system, of the original construction and shape of hull. The latter characterized by the wedge-shaped forebody successfully combining icebreaking and ice-separating properties was called later the 'Russian' type. Final pattern of the Russian type icebreaker had been formed after experimental voyages of Yermak to the Arctic in summer 1899. Resulting from these voyages, bow propeller of this icebreaker was taken off, forebody was reconstructed and modifications were introduced into the hull structure. Lines drawing of the refitted icebreaker is presented in fig. 2.2.

Extensive development of the icebreaker building took place during the World War I impelling Russia to urgently build abroad new icebreakers, in particular, in connection with the need of keeping all the year round operation of the port of Arkhangelsk. Within this period 7 icebreakers with horsepower from 4400 to 8000 were ordered and constructed in Germany, England and Canada. In 1917, a linear icebreaker Svyatogor of the Yermak type, in 1927 renamed Krasin, was built. It should be noted that technical solutions used on Yermak and well proved in practice were used when constructing icebreakers until the World War II.

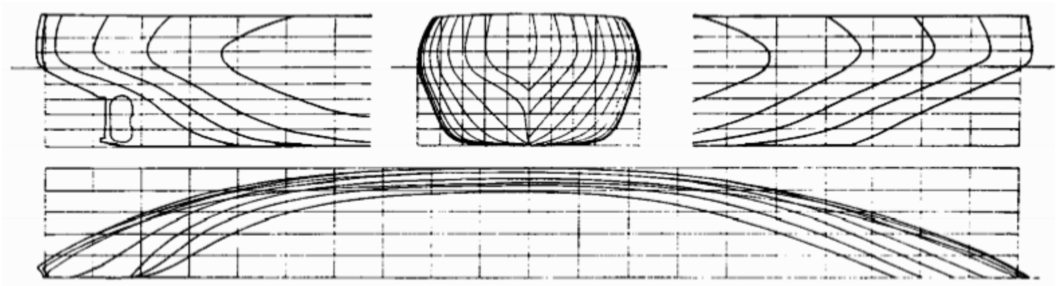


Fig. 2.2. Lines drawing of icebreaker Yermak after refitting

The application of electric propulsion played significant role in the development of icebreaker building. Replacement of steam engines with coal fuel boilers used on icebreakers as main engines by diesel-electric propulsion units permitted to raise the available power and maneuverability of icebreakers, their efficiency in operation. The first diesel-electric icebreaker was Swedish icebreaker Ymer with a horsepower of 10 000 built in 1932. Following the example of icebreaker Ymer in 1939 in Finland icebreaker Sisu was constructed and somewhat later in 1943-46 in the USA a series of diesel-electric icebreakers of the Wind type with a horsepower of 12 000 was built. It is noteworthy that these icebreakers had welded hulls. The welding for the hull shell plating was used for the first time in 1939 on American icebreaker Raritan.

At shipyards of the Soviet Union the construction of powerful sea-going icebreakers started in 1935. Following the example of Yermak and Krasin four icebreakers of the I.Stalin type (subsequently renamed Sibir) were built. The icebreakers had almost the same characteristics: length overall – about 107 m, breadth – 23 m, draft – 9.2 m, displacement – 11 200 t, speed – 15.3 knots. At a continuous speed they could surmount compact level ice up to 0.9 m thick.

Abroad, in the first half of the XX-th century mainly Baltic countries were building and operating icebreakers. These icebreakers were intended for the operation in freezing Baltic ports and at their approaches and therefore had bow propellers. Since the construction in 1954 of Finnish icebreaker Voima having a total horsepower of about 10000 fitted with two stern and two bow propellers, 'Baltic' type icebreaker came into being and the presence of two bow propellers became their particular feature.

The second half of the XX-th century is characterized by the full renewal of the icebreaker fleet. The previous experience has shown that for ensuring efficient work in ice of the Arctic basin and of other freezing seas it is necessary to construct more powerful icebreakers improving their ice performance. Therefore, particular feature of the development of the icebreaker building in the fifties and sixties was the increase of power of icebreakers which for these two decades as applied to individual large icebreakers increased three times and more – from 7-9 to 22-32 MW. As a result, the icebreaking capability of icebreakers increased 1.5-2 times from 0.8-1.0 m to 1.5-1.7 m thus enabling to increase speeds of the ships' escorting. Period of the arctic navigation was extended from two-three to five-six months.

Of especial significance in the history of the world shipbuilding was 1959, year of the construction of the first ever built nuclear turbo-electrical icebreaker Lenin with a power of 32350 kW (44000 h.p.). Characteristics of the icebreaker are given in table 2.1 and general arrangement plan – in fig. 2.3.

Arrangement of machinery spaces:
1 – bow turbo-generator room;
2 – bow electric power plant;
3 – bow auxiliary machinery room;
4 – nuclear steam-generating plant;
5 – stern auxiliary machinery room;
6 – side electric engines room;

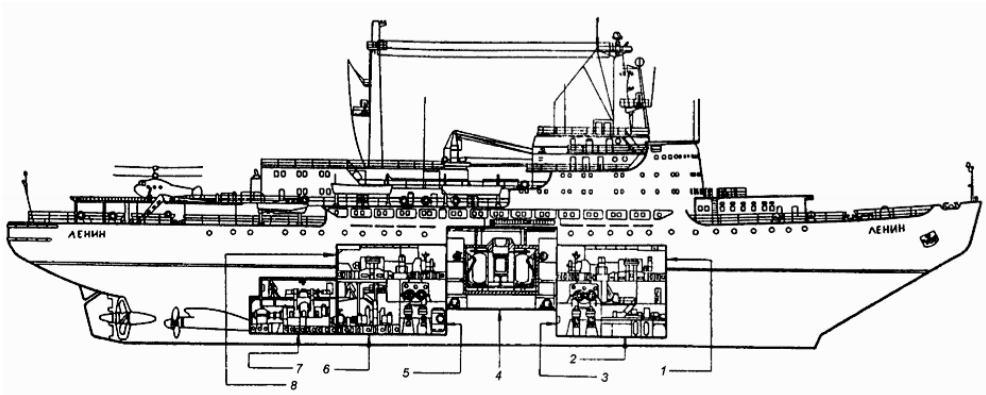


Fig. 2.3. The world's first nuclear icebreaker Lenin

7 – midship electrical engine room;
8 – stern turbo-generator room.

During the period from 1960 to 1971 there were substantial quantitative and qualitative changes in the composition of the soviet icebreaker fleet. Along with bringing into operation of n/i Lenin five arctic icebreakers of the Moskva type and 14 harbor icebreakers of the Vassiliy Pronchishchev type were constructed their principal elements being presented in table 2.1. Icebreakers of the Vassiliy Pronchishchev series were designed by the American type with one bow propeller and two stern ones. Total power of the icebreakers built in this period is about 180 MW, that is more than three times higher than that of the icebreakers the USSR had by the beginning of 1960. Along with the Soviet Union also Finland, Canada, USA, Sweden and Denmark were actively building new icebreakers.

Out of foreign icebreakers constructed during these years one should distinguish diesel- electric icebreaker Glacier put into operation in 1955 in the USA and Canadian steam turbine electrical icebreaker Louis S. St.Laurent introduced into service in 1969 principal characteristics of which after refitting are shown in table 2.2. Icebreaker Louis S. St.Laurent up to 1976 remained the most powerful among foreign icebreakers having used for the first time a steam turbine electrical unit. After the renovation of the icebreaker in 1988 this unit was replaced with a diesel-electric plant. The forward end was also replaced by an improved one and a hull air bubbling system for the increase of the icebreaking capability was installed.

During the last period starting from the seventies the world icebreaking fleet was supplemented by 30 sea and polar icebreakers the total power of which was more than twice higher than power of the icebreakers built in the fifties and sixties. During this period in the USSR five the world's most powerful nuclear icebreakers of the Arktika type (see table 2.1) were built.

Running trials of the lead n/i Arktika were held in December 1974, those of n/i Sibir – in October 1977. The following two icebreakers of this class – n/i Rossiya and n/i Sovetskiy Soyuz - were built in 1985 and 1989 accordingly. In 1992 the fifth nuclear ship of this series – Yamal – was put into service. The last three nuclear icebreakers having the same dimensions and power of nuclear plant (NPP) equal to 55.1 MW differ from the lead icebreaker by the presence of a higher efficiency air bubbling system (ABS) of domestic production and by some structural improvements.

From 1974 to 1976 Wärtsilä Oy delivered to the Soviet Union three the world's most powerful diesel-electric icebreakers of the Yermak type to provide for linear escorting of ships in the Arctic, in 1982-83 – a series of three units of auxiliary sub-arctic icebreakers of the Mudyug type, where for the first time in the domestic and Finnish practice a diesel-geared propulsion plant was used rotating two controllable pitch propellers. The operational experience and full scale trials showed that ice propulsion and maneuverability of icebreakers of the Mudyug type including the movement astern were not satisfactory enough.

Within the framework of joint cooperation between V/O Sudoimport and Wärtsilä Oy the construction of two nuclear icebreakers Taimyr and Vaigach with a restricted draft was carried out. In 1988 and 1989 the icebreakers were accordingly transferred by the Finnish company to the Baltic Shipyard for completion and put into operation in 1989 and 1990. Icebreaker Taimyr, just as its predecessors Lenin and Arktika, is a turbo-electric nuclear ship with a three-shaft propulsion plant. However main powerplant incorporates one reactor instead of two which generates steam for two steam turbines being a drive for two main ac generators. A principle of single electric power system is realized on the icebreaker.

In recent years, shipbuilders of the countries dealing with the development of icebreaking technology, paid much attention to problems of the improvement of ships' ice performance due to the application of fundamentally new non-traditional hull lines requiring less energy consumption for the breaking of ice. A considerable body of work in this direction was performed in Canada, Finland, West Germany and Sweden. With the purpose of finding out promising character of foreign proposals for the icebreakers operating under conditions of the Arctic and in other freezing seas the Ministry of Merchant Marine through the Murmansk and Northern Shipping companies decided to refit icebreakers Mudyug and Kapitan Sorokin by the West German company Thyssen Nordseewerke and icebreaker Kapitan Nikolaev by the Finnish company Masa-Yards. The reconstruction involved the replacement of their forward ends with those of the Thyssen-Waas system for the first two icebreakers and of the so called 'conical' nose suggested by the Wärtsilä Marine for the third icebreaker.

Particular feature of the reconstructed icebreaker Kapitan Nikolaev is the use on the new forward end of the clad steel plating with an external stainless layer to prevent from the growth of the hull/ice friction resistance in the process of operation due to corrosion resulting in the considerable reduction of the icebreaking capability of icebreakers. For the first time, this idea was made a reality in 1986 on the Finnish icebreaker Otso on which simultaneously problem of the hull cathodic anticorrosive protection was being treated.

Among modern European sea-going icebreakers with non-traditional solutions as to the hull shape and rudder-propeller system one should distinguish Swedish icebreaker Oden built in 1988. The icebreaker has a simplified box-like form of hull with a flat stem and a wider, in comparison with main hull, forward end changing in the bottom wedge and making a cleaner wider channel as well as improving the maneuverability of the icebreaker. Besides, to raise the icebreaking capability, icebreaker Oden is equipped with powerful water washing and fast-acting heeling systems. To reduce the circulation radius of the icebreaker special side attachments were used, which abut against ice when icebreaker is heeling creating additional turning moment. On the icebreaker a motor-reduction unit with two nozzle controllable pitch propellers is used.

Among the largest foreign icebreakers built during last 30 years there were American icebreakers Polar Star and Polar Sea of the same type constructed in 1976-1977 with a combined propulsion unit consisting of a diesel-electric and after-burner gas turbine installation and Japanese icebreaker Shirase of 1982 construction with a diesel-electric unit of 26 500 kW. On icebreakers of the Polar Star type for the first time in the practice of icebreaker building controllable pitch propellers were used, power being directly delivered form gas turbines via reduction gear to propeller shafts. These icebreakers are used mainly for the research in the Arctic and also, as icebreaker Shirase, for the supply of Antarctic stations.

Specially for the Antarctic, Finland delivered to Argentine in 1978 a twin- shaft icebreaker Almirante Irizar with a diesel electric plant of 14 MW. One should mention as well German research icebreaking ship Polarstern built in 1982 and used for Arctic and Antarctic expeditions. This ship has icebreaking hull shape close to a traditional one with forward end in the form of a concave wedge, motor reduction unit with a power of about 15 MW and two nozzle CPP. Particular feature of the hull shape of Polarstern, as of a ship designed for long transits in open water, is presence of a box-like keel 1 m high protruding beyond the basic line and playing the role of a passive stabilizer.

For carrying out conventional icebreaking works on the escorting of ships in the Arctic and freezing seas Canada for the period in question completed its fleet by a series of three icebreakers of the Pierre Radisson type with a diesel-electric plant of about 13 MW and one icebreaker Henry Larsen, also with a traditional diesel-electric unit of about 18 MW, but with an AC propeller drives.

In the mid-seventies Sweden and Finland have set in operation icebreakers of the Finnish construction of the Atle type having four-shaft diesel-electric propulsion units with two stern and two bow propellers.

Particular feature of the last decade of the XX-th century in the field of icebreaker building was further improvement of conventional hull lines and rudder-propeller systems as well as the construction of new icebreakers of multipurpose type. The latters during winter period provide for the escorting of ships in freezing seas and in summer serve as supply vessels of offshore drilling rigs.

As an example of that may be the construction in Finland of icebreaker Fennica which was put into operation in 1993. The second icebreaker of this type Nordica was delivered in 1994. It is envisaged to use these ships not only for icebreaking operations in winter in the Baltic Sea, but also as offshore supply vessels in the North Sea during summer period. Such purpose predetermined rigid requirements to ensure, along with high ice performance, good seaworthiness and maneuverability in open water. Accordingly, a combined icebreaking and seaworthy hull shape of the new ship was elaborated and two azimuthing propellers with a power of 7 500 kW each specially manufactured by Aquamaster-Rauma were used as a main propulsion rudder unit. Besides, three bow thrusters with a ship's dynamic positioning were installed. Thanks to the possibility of directing propeller jet sideways the icebreaker was capable of making the channel with a width much larger than that of the icebreaker proper.

In 1998 the shipyard Aker Finnyrds Oy delivered to the Finnish Maritime Administration a new multipurpose icebreaker Botnica having smaller dimensions and power in comparison with icebreakers of the Fennica type (see table 2.2), but is equipped with Azipod propulsion system. The icebreaker is designed to escort ships in winter principally in the Gulf of Finland. In summer, she, as Fennica, serves as an offshore supply vessel in the North Sea. Besides, drilling equipment may be installed aboard the ship. Her functions include operations on rescue, patrolling and escorting of ships, oil spills combating.

In 1999 the polar diesel-electric icebreaker WAGB-20 Healy built in New Orleans at shipyard Avondale Industries to order of the US Coast Guard was put into operation. Along with its direct purpose, icebreaker Healy is constructed for the research works in high latitudes. Icebreaker Healy has a traditional improved hull shape permitting to work practically under any ice conditions keeping acceptable seaworthiness. Being a research ship the icebreaker is equipped with laboratories and living spaces for the accommodation of 50 scientists. On the icebreaker there is also a helipad with a hangar for a board helicopter. This icebreaker is the last one of the sea-going icebreakers built in the XX-th century.

3.3.2 Escorting of Cargo Ships in Ice

Independent navigation of transport ships in ice is substantially restricted. In arctic seas, even during summer period, ships, as a rule, need the icebreaker support. Sailing in convoys is the principal type of movement of transport ships under ice conditions.

The icebreaker escorting of ships is performed by two main methods: by leading

Table 2.1. **Principal characteristics of Russian linear and port icebreakers**

Characteristics	Arctic icebreakers						Sub-arctic and port icebreakers		
	Lenin	*Moskva*	*Yermak*	*Arktika*	*Kapitan Sorokin*	*Taimyr*	*Kapitan Belousov*	*Vasiliy Pronchishchev*	*Mudyug*
Builder	USSR	Finland		USSR, Russia	Finland	Finland–USSR	Finland	USSR	Finland
Year of construction	1959	1960-69	1974-76	1974-92	1977-1981	1989-90	1954-56	1962-71	1982-83
Number of ships in a series	1	5	3	5	4	2	3	14	3
Main area of operation	Northern Sea Route				Estuary of the Yenisey river and shallow areas of arctic seas		Baltic and White sea	Ports and their water areas	
Length, m									
overall	134.0	122.1	135.0	148.0	129.4/135.5/141.4	150.0	83.2	67.7	88.6/111.4
on design waterline	124.0	112.4	130.0	136.0	121.3/125.8/130.2	140.6	77.5	62.0	78.5/89.8
Width, m									
overall	27.6	24.5	26.0	30.0	26.5/26.5/30.5	29.2	19.4	18.1	21.2/22.2
on design waterline	26.8	23.5	25.6	28.0	25.6	28.0	18.7	17.5	20
Depth, m	16.1	14.0	16.7	17.2	12.3	15.2	9.5	8.3	10.5
Design waterline draft, m	10.4	9.5	11.0	11.0	8.5	8.1	6.2	6.2	6.0
Design waterline displacement, t	19240	13290	20240	23460	14900/16020/17270	19600	4500	3100	5560/6880
Type of powerplant	Nuclear	Diesel-electric		Nuclear	Diesel-electric	Nuclear	Diesel-electric		Diesel
Number and power of main engines, kW	4×8090	8×2390	9×3380	2×27580	6×3050	2×18400	6×1470	3×1320	4×2390
Shaftpower, kW	28800	16200	26500	49000	16200	32500	7700	3450	7000
Number and type of propellers	3 FPP	3 FPP	3 FPP	3 FPP	3 FPP	3 FPP	4 FPP	3 FPP	2 CPP
Speed in open water, kn	19.7	18.3	19.5	20.8	19.0/18.7/18.0	20.2	16.5	14.5	16.5/16.1
Icebreaking capability, m	1.65	1.45	1.8	2.25	1.3/1.8/1.9	1.95	1.0	0.7	0.95/1.5
Endurance as to fuel capacity, days	unlimited	38	28	unlimited	28	unlimited	28	17	30
Crew	175	85	91	145	83	110	85	39	32

Notes: 1) For icebreakers of the *Kapitan Sorokin* type the consistent data are given on the original icebreaker built by *Wärtsilä Oy* and on icebreakers *Kapitan Nikolaev* refitted by *Masa-Yards* and *Kapitan Sorokin* refitted by *Thyssen Nordseewerke*

2) For icebreaker Mudyug the data are given before and after refitting by *Thyssen Nordseewerke*

Table 2.2. **Principal characteristics of modern world icebreakers**

Characteristics	*Louis S. St.Laurent*	*Atle, Urho*	*Polar Star*	*Almirante Irizar*	*Pierre Radisson*	*Shirase*	*Otso*	*Henry Larsen*	*Oden*	*Fennica*	*Botnica*	*Healy*
Country	Canada	Sweden, Finland	USA	Argentina	Canada	Japan	Finland	Canada	Sweden	Finland		USA
Year of construction	1969	1974-77	1976-77	1978	1978-82	1982	1986-87	1987	1988	1993-94	1998	1999
Number of ships in a series	1	3 + 2	2	1	3	1	2	1	1	2	1	1
Main area of operation	Arctic	Baltic sea	Arctic and Antarctic	Antarctic	Arctic	Antarctic	Baltic sea	Arctic	Baltic sea	Baltic and Northern seas		Arctic and Antarctic
Length, m												
overall	111.7	104.6	121.7	119.3	98.2	134.0	99.0	99.8	108.0	116.0	96.7	128.0
on design waterline	101.9	96.0	107.3	113.4	88.0	124.0	90.0	94.0	93.2	96.7	77.9	120.9
Width, m												
overall	24.4	23.8	25.5	25.0	19.5	28.0	24.2	19.7	31.2	26.0	24.0	25.0
on design waterline	23.8	22.5	23.8	24.8	19.2	27.0	23.4	19.5	25.0	25.2	23.1	24.4
Depth, m	13.1	12.1	13.2	12.6	10.8	14.5	11.3	11.1	12.0	12.5	11.7	12.8
Design waterline draft, m	9.0	7.3	8.5	9.5	6.0	9.2	7.3	6.3	7.0	7.0	7.2	8.5
Design waterline displacement, t	13300	9800	13400	14900	8310	18600	9200	8290	13200	•	•	16260
Type of powerplant	Diesel-electric	Diesel-electric	Diesel-electric+gas turbine	Diesel-electric	Diesel-electric	Diesel-electric	Diesel-electric	Diesel-electric	Diesel Direct	Diesel-electric	Diesel-electric	Diesel-electric
Number of main engines	5	5	6+3	4	6	6	4	3	4	4	6	4
Main engines power, kW	26100	18380	15400/44700	14340	13230	26500	21840	17700	18000	21000	15000	28800
Shaftpower, kW	20140	16240	13400/44100	11900	10140	22080	15000	12000	17600	15000	10000	22000
Type of propeller	FPP	FPP	CPP	FPP	FPP	FPP	FPP	FPP	CPP in nozzle	Aqua-master	Azipod	FPP
Number of propellers (stern + bow)	3	2 + 2	3	2	2	3	2	2	2	2	2	2
Speed in open water, kn	17.0	18.0	17.0/21.0	16.5	16.2	19.5	18.5	16.5	16.1	16.0	15.0	17.0
Icebreaking capability, m	1.2	1.4	1.2/1.8	1.0	1.1	1.5	1.4	1.2	1.8	1.8	1.2	1.4
Crew	72	54	138	100	59	174	25	52	26	20	16	75

Notes: 1) The characteristics of icebreaker *Louis S. St.Laurent* are given after modernization in 1988
2) For icebreaker *Polar Star* with combined powerplant the data on speed and icebreaking capability correspond with powers of diesel-electric and gas turbine plants
3) In some countries (Canada, USA, Sweden) the icebreaking capability estimates at the speed of 3 knots, for Finnish icebreakers *Fennica* – at 1 kn, *Botnica* – at 4 knots

and by towing.

Escorting by leading

When escorting by leading, ships move independently along the channel following an icebreaker-leader which makes the route in ice (fig. 2.4). The leading icebreaker follows the main principle of the choice of the easiest way with the use of cracks and clearings in the ice cover avoiding heavy hummocking formations. Simultaneously ice performance and maneuverability of transport ships imposing restrictions on the sinuosity of the channel were taken into account.

Fig. 2.4. Escorting of cargo ships in ice by leading

Along with simple convoys implying the sailing behind one icebreaker of one or several cargo ships, composite convoys may be formed, when a group of ships is escorted by several icebreakers. For the leading of composite convoys powerful linear icebreakers are used. Other icebreakers, as auxiliary ones, forming a part of a composite convoy, as a rule, are less powerful and carry out the breaking down of ice around stuck ships ahead and the escorting of those behind. These icebreakers may be also used for widening and rectifying the channel made by the leader or for towing more weak ships restraining normal advance movement of the convoy.

Correct choice of the distance of escorting and of speeds of the convoy is one of the main factors to ensure safe and efficient ships' escorting by the method of leading.

Minimum safe distance is determined by the length of stopway of ship in the event of its urgent braking with the reverse of propeller when moving in the channel behind icebreaker, if a suddenly emerged ice obstacle results in sharp braking and stoppage of the leading icebreaker. The ship should be capable of suppressing inertia and to stop avoiding collision with the icebreaker or with a ship in the convoy ahead. At the same time, unjustified increase of the distance between ship and icebreaker leads to the reduction of speed of the escorting in ice due to the probable narrowing of the channel under conditions of compression, its greater fullness with broken ice and accordingly to the higher ice resistance. Therefore optimum distance is that close to the safe one. Minimum safe distance depends on the initial speed of ship, its displacement, hull lines, time of reversing and ice conditions.

For the avoidance of ice damages of ship's hull structures with insufficient level of ice strengthening when moving behind icebreaker through ice of different characteristics the speed of escorting should not exceed certain safe speed values. Restricted, that is reduced down to a safe level, ships' escorting speeds are obtained by calculation depending on structure and hull lines, dimensions and displacement, age and state (wear) of the shell plating. Information on safe speeds of the movement of ship in the channel behind icebreaker and safe escorting distances is contained in a regulating document called the ship's ice passport. Availability of the ice passport enables soundly assigning principal parameters of safe operational modes of the movement of ship in ice.

Towing of ships in ice

Towing, that is the way of escorting when ship is taken in tow by icebreaker to be used under heavy ice conditions, especially with ice compacting as well as in moving along the 'tight' channel made in thick compact or heavy hummocking drifting ice, if a cargo ship is not capable of moving independently in the channel behind the icebreaker. In the overwhelming number of cases it is a 'close' towing (fig. 2.5). With such method the bow of a towed ship is pulled into the icebreaker stern cutting and fastened by a towing line called 'whiskies' running through hawse pipes. At the same time, in similar ice conditions and in 'old' ice channels made through the fast ice the towing in a short tow may be used the length of which usually does not exceed 50 m (fig. 2.6).

Advantage of the tow escorting is that towing speed is close to the speed of icebreaker under corresponding ice conditions. Therefore the towing permits to retain a high rate of escorting and serves as a means of smoothing disbalance between engineering capabilities of powerful icebreakers and cargo ships resulting in shorter time of ships being on ice route contributing to higher efficiency and safety of the ice navigation.

Fig. 2.5. Close towing with ice compacting

Organization of convoy

In the icebreaker escorting of ships matters concerning the formation of convoy, that is determination of number, arrangement and order of movement of ships (convoy's order) as well as choice of a safe distance between ships and speed of


Fig. 2.6. Towing in a short tow in the Yenisei Gulf

escorting when moving under different conditions are of importance. On the basis of practice of icebreaker escortings, when drawing up a convoy's order a ship of the lowest hull strength (ice class) and power is the first to follow the icebreaker, as it permits this ship to move in the wake behind the icebreaker and accordingly in the section of the channel less filled with broken ice. Ships as their power, strength and other ice performance qualities become higher follow.

The number of ships in convoy, method of their escorting and 'load' per one icebreaker (number of ships escorted by one icebreaker) are determined depending on ice and weather conditions, particular features of the area of navigation, characteristics and ice class of ships to be escorted and icebreakers taking part in the escorting. So, in the heaviest (extreme) cases as to ice conditions the convoys may be made up in such a way that each cargo ship is assigned to one linear icebreaker and taken in a close tow in the wake behind the leader (fig. 2.7). When number of icebreakers is not sufficient or escorted large ships with displacement exceeding that of icebreakers stick in some heavy places, the breaking down of ice around ships being not efficient, leading icebreaker uses method of pushing setting a bow against the stern towing fender of ship and working with it in 'tandem'.

Fig. 2.7. Escorting of cargo ships under heavy ice conditions each ship being towed by a single icebreaker

It should be noted that problems of large ship escorting are becoming of special urgency in connection with the perspective of the seaborne transportation of oil and liquefied natural gas extracted from deposits of the arctic zone. As the practice already gained shows, with the use in ice conditions of large ships the width and mass of which substantially exceed that of icebreakers the application of the above described conventional escorting scenario becomes problematic. Escorting of a large ship in the channel behind icebreaker increases hazard of risk, as with a sudden braking or stoppage of a leading icebreaker under conditions of a sharp worsening of ice conditions en route the probability is high of the collision of a large ship having acquired high inertia with the icebreaker which has lost its speed. On the other hand, in ice compacting conditions, a wide and long ship quickly loses its speed in the narrow channel right up to stopping and despite breaking down ice around the ship it is rather difficult to resume movement of such ship without possibility of taking it in tow. These circumstances necessitate the search for other ways of large ships' escorting. In particular, instead of leading, under relatively light ice conditions one has to resort to the individual escorting of ship by the icebreaker, instead of towing under heavy conditions – to pushing and in ice compacting – to the stepwise escorting by leading, when ship is following the icebreaker getting in parallel course at a possibly close distance thus permitting to break off ice into the channel not yet frozen up by compacting. From the design point of view, to ensure reliable escorting of large ice ships it is of great importance to choose a rational relationship between power of escorted ship and icebreaker.

Maneuvering in ice

For safe escorting of ships in ice it would be desirable to keep the convoy movement possibly rectilinear and non-stop. Sudden and frequent turns of icebreaker in ice complicate a lot the movement of ships, especially of large ones, in a resulting curvilinear channel. Therefore all the turns of a ships' convoy in ice are made as smooth as possible and a sharp course change is accomplished gradually in several steps by 10-15^o.

As a rule, when escorting ships under certain ice conditions a leading icebreaker has some margin of strength permitting to continuously surmount obstacles en route in the form of hummocked conglomerations or ice isthmuses. However, this does not exclude the necessity under especially heavy circumstances or in the absence of such margin of strength to resort to the forced crossing of ice by ramming. The forced crossing of ice by icebreaker is carried out by a number of methods developed in the practice of the escorting of ships in ice. Adequate takeoff run on the average is two-three hull lengths of the icebreaker. When working by ramming the icebreakers not fitted with the air bubbling system are subject to hazard of being beset in ice for a long time. During the forced crossing of ice isthmuses the convoy ships are left in the channel of icebreaker at such a distance lest the maneuvering of the latter is impeded.

In separate cases, instead of ramming the channel is broken through by stern moving ahead. In so doing the icebreaker is proceeding mainly without stopping and speed of making the channel, all other factors being the same, is two-three times as high as in the continuous work by ramming. However, in this case the risk is higher of damage of the icebreaker power helm unit, therefore in heavily hummocked thick ice this method is not used.

Special methods of maneuvering in ice involve breaking down of ice around ships by icebreaker. Main purpose of this procedure is that icebreaker passing alongside the ship stuck in ice somewhat relieves it of concentration and enables it of getting again underway. In individual cases the breaking down of ice is performed for generating a 'pillow' of small ice cake along hull of a drifting ship with the purpose of diminishing ice pressure against hull during compacting. There are two main types of breaking down ice around ship adopted in practice: by stern and by bow.

The first method is the most convenient and rapid one. It implies that icebreaker having received notification of the escorted ship being stuck in ice goes astern along the ship's side. The method of breaking down ice around ship by bow requires preliminary turn in ice by circulation or by 'herring bone' technique. It is usually used, when it is necessary to break down ice simultaneously around several ships stuck in ice.

When full-bowed ships are moving in the channel behind icebreaker, the formation of ice jams is frequently observed. Such ships are not forcing ice apart, but pushing broken ice ahead which gradually accumulates and consolidates leading to the stopping of ship. In such cases the icebreaker moving astern approaches closely to the jam and working up full speed ahead by propeller jets is washing out and driving ice alongside; after that ship is getting the possibility of moving.

3.4 Loading Facilities

In the Arctic, the decision of exploitation of a large hydrocarbon field involves huge investments and is strictly correlated to the possibility of organising regular, safe and profitable systems of transportation of the produced natural resources.

In the chain of the maritime transportation system, the end links are represented by the loading and unloading terminals, which constitute crucial points of accumulation of coordinated activities involving infrastructures and vessels.

The cruciality of the loading facilities can be ascribed to many reasons:

- the loading terminal is a bottleneck where the oil is conveyed from the exploitation areas and, due to the hostile nature of the environment, an uninterrupted availability is hardly achievable,
- conventional open-water loading systems with floating hoses cannot be used in the Arctic, due to the presence of ice, therefore innovative solutions suitable to allow safe and regular operations all year round need to be conceived and the identified ones, tested in operation,
- loading facilities have an important weight in the economics of the transportation system, due to the large capital investments (CAPEX) needed to create the infrastructures and the large operating costs (OPEX) to maintain operability and adequate safety levels,
- looking at possible risks during Arctic marine transportation, the loading operations are the most important issue, due to:
- the challenging environmental scenario, characterised by low temperature, ice, wave, wind exposition and current, as well as the uncertainty on long term data,
- the high distance from existing infrastructures,
- the large quantities and the high transfer flowrates of products to be handled,
- the need to keep the product parameters within defined limits,
- the movement of a number of vessels in proximity of fixed infrastructures, in exposed locations, with higher risk of human errors (approach, communication, operation control) and of equipment failure (vessel, cargo circuit, control system)
- the limited experience of Arctic loading. Although many years of experience of ships have demonstrated the feasibility of Arctic navigation, at least with the support of icebreakers, the loading operations still remain a task where significant research and development work is needed from the technological and organisational points of view.

3.4.1 Experience

The past experience with offshore loading dates back to the petroleum activities in the Canadian Arctic (Beaufort Sea), in the Seventies: many wells were drilled from gravel islands, floaters and caissons and many studies have been undertaken for tanker loading arrangements, but offshore production never became a real scenario. Year-round operations, with freighters of limited size, as well as with escorted tanker operations, in the Pechora Sea, for a number of years, have documented that year-round tanker transport is considered feasible and safe. Export operations, on an extended seasonal basis, have been initiated half a decade ago, in the Russian Far East, related to oil production at Sakhalin. Not to forget freighters operations in the Baltic Sea, Bothnia Gulf and, on seasonal basis and for limited quantities, in the Canadian and Russian Arctic. In particular for the Barents, Pechora and Kara Seas, a large number of studies have also been ordered in the latest 20 years, mainly sponsored by Oil and Gas Companies, with the substantial help from the Russian Design and Research Institutes.

At present, although no year-round large scale loading operations of tankers are maintained in the Russian Arctic offshore yet, the situation is riper since there are plans to make infrastructures ready to such purpose, taking into account that larger and ice capable vessels start to be available and others will be completed in the immediate future. In fact:

- at present, a project is in progress for extension of the existing temporary terminal of Varandey, to increase exported oil volume and size of received tankers,
- projects for large volume year-round export from offshore fields (Sakhalin, Prirazlomnoye) proceed towards completion and others for transportation from Western and Central Siberia onshore fields are at present matter of discussion.

In addition, research projects are going to create a platform of knowledge for Russian Arctic operations and ARCOP project is an example.

3.4.2 Design

Within the ARCOP Project, it has been envisaged to develop, at a conceptual level, an offshore tanker loading facility intended to be suitable for the oil export from the Varandey Area onshore fields.

Among the various commonly considered loading solutions, i.e. the direct loading from the platform, the loading from a Fixed Loading Tower, the Submerged Turret Loading and the SBAM system, the selected concept for the study was the fourth one. The reasons lay on:

- the offered unique safety characteristics of the SBAM, compared with other massive Single Point Mooring concepts, which expose critical elements to risks of damage for tanker impacts,
- a preliminary comparison of four methods for loading, made within ARCDEV Project, which considered the SBAM system a promising solution for Arctic and Sub-Arctic applications.

The original SBAM (acronym of Sea Bed Anchor Mooring) was developed by Tecnomare in 1996 for open water applications, but, due to its peculiar characteristics and after introduction of specific features on the mooring and loading components, its applicability was extended to Arctic and Sub-Arctic scenarios. The main functional characteristics of the concept can be summarised as follows:

- all crucial structural and mechanical components for mooring and loading are integrated in a subsea template. The 'lobster line', a hollow mooring line consisting of modular steel elements protecting the hoses, is the only element piercing the sea surface,
- remote actuation of the subsea valves from shore permits the control of the loading operations and the prevention of any significant oil spill, also in case of accidental damage to the hoses,
- the remote control of the basic parameters of the system and of the product is performed from shore,
- the crucial system components can be temporarily removed, if needed, for exceptional inspection and maintenance operations,
- with the use of interchangeable components for mooring and loading, the best performance both with 'winter' and 'summer' scenarios can be achieved.

The Arctic SBAM incorporates also significant prevention measures against oil spillage.

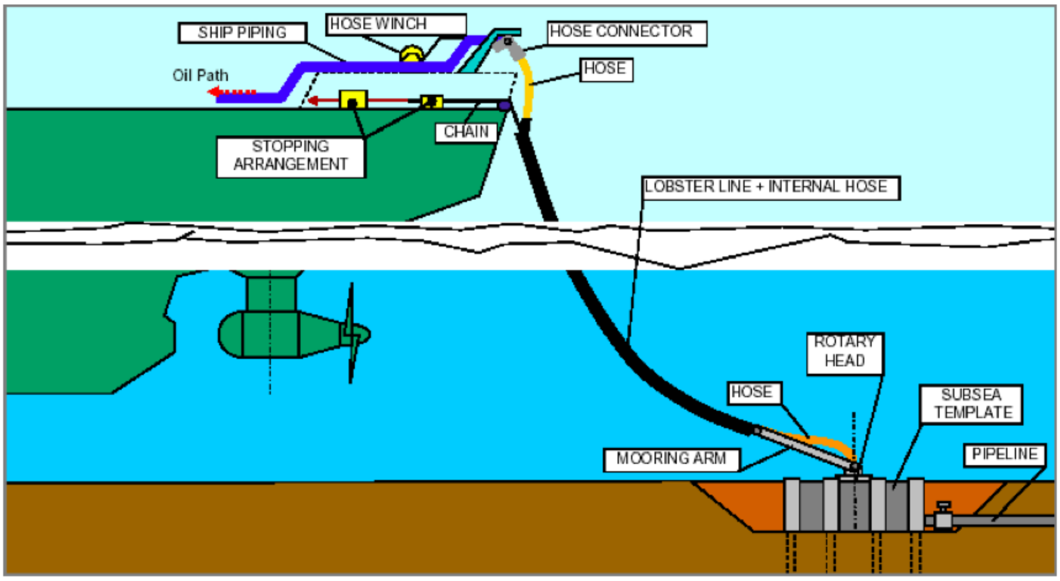
The main components of the Arctic SBAM system are:

- the subsea template, a six pile framed structure which transfers to the foundation piles the mooring loads applied to the rotary head. The template is installed in a trenched hole;
- the rotary head, located in the central part of the subsea template. It permits the weathervaning of the connected tanker all around the subsea template and provides the firm connection for the lobster mooring line, through a mooring arm;
- the lobster line, which integrates the functions of mooring line and loading hose and consists of a hollow string of hinged modular steel elements. It houses the flexible hose string for oil transport, which remains, in such a way, protected from any contact with the external ice formations. At the SPM side, the lobster line is connected to the mooring arm hinged to the rotary head;
- the product handling system consists of the subsea ball valves, which intercept the pipeline ends, the rigid piping, the product swivel and a rigid pipe section ending with a flange for connection of the flexible hose;
- the subsea control and monitoring unit, which permits to control and actuate the valves and to monitor the functional parameter of the handled product. It is connected to the onshore control room by an electrical umbilical.

For operation during the ice-free season, the lobster line with its internal hose string are replaced by a conventional mooring and loading assembly, consisting of a fibre rope hawser and a submarine hose string, connected to the mooring arm of the SBAM. This permits the application of the system as a conventional SPM for open-waters.

Within the ARCOP Project, the term 'loading facilities' has been referred to the offshore tanker mooring and loading system and the relevant pipeline system, up to the onshore storage and pumping station, as main components of the Loading Facilities.

The conceptual design process relevant to a loading facility, once the candidate type has been identified, starts from the compilation of the design basis, where the main data to be considered for the design of the loading terminal are defined, such as environmental conditions (including, e.g., ice, tide, wave, wind, current and temperature), soil conditions, functional and operational requirements (such as product data, export volume, loading rate), requirements regarding onshore storage, safety and environmental protection, applicable codes and standards. For this specific case, the scenario has foreseen loading of tankers of maximum 120,000 t DW, with a production level of about 330,000 bbls/day and a 48 km distance of the loading point off the coast, to reach a site characterised by water depth of about 22 m.



Operation during winter season with a Double-Acting tanker

At the initiation of the design work, which, as it is known, requires an iterative approach, statistical analysis of the environmental data was needed, to obtain long term, seasonal and, when possible, directional data. Monthly distributions of ice thickness and extreme values of thickness and drift velocity were fitted with statistical distribution functions.

The analyses to determine the variations of the thermo-hydraulic conditions of the handled product from the onshore plant, i.e. the pumping and storage complex, to the tanker receiving bow manifold, through the pipeline and the SBAM, require consideration of a range of pipe sizes and use of dedicated codes, which account for thermal transmission, hydraulic losses, composition and physical properties of the considered oil blend. PIPESIM multiphase simulation software was used to this purpose.

A primary design objective is to ensure that the required flow is driven by the pumping pressure available at the storage area, by optimizing the balance between cost of the pipeline materials, (which increases as the line diameter increases) and pumping plant and power generation costs (which decrease as the line diameter increases, because of the reduced pressure drop along the line).

Sensitivity analyses have been performed on four pipeline diameters whereas the wall thickness has been designed to resist internal pressure and to satisfy on-bottom stability criteria. Finally, two separate 28" lines in a loop have been selected for the pipeline, to allow pigging from shore and to enhance safety during installation and operation. The size of the piping on the loading system was also defined.

Having defined layout of the loading system, the mooring load assessment must account for both the 'winter' and 'summer' season operational conditions. For the considered scenario, the former condition clearly dictates the size of the structural components, however, in the Pechora Sea, waves, wind of current loads impose limits to be ascertained by proper hydrodynamic analyses and compatible with the use of standard arrangements (according to OCIMF guidelines) of conventional tankers and with the achievement of sufficient bottom clearance for the vessel.

For the arctic tanker connected to the Single Point Mooring with the lobster line, in presence of ice, the mooring load assessment followed successive steps:

- a preliminary calculation, based on a static approach, by using analytical methods to determine the ice resistance on the tanker and the direct load on the lobster line, as well as finite element programmes, where the external forces determine the geometry and loads on the lobster line and consequently on the structure of the SBAM;
- a more comprehensive calculation, by adopting an empirical approach based on experimental results of model tests of the SBAM, combined with analytical formulations to properly scale the forces for the 120,000 t deadweight tanker. The model tests have been carried out at the HSVA Ice Laboratories, in Hamburg, within the IHP Programme of the EU.

Thus, curves as a function of the ice thickness have been built-up, of use for the operability analysis of the SBAM.

The structural analyses of the subsea template and of the rotary head required the preparation of suitable structural models, which the load carrying elements are modelled in, and the identification of a number of load conditions, to cover the operational load envelope. The wire frame model of the subsea template included the constraints on the foundation piles imposed for the considered soil conditions. A solid model has been adopted for the rotary head.

The stress and stability checks have been carried out in accordance with the API and AISC codes.

Analyses at a more advanced design level would require consideration of the fatigue phenomena due to cyclic loads.

Proper design of the foundations includes pile axial capacity and pile yield checks, which were part of the executed design work.

The lobster line, characterising components of the SBAM, was preliminarily sized, after evaluation of a number of alternatives and the structural analysis permitted to ascertain its adequacy to bear the design loads. Stress levels have been determined by using a finite element model, for both aligned and rotated conditions of the elements and consistency with the adopted API codes has been checked.

3.4.3 Performance

The evaluation of the performance of a loading system calls for the assessment of its availability for tanker mooring and loading operations, for the site environmental conditions encountered throughout the year. The operability of a terminal is evaluated on annual basis, by assessing the time percentage which preset mooring load thresholds are not exceeded during the ice ('winter') period and the remaining ice-free ('summer') part of the year. The remaining time percentage represents the downtime, i.e. the condition which requires that the produced oil is stored at the onshore complex as the tanker cannot remain connected to the sea berth. Therefore, the downtime expressed in number of days per month, provides the information needed to establish the needed storage volumes of the onshore facilities.

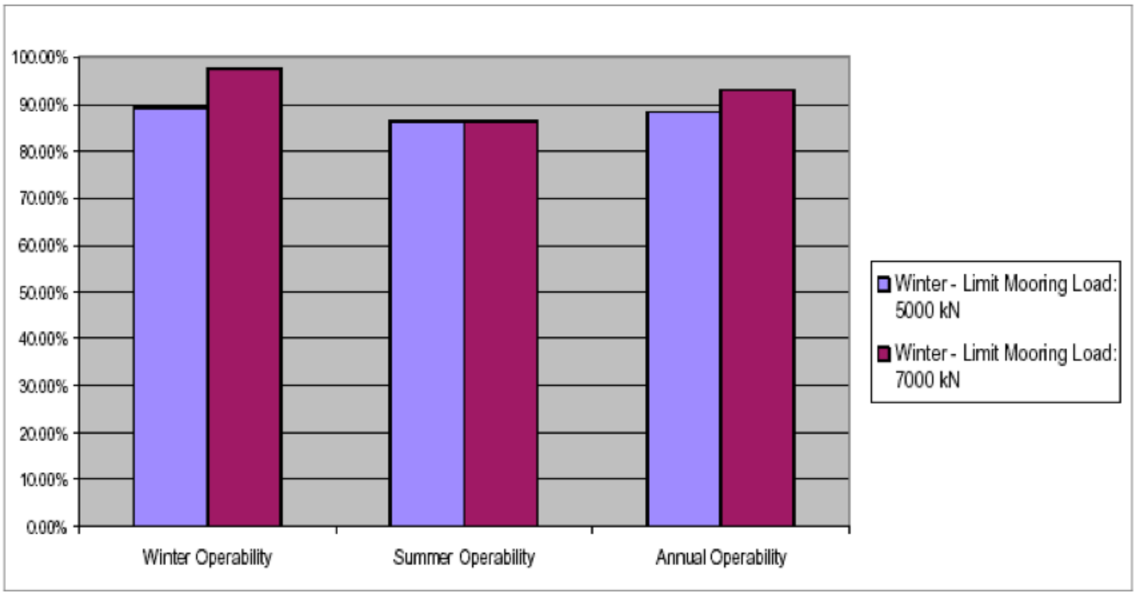
Considering the difference in the 'summer' (wave, wind, current) and 'winter' (ice) scenarios, separate calculations of operability have been performed and then combined accounting for the relevant durations.

For evaluation of the operability of the SBAM during the 'winter' season, use has been made of the relationships mooring tension vs. ice thickness determined through the mooring load analysis. Weibull distribution functions have been adopted to model the occurrence frequencies of ice thickness and of the ice drift speed. Information on the ridge occurrence frequencies and adoption of equivalent level ice thicknesses would permit to extend the adopted procedure, with the due simplifications, to deformed ice scenarios.

The operability for the remaining 'summer' months has required the execution of time domain simulations with a dedicated hydrodynamic code and a conventional trading tanker. The operational limits have been determined for various combinations of aligned and disaligned directions of wind, wave and current. The frequencies of occurrence of the incoming wave, wind and current have been modelled with Weibull distribution functions, to determine, for the values of occurrence probability corresponding to the predetermined operational limits, the summer operability.

Model tests with angled ice rift

For evaluation of the operability of the loading system, preset threshold values of the mooring loads are established and, if necessary, modified to achieve the desired operability. For the case under study, 5 MN and 2.5 MN were considered for the basic 'winter' and 'summer' calculations with a typical Arctic tanker and a trading tanker respectively, both having a 120,000 t deadweight. Neither contribution of the propulsion, nor assistance of an icebreaker for ice management has been prudentially accounted for. An operability calculation by accounting for a forward thrust corresponding to 35% of the bollard pull, to reduce the loads, indicated a significant increase of operability, which reaches, for the 'winter' period, about 90%. Active assistance from the propulsion system of the tanker, DP capabilities, azimuthing propellers, such as the Azipod, and stern thrusters to improve the capability to weathervane can significantly further reduce the mooring loads and increase the availability of the terminal to levels experienced with conventional systems for open waters. A further and determinant contribution to the reduction of the loads derives from the ice management actions undertaken by support icebreakers, which would permit the loading facility to operate, during the cold season, in a continuative mode.



Operability of the loading system, with forward thrust (35% of the B.P.)

3.4.4 Costs

The identification of the size of the main components of loading system and of the pipelines, the definition of outline installation procedures and of routine operations envisaged to guarantee a long term, proper and safe performance of the terminal constitute the basis for determination of the Capital Expenditure (CAPEX) and annual Operating Expenditure (OPEX) costs.

The CAPEX cost estimate required an examination of the sequence of realisation of the infrastructure, of the durations of the operations and of the involved vessels and equipment.

Items considered for the indicative CAPEX estimate have included:

- Engineering, project management & supervision, planning and logistic organisation,
- Classification & certification,
- Model testing,
- Insurance,
- Material & procurement, construction, assembly & installation, testing, commissioning & start-up of the onshore and offshore parts of pipeline system,
- Material, procurement & fabrication, loadout & marine transportation, installation, final commissioning & start-up for the SBAM system,
- Spare Parts.

For OPEX cost estimate purposes, the following items have been accounted for:

- SBAM System: periodical inspection and maintenance, arrangement for operation in ice-free and ice seasons, periodical planned replacement of components,
- Pipeline System: condition monitoring, maintenance and minor repairs.

The CAPEX cost estimate, exclusive of the onshore storage and pumping complex, considered part of the onshore treatment plant, has led to a figure of about 350 Million Euros, while the resulting annual OPEX results to represent about 1.7% of the capital expenditure.

3.4.5 Aspects to be investigated for further development

Based on the highlighted issues, which outline the work performed within ARCOP, for the part dedicated to loading facilities, the following recommendations are considered of importance for further development work and to secure, within a feasibility study, a reliable and proven site-specific solution:

- to establish, since the beginning of a project, a sound and, to the maximum extent, comprehensive design basis, to clearly define the available data, the assumptions, the functional requirements and requirements to fulfil. In particular, the design basis should include:
- environmental data of the area, on a long term basis and covering the whole year. Frequencies of occurrence should be accounted for ice, wave, wind, current and when practicable, directional statistics should be included. Extreme tidal ranges and monthly ranges of air and water temperatures should be considered, as well as visibility, which is important for the operability. Directional extreme values should be included on a statistical basis, covering return periods between the 100-year and the 1-year conditions;
- process data of the terminal, where in addition to the functional requirements, the operating requirements such as pigging, simultaneous handling of products, heating and in general treatment requirements are defined;
- tanker data, which, in addition to dimensions, cargo volumes and performance in ice, define also manoeuvring and propulsion control capabilities, strength capability of the arrangements for mooring and data on the loading arrangements, to ascertain the suitability to loading operations in 12 to 18 hours maximum;
- support fleet data, where the availability and extent of icebreaker support, as well as achievable ice management capabilities are defined;
- geophysical and geotechnical soil data, including also seismic data, if relevant, and occurrence of ice scouring and permafrost;
- oil data and loading system data, with type and composition, viscosity, specific gravity, arrival pressure and departure temperature, as well as loading rate;
- governmental rules, codes and industry standards to be adopted;
- to investigate, within successive steps in the design of the terminal, addi-

tional aspects relevant to:

- testing of operational procedures for approach to the terminal, mooring and loading, safe and expedient disconnection, and control of the tanker during loading. Such tests could be performed in laboratories, at model scale and, for some particular aspects, at semi full scale in selected representative locations;
- model testing of operational conditions of the loading facility in moving ice, considering the control of the tanker propulsion and the ice management action. Such tests would permit to analyse the effects of control on the mooring loads and to calibrate analytical methods, although it is known that the process of assessment of the mooring loads should take into account both results and, as far as practicable, to utilise also data from full scale measurements;
- evaluation of the suitability of off-the-shelf materials and equipment for the intended service at low temperatures and possible qualification of the same. This is of relevance for the materials of the structure and of the product handling system, as well as for components such as valves, swivels, bearings and particularly flexible hoses. In this respect, the SBAM would minimise such problems, being most of the system located underwater;
- risk assessment of the terminal, to identify the situations with higher risk, determine their probability occurrence and consequence, so as to arrive at the assessment of the risk level of the facility and, if necessary, to identify measures to reduce and mitigate the risk. Such analyses are normal practice in the offshore oil industry, but are of particular importance and should be tailored to systems, which operate in a hostile, lacking of infrastructures and conventional means at short distance and fragile environment as the Arctic.

3.5 Economics of the Transportation

The Economics of the Transportation is the main basis for conclusions of the feasibility of the alternative technologies to be used for the transportation. The ARCOP scenario is described in the report D3.1.3 "Design Basis for the Transportation System". The purpose is to transport 328.000 barrels day production from Varanday area to the European market. The fleet alternatives are described in the reports D3.2.1-2 "Parameters of the Transportation vessels" and D3.3.1 "Parameters of the Assisting fleet". The loading system to be used at the Varanday is described in the reports D3.4.1-4 "Loading Facilities". The computer simulations presented in the report D3.5.1 give the following data to be used as basis for the economic evaluations:

- Fleet size (number and size of tankers, number of icebreakers)
- Required storage volume
- Fuel consumption for tankers
- Fuel consumption for icebreakers

In this study the cost of transportation is calculated for following cases:

- Three different tanker sizes
- Two different modes of operation
- Two alternative routes
- Three different type of icebreakers
- Three different severity of winters

3.5.1 Study cases

Base cases

The base case assumes average type of winter and tankers with the capacity of 90.000 tdw. The fleet size was defined based on the capacity to transport all the produced oil within a year. This means that during the winter part of the oil will be stored and transported during the summer. The base case was divided into two sub-cases. Case 1.1 is conventional icebreaker assisted operation. This was compared to the alternative of independently operating tanker, Case 1.2. Both of these were divided in four sub-cases, two with direct transportation from Varanday to Rotterdam, Cases 1.1-1. and two with transshipment in Murmansk, Cases 1.1-2.2.

Winter type

The influence of winter types was studied by varying the ice conditions to correspond mild winter (P20) and heavy (P80) probabilities. This was done for all base cases listed above.

Tanker size

The effect of the tanker size was studied by making the simulation with 60 000 tdw to 120 000 tdw for all base cases.

Icebreaker type

The influence of icebreaker type was studied using the base cases and following alternative icebreaker solutions:

- wide bow single icebreaker, case 4.1.1
- one leading and one assisting icebreaker, case 4.1.2
- single oblique icebreaker, case 4.1.3

Fleet size and storage

The fleet size was defined so that the fleet was capable to deliver all the produced oil during the whole year. The basic fleet consists of a number of ice strengthened or ice breaking tankers. To minimize the number of tankers needed fot the basic fleet was minimized with the help of storage during the wintertime and with the help of open water tankers during summer time. This was done for all cases.

3.5.2 Cost calculations

The computer simulations have been described in the ARCOP report D3.5.1. For the economic evaluation following costs were considered:

Fuel cost for fleet

Different operational modes and operation hours in each mode have been separated for calculating the fuel cost of the fleet. Different modes are: sailing in open water, sailing in ice, loading/unloading and waiting. Total used energy is calculated when power consumption in each operating mode is known. Typical bunker consumption and lubrication oil consumption is assumed for calculating the total cost.

Operational costs

In this part, other operational costs for fleet (pay-roll, supplies, daily running costs, etc.) have been summed up.

Round trip based costs

This part is mainly costs of cargo handling when knowing the total number of loadings/un- loadings.

Shore side

This cost is assumed to be the office costs on shore.

Capital cost of fleet

Building costs of the fleet, based on estimated ship prizes from D3.2.1

Capital cost of loading system

Building costs of loading system according to D3.4.4

Storage cost

Capital cost of building the needed storage. Since the storage design was not part of the ARCOP, rough estimate of 200 Euro/m3 was used. The size of needed storage comes from the maximum cumulated volume of production-transportation balance in roundtrip calculations.

Cost of chartered tankers

Yearly costs if decided to charter open water tankers for summer months. The tanker size is Aframax of 106.000 tdw. This type of tankers are generally available, even with ice strengthening up 1 A class. The time charter rate used was 30.000 Euro per day.

Murmansk terminal cost

This cost is only for cases when transshipping oil via Murmansk. It is assumed to be additional storage and handling costs in Murmansk. The transshipment cost in Murmansk was taken as 2.6 Euro per ton.

Cost for open water tankers

Costs of transporting oil from Murmansk to Rotterdam were taken as market price for similar route. The value used in this study was 0.6 USD per ton of oil.

Icebreaker costs

Building and operational costs for icebreakers were estimated from the technical parameters presented in the ARCOP report D3.3.1. The costs are presented in the table below:

Number of needed icebreakers was calculated from fleet ice-sailing hours. The fuel consumption was calculated based on power used in ice.

Type of Icebreaker	LK-18	Wide Body	Taymyr Oblique
Building cost	80 000 000 Euro	100 000 000 Euro	40 000 000 Euro
Fuel cost	Actual cost	Actual cost	Actual cost
Operational cost	6 600 Euro/day	6 600 Euro/day	6 600 Euro/day

Fees

In this study the fee that each vessel had to pay was the one collected for waterway maintenance. The amount that was used was 1.2 Euro per ton of cargo. The icebreaker costs were calculated as actual costs based on the use of icebreakers. The independently operated tanker did not pay any fees for the icebreaker service.

Other arrangements to collect the cost of icebreakers have been studied in the ARCOP report D 2.5.1 b "Economic influences of the different fee systems".

Insurance

The insurance costs were taken from the ARCOP report D 2.4.2. The insurance cost issue was also discussed at the ARCOP Workshop 7.

Required Freight Rate

As a final result, total required freight rate is calculated by dividing total costs with delivered cargo per year.

3.5.3 Results

The summaries of the cost calculation results for the different routes and other parameters are presented in tables 1 to 4. These results have been used analyze the influence of:

- Operational mode

- Tanker size
- Route option
- Winter type
- Icebreaker type

It should be noted that the impacts of the parameters here are presented as if they would be independent. However there is some correlation between the impacts. The impact of the winter type for instance is different for the different route options. These interrelations are discussed more in detail in the chapters below.

Route alternatives

The route alternatives that were studied were copared were the direct transportation from Varanday to Rotterdam versus transshipment in Murmansk. In the transshipment alternative the cost for the use of the transshipment terminal was taken as a fixed fee per ton of oil. The results of the comparison are presented in figure 1. The figure also shows the impact of the two operational modes, independent Double Acting Tankers versus icebreaker assisted conventional ice strengthened tankers. The comparison is based on actual costs, not on any fee system for icebreaker assistance. In both cases the direct transportation is more feasible. The difference is smaller with the alternative where conventional icebreakers are used together with the icebreakers. The reason for this is that the conventional tankers have an icebreaking bow form, which is inefficient in open sea conditions. The use of such vessels to sail between Murmansk and Rotterdam is not feasible. The Double Acting Tankers have the bow optimized for open water conditions and thus they are, although more expensive to construct still more feasible to operate in direct transportation.

Size of tanker

The effect of the tanker size was studied separately for the two routes and for the two modes of operation. The results are presented in figures 2 and 3. Mainly the results show the generally accepted principal that with larger vessel you get

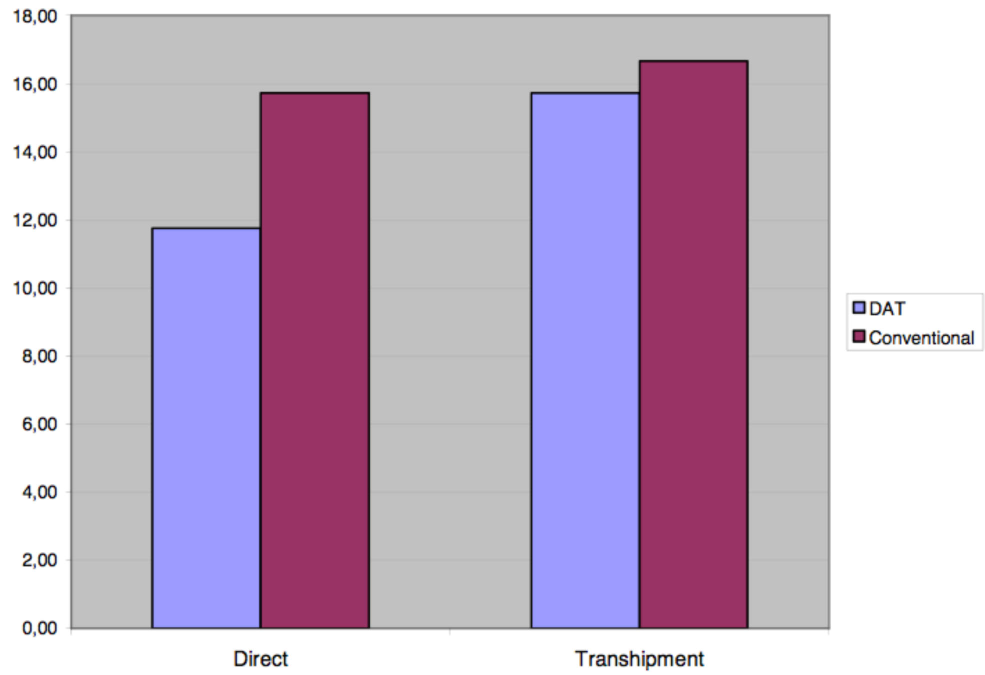


Figure 1

lower costs. The tendency is however quite weak. In the case with Double Acting Tankers on the route Varanday – Murmansk the increase in the vessel size from 90.000 tdw to 120.000 tdw even increases the costs. This result comes from the fact that on a short route the large vessels are non-flexible and the result is a large storage required during the wintertime (see also report D 3.5.1). There is similar tendency with the conventional vessels on this route but not quite as strong as with the Double Acting vessels. The reason for this is that in the case with the conventional tankers the same number of icebreakers is needed for all the tanker sizes and thus part of the overall costs are not increasing with the increasing size.

Icebreaker type

The study was made for three different types of icebreakers and one case with independently operated tankers. The icebreakers that were compared are:

- Conventional 18 MW icebreaker LK-18
- Modified Taymyr type icebreaker with reamers, Taymyr V3

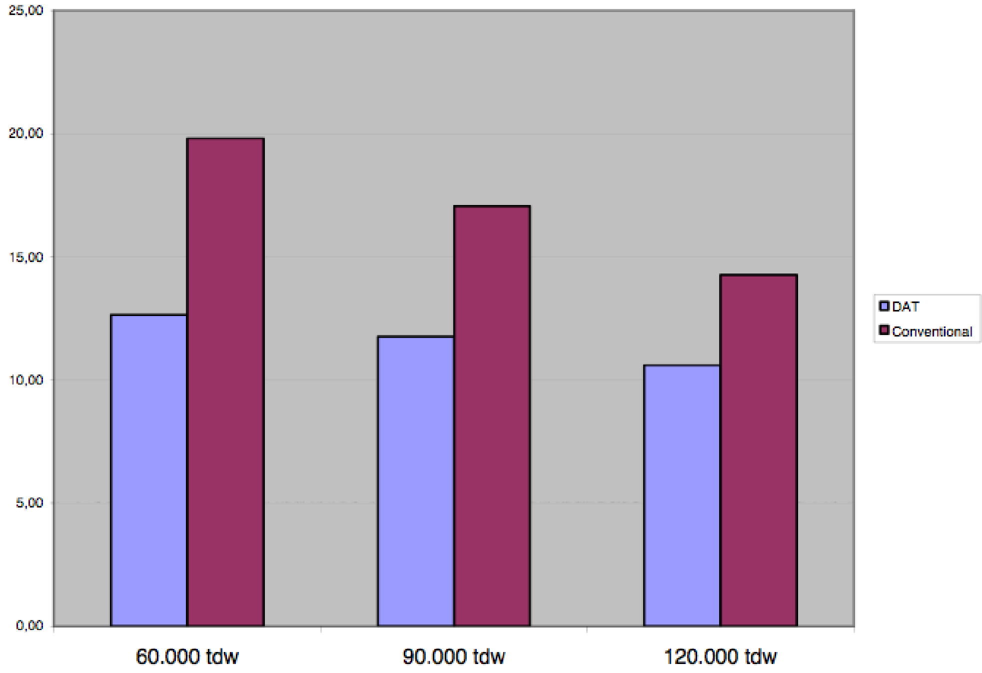


Figure 2: Route Varandey–Rotterdam

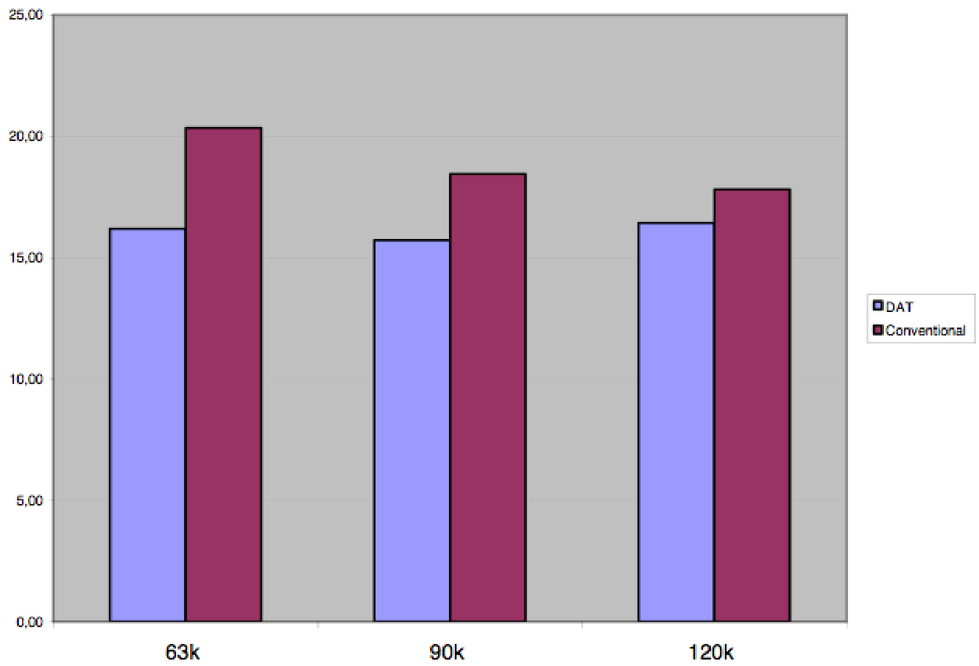


Figure 3: Route Varandey–Murmansk

- Oblique icebreaker utilizing the length of the hull for wider channel

The type of icebreaker has an impact to the investment cost needed for the icebreakers and to the speed of the convoy and thus to the number of tankers needed for the transportation task. The speed of the convoy will also have impact on the size of storage needed for the winter. The number of icebreakers that was needed was calculated with the assumption that always in ice the tanker must have a channel wider than the tanker beam. The tanker size that used for this comparison was 90.000 tdw. So each tanker in the ice covered part of the voyage needed to have either two LK-18 type of icebreaker or one Taymyr V3 or one Oblique icebreaker. This situation is also valid for the tankers of 60.000 tdw and 120.000 tdw, but due to the different beams of the tankers the convoy speeds will be different and this has an impact on the cost figures. The results of the comparisons are shown in figures 4 and 5.

The results show that the lowest cost level is achieved with the independently operated Double Acting Tankers. It can also be seen from the results that the cost level can be decreased by developing new technologies for icebreakers. The first step is increase the channel width so that one icebreaker is sufficient to assist one tanker. This should not be done on the cost of convoy speed. The results indicate that lowering the convoy speed create accumulated costs in the whole transportation system and the end result may be higher overall costs. Developing new technologies to achieve wider channel with less investment cost in the icebreakers is efficient way to reduce the overall costs. These technologies should however be properly tested in all operational situations. It should be noted that in this study all costs were calculated as actual costs and no fee system was applied. The fee system may have impact on the feasibility of the alternatives.

Winter type

The basic comparisons were made assuming ice conditions of an average type of winter. To see how the figures will change with changing ice conditions, the calculation was also made for the winters with 20% (mild) and 80% (severe) probabilities. These calculations were made for both of the routes but only for base cases

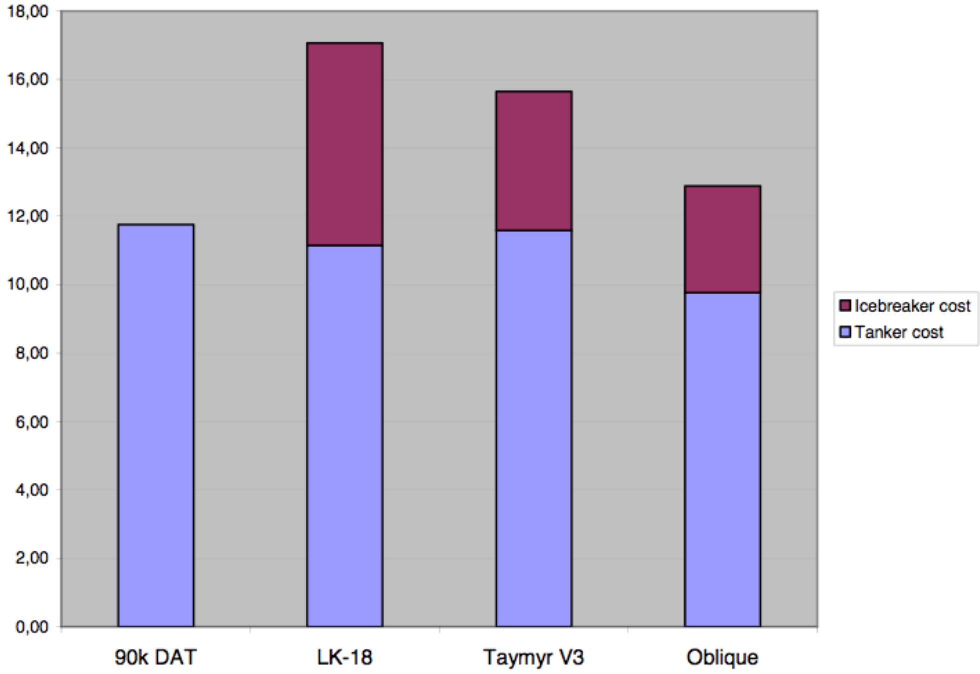


Figure 4: Route Varandey–Rotterdam

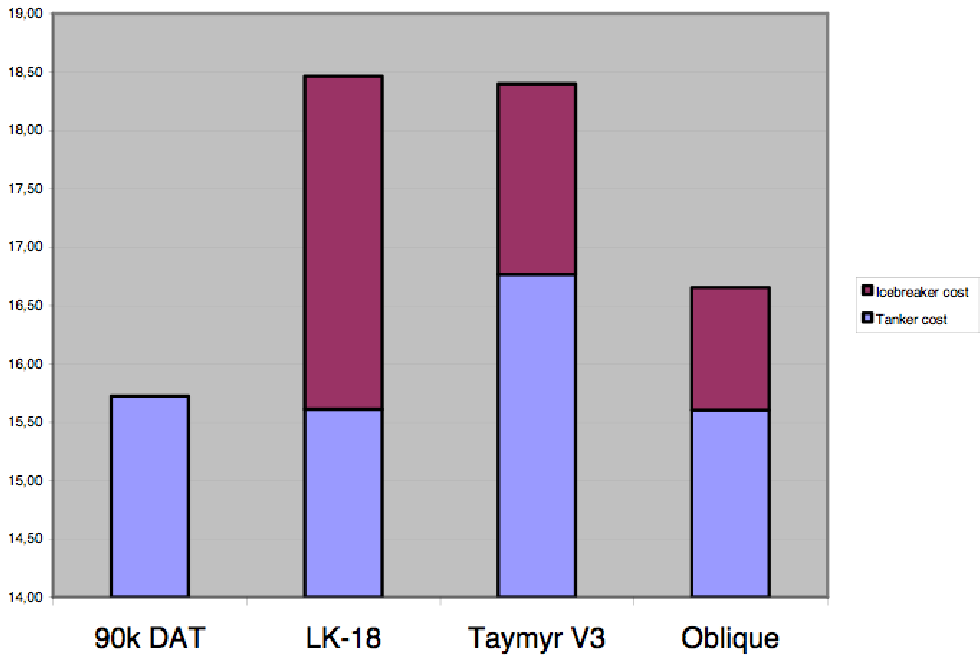


Figure 5: Route Varandey–Murmansk

with 90.000 tdw tankers and LK- 18 type icebreakers. The results are shown in figures 6 and 7.

On the route Varanday-Murmansk the results show steady increase of costs with increasing difficulty of ice conditions. On the route Varanday-Rotterdam similar tendency can be seen, but the impact of the ice conditions is much weaker. This is due to the fact that since considerable part of the voyage is always open water the change in the ice conditions do not influence so much on the overall costs.

There is one fact that should be taken into account when comparing the results during different types of winters. The study has now been made so that the storage required volume and the resulting cost is calculated separately for each type of winter. In practice this may not be the case. When designing the transportation system one has to decide for which situation he wants to plan the storage capacity. Once this decision has been made, the storage cost does not really change with the change in ice conditions. Thus the impact of the winter type could be even less than indicated in figures 6 and 7.

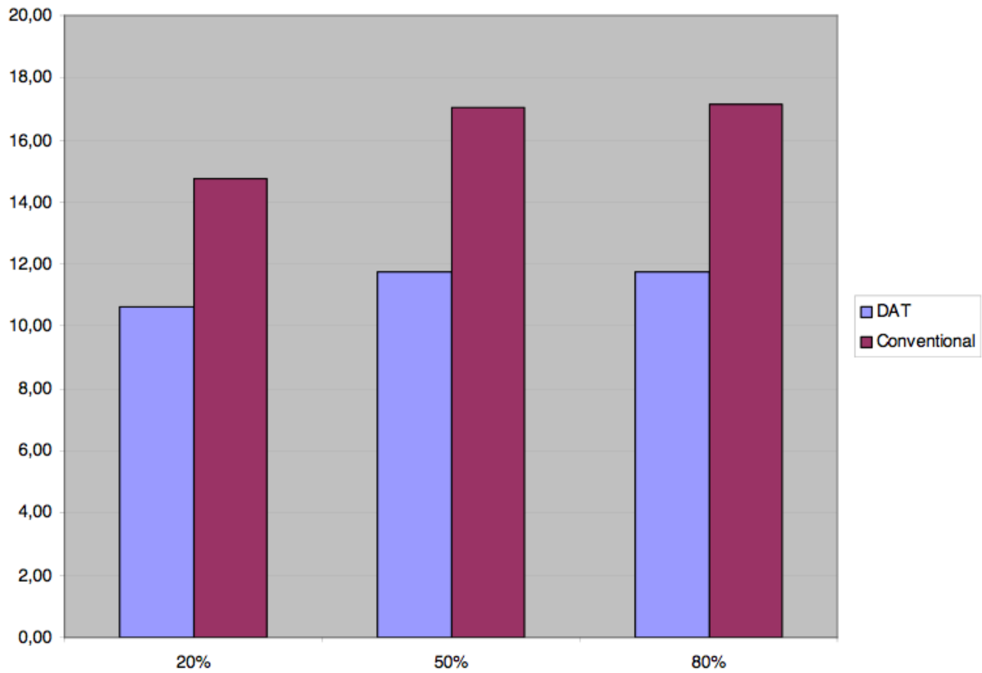


Figure 6: Route Varandey–Rotterdam

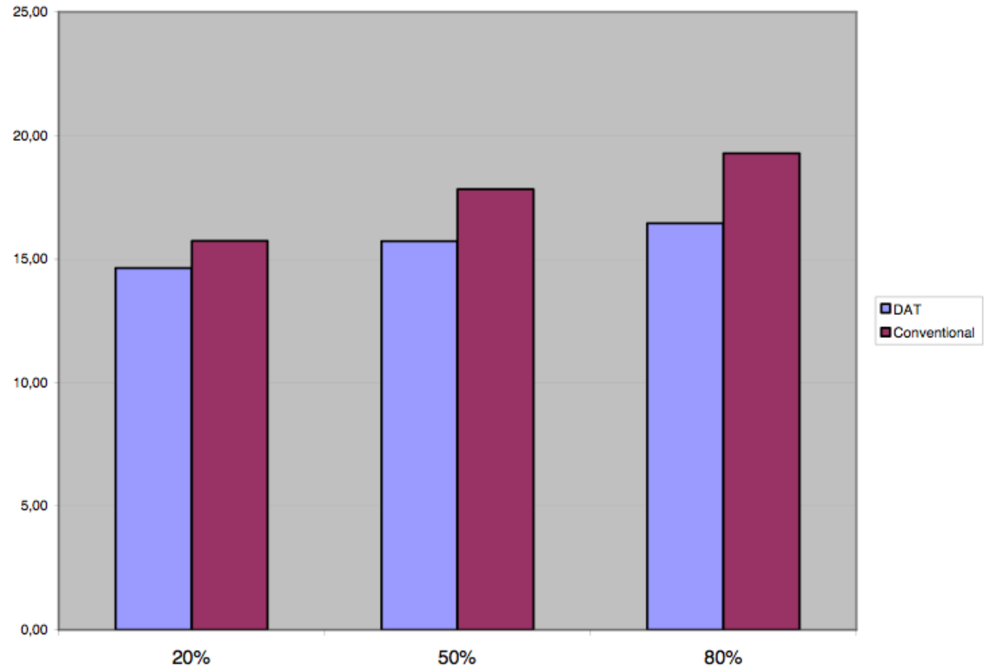


Figure 7: Route Varandey–Murmansk

3.5.4 Conclusions

The results of the economic evaluations show clearly that the most feasible way to transport the oil from Varanday to Rotterdam is to use Double Acting Tankers sailing directly from Varanday to Rotterdam. The size of the tankers should be maximum, in this case the 120.000 tdw tankers gave the best result. This conclusion is based on the actual overall costs. In case there are some administrative means regulating the fees or export dues or requirements towards the ships and their operation these may change the optimum solution.

If for some other than purely economic reasons transshipment in Murmansk would be required, then the optimum size of the vessel would be less than 120.000 tdw. The overall costs reduce when the size increases from 60.000 tdw to 90.000 tdw, but increase when the size is increased to 120.000 tdw. So the optimum is somewhere between 60.000 tdw and 120.000 tdw. The independently operated Double Acting Tankers would still be the most feasible alternative.

In case the icebreaker service is provided without any extra charge and the icebreaker service is always available then the best alternative is to use conventional tankers. In this case the overall minimum cost is achieved with the use of icebreakers that can open a channel wide enough for the tanker to follow. From the alternatives studied in this project the Oblique icebreaker seemed to be the most feasible one.

The general conclusion from this study is that the optimization can create considerable savings in the transportation costs. The figure below shows the difference between the best and worst alternative. In our scenario case the saving of 10 USD per ton corresponds 150 million USD per year or 3 billion USD over the lifetime of the project. This money may have impact on the feasibility of the whole planned project.

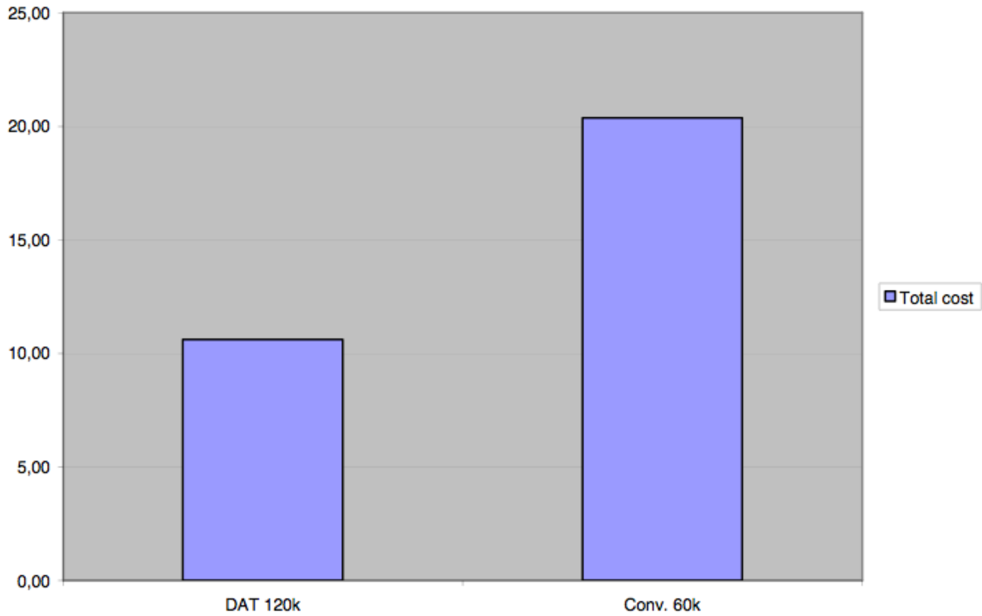


Figure 8: Total costs

3.6 VTMIS

3.6.1 Introduction

This deliverable provides recommendations for an Arcop VTMIS, taking into consideration the state of the art technology used for VTS. The recommended Services for an Arcop VTMIS are described briefly in chapter 2. They are structured according to the IALA Recommendations and were already described in depth in the deliverable 3.6.2. The IALA VTS Manual has been reviewed in order to show possible structures of a VTS which are briefly described in chapter 3.

Chapter 4 handles a VTS System, its technologies, elements and benefits. Chapter 5 is based on the recommendations for VTS personnel from IALA. Chapter 6 gives an overview of the costs of a VTMIS System for Arcop. And finally the chapter 7 handles the future prospect of the system.

3.6.2 Recommended VTS Services

The differences to a normal VTS are that in the NSR there is a low traffic density at the moment. The traffic in this area will increment, but will still keep being low. Furthermore the weather conditions can be considered extreme compared to other areas and at the same time the area of coverage for the VTS Service is very big. The existing rules for sailing in the NSR have to be considered when the ARCOP VTMIS is build up.

The recommended VTMIS services can be classified according to IALA in:

- Information Services
- Navigational Assistance Service
- Traffic Organisation Service
- Operating Rules and Regulations
- Co-operation with Allied Services, Port Operations, Emergency Services and adjacent VTS.

Information Services

An information service is a service to ensure that essential information is available to assist the shipboard navigational decision making process.

In the ARCOP context this is:

- Positions, intentions and destinations of vessels; restrictions on the navigation of other vessels, potential hindrances.
- Boundaries, procedures, radio channels or frequencies, reporting points etc.
- Hydrographic support to navigation: navigation charts, manuals, guidelines for navigation; supplying vessels; installation and operation of aids of navigation; pilotage; information to vessels about changes in navigation conditions; forecasts; cartographic support taking into account military areas.
- Legal information (incl. information about location of and behaviour near to military areas).
- Ice service/ice reconnaissance
- Hydrometeorological support should include:
  - general weather outlook;
  - forecast data of wind, wave and swell conditions for the intended or recommended route in tabular form or as plotted routes and forecast charts by e-mail; route recommendations and description of possible alternative routes

Navigational Assistance Service

Navigational Assistance Service in the ARCOP context comprises:

- Remote guidance of vessels (a specific kind of shore based pilotage and routing for navigation in ice),
- Ice pilotage (comparable with those of the Canadian Ice Service), undertake ice reconnaissance services to survey and forecast ice conditions,
- Navigational assistance, advice and operative navigation information:

- Course and speed made good by a vessel,
  - Position relative to fairways axis and way-points,
  - Positions, identities and intentions of surrounding traffic,
  - Warnings to individual vessels,
  - Navigation notes to Mariners,
  - Coastal preventions (warnings).
- Ice breaking support:
  - escort ships and organize convoys to travel through ice-infested waters,
  - free beset vessels to allow them to proceed,
  - maintain shipping channels and tracks in shore-fast ice, and
  - stand by in areas where requests for route assistance are likely, when requested and/or when the need is deemed to exist, and when resources are available.

Traffic Organisation Service

A Traffic Organisation Service describes a service to prevent the development of dangerous situations and to provide for the safe and efficient movement of traffic within the VTS area. For the ARCOP conditions it is anticipated that the traffic density is low. So this service should be related to:

- Traffic organisation, e.g. convoy, escorting;
- Establishing routes to be followed;
- Sailing plans e.g. ETA.

Operating Rules and Regulations

The Operating Rules and Guidelines are comparable to those of 'normal' VTS as described in the IALA manual. The delineation of the area and the required (communication) equipment might vary:

- Regulations within the VTS area:

  - Aids to navigation
  - Areas to be avoided
  - Constrained vessels
  - Precautionary zones
  - Ships' routing systems
  - Anchorage areas
  - Compulsory pilotage and pilot boarding areas
  - Patrol craft
  - Reporting points
  - Publishing and availability of local traffic movement rules and regulations
  - Delineation of the area: a segmentation of the NSR to gain wide area VTS might be desirable.

- Communication Rules and Procedures
  - Satcom (max 2 channels at 128 kb),
  - VHF allowing communication with airplanes, helicopters and ships in convoy (112.5 MHz),
  - NAVTEX,
  - Interport communication,
  - Email.

- Enhancement of onboard equipment such as ECDIS (real-time ice condition image, track recommendations, traffic & icebreaker positions image) and data communication (dedicated communication links and information servers).

Co-operation with Allied Services, Port Operations, Emergency Services and adjacent VTS

Generally this is a supporting activity of the VTS intended to increase the safety and efficiency of the traffic, the protection to the environment and the effectiveness of the VTS without adding to the reporting burden of the vessel. In the ARCOP context this comprehends:

- Ice clearance before berthing; harbour breakout

  - breaking out approaches and clearing ice from wharf faces of port terminals and facilities,
  - assisting shipping within ports and at marine facilities, by keeping ice clear of barge; operations and the ship at anchor, and by streaming petroleum off-loading hoses.
- Tugboat support of berthing operations
- Lighters
- Port services, repair
- Emergency services e.g. search and rescue (SAR)
- Passengers conveyance, e.g. aircraft connection
- Supply: food, bunker, technical
- Medical assistance
- Legal support, e.g. provision of necessary legal documents
- Organisation support
- Other services, e.g. mail.

Limitation of Services

The limitations which may affect delivery of 'physical' assistance (such as ice breaker support) services are:

- Weather restrictions: services may be reduced when current and forecast meteorological conditions will not permit successful delivery of the services;
- Severity of ice season: services may be reduced when current and forecast ice conditions will not permit successful delivery of the services;
- Physical restrictions: services will not be provided when hydrographic and/or geographic features of the area under consideration prevent safe;
- Safety restrictions: services will not be provided when conditions would unduly endanger service crew, ships or equipment, and/or those requesting the services; and
- Availability of resources: services will be provided when sufficient service units are available.

3.6.3 Structuring the ARCOP VTMIS

The overall parameters of the VTS are described in the Deliverable 3.6.2 User Requirements. The Arcop VTS Authority should organize the traffic in its area of influence. The organization of traffic should be done by:

- geographical division,
- distance separation or
- time separation/time slots.

Geographical division is a passive traffic management technique which separates traffic streams by instituting Traffic Separation Schemes, designating anchorage areas for all or special categories of ships, designating areas for cross traffic, etc. These measures should be well publicised in advance and included in navigational pilots and charts.

Distance separation is a method whereby vessels are given a minimum distance between each other in order to transit the whole or certain areas and restricted passages. The separation distances to be maintained are allocated and monitored by the VTS centre and may differ depending upon the categories of vessels or the cargo which is carried. Overtaking restrictions and/or minimum passing distances may be part of this method of traffic organisation.

IALA also recommends a time separation method, where a vessel has an exclusive use of a certain area or a restricted passage for a given time span. The time slots are then part of the VTS sailing plan, because the ice breaker service will be provided for example at fixed hours.

Infrastructure of the ARCOP VTMIS

The infrastructure recommended for the Arcop VTS can be divided in operational and technical aspects.

Operational aspects of the Infrastructure

For the Arcop VTS, one centralised VTS System which gathers information and disseminates is recommended. Surveillance and communication equipment at remote sites can transmit the information to the VTS centre. This has the advantage of lower operational costs especially regarding personnel, administrative support and capital costs. It must be ensured that the remote controll facilities from sensors and radio communication equipment is reliable. In case of equipment failure in one sub-area or sector, an adjacent sub-area or sector can extend temporarily until defective equipment has been repaired.

The disadvantage would be that in case of total power failure at the VTS centre the provision of a limited VTS Service would be difficult.

Technical aspects of the infrastructure

It is recommended to utilize Radars and AIS base stations to ensure a complete coverage of the area. The information detected by several radars can be transmitted to the VTS centre through a satellite link. Maintenance of the remote equipment and at the VTS centre should be done on contractual basis.

Communication facilities to adjacent VTS centres, local authorities, support organisations and related services has to be provided.

3.6.4 VTS System

Open System Architecture

The VTS system should have an Open System Architecture. The application of OSE/OSI standards with the use of Ethernet or FDDI LANs on system level allows extensions to add future capabilities or updates without loss of previous investment.

Modular System

Closely connected to the Open System Architecture a modular architecture of VTS systems provide flexibility to meet specific needs and guarantees future extensions. Modularity also eases repair, maintenance and training.

Standard Interfaces

The use of standard hardware interfaces, e.g. serial and LAN interfaces, and the platform independent CORBA would allow a flexible hardware configuration enabling the selection of system components best fitted for their purpose. It would also simplify the use of existing telecommunication infrastructure. Furthermore interfacing of management and Information database systems would be possible.

Hardware and Software

The VTS system should use mainly Commercial-Off-The-Shelf (COTS). This would be an advantage for system extensions, as well as for spare parts supply. If required, these components can be replaced by local supply. Nevertheless, those components decisive for excellent VTS performance are developed and produced normally by the system provider. These are the Radar Interface (RIF) board and the Radar Scan Converter (RSC) board. In order to reduce hardware, these boards can be inserted in standard PCs. They perform high-speed radar signal processing using most up-to date Digital Signal Processors(DSPs). The RIF also performs clutter reduction, target detection and tracking.

Built-In Redundancy

The major objective of VTS is to improve the safety of navigation. Hence, VTS systems need to be highly reliable. The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommends an availability of 99.9%, which is equivalent with a cumulative downtime of approx. 9 hours per year, a condition that is possible to reach with a system of medium complexity. For an availability of 99,99% or a downtime of less than one hour per year, major system components must be configured with redundancy, e.g. use of duplicated radar transmitters.

Digital nautical VTS documentation

In the case of remarkable events or even accidents, it is practical to be able to repeat screen displays as well as other relevant information in order to explain and understand any sequence of events. The new system should be provided with comprehensive radar image recording which is independent of the traffic display so that events occurring outside the currently set visual range of a traffic display can also be reproduced and investigated.

Equipment

It is reccommended to use latest VTS technology regarding radar signal processing and automatic radar tracking.

AIS transponders onboard vessels can communicate directly with the system, so that the initial identification of a vessel can be performed automatically and thus reliably.

Automatic radar tracking

The system should be capable of signal processing for detailed, high resolution display of radar targets, and also of integrated automatic radar tracking. Similar to air traffic, any relevant target on the screen should be displayed with an attached text label so that its identity is known at any time. It should also allow the electronic computation of course, speed, arrival time at specific destinations and other evaluations supporting and making the job of the navigator easier. Thus, individual vessels should be easily identified, tracked and addressed specifically.

Automatic target tracking should also be a prerequisite for a sensible connection of a vessel data processing system with the VTS, enabling the navigator to call up information on expected vessel movement on his traffic situation display.

VTS display units

Vessel traffic in the NSR should be monitored by radar sensors. The monitoring range of each radar more or less corresponds to the visual range of the human eye's. Within the frame of their monitoring tasks at the traffic display units in the nautical centre, the navigators frequently need sectional views of images which cannot be completely covered by one radar station.

A combination of several radar images on one display should be possible to avoid a switching back and forth between the radar stations in order to obtain an image completely meeting the requirements of the navigators.

In addition, such a technology also allows the displays of images within images or a zoom window. In that case, also the raw radar data signals could be shown in zoom windows in order to identify the position of the monitored vessels as accurately as possible. In order to make it easier for the users to achieve different possibilities, various types of representations could be stored. These representations should be afterwards available at the touch of a button.

One of the appliances which would facilitate the interpretation of the traffic displays is the representation of an electronic sea chart as a 'base' for the moving vessel targets. The system should include a chart editor so that independent updating of their electronic sea chart by the navigators is possible. It should also be possible to log, change or eliminate special information such as the 'radar-guided track' or fairway limitations and also temporary impediments.

Any relevant vessel data from the vessel data processing system which are important for the navigators – such as length, width, draught etc. – should be displayed by the system.

The main task of the navigators is to ensure safety and ease of vessel traffic. One of the means which help to achieve this goal is an exchange of information and the distribution of traffic information. Therefore, modern traffic situation displays is not an end in itself, but an important tool for each navigator in a traffic centre. It should be supplemented by communication systems, data processing and other sources of information. New technologies offer a very good image quality, with ergonomic advantages for the users.

Functional Elements

Radar

VTS radars should provide extended performance and additional functions, such as extended dynamic range, pulse repetition frequency, power monitoring, and others. For enhanced detection capability against weak, i.e. small or distant, targets a special frequency diversity transmitter set should be provided. The VTS transceivers should be available in the radio frequency X-and S-band versions.

Video Presentation

The VTS system should be provided with two radar video processing and presentation principles:

- Raw radar video with hardware radar scan converter. This provides a loss-free video presentation, processed in parallel to target extraction and tracking. The system processes the whole radar signal dynamics including clutter and noise. It is the best solution when weak targets, such as rubber boats, have to be detected in a sea clutter environment or at long ranges. Other typical applications are coastal surveillance for security, fisheries protection, and border control. For signal and data transmission to the centre broadband links are required.
- Extracted radar video with combined video and track extraction by software. In this principle only useful targets are extracted and tracked in one process, then transmitted to the operator work station. Through this data reduction, the data rate is only in the order of 3 to 5% of that of the other solution.

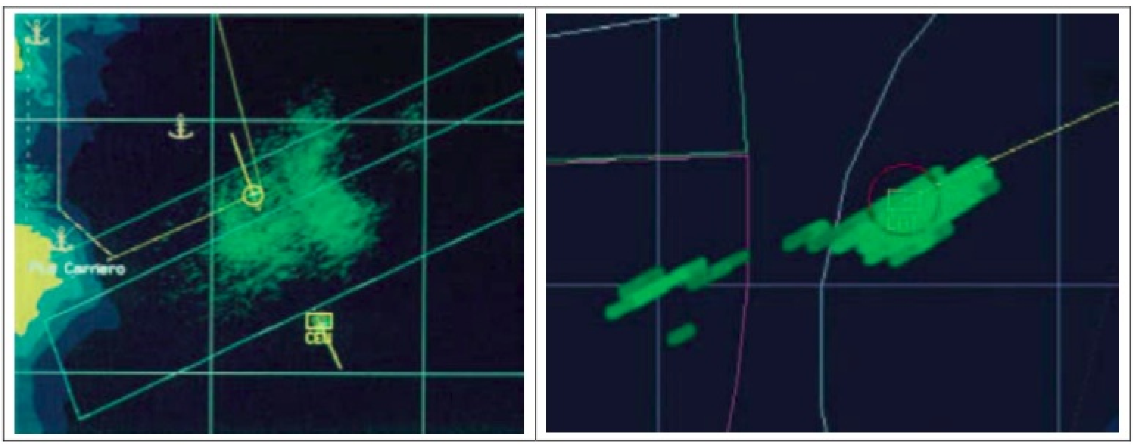


Figure 1: Raw radar video and extracted radar video

Radar Signal Processing

In a VTS, the radar signal processing capabilities define the quality of the system. Detection of small targets in a clutter environment, display precision, resolution between adjacent targets, and reliable tracking with a low target loss rate are all dependent on the capabilities of the radar signal processing.

The radar signal processing should be done with DSPs (digital signal processors chips). The processing ensures that the information content of the radar signal is preserved and evaluated and is not degraded by the transmission between radar station and the operator display. A sampling rate of 75 MHz and an amplitude resolution of 8 bit would ensure the retention of the information content of the radar signal, so that very small and short radar echoes are not lost. A two dimensional correlator reduces the noise and eliminates false echo signals.

To reduce noise resulting from clutter, an adaptive area-related Sensitivity Time Control (STC) should be provided. An automatic STC function is not globally applied to the complete range or azimuth. It is limited to noisy areas. A normalized signal-to-noise ratio across this area, ensures an improved target detection capability. To eliminate video returns from areas which are unimportant for traffic management, such as land, a receiver blanking map should be set up with a precision down to 1m. This reduces the data rate required for signal transmission to the centre considerably. For extracted video, narrow bandwidth transmission channels are sufficient.

ECDIS

Electronic Chart Display and Information System or simply ECDIS displays the vector format Electronic Navigational Charts (ENC) - an equivalent of the paper charts produced by, or on behalf of, the Hydrographic Offices of the world. It is more than a navigational and antigrounding tool of a ship, its safety features are much more sophisticated and it should be regarded as the main safety tool onboard a vessel. The application includes a an electronic updating mechanism to keep charts up to date without much operator intervention. This navigational tool can also be used inside the VTMIS for assisting the VTS operator to make a security check of the traffic situation. Even the present generation of ECDIS is already more than a paper chart on the screen, it provides more information, faster and more accurately than any previous navigational system. It can help the VTS operator to visualize the traffic situation in a two dimensional model. ECDIS is utilised today in a number of VTS stations as Flint in Sweden, Brunsbüttel and Hamburg in Germany, Harwich in U.K.. A key advantage of ECDIS is its ability to up date automatically by the a national Hydrographic Service as implemented in Warnemünde, Germany. ECDIS is also used in other VTMIS-related land-based applications, e.g. for Marine Pollution Control or Search and Rescue.

Multi-sensor fusion

This function processes sensor inputs from all available sources, as AIS, or other to establish a target's track. Sensor fusion is important as AIS systems aboard of ships larger 300 GT in international trade are mandatory. One particular ship might be detected by radar and AIS simultaneously. This would result in two sets of target symbols for the same target, a situation, which is unacceptable for the VTS operator. In such a situation the track fusion process would set in: the tracking software would compare the positions supplied by the two sensors, the motion data of the two targets and would decide on the basis of pre-set criteria, if the two targets could be one and the same. If this decision would be the case, the target will be related with just one track calculated from the different inputs.

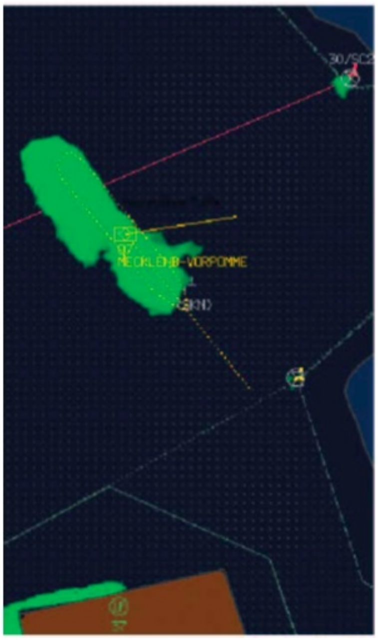


Figure 2: Combined Radar / AIS Track

Automatic Identification Systems (AIS)

Automatic Identification System (AIS) is an advanced navigation system developed and used by ships and vessel traffic systems (VTS) for collision avoidance at sea. The IMO SOLAS requires AIS to be fitted aboard all ships of gross tonnage =>300 for international voyage.

AIS base stations

AIS base stations incorporated in VTS offer further functionality. They are used to transmit safety-relevant messages addressed individually to one vessel or to a group of vessels. These messages replace a great amount of voice communication.

An AIS base station can also disseminate differential position corrections for GPS. They can also be used for monitoring of floating Aids TO Navigation (ATONs) equipped with an AIS set, and they can even create virtual ATONs.

Benefits of AIS

The benefits of AIS are:

- Automatic Vessel Identification
- VHF communications
- Improved Vessel Tracking

Automatic Vessel Identification

The automatic and immediate provision of vessel identity (MMSI, call sign etc), thereby facilitating rapid radio communication where necessary is a benefit to VTS authorities.

Achieving vessel identity relies on such vessels reporting both identity and location to the VTS centre, and the VTS operator then correlating this information with an unassigned radar track.

The process is time consuming and wholly reliant on the co-operation of participating vessels. It is not uncommon for some vessels to fail to comply with this requirement, thereby creating a potentially dangerous situation, and creating further distraction for the VTS operator.

Even where VHF direction finding equipment is fitted, the VTS traffic image is still reliant on vessels reporting identity via VHF thereby permitting the correlation of identity with the radar track identified by DF. AIS helps to overcome the safety weaknesses and time consuming procedures.

VHF communications

A major benefit of AIS is likely to be the reduction of VHF voice messages. The use of AIS reduces language problems and the chances of vessels misunderstanding messages from a VTS centre and vice versa.

Improved Vessel Tracking

Wider geographical coverage.
: AIS data will be received by other AIS transponders, or by base or repeater stations. Thus where a VTS organisation is fitted with such equipment, it will be capable of receiving both identity and precise location of a vessel at the maximum reception range of the radio communications frequency in use. Often this will be VHF, and as a consequence will normally permit detection of vessel target outside of radar coverage. Even where this is not possible due to the need to screen base stations from adjacent VHF interference, extended VTS detection range may be achieved by the installation of additional base or repeater stations connected into a network at much lower cost than radar.

Positional accuracy.
: AIS aims to achieve positional accuracy better than 10 metres when associated with DGNSS correction signals.

Absence of 'radar shadow' areas.
: In coastal and harbour waters radar tracking of vessels can be masked, or otherwise affected by the proximity of land and buildings. The resultant 'shadow' areas can cause radar based VTS to lose track, thereby denying the VTS centre the ability to monitor accurately vessel movement. The loss of tracking may also result in the need to reacquire and re-identify lost tracks.

Whilst AIS tracking is expected to avoid the majority of such effects, the very close proximity of buildings and bridges can cause difficulties for AIS transponders in heavily built-up areas. This is a consequence of inhibiting either the reception of the differential GNSS signal by the AIS transponder, or the transmission of the subsequent AIS message.

Traffic image accuracy

Vessel tracking can similarly be interrupted when two vessels pass close to one another, with the result that the radar tracking of one contact may be confused by the proximity of the other. This may result in the identity of one track transferring or 'swapping' to the other. The more precise tracking associated with AIS has been shown to prevent the incidence of 'track swap'.

Real time manoeuvring data.

Radar based VTS systems will typically provide details of a vessel's course speed over the ground. Of necessity, this information is historical in that it is calculated from track made good by a vessel. However, AIS in addition to course and speed information provide elements of real time manoeuvring data such as Ships Heading and Rate of Turn. These are derived directly from the vessel navigation systems and are included automatically in Dynamic Message broadcast by the AIS.

Weather effects on tracking performance.

Navigational radar performance is often adversely affected by precipitation as a function of the radio frequency on which it operates. In heavy rain or snow, effective radar tracking sometimes unachievable, even with the use of modern suppression techniques. However, radio transmissions are not so attenuated and consequently a VTS centre is much more likely maintain an accurate traffic image in adverse weather where that tracking is based on AIS data.

VHF radio transmissions can be affected by atmospheric ducting. In these conditions, VHF reception ranges can be greatly extended. Where AIS messages are received at such enhanced reception range, the system will automatically overcome ignore signals originating from vessels at long range.

Provision of more precise navigational advice.

Where a VTS centre is able to receive AIS information from vessels within or adjacent to its area, it is expected that the quality, accuracy and reliability of vessel tracking will improved markedly. The VTS centre would therefore be able to provide more precise navigational advice, as and when required, or when deemed necessary. In addition, availability of certain real time manoeuvring data within the VTS centre is expected to enable VTS operators to appreciate more rapidly, and in greater detail, actual vessel movement.

Electronic transfer of port passage information If AIS is integrated into a VTS system, it would become possible for suitably equipped vessels and the VTS centre to exchange passage information such as intended way points, provided the appropriate software is available.

Electronic transfer of safety messages.
The facility available within AIS for the transmission of short safety messages makes possible the electronic broadcasting from a VTS centre of local navigation warnings, and similar safety related messages to suitably equipped ships. VTS centres could also the capability of broadcasting local chart corrections to ECDIS fitted ships via AIS.

Automatic indication of Voyage Related Information(cargoes, dangerous substances, etc)
Vessels are normally required to report to VTS authority any dangerous substances being carried. The AIS voyage related message will permit the inclusion and automatic transmission of this information.

Archiving data
The automatic availability of AIS data for suitably equipped vessels in a VTS Centre would facilitates the rapid and comprehensive recording, replay and archiving of their data.

System redundancy
By equipping VTS centres with AIS, an alternative method of tracking and monitoring the navigation of suitably equipped would be introduced, thereby improving system redundancy significantly.

Potential for interaction within regional AIS network
Increasing emphasis is being placed on networking VTS centres on a re-

gional basis. Such an arrangement facilitates greater efficiency by making possible the rapid transfer of vessel details between different centres. This benefit may be enhanced by the provision of AIS within the relevant VTS centres.

Improved SAR management

Many marine authorities are expected to equip SAR units, including aircraft and helicopters, with AIS transponders. The AIS voyage related message permits vessels to transmit the number of persons onboard a vessel. Whilst this is not mandatory for vessels at sea, it can be made a formal requirement in a VTS area. The provision of such details, and the ready identification and location of SAR units is expected to facilitate the management and evaluation of any SAR response.

Installation of AIS into a VTS

The issues to be considered when installing AIS into a VTS are:

- Number/location of base stations/repeaters
- Operability with adjacent VTS organisations
- Availability of suitable VHF Communications channels
- Availability of national/regional/local DGNSS corrections

Number/location of base stations/repeaters

In deciding the size, and thus cost, of integrating AIS into a VTS system, a careful study needs to be undertaken to establish the number and location of base and repeater stations required to achieve full and reliable coverage.

Operability with adjacent VTS organisations

Where it proves necessary to use more than one base station, or where a VTS organisation involves more than one VTS centre, the method of connecting the component elements into a local network needs to be given careful consideration.

Availability of suitable VHF Communications channels.

Two maritime VHF Channels have been allocated by the ITU for the international use of AIS in its primary ship-to-ship mode. The need for additional channels will be where the VTS centre has a particular interest in deriving vessel identity at maximum range.

Availability of national/regional/local DGNSS corrections

In order to monitor vessel navigation with the 10 metre precision required for port approach and harbour navigation, a reliable DGNSS correction signal will need to available to all vessels throughout the VTS area and such services are provided nationally or regionally in many areas. However, where such a service does not exist, the VTS may consider providing this service by transmitting the relevant corrections using the AIS system.

AIS and Aids to Navigation

A further potential application of AIS is as an aid to navigation. When positioned at a significant geographic point or danger to navigation, an AIS transponder could provide information and data that would serve to:

- complement or replace an existing aid to navigation;
- provide identity, state of 'health' and other information such as real time tidal height, tidal stream and local weather to surrounding ships or back to the shore authority;
- provide the position of floating aids (primarily buoys) by transmitting an accurate position (based on DGPS corrections) to monitor that they are 'on station';
- provide information for performance monitoring, with the connecting data link serving to remotely control changes of navaid parameters or switching in back-up equipment;
- as a supplement to radar transponder beacons (racons), providing longer range detection and identification in all weather conditions; and,
- as a data gathering tool, providing information on all AIS fitted shipping traffic passing within VHF range of the site.

AIS for Meteorological and Hydrological information

Another potential application is the transmission of meteorological and/or hydrological data.

Options for implementing this application include:

- Connecting a measuring station directly to a local AIS-unit, which then broadcasts the relevant information.
- Several measuring stations can be connected to a base station network via a data communication system. Information can then be broadcast from appropriate base stations.
- A measuring station can be co-located with an Aid to Navigation equipped with AIS. The AIS-unit can then be used to broadcast both the Aid to Navigation information and meteorological and/or hydrological information using separate messages.

Examples of information to be broadcasted:

- Wind speed, average and gust values
- Wind direction
- Water level
- Water temperature
- Air temperature
- Current speed and direction on different depths
- Tide information

The availability of such data would permit the presentation of real time information at receiving stations, including onboard ships within VHF range.

Legislative Elements

IALA Recommendation

By the end of 2004 most of the merchant ships have to carry AIS systems under Regulation 19 of Annex V to the SOLAS (Safety of Life at Sea) convention. IMO currently discusses to extend AIS to the open sea by adapting AIS to a satellite-based interface.

The AIS unit aboard broadcasts at defined intervals (depending on speed and rate of course change) on the two assigned VHF channels the ship's identity, current GPS position, course, speed, rate-of-turn and further ship and voyage related data. The transmissions are received by other ships in their AIS sets, indicated on the bridges and used by the officers for navigation and collision avoidance purposes. Particularly a ship's position transmissions, but also its motion data, have a great significance to VTS operations. For this reason, IALA recommends the use of the AIS ship broadcasts in VTS stations.

Data exchange

An important legal aspect of information networks is data protection. Technically this is, in most cases, easy to achieve. However, convincing the users is more challenging. This applies especially to any connection to / from VTS centres in regard to the kind of information to be exchanged. Here significant resistances may to be overcome. The agreements of co-operation between administrations, users and third parties are a first step in this direction.

VTS Benefits

Benefits gained from a VTS can be in issues regarding navigational assistance, sequencing of vessel traffic, reduction of accidents, increased traffic efficiency, well distributed information, efficient resource planning and port development among others.

Navigational Assistance

In confined waterways and under adverse weather conditions, vessel navigation is a complex task. With an ever growing vessel size and increased transport of hazardous goods, the ships' masters cannot rely on the traffic information that can be obtained on board the vessel alone, but draw on the support from shore-based Vessel Traffic Services. By means of electronic systems such as radar, AIS, direction finders, meteorological and hydrological sensors, the VTS are able to compile a traffic image with all relevant information within the area concerned.

With this information, hazardous situations can be identified before critical situations develop, and appropriate advice can be given to the masters of the vessels.

Sequencing of Vessel Traffic

Vessel navigation in waterways having limitations must be planned in advance in order to avoid dangerous situations, such as groundings. Vessels navigating in the NSR must properly take into account the meteorological and hydrographic information. This is best supported by a VTS having an overall traffic view. The VTS, however, can not only support the ship, but can also ensure the best possible use of the waterway's transport capacity.

Reduction of Accidents

Similar to road traffic, several accidents happen every day at sea. Most of these are of minor nature with only little damage. However, each year a number of serious marine casualties occur, often with loss of life and material and sometimes with dramatic consequences to the environment. To a large extent, such accidents result from the lack of knowledge of the waterways, bad communication between the involved vessels, human error to recognise the developing situation.

The COST 301 study (a joint research project on shore-based marine navigation aid systems) of the European Union has established that at least 50% of such accidents can be avoided if a VTS system is used. This figure is well supported by practical experience with numerous VTS systems world-wide.

Information Distribution

The VTS authority is normally the origin of up-to-date shipping information. It has become customary that this information is offered and distributed to third parties, such as agents and ship owners. In this way, VTS will also contribute to the attractiveness of a shipping area or port, as the shipping world appreciates the land-based support from such a source. This helps attracting further shipping and shipping business.

Resources Planning

Improvement of efficiency requires best use of existing resources such as pilots, tugs, lines-men, berths and cargo handling facilities. The VTS system supports the just-in-time allocation of these resources by provision of comprehensive and up-to-date information on a vessel's particulars and its estimated time of arrival (ETA), and thus helps in the planning of capacities.

3.6.5 Personnel

A major factor in the efficient operation of a VTS Centre is the standard of competence of its personnel. Recognising that VTS personnel are members of a profession whose principal interaction is with mariners and maritime pilots in the safe management of maritime traffic, their competence needs to reflect that professional responsibility.

VTS personnel should be capable of providing VTS information, rendering navigational assistance when required and establishing a traffic organisation service in a VTS area as specified by the relevant VTS Authority. For the ARCOP VTS, the Centre may comprise VTS Operators, VTS Supervisors and a VTS Manager.

The purpose of standards for training VTS personnel is twofold. First, to ensure the competence of personnel that occupy key positions in VTS in which critical situations can occur and, secondly, to provide uniform consistency of procedural communications with ships throughout the world. A series of publications has therefore been prepared by IALA that provide recommended standards and guidelines on all major aspects of the training of VTS personnel.

The publications are:

- Recommendation V-103 on Standards for the Training and Certification of VTS Personnel;
- Model Course V-103/1 – VTS Operator Basic Training;
- Model Course V-103/2 – VTS Supervisor Advancement Training;
- Model Course V-103/3 – VTS On-the-Job Training, VTS Operator, VTS Supervisor;
- Model Course V-103/4 – VTS On-the-Job Training Instructor;
- Guidelines for the Accreditation of VTS Training Institutes;
- Guidelines on the Assessment of training requirements for existing VTS Personnel, Candidate VTS Operators and the Revalidation of VTS Operator

Certificates

Recommendation V-103 on Standards for training and certification of VTS Personnel

The Recommendation describes the principles and objectives of VTS training, it outlines possibilities for career enhancement, proposes entry standards and aptitude testing and describes the basis for the conduct and award of qualifications, certification, annual assessment and revalidation. Advice on the training of VTS personnel follows the format used by IMO for the training of shipboard personnel and sets out the requirements for competency-based training for VTS Operators and Supervisors.

The main topics of the Recommendation include job descriptions, selection and recruiting, training, qualification and certification and competence charts.

The purpose of Recommendation V-103 is to ensure that VTS Operators are professionally qualified personnel capable of contributing to safe and efficient marine operations. However, many existing VTS Operators have already reached the required level of competence, and therefore a way to evaluate and assess their knowledge, understanding and skills has been devised as a process to certificate them.

The basis of the process is that an individual assessment is made of existing VTS Operators by using the following tools:

- Portfolio review
- Demonstration
- Standardised tests
- Programme review

The assessment should be carried out in steps (see Figure 3). Where the assessment indicates that the candidate has the required competence, no training needs to be given and the competent Authority should award a VTSO Certificate and VTS Certification Log.

When the assessment indicates that the candidate does not have the required competence, appropriate training should be given.

3.6.6 Costs

The cost components of a new VTS consist of two distinctive groups, investment costs and operation costs.

The investment costs are:

- planning (e.g. feasibility studies, tendering, procurement, legislation)
- building works (e.g. VTS stations, radar posts, VHF masts, power/water/telephone connections)
- equipment purchase and installation (e.g. radar, VHF and other communication, computers, software, VTS work consoles, vessels/vehicles)
- organisation set-up (e.g. recruitment and training of staff, developing procedures)
- project management and administration (including intermediate measures)

The operation costs:

- maintenance and repairs of the building works (including spare parts)
- maintenance and repairs of the equipment (including spare parts)
- personnel (including replacement and additional/refreshment training)
- consumables (e.g. power, water, telephone, in/outgoing documents)
- insurance cover (if appropriate)

It is not possible to give figures of exact costs for an ARCOP VTMIS. The system providers are not willing to give list prices and the costs depend on the technical features of the system required. The price of the system must be negotiated and maintenance contracts for example will have an influence on the VTS purchase cost. If the system provider gets the maintenance contract for the VTS system, the purchase costs of equipment can be lower.

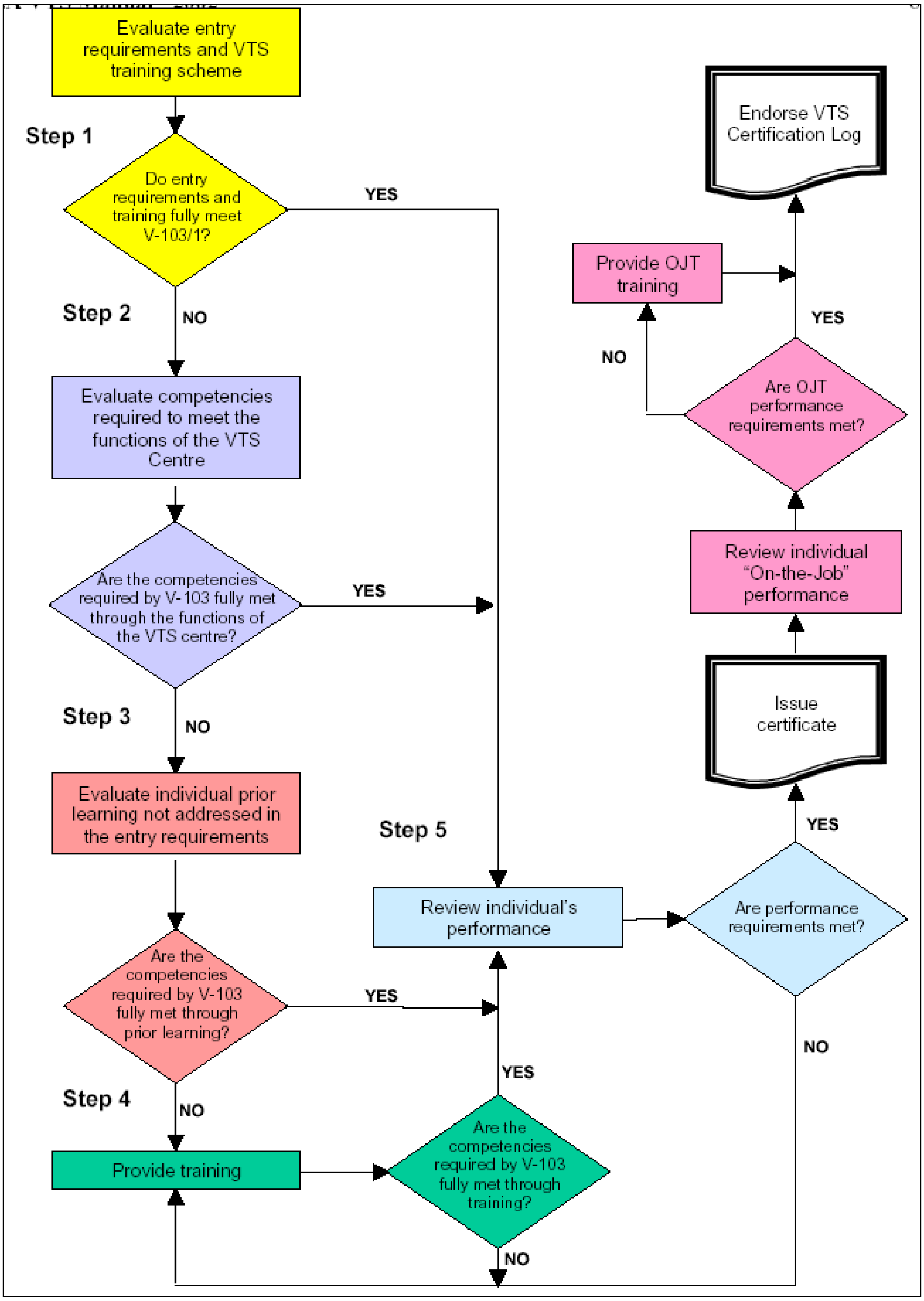


Figure 3: IALA Flow diagram for Recommendation V-103 VTS Operator Certificate to existing VTS Operators

It was not possible to find out the existing VTS centres in the NSR. A VTS centre in Murmansk and one in Varandey provided by a Russian system provider. It has to be further investigated which VTS functionalities these centres offer in order to upgrade the VTS System to the functionalities recommended in the former chapters. The desired area of coverage must be delineated and afterwards a Cost Benefit Analysis can be realized. With the information gathered till now it is not possible.

3.6.7 Future Prospects

The progress of technical development is such that it is increasingly difficult for all persons involved to prepare for any eventuality. Therefore, great importance should be attached to a modular system design of the technology which makes it possible – as far as foreseeable today – to maintain the system's relevant required state of the art in future by stepwise and scheduled partial modernisation. This should include an extensive use of standardised interfaces between main components, up to and including broadband signal processing, without the previously required signal switches.

In order to ensure an extensive availability of the system, care should be taken that a possible failure of one subsystem does not affect other intact system parts as far as possible, and that the remaining system is capable of taking over any essential functions of the failed part. Furthermore, there should be the possibility to support the technical and engineering service personnel by remote diagnostics of the manufacturer directly via a telephone data line. A reliable, continuous 24-hour operation could be ensured over many years.

For future investigations of VTMIS systems in the NSR it should be stressed to delineate the VTS coverage area. The recommended functionalities in this report should be part of the VTS System. As VTS Systems are cost intensive it should be found out which VTS centres and its functionalities already exist to upgrade the system. In the context of this Workpackage it was not possible, but it can be included in a future research project that builds upon the results of ARCOP.

3.7 Training for Arctic Navigation

ARCOP aims to find the practical solutions to the major problems including the training of crews navigating in ice.

In phase one of this study we determined how shipping companies currently train their crews for navigation in ice. And in the second phase of this assignment we have investigated the existing training courses and facilities.

The purpose of this third phase is to prepare recommendations for future training centres with contents of their education programs and requirements for the facilities including navigation simulators.

Purpose of training for navigation in ice

The purpose of the specialized training of navigators is to teach skill of features of manoeuvring and handling transport ships of various types and icebreakers which will take part in transport on Northern Sea Way in different ice conditions.

Rules and Regulations

Training requirements with regard to navigating in ice do exist, but are not specifically mentioned in applicable international rules and regulations like STCW 95 and the ISM Code.

In 2002 IMO has published Guidelines for ships operating in ice-covered waters, but the guidelines are not mandatory.

Russia has set rules for access to the Northern Sea Route with regard to experience in operating vessels in ice with their "Guide for Navigation through the Northern Sea Route".

Data on human factor in incidents and accidents

There is virtually no information available on the subject of human factor in incidents and accidents. Most of the accidents and incident that involve human factor are accidents while sailing in convoy behind an icebreaker.

In order to collect more data on human factor in incidents and accidents we recommend training institutes to set up a database of experiences of their trainees and the companies they work for with regard to incidents and accidents.

Aspects that influence navigation of the Northern Sea Route

Cost and duration of training should be limited in order to keep companies and navigators motivated to do the training for example by designing the training not just for the Northern Sea route, but make the training usable for other ice infested areas too.

The main factors that will influence navigation in the Arctic Region are ice formation, vessel design, the transport system to be used and the intensity of the traffic.

Development of collection methods for ice information and ice forecasts in view of choosing transport routes is covered in WP 1 of this project.

WP 3.7 interrelates with work packages WP3.2, WP3.3 and WP3.4, which cover the vessel design and the physical transportation system.

The reports of these work packages deal with basic ship design matters such as:

- alternative general arrangements of the tankers;
- main dimensions and their influence on the cargo capacity, performance in ice and costs of investment;
- configuration alternatives for propulsion arrangements;
- ice-going performance with a range of main dimensions and propulsion systems;
- performance in different kinds of ice conditions when assisted by icebreakers;

- technical characteristics of different kinds of icebreakers and their propulsion systems;
- operational characteristics of icebreaker types;
- description of environmental and ambient conditions that are forming the design basis for the terminal infrastructure as well as for the complete loading system;

According to the CNIIMF official information, the expected structure of the transport fleet, which provides transportation of predicted amount of cargoes by the Northern Sea Route, will be the following for the period till 2020:

- 93 transport ships of ice class:
- 15 icebreakers:

Levels of Training

There is a difference in required skills and knowledge between the different positions, like pilots, navigating officers and engineers. That is why a modular training would be ideal.

MIWB have had good experiences with a Dutch chemical tanker company during ice navigator courses in which personnel of the Technical Department were participating in the course.

As this course is very specialized there should be an "entry level" for participating in the course, to avoid that the course will be given to students of Nautical colleges at a stage when they are not ready for it.

Recommended Framework for the Training

The course should be a standardized maritime course about navigation in ice-infested waters. From this point of view the STCW code can serve as a standard.

The IMO Guidelines for ships operating in Arctic ice covered waters can serve as a basis for training ice navigators for the Northern Sea Route.

The framework allows choosing modules for different positions. The items in black in the first column of the table are the basic training in accordance with the IMO Guidelines for ships operating in Arctic ice covered waters. The items in red in the first column of the table are added to make the training suitable to train crews for navigation of the Northern Sea.

Practical training is most effective when the navigator is considered a trainee and is on board in addition to the regular crew and can observe experienced officers and practice under supervision of experienced officers.

If practical training o/b is used as replacement of the complete or part of "Theoretical Ice Navigation Training" the supervising officer o/b must be a certified assessor and the whole training must be supervised by a training institute.

Currently the functionality and realistic appearance of the ice field movements and the dynamic interaction between ship hull and ice are restricted to very simple cases such as navigation in level ice, navigation in an opened lead and ship handling during convoy operations. Thus, the ice navigation capabilities of the simulators have mostly been applied to the basic training of deck officer students.

Compared to a conventional training simulator for open water navigation the main features requiring special attention considering ice navigation simulators can be grouped in the following way:

- equipment on navigation bridge and the visualization system
- ice field and its properties
- the interaction between ship and ice models

In the ideal case of a fully developed ice navigation simulator the complex should consist of several bridges that can be connected to the same exercise scenario in order to enable the interaction and intercommunication between the ships operating in the same area.

Functions or qualitative features required in a full-scale ice navigation simulator and estimates of their current stage of development.

If the development of simulators were looked a little forward in the future, then the next relatively tempting and already feasible improvement would be the implementation of the interaction between local ice loads and the strength of ship's hull plating and stiffeners.

Finally, as a step towards the concept of dynamically managed ice field, a simple model of the drifting ice and moving ice fields causing pressurized zones in the exercise area should be implemented.

Duration and Cost of Training

Theoretical basic ice navigation training 3 days at 150-200 euro/day/trainee

At this stage it is not possible to be specific about the needed time en costs of the additional items as the courses are not developed and available at this moment.

Simulator training 3000 euro/day depending on the number of simulators used.

Theoretical training for management 1-day 150-200 euro/day/trainee.

Theoretical training for engineers 1-day 150-200 euro/day/trainee.

Expected number of trainees

We cannot predict the exact numbers of trainees, but based on CNIIMF indication on number of vessels in NSR we expect that 3390 crewmembers will need training and in a newspaper article about the planned cooperation between Stena and Sovcomflot in the Baltic with regard to tanker transports it says that some 2400 crewmembers will need training.

Certification of the Training

IMO Guidelines 14.2 Ice Navigator qualifications and training states: "The Ice Navigator should have documentary evidence of having satisfactorily completed an approved training program in ice navigation"

This means that the Training for Arctic Navigation must be "approved".

- Approved by the authorities of the country in which the Training Institute is situated.
- Or approved by a classification society.

The international approval of training packages is difficult without any contribution from IMO or some other remarkable authority on international level (e.g. EMSA).

The only national authority that can do something just now or in the near future is Russia because of the prospected operation of ARCOP scenario. If the approval is given to the hands of classification societies without any regulation from an international authority, the resulting variety of certification and/or audit policies may turn out to be a nuisance.

Points of Discussion

In our view there are some points that need further discussion.

- Simulator training
  - Necessity of simulator training
  - Financing development of simulation models
- Uniform certification
  - IMO Ice Navigator versus Canadian Ice Navigator
- Human Factor
  - Availability of data at Class Bureaus
  - Proposal for collection of data by training institutes

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**Naviga-tors**	**Engi-neers**	**Mana-gement**	**Naviga-tors**	**Engi-neers**	**Mana-gement**
Introduction							
Course overview	yes	yes	yes	yes	yes	yes	yes
Introduction in the several aspects of ice navigation.	Yes	yes	yes	yes	yes	yes	yes
Guidelines for ships operating in Arctic ice covered waters							
Introduction of the Guidelines	yes	yes	yes	yes	yes	yes	yes
Summarizes the most important points of the Guidelines	yes	yes	yes	yes	yes	yes	yes
Description of the area and legal status of the Guidelines	yes	yes	yes	yes	yes	yes	yes
Guide to navigation through the NSR	*yes*	*yes*	*no*	*yes*	*yes*	*no*	*yes*
Ice recognition							
Ice Indications							
Describes the affected areas	yes	yes	yes	yes	yes	yes	yes
Describes the signs of proximity of ice	yes	yes	no	optional	yes	no	optional
Describes the signs of icebergs in the vicinity	yes	yes	no	optional	yes	no	optional
Identifies the limitations of the use of radar in ice	yes	yes	no	optional	yes	no	optional
Recognition of ice formation and characteristics							
Describes the freezing of salt water	yes	yes	no	optional	yes	no	optional
Describes the whole process from freezing to melting	yes	yes	no	optional	yes	no	optional
Characterizes the process of ice deformation	yes	yes	no	optional	yes	no	optional

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**Naviga-tors**	**Engi-neers**	**Mana-gement**	**Naviga-tors**	**Engi-neers**	**Mana-gement**
Describes the different types of ice and their characteristics	yes	yes	no	optional	yes	no	optional
Definitions; defines the sea ice nomenclature	yes	yes	no	optional	yes	no	optional
Navigation in ice							
The use of ice forecasts, atlases and codes							
Describes the different forms of ice information	yes	yes	no	optional	yes	no	optional
Describes the ice information of the Northern Sea Route	*yes*	*yes*	*no*	*optional*	*yes*	*no*	*optional*
Characterizes what information is relevant at what time	yes	yes	no	optional	yes	no	optional
Describes the codes and symbols used in ice reports and charts	yes	yes	no	optional	yes	no	optional
Describes the IIP (International ice Patrol)	yes	yes	no	optional	yes	no	optional
Practice in the use of ice reports and charts	yes	yes	no	optional	yes	no	optional

	Pilots	Icebreaking Vessels			Ice Strengthened Vessels		
		Naviga-tors	**Engi-neers**	**Mana-gement**	**Naviga-tors**	**Engi-neers**	**Mana-gement**
Effect of ice accretion on vessel stability							
Describes the process of ice accretion	yes	yes	no	optional	yes	no	yes
Characterizes the dangers of icing with tanker example	yes	yes	no	optional	yes	no	yes
Practice in stability effects	yes	yes	no	optional	yes	no	yes
Ice manoeuvring							
Describes the precautions and reminders for operations in cold climates	yes	yes	yes	optional	yes	yes	yes
# 4 dealing with cold ambient (engineers)	*no*	*no*	*yes*	*optional*	*no*	*yes*	*optional*
Describes all relevant aspects when maneuvering / navigating in ice without escort	yes	yes	no	optional	yes	no	yes
#1 Operation of DAT concept (principles)	*yes*	*yes*	*no*	*optional*	*yes*	*no*	*optional*
#7 Independent navigation in different ice conditions	*yes*	*yes*	*no*	*optional*	*yes*	*no*	*yes*
Hull stress caused by ice							
Describes the different ice classes	yes	yes	no	optional	yes	no	optional
Describes where to find ice strengthening in the ship	yes	yes	no	optional	yes	no	optional
Practice with identifying ice strengthening in a ship	yes	yes	no	optional	yes	no	optional

	Pilots	Icebreaking Vessels			Ice Strengthened Vessels		
		Naviga-tors	**Engi-neers**	**Mana-gement**	**Naviga-tors**	**Engi-neers**	**Mana-gement**
Escorted operation							
Ice braking operations							
Describes the organization and working methods of different icebreaker services	yes	yes	no	optional	yes	no	optional
Characterizes the instructions for the assisted vessel in the publications	yes	yes	no	optional	yes	no	optional
#11 General tactics and modes of escorting and assisting	*yes*	*yes*	*no*	*optional*	*no*	*no*	*no*
#12 Operation of new designs	*yes*	*yes*	*no*	*optional*	*no*	*no*	*no*
#13 Operation of special machinery	*no*	*no*	*yes*	*optional*	*no*	*no*	*no*
Ice escort operations							
Characterizes all relevant aspects when navigating under icebreaker assistance; what to do	yes	yes	no	optional	yes	no	yes
#08 Navigation in narrow channels	*yes*	*yes*	*no*	*optional*	*yes*	*no*	*optional*
#09 To be escorted by two icebreakers	*yes*	*yes*	*no*	*optional*	*yes*	*no*	*optional*
#10 Escorting with two icebreakers	*yes*	*yes*	*no*	*optional*	*no*	*no*	*no*
Defines the standard communication with the icebreaker	yes	yes	no	optional	yes	no	optional
Related Information							
Working procedures							
Describes regulations for working in cold environments	yes	yes	yes	optional	yes	yes	yes

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**Naviga-tors**	**Engi-neers**	**Mana-gement**	**Naviga-tors**	**Engi-neers**	**Mana-gement**
Characterizes the dangers of working in cold environments	yes	yes	yes	optional	yes	yes	yes
Practice with case studies for applying the working procedures on board	yes	yes	yes	optional	yes	yes	yes

Additional information							
#05 & # 15 Single point mooring in ice	*no*	*no*	*no*	*no*	*optional*	*no*	*optional*
#06 & # 16 Dynamic positioning in ice	*yes*	*yes*	*no*	*no*	*optional*	*no*	*optional*
Engineering and machinery operations: #02 Operation of coupled low-speed engines	*no*	*no*	*optional*	*optional*	*no*	*optional*	*optional*
Engineering and machinery operations: #03 Operation and control of high-voltage electrical network	*no*	*no*	*optional*	*optional*	*no*	*optional*	*optional*

FUNCTION OR FEATURE	IMPLEMENTED	PROTOTYPE STAGE	DOES NOT EXIST
Multiple bridges connected into one complex	X	-	-
Navigation bridge and infrastructure			
- ice conditions on radar display	-	-	X
- search lights	-	-	X
- satellite based ice information	-	-	X
- 360° visualization system	X	-	-
- realistic scenery of ice field	-	(x)	X
Ice field models			
- dynamic management of ice field models	-	(x)	X
- level ice	-	X	-
- opened lead	-	X	-
- ridged ice zone	-	-	X
- drift ice, ice floes	-	X	-
- pressurized ice field	-	-	X
Ship-Ice interaction			
- horizontal movements	-	X	-
- vertical movements	-	(x)	X
- ice loads on hull vs. local strength	-	-	X
- ice loads on propeller and rudder	-	-	X

4. WP4 Environmental Protection and Management System for the Arctic

4.1 Characteristics of Shipping and Navigation in the Northern Seas

The sailing frequencies in the Barents Region are expected to increase due to changes in the Russian infrastructure in the north, new exporting markets and exploitation and development of oil-and gas fields in the region. Due to limitations in terminal facilities, shallow water and sea ice conditions during winter, small tankers will to a large degree transport the oil and gas to reloading terminals in Archangelsk and Murmansk, for reloading to larger cargo tankers.

Statistical updates of values of oil transportation from Russia passing the coast of Norway are presented. A technical risk analysis for the probability of accidental events give a picture of the risk related to the shipping activity.

It is expected that mainly crude oil will be exported from the Barents Sea Region while oil product will go through the Baltic Sea.

This report contains an assessment of accidental releases to the sea of crude oil from ship traffic in routes in the area Lofoten - Barents Sea - Varandey. The following serious ship accidents, with potential of causing oil spill from loaded tankers, are included in this report:

- Collision with meeting traffic ('meeting' collisions)
- Collision with crossing traffic ('crossing' collisions)
- Grounding under power (Powered grounding)
- Grounding after mechanical problems (Drifting grounding)
- Structural failure
- Fire/Explosions

The results are presented as expected frequency per year of crude oil spills of various sizes. Assessments are given for years 2003, 2012 and 2020. In the assessment, expected risk reducing measures are included, of which traffic separation and contingency measures such as tugs are expected to play a major part.

A summary of the result of the frequency calculations for all accidents with loaded oil tankers is given in Table 1-1 - Table 1-3.

Some observation can be made from the results:

- Only serious accidents causing crude oil spill from cargo tanks of loaded tankers are included in the analysis. Neither collisions in which tankers hit other ships nor collisions in which ships are assessed not to penetrate oil tankers are included
- The accidents with the highest frequencies are drifting grounding
- The added frequency of structural failures and fire/explosion is somewhat lower than the drifting grounding frequency
- After the introduction of a Traffic Separation Scheme in January 2004 (assumed to be extended), meeting collisions are almost eliminated, and play an insignificant role in the risk
- Crossing collision with Svalbard traffic and transiting fishing vessel (2003 only) also play an insignificant role in the risk picture
- Total losses have a total frequency of 1/6 to 1/10 of the total accidents. In the majority of accidents of total losses the ship will be subject to drifting grounding or fire/explosion
- The probability that an oil tanker will sink at sea in the area due to collision or fire/explosion in the period 2003-2020 will be about 0.5%
- 3 navigational 'Hotspots' have been identified. In this report, the term 'Hotspot' is used for a limited area in which the navigational risk is significantly higher than elsewhere within the area of analysis. The collision frequencies are higher within and inside the Murmansk Fjord than anywhere else in the area. The large number of Varandey tankers and cargo ships play a significant role with regard to collisions. The collision frequencies for the Svalbard crossing are about 2 orders of magnitude lower.

The main results are presented in Table 1-1 - Table 1-3 below, for the years 2003, 2012 and 2020 respectively.

Table 1-1: Year 2003 – Frequencies and return periods for serious oil spills

Zone	1	2	3	4	5	Total (All zones)	Total (excl. zone 5)
Length (km)	280	110	140	900	1000	2430	-
Accident frequency (per km per year)	2.28E-6	2.28E-6	2.28E-6	2.28E-6	4.41E-7	1.52E-6	-
Accident frequency (per yr) *)	6.38E-4	2.51E-4	3.20E-4	2.05E-3	4.41E-4	3.7E-3	-
Return period (years)	1600	4000	3100	490	2303	270	-
Accident frequency (per yr) (Group 4 only)	4.03E-5	1.58E-5	2.02E-5	1.30E-4	7.31E-5	2.79E-4	2.06E-4
Return period (years) (Group 4 only)	25000	63000	50000	7700	13700	3580	4900

*) Frequency per year for fishing vessels has been added. Group 1 only. The contribution is however insignificant.

Table 1-2: Year 2012 – Frequencies and return periods for serious oil spills

Zone	1	2	3	4	5	Total (All zones)	Total (excl. zone 5)
Length (km)	280	110	140	900	1000	2430	-
Accident frequency (per km per year)	1.07E-6	8.06E-7	7.84E-7	7.02E-7	5.78E-7	7.04E-7	-
Accident frequency (per yr) *)	3E-4	8.86E-5	1.1E-4	6.3E-4	5.78E-4	1.71E-3	-
Return period (years)	3300	11200	9000	1600	1700	590	-
Accident frequency (per yr) (Group 4 only)	8.32E-5	3.27E-5	8.47E-6	5.85E-5	1.61E-5	2E-4	1.84E-4
Return period (years) (Group 4 only)	120000	30500	118000	17100	62000	5000	5500

Table 1-3: Year 2020 – Frequencies and return periods for serious oil spills

Zone	1	2	3	4	5	Total (All zones)	Total (excl. zone 5)
Length (km)	280	110	140	900	1000	2430	-
Accident frequency (per km per year)	1.94E-6	1.94E-6	1.26E-6	1.17E-6	3.89E-7	9.71E-7	-
Accident frequency (per yr) *)	5.43E-4	2.13E-4	1.64E-4	1.05E-3	3.9E-4	2.36E-3	-
Return period (years)	1800	4700	6100	950	2600	420	-
Accident frequency (per yr) (Group 4 only)	1.96E-4	7.7E-5	1.35E-5	8.59E-5	8.05E-5	4.53E-4	3.72E-4
Return period (years) (Group 4 only)	5100	13000	74000	12000	12500	2200	2700

4.2 Environmental Impact Assessment (EIA) and Environmental Risk Analysis (ERA)

4.2.1 Introduction

ARCOP WP 4.1.2 and 4.1.3 are designed to provide a decision-making foundation in terms of an Environmental Impact Assessment (EIA) and an Environmental Risk Analysis (ERA) of sea-borne transportation in Russian and Norwegian Arctic waters (cf. Section 2). Such studies relies on baseline data; on one hand relevant knowledge on the temporal and spatial distribution and abundance of ecosystem components likely to be affected by the activity (i.e. resources at risk), on the other hand, corresponding knowledge on the sea-borne transportation for specification of the factors likely to cause impact on the environment (i.e. the impact factors). Without relevant baseline, the resolution of the assessment and analysis may be poor and the decision-making foundation of less significance.

The baseline used and presented in the oil spill contingency plan of the Barents Sea recently developed by CNIIMF (cf. CNIIMF 2001), provide excellent examples of data considered highly relevant for the ARCOP EIA and ERA. The access to the data, however, is considered uncertain. The INSROP dynamic environmental atlas is another example (Brude et al. 1998). These data are available in ArcView shapefile format, but the geographical area covered is limited to the NSR east of the Kara gate.

This memo forms a presentation of the current status of environmental baseline compiled by DNV for assessment and analysis purposes in ARCOP.

Some elements should be carefully considered in this regard:

- The EIA and ERA will address possible impact on environmental components like shallow water benthos, plankton, fish, sea birds and marine mammals. However, a complete description of the marine flora and fauna of the arctic waters is beyond the scope of ARCOP, and focus will be placed on a limited number of priority resources, i.e. the ecosystem components fulfilling criteria's like high vulnerability and ecological significance (cf. Section 3.1).
- When ARCOP is concluded, data will be available to the project participants in line with the overall agreement (cf. the EU regulations of data and results in the contract).

In the following sections the data sets are briefly described with regards to themes, geographical areas, source etc. Available data identified but not yet compiled are also listed. Emphasis is placed on the temporal and spatial distribution of natural resources / ecosystem components likely impacted by sea-borne transportation (cf. Section 3.1). Relevant data can be viewed at the complementary CD-rom as part of this delivery.

4.2.2 Study area

The study area of ARCOP is not strictly defined, but may include the Northern Sea Route as well as Russian and Norwegian waters of the Barents Sea. Considering a project core area however, corresponding to areas with the highest potential for increasing sea-borne transportation, the waters from Yamal in the east to Lofoten in the west, appear most relevant (cf. Figure 1).

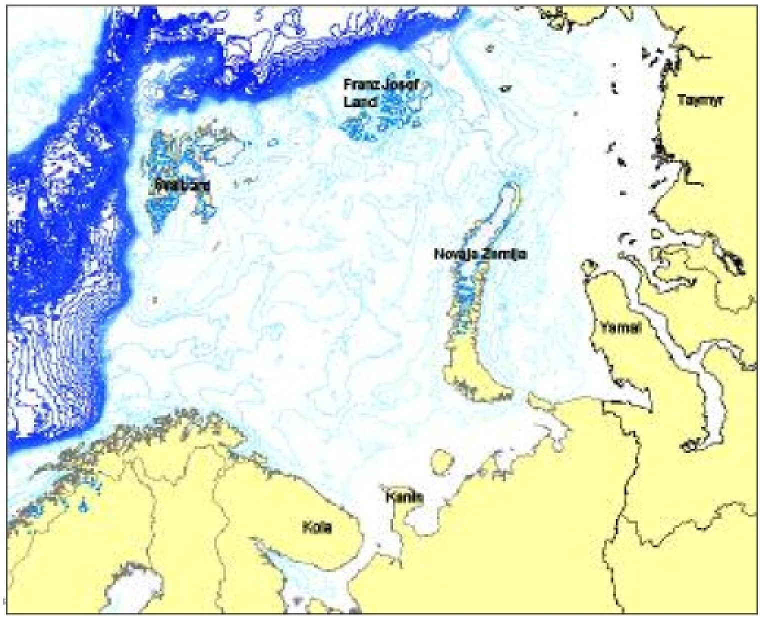


Figure 1: The core area for the ARCOP Environmental Impact Assessment and -Risk Analysis.

4.2.3 Organization of data

The datasets are organized into the following four main groups:

- Base cartography
- Sea ice data
- Biological resources
- Protected areas

Biological resources are further divided into five topics; Plankton, Benthos & water-land border zone, Fish, Marine birds and Marine Mammals)

Criteria's for data compilation

The data should be relevant for the EIA and ERA. This means that all baseline data should be tailored for the purposes of impact assessment and analysis; i.e. if reliable interactions between a given data issue and the sea-borne activity cannot be developed, effort should not be placed on the given data.

Two overall criteria's should be considered for further data compilation:

- Vulnerability; i.e. focus should be placed on those resources considered most vulnerable to the sea-borne transportation activity. In this regard, accidental oil pollution is considered a dimensional impact factor, and resources like e.g. shallow water benthos, shoreline substrate and communities, fish eggs and larvae (spawning grounds), sea birds, seals and walruses may be significantly affected.
- Ecological significance; this means that effort should be placed on the most important resources, e.g. large populations of fish, sea birds, seals etc. Resources of minor ecological importance should not be compiled.

Sources of baseline data

INSROP

The International Northern Sea Route Programme (INSROP) was a comprehensive multi-national, multi-disciplinary research programme designed to investigate the possibilities for commercial navigation on the Northern Sea Route (NSR) and adjacent waters (cf. the Northeast Passage). In this programme there were developed a comprehensive Dynamic Environmental Atlas (DEA) which forms the baseline of environmental data sets for impact analysis and assessments in the NSR (Brude et al. 1998; Brude & Løvås 1999).

Area: The NSR covers the area from Novaya Zemlya in the west to the Bering Strait in the east (Brude et al. 1998).

Baseline data: Various baseline maps, detailed ice data, benthos (sediment composition, benthos invertebrates), fish (catch areas and statistics), birds (several species and activities), marine mammals (main species distribution), protected areas (NSR).

Validation: Best available baseline data for the NSR at the time when DEA were developed.

EPPR

The EPPR project "Circumpolar map of resources at risk from oil spills in the arctic" has developed a database containing important natural and human features of the Arctic. This information was further used to identify areas of congruence between petroleum activities, the environment and other human activities. The results of the project presented a priority list of selected resources passing a set of criteria identified in the project (Carol 2002). The results of the project are presented at http://www.akvaplan.niva.no/eppr/

Area: The EPPR study area includes the circumpolar arctic, and cover the whole study area of ARCOP (ref. section 2). Only data in the main focus area will be further evaluated (Regional view: Scandinavia & W. Russia).

Baseline data: Fishes (6 main species), birds (several species), marine mammals (main species), protected areas (world heritage sites, international biosphere sites, Ramsar sites and sites designated IUCN category I-V) (Carol 2002).

Validation: Digital data available from EPPR. Mainly maps on resource distribution in four seasons (winter, spring, summer and autumn) (Carrol 2002).

CNIIMF

The "Barents Sea regional oil spill contingency plan" presents a set of maps of ecological sensitivity of resources of Barents, White and Pechora seas to oil spills (CNIIMF 2001).

Area: The study area of the Barents Sea regional oil spill contingency plan includes the Barents Sea, the White Sea and the Pechora Sea.

Baseline data: Characteristics of beaches, breeding and migration of fishes, auks and marine mammals (CNIIMF 2001).

Validation: Digital data not yet available. Detailed data on distribution, migration, feeding areas (CNIIMF 2001).

NoBaLes

NoBaLes (In Norwegian: Norsk Barentshavs letesamarbeid) was a cooperation initiated between Hydro, Statoil, Saga, Elf, Mobil and Norsk Agip in connection with exploration of potential new petroleum areas in the Norwegian part of the Barents Sea.

In a project founded by NoBaLes the distribution of the most numerous seabird species in the Barents Sea in three different seasons (winter, spring/summer and autumn) were studied (Systad et al. 1999). The results include digital data on seabird distribution as a decision making tool in connection to potential petroleum activity in the Barents Sea.

On behalf of NoBaLes and OLF (Norwegian Oil Industry Association), sea shore baseline data on substrate and resources for use in environmental impact assessments, environmental risk assessment and contingency planning were developed as a separate project (Moe et al. 2000).

Area: Norwegian part of the Barents Sea

Baseline data: Benthos (sediment composition, resource distribution), bird (sea birds at open sea, distributed in 5 main ecological groups)

Validation: Best available data on sea shore sediment composition and resource distribution and large scale distribution of sea birds at open sea.

Assessment programme in the Lofoten – Barents Sea area (ULB)

The potential for coexistence between petroleum activity, fisheries, shipping and other activities are under evaluation by the Norwegian authorities in a large assessment programme in the Lofoten and the Barents Sea area. Early in the process there were developed a common basis of environmental data covering the main resources in the assessment area (Føyn et al. 2002; Moe et al. 2003).

Area: Lofoten and the Norwegian part of the Barents Sea.

Baseline data: Zooplankton, fish (5 main ecologic and economic species) distribution, eggs and larva, marine mammals (ordinary species) (Føyn et al.

2002), as well as data on sea shore sediment composition and benthos distribution (Moe et al. 2003).

Validation: Detailed data on zooplankton, fish distribution and eggs and larva, only coarse distribution area on marine mammals. Detailed data on sea shore sediment composition and resource distribution.

WWF

World Wide Fun for Nature (WWF) has recently presented a Biodiversity assessment report for the Barents Sea region (Larsen et al. 2003). In this study, Russian experts and scientist have provided both data and documentation. Examples are given in the table below.

Area: The Barents Sea

Baseline data: Baseline maps (bathymetry, currents), sea ice, benthos, coral reefs, fish (main species), birds (colonies, migration, moulting and feeding), marine mammals (main species distribution), protected areas (Europe, Asia).

Validation: Detailed and updated data covering the Barents Sea. Potential for data gaps mainly in the Russian part of the Barents Sea.

SMO

Particular Environmental Sensitive Areas and Petroleum Activity (SMO) is an assessment tool established for presentation of especially environmental sensitive areas to acute oil pollution. The work was founded by The Norwegian Pollution Control Authority (SFT) and the Directorate for Nature Management (DN) in Norway and implements criteria on regional, national and international level. The results are presented on CD as digital maps on individual species (Moe et al. 1999). A GIS database (SMO module) for ecological species groups has later been developed by Brude et al. (1999).

Area: Coast of Norway

Baseline data: Fish egg and larvae (cod, herring, capelin), sea birds (several species and ecological groups), marine mammals (harbour seal, grey seal, walrus and polar bear).

Validation: Detailed baseline data used as basis for analyses on sea birds, and the few marine mammal species included. Results present resources at regional, national or international level regarding sensitivity to oil spills.

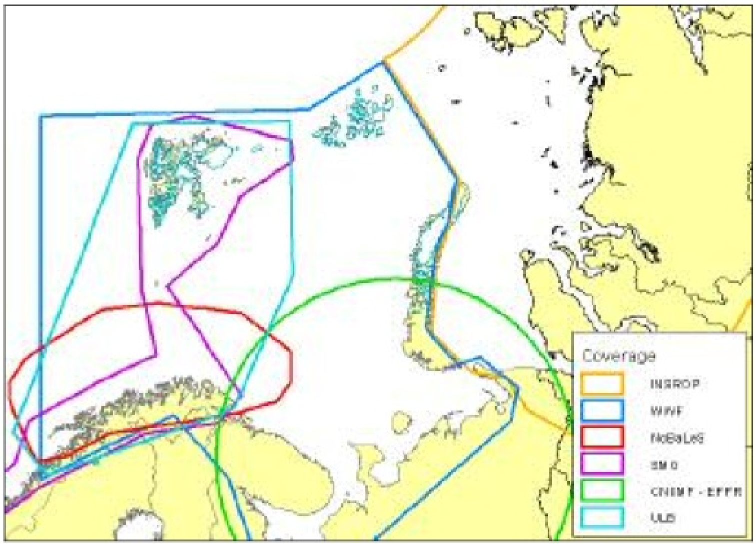


Figure 2: Geographical coverage of data sources. INSROP data continues eastward to the Bering Strait, while CNIIMF – EPPR data are not available digitally.

Base cartography

Base cartography is compiled from freely available sources like the Digital Chart of the World (DCW 1:1 mill) and the World Vector Shoreline (WVS 1:250 000). In addition bathymetric data are compiled from the General Bathymetric Chart of the Oceans (GEBCO 1 min) and The International Bathymetric Chart of the Arctic Ocean (IBCAO 1 min) datasets.

Data sets	Theme-ID	Description	Source
Bathymetry		1 min grid	GEBCO + IBCAO
Bathymetry	bathymetry	depth contours	WWF
Cities	cities		DCW 1:1 mill
Coastline DCW	dcwcoast		DCW 1:1 mill
Coastline WVS	Wvs_nsr_1		WVS 1:250 000
Currents	currents		WWF
Rivers			DCW 1:1 mill
Land area			DCW 1:1 mill
Meteorology data sets			INSROP
NSR Maritime boundaries	maritimeboundaries.shp		INSROP
NSR Ports	Ports		INSROP
Roads and tracks	roads and tracks		DCW 1:1 mill
Russian economic zone	rus12nm.shp	12 nm	INSROP
Russian territorial waters	rus200nm.shp	200 nm	INSROP
Russian administrative borders	Adm_bord		INSROP
Russian baselines	Base_		INSROP

Concluding remarks:

Base cartography data sets (land, sea, coastline, rivers, cities etc.) are available for the whole study area at a 1:1 million scale (DCW) and the coastline are also available at 1:250000 (WVS). In addition, the INSROP project has compiled several administrative datasets covering the NSR area.

Sea Ice Data

A huge amount of digital sea ice data has been prepared through INSROP, covering the eastern part of the Barents Sea (40o E) to the Bering Sea. In addition data has been prepared as monthly GIS files presenting probability of sea ice (1966-1989) based on data from the Norwegian Polar Institute (NP) and The Norwegian Meteorological Institute (Met.no) covering the Barents Sea. In addition historical Barents Sea ice coverage maps are available at ACSYS historical Ice Chart Archive (http://acsys.npolar.no/ahica/gis.htm).

Data sets	Theme-ID	Season, months	Description	Source
Probability of sea ice		monthly		INSROP
Sea ice stage of development		monthly		INSROP
AARI Sea Ice Chart statistics		monthly	Ice concentration and ice thickness 1967-90	INSROP
AARI - Discontinuities in ice				INSROP
INSROP data from the AARI-SOF data transfer 1996		monthly	Ice concentration and ice thickness, hum mocked ice, ridge frequency, fast ice break-up in straits	INSROP
Ice data from INSROP - Box B - Work Package 2		monthly by ship route	Cold sum, Ice concentration, Ice thickness, Floe size, Ridge height, Ridge density	INSROP
Ice data from INSROP Project I.4.2			Discontinuities in ice, Ice pressure points, polynyas, Ice thickness - frequency of occurrences	INSROP
Ice data from INSROP Project I.5.8		monthly	Frequency of occurrence of ice concentration	INSROP
Probability of sea ice		monthly		DNV
Sea ice	sea ice	September, March		WWF

Concluding remarks:

A broad range of digital sea ice data covers the area west of 40o E within the study area. In the western part of the Barents Sea there is available some statistical information on monthly probability of sea ice.

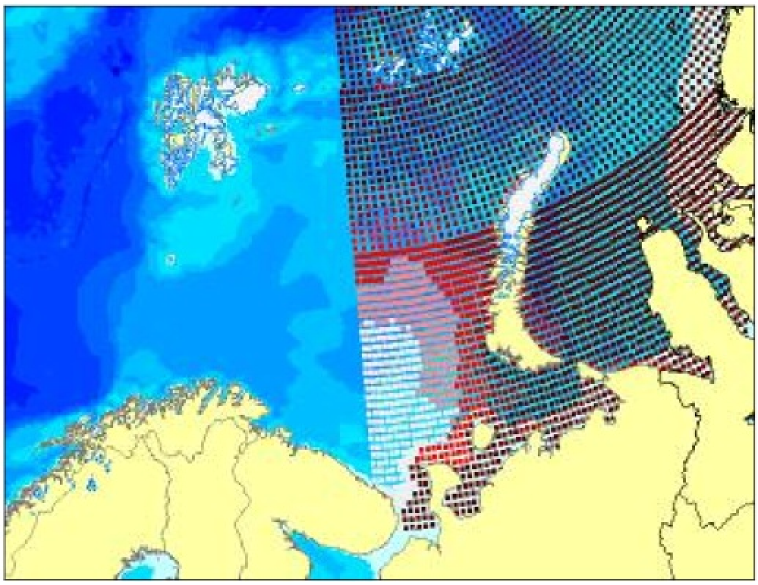


Figure 3: Example illustrating mean sea ice concentration in April (source: INSROP)

Biological resources

The data on biological resources has been divided into five topics according to their tropical level.

Plankton

ULB (Føyn et al. 2002) has presented digital data on distribution on zooplankton in the Barents Sea based on observations from the Institute of Marine Research (IMR) in 1992 and 1994. Data on primary production and phytoplankton distribution are available at a global scale from the SeaWiFS Project (http://seawifs.gsfc.nasa.gov/SEAWIFS.html).

Concluding remarks:

Limited datasets on zooplankton distribution have been compiled for the Barents Sea, while no such data have been identified further east. There is available satellite data (SeaWiFS) on primary production for the whole study area, but none

Data sets	Theme-ID	Description	Source
Primary production, phytoplankton	-	Satellite data	SeaWiFS Project
Zooplankton	Plankton 10x10	Sept 1992	ULB
Zooplankton	Plankton 10x10	Sept 1994	ULB

of these have been compiled for usage in ARCOP yet. Generally, plankton is of less importance in connection with EIA and ERA.

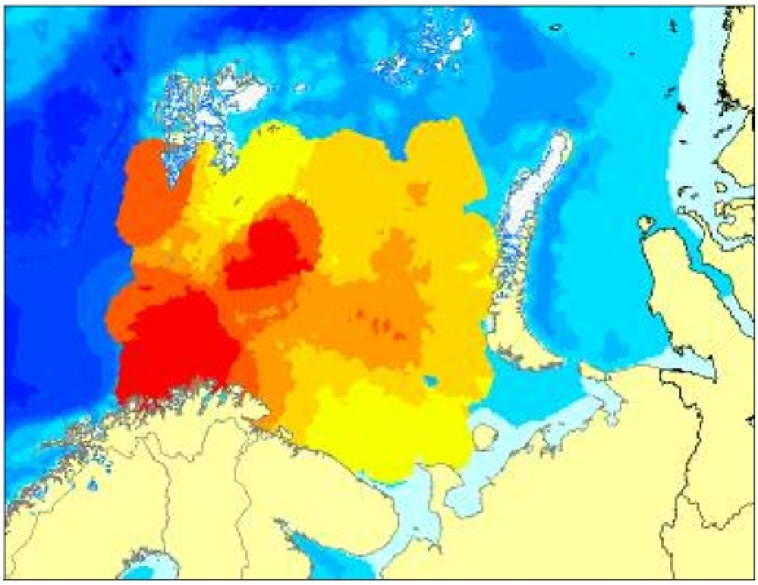


Figure 4: Example showing zooplankton distribution in the Barents Sea in September 1994 (source: ULB)

Benthos & Water-land border sone

Benthic invertebrates sampling stations for the NSR area were collected and made available through INSROP. The data includes biocenoses areas in the Laptev Sea. In addition, benthic diversity maps are available for the Barents Sea (Larsen at al. 2003) for specific years. Regarding the water-land border zone, shoreline sediment composition are available at a coarse scale for the NSR area, and with better resolution (1: 50000) for the Norwegian coastline in the Barents Sea (Moe et al. 2000). The latter includes modelled abundance of hard bottom resources. Coastal types in the White Sea, the Barents Sea and the Pechora Sea have been compiled in the "Barents Sea oil spill contingency plan" (CNIIMF

2001) but digital versions of these data have not yet been obtained.

Data sets	Theme-ID	Description	Source
Biosciences	Biocenos.shp	Composition on faunal associations	INSROP
Benthos	benthos diversity 91-91	Diversity (number of species) 1991	WWF
Benthos	benthos 91-94	Concentration 91-94	WWF
Coral reefs	coral reefs	Distribution (coast of Norway)	WWF
Benthos sampling stations	cs.shp	Sampling stations and benthos invertebrates	INSROP
NSR Shoreline	nsr_sh	Sediment composition (pelite, silt, sand, coarse sediments, rocks and ice)	INSROP
Shoreline habitat		Sediment composition and resource distribution	NoBaLes / ULB
Coast types		Coast types of the White Sea, Pechora Sea, Barents Sea	CNIIMF

Concluding remarks:

Georeferenced data describing shoreline habitat and substrate are considered of vital importance for assessment and analysis of oil contamination of the shore. The INSROP data only covers the NSR east of the Kara gate. For Russian waters west of the Kara gate, this topic should be given high priority before conducting the ERA/EIA.

Fish and Fisheries

The ULB has made available several digital survey data in the Barents Sea, including spawning areas, eggs, larvae and 0-group distribution on several commercial fish stocks (Føyn et al. 2002). In addition WWF have compiled some spawning areas and larvae distribution also in the Barents Sea (Larsen et al. 2003). Through the EPPR initiative (Carrol 2002) there are available distribution maps on selected fish stocks (cod, polar cod, capelin, herring and haddock) in four seasons (winter, spring, summer and autumn) (digital data not available). In addition several maps on migration ways, feeding and spawning areas for different fish species in the Russian part of the Barents Sea, were published in the "Barents Sea regional oil spill contingency plan" (CNIIMF 2001) (digital data not yet available). In the NSR area some information regarding catch areas and catch statistics are available for main rivers and estuaries (Brude et al. 1998; Brude & Løvås 1999).

Data sets	**Theme-ID**	**Description**	**Season, month, year**	**Source**
American plaice *(Hippoglossoides platessoides limandoides)*	hippo_pl	Catch areas and catch statistics		INSROP
Arctic char			Summer	EPPR
Arctic char		Feeding areas (Pechora Sea)	Summer	CNIIMF
Arctic cisco		Spring migration ways, feeding areas, spawning migration ways (Pechora Sea)	Spring, summer, autumn	CNIIMF
Arctic cod		Distribution & migration ways (Pechora Sea)	Early spring, autumn/winte r	CNIIMF
Arctic flounder *(Liopsetta glacialis)*	liop_gla	Catch areas and catch statistics		INSROP
Asian smelt		Spawning migration ways, feeding areas (Pechora Sea)	Spring, summer	CNIIMF
Atlantic & humpback salmon		Migration ways * & spawning areas** (White Sea)	* summer and autumn ** Sept-Nov	CNIIMF
Atlantic salmon		Spawning migration ways (Pechora Sea)	Summer, autumn	CNIIMF
Atlantic salmon		Migration ways, main spawning rivers (eastern Barents Sea)		CNIIMF
Broad Whitefish *(Coregonus autumnalis nasus)*	core_aun	Catch areas and catch statistics		INSROP
Burbot (*Lota lota)*	lota_lot	Catch areas and catch statistics		INSROP
Capelin			Winter, spring, summer	EPPR
Capelin	Fisk 10x10_hav	Adult	1994, 2001	ULB
Capelin	capelin spawning	Spawning		WWF

Capelin	Fisk 10x10_hav	larvae	Jun 1996, 2000, 2002	ULB
Capelin	Fisk 10x10_hav	0-group	Aug-Sept 02	ULB
Capelin *(Mallotus villotus villotus)*	mallo_vi	Catch areas and catch statistics		INSROP
Capelin (Atlantic)		Concentrations , migration ways (Barents Sea coasts)	January	CNIIMF
Cod (Atlantic)			Winter, spring, summer, autumn	EPPR
Cod (Atlantic)	cod spawning	Spawning		WWF
Cod (Atlantic)	cod larvae	Larvae		WWF
Cod (Atlantic)	Fisk 10x10_hav	Adult	Feb/Mar 1996, Jan/Feb 1999, Jul/Aug 1996, 1999	ULB
Cod (Atlantic)	Fisk 10x10_hav	Egg	Mars1985	ULB
Cod (Atlantic)	Fisk 10x10_hav	larvae	May 1984	ULB
Cod (Atlantic)	Fisk 10x10_hav	juvenile	July-Aug 1989,1991	ULB
Cod (Atlantic)	Fisk 10x10_hav	0-group	Aug-Sept 02	ULB
Cod (Atlantic)		Migration (eastern Barents Sea)		CNIIMF
Cod (Atlantic) (*Gadus morhua morhua)*	gad_mor	Catch areas and catch statistics		INSROP
White-Sea cod		Spawning areas (White sea)	February-May	CNIIMF
Fish		Areas of threatened and vulnerable fish species (eastern Barents Sea)		CNIIMF
Gadus mallus	gad_mal	Catch areas and catch statistics		INSROP
Haddock			Winter, spring, summer, autumn	EPPR
Haddock	haddock spawning	Spawning areas		WWF
Haddock	Fisk 10x10_hav	Adult	1998, 2001	ULB
Haddock	Fisk 10x10_hav	0-group	Aug-Sept 02	ULB
Haddock	Fisk 10x10_hav	Egg	April 1987	ULB
Haddock		Migration (eastern Barents Sea)		CNIIMF
Herring			Winter, spring, summer, autumn	EPPR
Herring	herring spawning	Spawning areas		WWF
Herring	Fisk 10x10_hav	0-group	Aug- Sept 02	ULB
Herring	Fisk 10x10_hav	Young	Jun 1997	ULB
Herring	Fisk 10x10_hav	Old	Feb 1998	ULB
Herring	Fisk 10x10_hav	Larvae	April 1999,	ULB

			2002	
Herring (Atlantic-Scandinavian)		Distribution, migration (eastern Barents Sea)		CNIIMF
Pacific herring *(Clupea palassi suworowi)*	clup_pal	Catch areas and catch statistics		INSROP
Pechora herring		Distribution, migration ways (Pechora Sea)	January – July, July-December	CNIIMF
Pechora herring		Distribution, migration (eastern Barents Sea)	March-August	CNIIMF
White-Sea herring		Distribution of local populations (White-Sea)		CNIIMF
Humpback whitefish (*Coregonus lavaretus pidschian)*	core_lav	Catch areas and catch statistics		INSROP
Inconnu *(Stenodus leucichthys nelma)*	steno_ln	Catch areas and catch statistics		INSROP
Longnose Siberian sturgeon *(Acipenser baeri)*	aci_baer	Catch areas and catch statistics		INSROP
Muksum (*Coregonus muksun)*	core_muk	Catch areas and catch statistics		INSROP
Navaga (*Eleginus navaga)*	ele_nava	Catch areas and catch statistics		INSROP
Omul (*Coregonus autumnalis peleda)*	core_aup	Catch areas and catch statistics		INSROP
Polar Cod			Winter, spring, summer, autumn	EPPR
Polar Cod	polar cod larvae	Larvae		WWF
Redfish	Fisk 10x10_hav	Adult	Feb 1988, 2001	ULB
Saithe	saithe			WWF
Saithe	Fisk 10x10_hav	Adult	2001	ULB
Salmon rivers		Status		WWF
Sea perch		Migration (eastern Barents Sea)		CNIIMF
Shrimps		Commercial aggregations		WWF
Siberian cisco (*Coregonus sardinella)*	core_sar	Catch areas and catch statistics		INSROP
Vendace		Spawning migration ways, feeding areas (Pechora Sea)	Summer, autumn	CNIIMF

Concluding remarks:

Identified information on fish resources covers the whole study area. Availably digital data covers the Norwegian part of the Barents Sea, and the NSR area. Some data exist, but there is a gap in detailed data in the eastern part of the Barents Sea, from the Kara Gate to the Norwegian border.

Marine birds

In the NSR area a wide range of sea birds, eiders and ducks have been mapped regarding breeding and non-breeding areas (Brude et al. 1998; Brude & Løvås 1999). In the Barents Sea, seabird colonies and some migration and moulting areas have been compiled from various sources (CNIIMF 2001; Carrol 2002; Larsen et al. 2003). In the western Barents Sea there exist some coarse data on the distribution of sea birds at sea, as well as information on particular environmental sensitive areas (SMO) for ecological groups of sea birds (Moe et al. 1999). There should be mentioned that open-sea modelling of distribution of some pelagic diving species in the Barents sea are performed by Norwegian oil companies, but data are not yet public available.

SU=summer, Au=autumn, W=winter, Sp=spring

Data sets	Theme-ID	Activity	Season, months	Source
Arctic Tern			Su	EPPR
Barnacle Goose			Sp, Su, Au	EPPR
Barnacle Goose	barn_	Breeding & nonbreeding areas		INSROP
Bean Goose	beang_	Breeding & nonbreeding areas		INSROP
Black-legged Kittiwake			Sp, Su, Au	EPPR
Brent Goose	brent_	Breeding & nonbreeding areas		INSROP
Brent Goose			Sp, Su, Au	EPPR
Brunnich's Guillemot	urlom_	Breeding areas & pelagic distribution		INSROP
Common Eider	com_	Breeding & nonbreeding areas		INSROP
Common Eider			W, Sp, Su, Au	EPPR
Common Murre (Guillemot)			Sp, Su	EPPR
Common Guillemot		Distribution		CNIIMF
Emperor Goose	emp_	Breeding & nonbreeding areas		INSROP
Fulmar (Northern)			Sp, Su, Au	EPPR
Ivory Gull	ivorg_	Breeding areas & pelagic distribution		INSROP
Ivory Gull			W, Sp, Su, Au	EPPR
King Eider	king_	Breeding & nonbreeding areas	-	INSROP
King Eider			Sp, Su	EPPR
Kittiwake	kitt_	Breeding areas & pelagic distribution		INSROP
Long-tailed Duck	long_	Breeding & nonbreeding areas		INSROP
Long-tailed Duck			Sp, Su	EPPR
Puffin			Sp, Su	EPPR
Spectacled Eider	spec_	Breeding & nonbreeding areas		INSROP
Steller's Eider	stell_	Breeding & nonbreeding areas		INSROP
Steller's Eider			W	EPPR
Thick-billed Murre			W, Su	EPPR

Concluding remarks:

Identified information on sea birds covers the whole study area. Available digital data covers the Norwegian part of the Barents Sea and the NSR area, while there is less data in the eastern part of the Barents Sea, from the Kara Gate to the Norwegian border. Data is focused on coastal areas while less data exists on sea birds at open sea.

(Brünnichs Guillemot)				
White-fronted Goose	wfront_	Breeding & nonbreeding areas		INSROP
Marine ducks	duck_			INSROP
Birds		Distribution (Pechora Sea)	Summer (July-Aug.)	CNIIMF
Birds		Distribution, migration ways (Pechora Sea, southern Barents Sea)	Period specified	CNIIMF
Marine colonial birds		Distribution (Pechora Sea)	June – early Oct.	CNIIMF
Seabird colonies	Colonies			INSROP
Seabird colonies	seabird colonies			WWF
Seabirds		Auks & ducks, moulting & feeding		WWF
Seabirds		Auks & ducks, winter density	W	
Seabirds		Migration & moulting		
Seabirds	seabird winter1	Winter	W	WWF
Waders, Geese and Swans		Moulting & feeding areas		WWF
Waterfowl & water birds		Distribution after the end of nesting (Pechora Sea)	Mid-July – early Oct.	CNIIMF
Waders	wader_	Feeding & resting	Monthly	INSROP
Pelagic diving		Particular env. sensitive areas	Monthly	SMO
Pelagic surface feeding		Particular env. sensitive areas	Monthly	SMO
Coastal diving		Particular env. sensitive areas	Monthly	SMO
Coastal surface feeding		Particular env. sensitive areas	Monthly	SMO
Anseriformes (Andefugler)		Particular env. sensitive areas	Monthly	SMO
Podicipediformes (Dykkere)		Particular env. sensitive areas	Monthly	SMO
Procellariiformes (Stormfugler)		Particular env. sensitive areas	Monthly	SMO
Sulidae (Suler)		Particular env. sensitive areas	Monthly	SMO
Ciconiiformes (Storkefugler)		Particular env. sensitive areas	Monthly	SMO
Charadrii (Vadere)		Particular env. sensitive areas	Monthly	SMO
Laridae (Måker)		Particular env. sensitive areas	Monthly	SMO
Alcae (Alker)		Particular env. sensitive areas	Monthly	SMO
Phalacrocoracidae (Skarv)		Particular env. sensitive areas	Monthly	SMO
Stercoraridae (Joer)		Particular env. sensitive areas	Monthly	SMO
Sternidae (Terner)		Particular env. sensitive areas	Monthly	SMO
Gaviiformes (Lommer)		Particular env. sensitive	Monthly	SMO

		areas		
Seabirds at sea				NoBaLeS

Marine mammals

Several sources (Carrol 2002; Brude et al. 1998; Brude & Løvås 1999; CNIIMF 2001; Føyn et al. 2002: Moe et al. 1999; Larsen et al. 2003) present information on marine mammals in the study area. Common for all the availably data are that they mainly contribute distribution areas, and no detailed information on population size. In the western Barents Sea there exist compiled data on particular environmental sensitive areas for marine mammals.

Data sets	**Theme-ID**	**Description**	**Season, months**	**Source**
Bearded seal			W, Sp, Su, Au	EPPR
Bearded seal	bearded seal	Main breeding distribution		WWF
Bearded seal	Bearded_	Distribution area	July-Okt, Nov-June.	INSROP
Bearded seal		Distribution, migration ways (Pechora Sea)		CNIIMF
Harp seal			W, Sp, Su, Au	EPPR
Harp seal	harp seal breeding & moulting	Breeding & moulting		WWF
Harp seal	Sjp 10x10	Range	Mars-Nov	ULB
Harp seal		Distribution, migration ways (Pechora Sea, eastern Barents Sea)		CNIIMF
Ringed seal			W, Sp, Su	EPPR
Ringed seal	ringed seal breeding sites	Breeding sites		WWF
Ringed seal	ringed_	Distribution areas	July-Oct., Nov-June	INSROP
Beluga (White whale)			Sp, Su, Au	EPPR
Beluga (White whale)	beluga	Distribution range	Summer, breeding, wintering	WWF
Beluga (White whale)	white_	Distribution areas	Monthly (May-Nov.)	INSROP
Bowhead whale	bowhead whale	Distribution		WWF
Bowhead whale	bowhead_	Distribution	May, June, July, Aug., Sept., Okt., Nov.	INSROP
Common porpoise	Sjp 10x10	Range	Mars-Aug	ULB
Gray whale	gray_	Distribution	May, June, July, Aug., Sept., Okt., Nov.	INSROP

Humpback whale	Sjp 10x10	Range	Mars-Aug	ULB
Killer whale			Sp, Su, Au	EPPR
Killer whale	Sjp 10x10	Range	Mars-Aug	ULB
Little picked whale		Distribution (eastern Barents Sea)		CNIIMF
Minke whale			Sp, Su, Au	EPPR
Mink whale	Sjp 10x10	Range	Mars-Nov	ULB
Narwhale	narwhale			WWF
White sided dolphin	Sjp 10x10	Range	Mars-Aug	ULB
Polar bear			W, Sp, Su, Au	EPPR
Polar bear	polar bear	Den density, range		WWF
Polar bear	polarbear_	Distribution	Monthly	INSROP
Polar bear		Distribution, migration ways (Pechora Sea)		CNIIMF
Walrus			W, Sp, Su, Au	EPPR
Walrus	walrus	Haul out		WWF
Walrus	walrus area	Distribution area		WWF
Walrus	walrus_	Distribution area	Monthly	INSROP
Walrus		Spreading (Pechora Sea)		CNIIMF
Marine mammals		Particular env. sensitive areas	Monthly	SMO

Concluding remarks:

Identified information on marine mammals covers the whole study area. Availably digital data covers the the Barents Sea, and the NSR area. There is less detailed data in the eastern part of the Barents Sea, from the Kara Gate to the Norwegian border.

Protected areas

Current status on protected areas and proposed protected areas (IUCN categories I-V) in the study area is reported in several references (Carrol 2002; Brude et al. 1998; Brude & Løvås 1999; CNIIMF 2001; NKV 2002; Rådgivende utvalg 2003; Larsen et al. 2003) Data on protected areas are digitally available.

Data sets	Theme-ID	Area/group	Description	Source
Protected areas	eurprotected	Europe	IUCN categories I-V	WWF
Protected areas	asiaprotected	Asia	IUCN categories I-V	WWF
Protected areas	protarea	Northern Sea Route (NSR)	Russian protected area (CAFF 1994)	INSROP
Protected areas		Circumpolar	World heritage sites, international biosphere sites, Ramsa sites and sites designated IUCN I-V	EPPR
Protected areas		Norway		NKV
Proposed protected marine areas		Norway		Advisory committee 2003
Protected areas		White Sea Region, Pechora Sea & Barents Sea	Boundaries of existing and proposed	CNIIMF
Ramsar sites & key bird areas		White Sea Region, Pechora Sea & Barents Sea	Boundaries	CNIIMF

Concluding remarks:

Identified information on protected areas in the whole study area. Availably digital data covers protected and proposed protected areas and IUCN areas.

4.2.4 Environmental atlas

The EIA and ERA will address possible impact on environmental components like shallow water benthos, plankton, fish, sea birds and marine mammals. However, a complete description of the marine flora and fauna of the arctic waters is beyond the scope of ARCOP, and focus has been placed on a limited number of priority resources, i.e. the ecosystem components fulfilling criteria's like high vulnerability and ecological significance (cf. Section 3.1).

These data are presented on a CD-rom, the ARCOP environmental atlas, complementary to this report, and part of the delivery.

4.3 Social Impact Assessment and Local Participation to EIA

4.3.1 The oil marine transportation system: overview of possible impacts and socio-cultural indicators

The following part of the report deals with the complexity entailed in the various impacts of implementing the oil sea transport system. The data from the fieldwork demonstrate that the Nenets people are deeply concerned about the sustainability of their natural environment, which may be affected not only by tanker transportation but also altered by the coastal facilities and could affect:

1. Water resources
2. Land resources

Impact on water resources

For the local inhabitants of the district, the ecological condition of ice and sea-river system, the purity of water resources as a common heritage, is of vital importance.

The inhabitants of the rural area are as well concerned about the reproduction of fish and waterfowl, but since they are not provided with information from project-planners on the frequency and exact routes for current and future sea navigation and with data from ecologists about dynamic of fish resources, the opinion of local

Picture 9: Portable water taken from the river (Viucheskoe village Nenets AD)

peoples is based mainly on their own experience. For example, there was an oil spill in the vicinity of Dolgii Island (Dolgii Island is situated in the Barents Sea not far from Varandey and is part of the Nenets National Reserve) for which no one admitted responsibility. One reindeer herder wondered, "If environmental safety is announced for the future, why doesn't it work now? Who will be responsible for the spill of oil in the sea?"[1]

In the Nenets Autonomous District, State control over marine nature management and environmental protection is executed by the Specialized Marine Inspection of the RF Ministry of Natural Resources. Jurisdiction of the inspection unit covers 800,000 sq. km of water area including 3,000 sq. km of the Barents Sea coast. However, Marine Inspection has no ships and it acts within its limited budget: in 2002, with a staff of only three inspectors. To perform even planned control, the inspectors have to ask companies to provide them with a helicopter ride or they use the occasional possibility to carry out spot checks together with Frontier Guards or they join other parties. An officer from the Sea Inspection confessed that the provision of control in such poor financial conditions might only be at the surface level because it was possible to rarely check up on more that fire safety.

[1] Field notes, Varandey tundra, Nenets AD, 2004.

Therefore, the Specialized Marine Inspection currently confines its activities to the coastline and Pechora estuary only.

Impact on land resources

An additional 10,064 hectares of the land are required in order to enlarge storage capacity, pumping stations and other terminal facilities (9,287 hectares of which, according to the official documents will be taken from the pasture lands used by the 'Erv' reindeer herding cooperative).[2] Officially, the cooperative will be reimbursed the loss of possible profits, but the reindeer herders are concerned about how the company would interpret this agreement and apply it in reality. (Data from interviews indicate that there are cases where activities were carried out to enlarge the terminal without an official permit and without prior agreement or with non(-)observance of the statements of agreement (the sand quarry on the Varandey tundra, at Pilnya Lake and Peschanka River).[3]

Picture 10: Used barrels by the Indiga River

Not only the reindeer herders but also officers from the Land Utilization Committee confirm that despite the officially accepted land allotment, the size of which is relatively small in the documents, the plots of land cut are larger. Such a situation is common in other places of the Russian Arctic.[4]

[2]Technical substantiation of Varandey terminal.

[3]Interview with Khabarov P.A. (director of the koophoz Erv), Field notes, Naryan-Mar, Nenets AD, 2004.

[4]Khrushev S., K. Klokov 1998. p. 29.

Two principal reasons explain this:

1. Construction is accompanied by different types of pollution: chemical, noise, debris, etc. All these spread, and the land becomes useless for the traditional needs of the local inhabitants.
2. A company constructs its facilities on a plot of allotted land but the infrastructure's (roads and pipelines) cuts through and makes inaccessible other parts of the vicinity, which usually are not officially allotted.

Picture 11: Pipelines cut through the reindeer migration route Varandey tundra
Photo from the Association of Nenets People Yasavey archive

An example from the Varandey coast illustrates the second statement: a huge area of about 20 thousand hectares of pasture became inaccessible after a pipeline from Myadsei deposit to Varandey terminal had been laid. That happened because a lack of information and little interest about local needs. An employee from the Naryanmarneftegaz Company said in an interview, pointing to a map, "Look here, to the Varandey coast! Who can we disturb? There is nothing at the place but bogs and grass covered with water. It's not pasture!"[5]

Reindeer herders think differently about the coastal lands and consider the seaside halophyte meadows as valuable pastures. The reindeer eat grass, which is rich in both nutrients and salt, and then they quickly gain weight. What the more such pastures are often shrouded in sea fog and frequently, cold winds pass over

[5]Field notes, Naryan-Mar, Nenets AD, 2004

them, which helps animals to escape biting insects and also favour for the good and calm pasturing.

Picture 12: Current and planed pipelines in the Varandey area

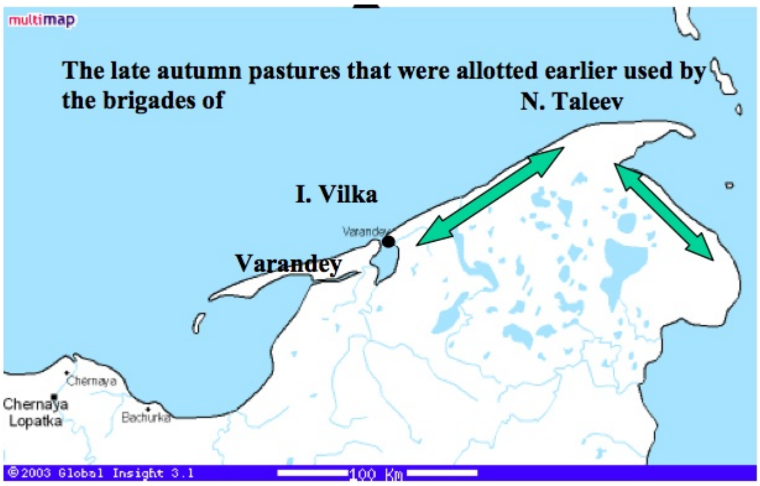
V. T., the wife of a reindeer herder from a family that has pastures along the Barents Coast spoke up,

> "The reindeer get fat during the beginning of the autumn, but they need to have some reserve energy stock for the coming winter. That's why till recently we always went for about two weeks to the coastal pastures in October. The grass is salty there and the reindeer like it, and they fatten up very quickly. We call this kind of pasture 'tamb'. But it's now been 3 years since access to this pasture has been cut off by the pipeline, so we have to turn back and migrate our herds far from that place."[6]

The head of another family, T. N., added:

> "Now listen! Why are the coastal pastures so important? One reindeer should be fat enough for slaughtering while the other one should live through winter and survive during the hard spring. If a reindeer eats only one type of food, like lichen, it will take some fat,

[6]Field notes, Varandey tundra, Nenets AD, 2004

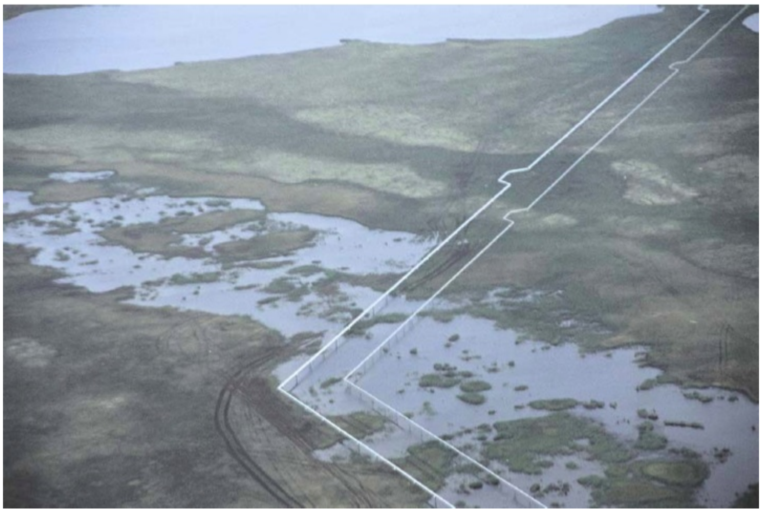


Picture 13: The territory of common use

> though it will loose it quickly. To reach a better state, it should have alternating fat and meat layers under its skin and we have to change pastures for this. The salty coast pastures are the best before the preceding winter frosts in October; the reindeer really love it."[7]

The situation became complicated in 2001. Because of the unofficially allotted by companies pastures, the reindeer herders delayed giving permission for using additional lands needed for further construction. In response, the oil company took some land and began construction without official permission. These in turn resulted in a number of consequences (the loss of taxes for the regional budget, the poor responsibility of the company for the condition of unofficially allotted lands, etc). The conflict between land users was sharp but in the end (after many hours meetings and discussions) the oil company (at that time it was Varandeyneftegas) constructed special passes for reindeer. This could have been done from the very beginn ing, if early consultation with the indigenous peoples had been considered an integral part of construction planning.

[7]Field notes, Varandey tundra, Nenets AD, 2004



Picture 12: Pipelines in the Varandey coastal area

4.3.2 Indirect and cumulative impacts of oil crude sea transportation

Possible negative consequences

Disabling the use of one specific pasture (such as the autumn coastal pastures) results in changing the cycle of pasturing. This means that reindeer herders are forced to look for a new plan for seasonal migrations, because:

1. Practically all lands suitable for reindeer breeding are distributed between reindeer enterprises.
2. The choice of pasture land should meet a number of mandatory natural requirements: there must be suitable places for extended stops, places for watching herds, a good water source, resting places and safe places for spring calving. (For instance, the best watering places are lakes or running rivers with dry shores and no miry bottom; marshes are not good, they have stagnant water; the same can be said about small grown-over lakes with swampy shores: They do not fit requirements).

Field data and literature on SIAs shows that the phase even before active operations – construction – is of no lesser importance and it actually may often cause many impacts on the economic and social well-being of the local and indigenous peoples.

Herders state that most impacts they suffer from come from the company's unpreparedness for accidents, from violation of the law and disclaiming responsibility.[8] A Nenets herder who has pastures in the close vicinity to Varandey terminal states:

> "During the winter of 2002, a big tractor sank in the Peschanka canal on Varandey tundra, which resulted in lots of crankcase oil being leaked. So now, there is no fish in the Bolshoi Toravey lake."

Herders contribute to local sustainability, but there are an alarming number of oil spills or other violations of environmental norms, even changes and mutations in local flora and fauna. Actually, the reindeer herders who migrate along the oil pipeline and coast are often the first /or the only ones who react to violations against the ecology.

Possible indirect consequences of social character

The social, economic and biophysical constituents of human well being are closely and tightly interconnected. The good practice of an SIA must develop an understanding of the impacts and chain reaction across the domains.[9] Data on social impact assessments within the INSROP project stresses that the influence of the NSR upon indigenous peoples is revealed not solely in the direct effects of marine transportation but also in the indirect and cumulative effects of the industrial development on the northern territories.[10]

Indirect impacts can bring changes in the local social and economic systems. For example increased gap between income of the the local population and the seasonal terminal staff. In 2004, the average salary for the oil industry workers came to 27,000 roubles compared with 5,500 for agricultural workers (in reality the difference is much more).[11] An increase in income per se is positive factor but if

[8] See also Forbes B. 2004.

[9] Vanclay F. International principles for Social Impact Assessment. Impact assessment and project Appraisal. March 2003, p. 6.

[10] Anderson D.G. 1995; Boyakova S.I. 1996: 2.

[11] Izmailova M. 2004 (a).

to take in account that prices in the regional centre (especially for real estate) are increased also and suit only those groups with high income and exacerbate social differentiation. For example, in 2003-2004, a two-room apartment in Naryan-Mar cost 1.5 million roubles[12]; clearly, it is impossible for a reindeer herder to buy a flat. Additional social programmes must be implemented in order to bridge this gap.

Many important aspects of the social environment are not strictly economic or quantifiable. For instance, the way people interact with the environment, their environmental ethics and norms may be of critical importance to the identity of indigenous communities. This kind of data does not apply to simple counting, though it should certainly be taken into account.

The tundra area, lanscape, its flora and fauna, is more than just a place where the Nenets people live. The tundra is the keystone of their world outlook. A hill, a sand peak or a weirdly shaped lake and other natural beauties, might be a sacred site ("hebidya ya" – "sacred land" in the Nenets language).[13] Different places may be holy for all the Nenets; other spots may be sacred only for a clan or a family. For example, Vaigach Island is sacred for all the Nenets; Seven Headed Hill is sacred for inhabitants of the Varandey tundra. Places of burial – "Khalmer", are situated on the tops of high hills and considered not only sacred but also land-markers that show which clan or family it belongs to. In the Nenets culture, the destruction of the burial sites of ancestors is a huge sin because this cuts off the spiritual connection between ancestors and descendents.[14] Hundreds of stories still live in the memory of the people. These stories tell about character of a sacred place; such things make a link between the old and the young and tell a lot about environmental ethics to younger generations.

The special status of sacred places and cultural monuments is recognized in the Law of the Nenets Autonomous District about Territories of Traditional Land Use of Indigenous Peoples of the North (Section IV, 4.1). According to the law, any industrial activity in the tundra should take into account places of cultural and historic heritage. Some difficulties pertain to the issue: the Nenets culture specificity forbids revealing the location of sacred places to strangers; thus, information on

[12] Izmailova M. 2004 (c).
[13] Kharychi G.P. 2001: 81-196.
[14] 1-128. Gulevskiy A. N. 1993:12

the location of such places is kept secret and it is often shared only among the members of a community. Mutual respect for traditions and cultural nuances is important but for the future development, it will be necessary to make a cautious mapping of such places in order to avoid damage and disruption by non-natives.[15]

Picture 12: Nenets traditional cemetery and oil storage in Yamalo-Nenets autonomous region

The removal of lands without appropriate mitigating measures and social programmes could arouse a number of negative effects that tend to become cumulative; it is a well-known fact in the history of the Russian Arctic. For example, if the reindeer herders from "Erv" cooperative farm are ousted from their habitual sites they will be compelled to migrate closer to neighbouring territories (in this case, the neighbours of the "Erv" are two farms: "Izhemsky Olenevod"[16] and "Kharp"). Currently, the herders have a friendly relationship with each other but in time, there may be tension between the herders from different enterprises and this may lead to tensions between individuals and eventually have a negative impact on the psychological climate and everyday life of the villages. Such cases are known both in the Nenets and in the Yamalo-Nenets Autonomous Districts.[17]

New difficulties can lead to a situation where groups of reindeer herders may lose the opportunity and desire to continue their activities. In this case, they would be compelled to change their way of life and habits and settle down somewhere.

[15]The conservation value of sacred sites of indigenous peoples of the Arctic: a case study in Northern Russia. Report on the state of sacred sites and sanctuaries. October 2002. CAFF Technical Report. No 11. Draft.

[16]The area of 4045588 hectares in NAD is in long-term use of the Komi Republic farms.

[17]Leont'ev A. V 2002:1

This would lead to changes in the life of the local community.

There are groups of reindeer herders who have no permanent houses or apartments in villages; thus, their unexpected re-settlement without an appropriate housing policy would lead to overcrowding in the existing private dwelling fund. It is a well-known fact that deterioration of dwelling conditions affects people's state of health (non-observance of hygienic norms in houses leads to epidemics of social diseases such as tuberculosis). In 2003, 29 reindeer herders' families had no permanent home in Krasnoe (24 families were from the "Erv").[18]

Another consequence is that those reindeer herders who are compelled to leave the tundra will face the harsh reality of being soon unemployed, which is especially bad among inhabitants of small villages. For the people of working age (especially for men), the impossibility of obtaining a job that can meet one's needs and requirements means the loss of the meaning of life and the impetus to live (living on pensions and children's grants or relatives, or on humanitarian aid does not promote the true development of a person). In 2003, 1,096 people were registered as unemployed in the Nenets Autonomous District, 411 of them representing northern indigenes (36.4%) (percentage of unregistered unemployed is high especially in the villages).[19]

The sharp change of the way of life has had negative consequences on the health of the indigenous peoples. The medical study in the Yamalo-Nenets Autonomous Region showed that cardio ischemia was 2.6 times more common among indigenous peoples settled in villages than among the indigenous nomadic population in the tundra.[20] As shown in the previous section, it is not easy to adapt to a new way of life. Mutually constraining factors intertwine with each other, making it difficult for a person to plan for the future (a passive life leads to other negative consequences, the most serious of which are alcoholism, deviant behaviour, suicide etc). In 1987, the death rate for people of active age in the NAD came to 39% of all registered deaths and 10 years later, in 1996, it raised to 47%.[21]

[18] Data from interview with director of Erv Khabarov P.A.
[19] The data from the Department of Employment of the Nenets AD
[20] Buganov A.A. 2003: 46.
[21] Apitsin A. 1997: 390-395.

Table 4 Cause of death in the Nenets AD[22]

	1997	1998	1999	2000
Total number of deaths	427	435	433	531
Caused by				
Disease connected with blood circulation	233	221	221	260
Trauma, poisoning and accidents	100	111	98	137
Neoplasm	54	67	65	67
Disease of the respiratory apparatus	14	11	10	12
Disease of the digestive apparatus	9	3	11	13
Infection and parasitic [invasion] diseases	4	6	6	7
Etc.	13	16	22	35

The death rate among adult men is 4.5 times higher than that of women.[23] It could be explained that the process of adaptation for women is easier because they would also be busy taking care of home and children in any other place. For a Nenets man, professional life is traditionally linked to the tundra environment, and finding a new meaning in life is always a challenge.

Possible positive consequences

In analysing positive impacts, it is important to be confident that thorough consideration is give to interests of a group influenced by negative impacts. Expanding oil sea transport operations can have positive impacts on both the indigenous and other local population.

Oil transportation and oil extraction are interdependent vectors of development. For the Nenets Autonomous District, oil transportation is one of the key tasks for further development of the hydrocarbon extracting industry. What benefits can bring expanding the extraction and transportation of oil to the local indigenous community?

The oil companies operating in the Nenets Autonomous District have several financial obligations: to pay taxes for the use of land, for the profit they receive and

[23]Ryabikov A.D. 1997: 390-395.

for environmental damage. Four per cent of the oil company's income goes to the regional budget and it is distributed according to the regional programme of development.

A State Fund for Support and Development of Northern Indigenous People was also established in the Nenets AD. Its budget comes from 4% of severance taxes, contributions of legal entities, persons and other sources. The fund is allocated in accordance with certified programmes and events geared to:

1. Developing national culture, education and sports.
2. Supporting the traditional economy.
3. Supporting indigenous intelligentsia and entrepreneurs.
4. Financing residential construction projects for minorities of the North.
5. Promoting the social and economic development of the minorities of the North, including financial and humanitarian aid.

Measures, elaborated by the regional administration, have some positive impacts on the Nenets people. One of the most visible successes is the result of the Support of Reindeer Husbandry programme (supported by the regional budget).

The compensation for the delivery and transportation of meat products paid in accordance with the programme has a positive impact on the development of reindeer husbandry. In the Nenets Autonomous District, most reindeer meat is transported to consumers by air but the cost of this is too high for producers (in 2004, it amounted to 45,000 roubles or about 1,300 euros for a one-hour helicopter flight). Since the late 1990s, 80% of the transportation costs for meat products have been met by the local budget.

Another important measure is compensation for reindeer husbandry production losses. Due to market conditions, the price for reindeer meat is relatively low in the Nenets District. To cover this loss, herders are subsidized for each kilo of meat sold (in 2002, meat subsidies were set at the level of 44.50 roubles if sold to a meat factory, 35.90 roubles for venison sold to State-financed organizations and 16 roubles for venison sold to other organizations and companies.

The head of the Reindeer Husbandry Department of the Agricultural Committee of the Nenets Autonomous District said that the increase of reindeer stock in

2003 (the number of reindeer in the Nenets AD totalled 128,213; it rose by 3,606 when compared with statistics for 2001, which showed 123,347) was the result of several factors, the main one being the financial support of reindeer husbandry and the adoption of the regional law on reindeer husbandry.[24]

Besides the authorized payments by the oil companies to the regional budget, existing relations and agreements between oil companies and reindeer husbandry enterprises can provide concrete benefits and positively impact on current condition of reindeer husbandry.[25]

Picture 13: The VarandeyNeftegaz Company sought agreement with ERV. Label on the box with goods: "Varandeyneftegas to the herders of the 'Erv' cooperative farm"

Indemnification for land withdrawal and the associated inconveniences.

1. Helicopter flights for the needs of reindeer herders.

[24]There were also regional subsidies for the needs of reindeer husbandry (relocation and construction of corrals, purchase of equipment, radio sets for communication with remote brigades, etc). The programme covered also reindeer diseases and natural hazard insurance (2.2 million roubles) and protection of reindeer from predators (3.5 million roubles).

[25]Taleeva V. 2002: 184-186.

2. Social programmes for settlements of reindeer herders (for example, house building).

There are many cases of such negotiations between companies and reindeer husbandry units in the Nenets Autonomous District.[26]

Coastal industrial operations can have other benefits for the area's reindeer herders. The need is to integrate reindeer husbandry into the market economy. The terminal staff can be end consumers for reindeer meat. For herding enterprises, it is more convenient to slaughter and deliver meat to consumers who are as close as possible to the autumn pastures when reindeer have a good weight.

> During the autumn of 2003, two brigades of the "Erv" sold 10 tons of reindeer meat to the Varandey terminal, the herders benefited from that deal.[27] The scheme is also beneficial for the terminal's employees because they can eat fresh meat instead of frozen (actually, many times frozen and re-frozen) products delivered by helicopter from the South.

It is important to note that quite often, the local people have claims to environmental policy and the attitude of a company but at the same time, on the individual level, many herders point out that friendly contact with oil industry employees during the seasonal migration is a positive feature with respect to the development associated with oil. The Nenets and Komi herders used to visit oil deposits to borrow or barter tea, fuel or spare parts for diesel engines, etc. Even the possibility of direct human contact was mentioned as a positive feature:

> "When they [companies, N.M.] respect nature, then we do not object to their presence, especially during the dark time of the northern winter. We suffer from a lack of outside contact and it is nice to visit people and to have interesting talks with them."[28]

[26] It is important to be aware of the possible pitfalls of this kind of relationship. Some companies granted gifts and other benefits to reindeer herders at the time they were seeking agreement with reindeer herders on the allotment of land, without intending to establish a long-term relationship.

[27] Field notes. Nenets AD. 2004.

[28] Field notes. Nenets AD. 2004.

Picture 14: Representative of Varandeyneftegas Company with reindeer herder in Varandey tundra (photo from "Erv" archive)

4.3.3 The future perspectives related to the social impact assessment of sea transportation and associated infrastructures on Arctic Russian communities

Indigenous position in change

In practice, industrial projects can face quite many unpredictable factors. Any particular situation usually depends on a number of factors: current changes in economics and politics may often lead to consequences that could hardly be foreseen in detail during only one phase of social assessment. That is why it is important to make it a rule that a specific SIA should be prepared for each project and the possibilities for further monitoring different stages of the project should be maintained.

It is a well-known fact that any pressure on the vitally significant natural and social environment inevitably encounters reaction from the indigenous peoples whose self-esteem and general positions strengthen with time.[29] After obtaining personal and international experience, indigenous peoples turn from some sort of

[29] O'Faircheallaigh C. :1999: 63-80.

"asking for benefits" position to strict demands in order to establish control over the lands of their traditional use. Any society reacts to changes and adapts to them, but it also is capable of producing an active influence upon the dynamics and the vector of development. This is a distinctive feature of society. The following example is from another northern country, Canada. The ratification of numerous industrial development projects in Canada went parallel with comprehensive land claims negotiations and the creation of the Nunavut Territory. Stimulated by imminent profits from the oil and gas industries, the government took more case considering the demands of the indigenous people in order to safeguard itself against further court cases. Inuit participation in land demand contracts, special sessions conducted in accordance with the environmental impact assessment procedures, signing of agreements for planned use of lands and Inuit Circumpolar Conference have made the political consciousness of Inuits considerably more active. Several years were enough for the development of Inuit capability to interact with a whole complex of government institutions and regulation processes in Canada in order to defend their political interests and constitutional rights.[30]

Actually, the sharp conflict between 'Erv' and 'Varandeyneftegaz' in 2001–2002 (the company that at that time was the most active in the Varandey tundra) became a catalyst for the public discussion in the Nenets Autonomous District and attracted the attention of other reindeer husbandry enterprises, oil companies and representatives of the civil society. The Association of the Nenets people 'Yasavey' and 'The Union of the Geologists and Oil Workers' formed a working group to solve the problems of the future development of the oil industry in the district. Both reindeer herders and representatives of the oil industry participated in various activities and showed interest in reaching consensus: since 2001, the Round Table concerning the future of reindeer husbandry and oil industry in the Nenets AD has been held annually.

A seminar "Reaching and Following Agreements in Implementing Mineral Resources Exploitation Projects" was held in Naryan Mar on 14-16 May 2003, which discussed the possibilities for mutually profitable relations and cooperation between the indigenous people's traditional way of life, oil-producing companies and regional administration. Representatives of the reindeer husbandry enterprises

[30] Transit management in the Northern Passage. Problems and prospects. Ed. By Lamson C., Vanderzwaag D. 1986:56.

and oil companies were among the participants. Representatives of Canadian Institute of Natural Resources Law, who coordinated this seminar, shared their experience in interacting between the indigenous people and mineral resources users in Canada and on legislation in this sphere. Consequently, future industrial development could not ignore the reactions of indigenous peoples on different levels of regional, national or international powers.

Picture 15: Round table in Naryan-Mar discussion about future of oil industry and reindeer herding

Mitigation measures

One of the most important tasks of the social impact study is to highlight the mitigation measures that should be thoroughly studied in order to minimise any future harm and maximise benefits from planned and ongoing activities.

Actually, the list of possible mitigation measures that the local inhabitants and reindeer herders discuss is long and quite detailed and it should emphasise concern about their future. They suggest that the measures should not only be for the short-term but rather promote long-term effects. The main principles for all the measures are:

- Direct early and continuous consultation with communities during all stages of the industrial activity and its planning.

- Strict adherence to the existing environmental laws and regulations.
- Fulfilment by the companies of their obligations toward local communities.

Listed below are some details concerning the possible mitigation measures mentioned by reindeer herders. All of them are cases for the general principles mentioned above:

1. At any stage of planning a network of oil pipelines, it is necessary consultation reindeer herders about the passes for reindeer and both parties should discuss the pipeline parameters (height, width, etc).
2. Construction of a faktoriya (intermediate base, trading supply, mini-plant for processing raw material from reindeer husbandry, base of rest, social, medical and other services for the reindeer herders in remote areas) could favourably affect the economy of reindeer husbandry in the district. A faktoriya with a mini processing plant could provide appropriate conditions for reindeer slaughter and enable long-term storage with subsequent realisation (meeting EU standards) for meat production both for domestic and foreign markets. This could effectively help integrate the indigenous population into the market economy, create additional working places for the natives, increase efficiency and economic profitability of reindeer herding enterprises.

> "Before the village of Varandey was abandoned, reindeer herders coming to that district during the autumn migration had the possibility to sell meat and buy food in the village as well to use medical help and visit the local post office. Now they've lost it all. At present, the herders from the 'ERV' often have to move their reindeer herds from autumn pasture to the slaughtering place and it takes a longer time because the distance is also longer (it is undesirable, for the animals lose their weight). A post with a slaughterhouse construction somewhere on the migration route could solve technological, social, cultural as well as trading and purchasing problems. Such a point should be adjusted by several reindeer herding enterprisers to proper serviceability for everyone. It is convenient for several reindeer farms ('Izhemsky Olenevod',

'Druzhba Narodov' and 'Kharp') to place the facility on the Pae Yaha (Stone River) junction of the rivers Chernaya and Sada Yaha. The physical characteristics of the site must also be taken into account (soil, topography).

This factoriya may help provide reindeer herders and hunters with food (the first with the high quality products of reindeer husbandry, fishing and hunting, the latter with food and the most necessary goods). Besides, the trading post could create additional working places for the indigenous people?"[31]

3. The programme of training and the creation working places for the youth from small villages is important. Currently, unemployment is the critical issue in the small villages of the Nenets District. If special programmes for the local youth are elaborated, it could have additional social benefits. For trained local people (not only indigenous), it would be easier to work in shift brigades because the climate and regional specifics are more familiar for them; they would not need to adapt and readapt, as southern migrants should. The local people take more care of the local nature.
4. Industrial constructions in the tundra should be erected only after thorough investigation as to whether the chosen place is a sacred native site.

The specific list of mitigation measures should be updated with the passage of time as situation at the place of active development changes.

Future Impact.

The future impact of the oil marine transportation will vastly depend upon the place accepted for the location of the terminal. Each scenario should be done together with social impact assessment based on the specific technical data for each project. It is possible to predict the general features of possible impacts but the scenarios will vary. They may differ, starting from the initial point and ending with various accompanying circumstances.

[31] Field notes: Interview with vice director of cooperative farm Erv - Alexandr Viucheisky, Krasnoe, Nenets AD, 2003

The Varandey terminal already exists in the Nenets AD and the Svyatoi Nos terminal is under discussion. Indigenous and local peoples have a realistic point of view, expressing it in a statement that "what was done already is done" (which means that huge financial investment was expended on the terminal and its infrastructure and that regardless of their opinion, it will not be removed). The local people considered that the best in this situation is to look for the points for future mutually beneficial agreements and coexistence.

The reaction on the local administration's proposal for the Svyatoi Nos scenario is different. An overview of the mass media data and interviews gave the notion that many questions for this project are without an answer. A public hearing on the Svyatoi Nos terminal was held in October 2004. The peoples asked, "Is it really necessity? How can local interests be protected and guaranteed?" Many questions still were without an answer.

Some inhabitants of the village of Indiga, who are not tightly linked to reindeer husbandry, have expectations for positive impacts on their life, if this scenario is accepted. They hope that the benefits would not be concentrated only in the region's capital but also could be enjoyed by the villagers. They hope that terminal will increase their opportunities for employment (meanwhile an officer from the Department of the Nature Committee of the NAD administration said that for the terminal construction will hire mostly qualified workers from other parts of Russia). However, even those who support the idea of the Svyatoi Nos terminal are anxious about fishing resources – the main source of subsistence for everyone in the village (Nenets, Komi, Russians, etc.).

Their opponents argue that in this scenario, the pipeline connecting the terminal with oil deposits will cross the territory of the region for more than 450 km and this will impact not only the well-being of the Indiga villagers and reindeer herders of the Indiga SPK but also on the interests of other reindeer enterprises of the Nenets Autonomous District (OPH, Nyaryana Ty).[32] The proposed pipelines and roads will cross the Pechora River and other spawning rivers and the assurance of the local authority that the construction will be accomplished in an environmentally safe manner did not convince the local population, who have had quite the opposite experience.

[32] Izmailova M. 2004 (b)

The local people from Indiga showed places on the coast and in tundra filled with tonnes of rusted metallic constructions. In Indiga, they named it 'Kurskaya duga' (the place of the famous tank battle during the Second World War, when hundreds of destroyed tanks were scattered all over the field of battle). These metal constructions on the tundra and coast are evidence of the intended activity, the result of suddenly changed State policy or financial crises. Many locals consider that before they are implemented, the plans should be carefully elaborated.

In other words, the local people expect benefits from the oil industry and oil marine transportation but in the meantime, they worry about the natural environment they depend on. Benefits seem possible but uncertain, disturbance to nature is very well known. The head of the reindeer-herding brigade shared his thoughts:

> "We should think about heritage and be concerned about the future, which we don't know yet. We experienced how political and economic changes reflected on our life. OK. I can earn money today, buy something, and let my land be destroyed, but if internal and external policy are changed tomorrow whereas the oil price changes, what if all oil workers abandon the site? We will stay here and face our disturbed environment. My son and his descendants won't feed themselves from the land and will have nothing in the other world."

Actually, the companies' contravening its internal rules and day-to-day deviations from environmental norms together with other unsolicited impacts that oil workers might cause without proper control (liquor barter, reindeer and fish poaching, abandoned dogs) could be cheaper for the company but will lead to numerous problems and conflicts in the future. Many international companies in Russia and companies that work with the support of the EBDR understand this.

Published and field data provides information about examples of friendly environmental and social policies of joint international ventures at the Ardalin oil deposits. Another example comes from the Yuzno-Shapkino oil field, which is operated by the SeverTEK Company (a joint venture created by the Finnish corporation Fortum and Russia's Komitek). SeverTEK received a loan from the European Bank for Reconstruction and Development. According to the agreement signed with the EBRD, the company has to make an annual report to the bank's experts about the implementation of social and environmental programmes.

SeverTek observes strict regulations for the staff, which includes prohibiting bringing guns, fishing nets, dogs and alcohol to the deposit and the company also bans hunting, fishing and private bartering with reindeer herders. The principle of protecting cultural diversity does not often has the same priority as biological diversity. But industrial activities if regulated with participation of indigenous communities would be subject to more stringent environmental protection in order to allow the local subsistence based economic activities co-exist.[33]

Picture 16: Working group: Indigenous peoples and Oil extracting companies in Nenets AD

4.3.4 Conclusion

The marine oil transportation in safe and economically profitable manner and is important for the future development of EU and Russia, it have international, national and local levels of impacts. The social impact assessment considers not only the consequences of vessel operations but also the impact of the terminal and its infrastructure on local communities. (Loading, pumping and storing area together with tankers, icebreakers, etc. is an indispensable and integral component of the oil marine transportation system in the Arctic). The main consequences for the local peoples are derived from activity (shipping) on the sea and activity

[33] 5-132 Osherenko G. 1992: 11

in the coastal area (different stages of terminal construction and operation). Both positive and negative impacts could be direct, indirect and cumulative with time.

In the Nenets Autonomous District, the positive indirect impact from the oil marine transportation is connected with the future increase of oil extraction and its result in swelling revenue for the local budget. These positive changes are very welcomed by the inhabitants of the NAD, but to optimise the benefits from the oil transportation, additional measures and social programmes are required.

The possible changes would impact on the very basis of local traditional occupation: fishing, waterfowl hunting and reindeer husbandry.

Interviews with local inhabitants and the good examples of the Ardalin and Sever-Tek companies in Nenets Autonomous District demonstrate that negative impacts are not an inevitable and inherent condition of industrial operations. Importantly, frequently negative consequences are caused by ignoring timely and permanent consultation with the indigenous and local inhabitants and interested parties. Another source of negative impact is infringement of the existing regional and environmental laws, norms and other regulations. This is especially true when environmental control over industrial operations is inefficient.

The Arctic is a zone of mutual international interest and businessmen, policy makers and representatives of civil society could contribute to positive change by focusing their attention on the environmental and indigenous perspective of each project and on each phase of the project's implementation.

The contribution of Arctic international organisations in building the capacity of northern indigenous peoples in Russia will serve to strengthen their position and increase their possibility to participate in co-managing large industrial projects (such as oil marine transportation). Equal open dialog between all interested participants and actors will serve to increase trust and mutually beneficial co-operation.

4.4 Oil Weathering and Oil Spill Countermeasures for Ice-infested Waters

4.4.1 Introduction

The objective of this sub task in the ARCOP project, work package 4 'Environmental Protection and management System for the Arctic', is to provide research needs for further technical work according to improvement and development of new oil spill response concepts in Arctic and iceinfested waters as a basis for development of an environmental protection and management system for the Arctic region. The main focuses in this report are divided into following sections:

- Improvement and development of mechanical recovery
- In-situ burning
- Use of dispersants

The goal is to give common recommendations of research needs for the improvement of existing equipments, and developing new technologies in the assessment to the environmental safety. A future approach should be to develop Operational Model Tools both for contingency planning and decision making during response operations, for oil spills in ice-infested water. The model concepts could be important tools to predict the 'time window' to determine the most efficient response techniques to combat various types of oil spill in different environmental conditions. This will also include environmental risk analysis. It is important to improve our understanding and to obtain better documentation as a basis for ensuring an optimal response if an oil spill incident should happen in the Arctic region.

The basis for this report is results from recent oil spill response research and research need defined through different processes and discussions within the scientific community. This includes also articles / papers and reports that are considered to be important aspects for oil spill countermeasures. Among the references used are:

- Recommendations from Sub-Task 4.2.1.1 'State of the art report on oil weathering and on effectiveness of response alternatives' (Evers et al., 2004), development of existing and potential new concepts for oil spills in sea ice as a platform for further developments and investigations have been suggested.

- Results obtained in previous projects (e.g. INSROP, ARCDEV, MORICE and national RTDs).
- A workshop process according to work done for MMS (U.S Minerals Management Service), refers to SINTEF 'Final Report and White paper' (Reed et al., 2002). The 'white paper' summarizes the results of a preliminary workshop (Oct., 2002) at MMS Alaska Regional Office in Anchorage. The recommendations from the 'white paper' are further considered in this report.
- The Interspill conference, in Trondheim Norway 2004, session 7: 'Oil Spill Response in Cold and Ice-covered Water'. This session presented the results of recent oil spill response research in cold and ice-covered waters (Owens, 2004; Mullin, 2004; Buist, 2004; Jensen, 2004; Brandvik et al. 2004; Dickins, 2004).
- Oil Spill Response in Ice Infested Waters, (Vefsnmo et al., 1996). The report presents the status on oil spill response in ice- infested waters both for mechanical equipment, dispersants and in-situ burning. The recommendations described in report for status on 'Oil protection in the northern and Arctic water – ONA' (Løset et al., 1994) are in addition considered in this report. This report is based on earlier studies carried out in Norway.

In addition to the referenced information, meetings and workshops have been arranged within the ARCOP project. Research needs within this area were also discussed during the Statoil International Summit in Trondheim, Norway in 2004. More recently SINTEF presented some papers covering these issues during an Intsok seminar in Houston, USA in March 2005. There are a number of other research needs, not further discussed in this report, which will be of high relevance for an effective oil spill response in ice covered waters:

- Mapping of weathering properties of relevant oil types (crude oils and oil products) in Arctic areas.
- Studies of water-soluble fractions of relevant oil types and potential biological effects from water-soluble oil components as well as dispersed oil

droplets.

- Remote sensing and monitoring of oil under, in, among or on top of ice.
- Operational aspects including operations in remote areas, operations in darkness, operations in harsh and cold climate.
- Improvement and development of modelling tools for:
  - Predicting weathering data of oils and time window for use of different response techniques.
  - Predicting drift and spreading of oils at sea in ice covered waters.
  - Environmental Risk Analysis (ERA).
  - Net Environmental Benefit Analysis (NEBA) and oil spill contingency analysis.
- Alternative oil spill response techniques, like e.g.:
  - Potential use of bioremediation.
  - Use of adsorbents.
- Shoreline cleanup.

This task is part of the ARCOP (Arctic Operational Platform) program, which focuses on the shipping route from the loading terminal at Varandey to Murmansk. Both for this area and other areas in the Arctic as well, long distances to land and also partly remote areas compared to existing infrastructure contributes additional challenges.

4.4.2 Conclusion

The aim of this project has been to identify research needs for improvement and further development of oil spill response concepts for the use in ice-infested waters. The project is part of the ARCOP (Arctic Operational Platform) program, a research and technology development program with the overall objective to form an operational platform for development of petroleum transportation in the Arctic region.

The core issue in ARCOP is the transportation of oil from a terminal at Varanday to the European market. This could be done either by tankers going all the way from Varanday to the western Europe, or to some reloading terminal, for instance in the Murmansk area. We are talking about year round shipping, which means that the transport will go through areas with ice during the winter months. Sea transportation of oil and gas products from the Pechora and Kara Sea region as well as oil/gas exploration in arctic waters will increase the risk of oil spills in this highly vulnerable environment. Most of the research needs highlighted in this report are valid both for the part of the transportation route from Varanday to Murmansk covered with ice during winter and spring as well as other ice covered Arctic areas.

To establish an efficient oil spill contingency for winter/spring conditions in Arctic areas requires improvements of existing methods and developments of new oil spill response concepts. Up to date, there has been a lack of field trials for operational testing of combating techniques related to the Arctic. Three main subjects have been discussed in this report: mechanical recovery, in-situ burning and use of dispersants. Remediation technologies and shoreline cleanup are also important aspects when discussing countermeasures in cold environment, but these issues are beyond the scope of this report.

The following recommendations are given for the different areas of research and development:

Mechanical recovery

Due to the low temperatures normally found in the Arctic and the presence of ice, existing response equipment needs to be modified to operate under harsh conditions (winterization). This may include improved ice processing, reduction of icing/freezing (heat supply), transfer of recovered products (including ice), and separation of oil from ice.

The MORICE recovery system is one of the most recent developments for mechanical recovery of oil in ice and has a potential for further improvement and commercialising. The same is also valid for the Lamor Oil Ice Separator (vibrating unit), which is also a recent development.

FRAMO Engineering AS has described some technical solutions for oil spill scenarios around oil installations and vessels. This is by use of existing booms, powerful vessels and weir skimmers with high pumping capacity. They also describe a concept for recovery of oil underneath the ice. These ideas should be further evaluated and there may be a need for winterization of the equipment.

In-situ burning

In-situ burning may have a considerable potential for its application in ice conditions and may offer the only practical option for removal of surface oil in such situations. Much research, including field activities, has been done in this field in USA, Canada and in Norway. In this report the importance of identifying the 'window of opportunity' for ignition and efficient burning of oil spills in the Arctic has been stressed. The 'window of opportunity' will vary between different crude oils and oil products. Based on a systematic laboratory testing and field validation it is suggested to include the 'window of opportunity' for burning as a standard prediction from weathering predicting models.

Ignition technology is another important aspect that needs to be looked into. When operating in remote areas it is necessary to have igniters that do not necessarily rely on aerial ignition.

Even if in-situ burning has the largest potential in ice; it should also be evaluated as a potential response option for remote shorelines and inaccessible mudflats in Arctic areas.

Use of dispersants

There is also a potential for use of dispersants in cold-water environments with ice. For obtaining an effective dispersant operation in Arctic areas, it is important to evaluate the following critical parameters:

- Access (contact) of the dispersant to the oil.
- Sufficient mixing energy for the dispersion process.
- Oil properties at low temperature (weathering degree), with emphasis on viscosity and pour point.

- Dispersant performance and properties under the relevant conditions (salinity of sea water, temperature, oil type).

Recent promising results in tank tests sponsored by industry have spurred a re-examination of dispersants as a potential strategy for certain oil-in-ice scenarios (Mullin, 2004). The use of icebreakers or other vessels to introduce the necessary mixing energy, in combination with dispersants formulated for longer retention by viscous oils, could lead to dispersants becoming a practical response option for oil spills in ice. A combination of systematic laboratory and basin studies and field validation is needed to make dispersants use a practical countermeasure in icecovered waters.

It is important to improve the documentation of the effectiveness of dispersants at low temperatures (in water and air), at low water salinity and the presence of ice. This may include a screening of existing products, potential development of new products and to find the optimal dosage for various oil types.

Application technology is another key element. Aerial application, vessel application and the potential injection of dispersants from the seabed should be further explored. Due to the wave damping effect by the presence of ice means of creating artificial turbulence should be further investigated.

The potential ecological effects caused by the dispersed oil droplets and the water-soluble oil components often cause public concern. The potential effects should be studied both for icecovered waters as well as at the ice edge. The fate and degradation of the dispersed oil should also be further studied.

4.5 Scenario-based Oil Spill Response Analysis

4.5.1 Introduction

The present report concerns the oil drift modelling and oil spill response part of the ARCOP work package on Environmental Protection and Management System for The Arctic (WP 4). Work Package 4 was justified from the fact that sea transportation of oil and gas products from the Pechora and Kara Sea region as well as oil/gas exploration in arctic waters will increase the risk of oil spills in this highly vulnerable environment.

One basic task of WP 4 was to identify and quantify relevant impact factors in terms of e.g. shipping routes, ship types, and regular discharges to sea and emissions to air. Based on the inherent dynamics of the environment, in combination with key characteristics of the shipping activity, knowledge has provided on the temporal and spatial distribution of resources at risk as well as sailing routes and sailing frequency. On this basis, semi-quantitative and quantitative analyses of environmental risk will be made to identify 'hot spots', i.e. geographical areas and periods of time with significant environmental risk, which subsequently can form the basis for analyses of mitigating measures and remedial actions.

The general fate and weathering of oils spilled in open / ice-infested waters is documented in a 'state-of-the-art' study (Evers et al 2004). This study also reveals needs to perform (at a later phase, but not within this project) a more specific oil weathering study according to standardized methodology on relevant types of oil in connection to the planned transportation from the Pechora and Kara Sea region.

The performance capability of various oil spill response techniques (both existing and eventual new concepts) has been identified and documented (Singsaas and Rist Sørheim, 2005). This documentation is essential both in connection with oil response analysis and in order to build up efficient and cost-effective oil spill response solutions for the area.

The present report deals with subtasks 4.2.2.2 and 4.2.2.3 of WP 4, and is concerned with oil drift simulations and oil spill response analyses in the region of concern. The oil drift simulations provide information on the potential area of influence from major oil spills in conjunction with tanker transport in the area of concern, while the response analyses will form the basis for setting up a framework and guidelines for preparing an oil spill plan for the area. This plan will also evaluate the potential for improvements and come up with recommendations for further development and experimental research.

4.5.2 Conclusions and Recommendations

The present report deals with simulations of oil drift and oil spill response for possible spills from tanker transport of oil products from Pechora Sea to the Murmansk region. The oil drift simulations provide information on the area of influence from possible major oil spills in conjunction with tanker transport in the area of concern, while the response analysis will form the basis for setting up a framework and guidelines for preparing an oil spill plan for the area.

Oil drift simulations

The oil drift simulations are made with SINTEF's OSCAR model, which is a state-of-the-art oil drift and fate model which can be run both in single scenario and statistical mode. Both modes are used in the present study. The statistical mode provides the geographical area of influence of a spill of a certain oil type, taking place at a given location within a certain season of the year. The statistics are obtained by running a set of oil drift scenarios within a specified season with spill starts within different years of available historical wind data. Worst case scenarios for the season of concern (e.g. maximum stranded oil) may be selected from this set of simulations, and single scenario runs may be made for these scenarios to reveal more details (e.g. time development of mass balance). In the present study, the simulations are based on gridded seasonal background current data and hindcast wind data provided by the Norwegian Meteorological Institute, supplemented by historical ice coverage data from the same source.

In the present study, we have focused on two potential spill sites – one located near the outlet of the Murmansk Fjord (the western location), and one located in the Pechora Sea in the passage between Novaya Zemlya and Kolguyev Island (the eastern location). The eastern location is chosen as representative for regions with seasonal sea ice, while the western location represents regions with all-year open water. For both locations, the release was presumed to amount to 10,000 m3 of crude oil, discharged over a 10 hour period. A Norwegian crude oil (Troll) with fresh oil properties similar to the Varandey oils was used in the simulations.

The results for the western location showed only minor differences in the area of influence in the two seasons considered (spring and autumn), while the results for the eastern location demonstrated a marked seasonal variation, depicted in terms of a significant reduction in the extent of the influence area due to the presence of sea ice in the spring season.

Statistical simulations were also made for multiple spill sites distributed along a possible tanker route. By combining such simulations with data on the spatial distribution of sensitive resources, such simulations can be used for assessments of environmental risk for optional tanker routes.

Oil spill response

The OSCAR model is designed to perform simulations of oil spill response. Oil spill response options are defined in terms of number of response systems, mobilization time and transfer time of each system from the base to the release site, in addition to boom and skimmer capacities, weather limitations, on-board storage volume etc. On this basis, the effect of a given response operation is simulated in terms of amounts of oil recovered and corresponding reductions in stranded oil in particular, and area of influence in general. In the present study, oil spill response simulations have been made both in single scenario mode and in statistical mode.

For the western site, statistical simulations were made for two response options – one option involving two response systems, and one option involving four response systems. The base case involved two response systems – one mobilized from a presumed oil contingency base in the Murmansk Fjord, and one from the Norwegian Sector. The second case represented a doubling of this response effort (two systems from the Murmansk Fjord; two from Norway). All systems were presumed to be equipped according to the standard defined by the Norwegian Clean Sea Association for Operating Companies (NOFO). The results indicate that only a marginal gain could be obtained by this increase in response effort: An almost insignificant reduction was obtained in the stranded amounts of oil by doubling the response effort. This rather discouraging result is typical for near-shore oil spills. In the period required for recovery of the spilled oil (about two days in the present case), stranding of oil remaining on sea can not be prevented due to the short drift time to the shoreline.

The oil spill response simulations for the eastern location were limited to the season with ice free conditions (autumn), as the potential effectiveness of conventional response options are not documented in the season with sea ice. The statistical simulations for the base case option (two response systems) demonstrated a significant reduction in the area of influence, as well as a significant reduction in the stranded amounts of oil, compared with simulations with no oil spill response. Single scenario simulations were performed for the worst case scenario (largest amount of stranded oil) to investigate effects of increased response efforts. The results showed that in this case, escalation of the response effort might give significant gains in terms of reduced amounts of stranded oil. This encouraging result was related to the fact that a significant part of the oil spill could be recovered before the oil would hit the shoreline (two days minimum drift time).

Recommendations for future work

Modelling of oil drift and fate in open waters may be considered as well established, based on many years of accumulated experience from laboratory and field studies, as well as hindcast studies of accidental spills. Due to limited experience, modelling of oil drift and fate in the presence of sea ice is more uncertain. Thus, in the present study, the influence of sea ice on oil drift and fate is accounted for in a simplified way, with the effect of sea ice parameterized in terms of the local ice coverage. This is a crude approximation, partly because the fate of the oil in ice is known to depend on the specific ice form (broken ice, brash ice etc.), and partly because the rate of weathering processes such as natural dispersion and formation of water-in-oil emulsions are influenced by non-local processes, e.g. wave attenuation by sea ice. Presently, however, lack of detailed ice information does not justify algorithms which accounts for various ice forms or wave attenuation in sea ice.

In the present study, simulations of oil drift and fate in sea ice have been based on historical ice coverage data, combined with climatological current data and hindcast wind data. In a state-of-the art operational oil drift forecasts system, we anticipate that sea ice data will be provided by ocean circulation models coupled with an ice drift model. This same approach might be used in impact assessments, based on one or more 'design-years' of hindcast data from a coupled ocean current and sea ice model. This will provide a more realistic picture of the ice drift pattern, since simulated ice drift velocities will be available in addition to ice coverage.

In summary, we may conclude that:

- Future improvements in modelling of oil drift in regions with sea ice will to a large extent depend on relevant input on ice conditions. Coupled ocean circulation and ice drift models may provide data on ice coverage, ice drift velocities, and ice thickness, but information on ice forms (broken ice, brash ice etc.) are not readily available.
- The influence of sea ice on weathering processes such as natural dispersion and formation of water-in-oil emulsion depends on wave attenuation induced by the sea ice. This process is non-local, in the sense that the wave conditions at one location in the ice field will depend on the ice conditions (ice coverage and thickness) in the ice field upwind from that location. Wave prediction models that accounts for attenuation of waves in sea ice may improve such predictions, but more studies on oil-ice interaction will also be required to establish empirical relations between local wave conditions and weathering rates of oil in ice.

In our view, the following enhancements should be considered on short terms:

- Findings from earlier oil-ice interaction studies should be reconsidered with the aim of formulating improved oil-in-ice drift and fate algorithms. Such improvements could for instance account for partitioning of oil in the ice: Oil found on the surface water between ice floes or in ice leads, on the surface of ice floes, or trapped under the ice will be subject to different weathering exposure.
- Simulated ocean current and ice data (coverage, ice drift and thickness) from coupled ocean circulation - ice drift models should replace the present historical ice coverage data and climatological currents.

Possible enhancements on longer terms depend to a large extent on the outcome of future research on oil-ice interactions, i.e. on the availability of relevant empirical data from laboratory studies and field tests. The major unanswered questions seem to be related to the influence of sea ice on weathering processes such as emulsification and natural dispersion. Prediction models for wave attenuation in sea ice may be useful in this context, but more research is also needed the establish correlations between sea state and weathering rates in various ice conditions.

4.6 Requirements for Contingency Planning

4.6.1 Introduction

ARCOP (Arctic Operational Platform) is a research and a technology development project with the overall objective to form an operational platform for the development of oil and gas in the Arctic region.

The objective of this task in Work Package 4 of the ARCOP program is to provide recommendations to oil spill contingency planning in Arctic areas. This constitutes a basis of an environmental protection and management system in the Arctic region. This task is mainly focusing on recommendations of oil spill response along the shipping route from the loading terminal at Varandey to the transhipment terminal at the Murmansk Sea port. Along this route the tankers will meet various type of ice and open water conditions during year round shipping.

Within the ARCOP transportation area there are various activities related to exploration, development, production and transportation of oil products, and the level of activities is expected to increase significantly in the years to come. Total amount of crude oil shipped from Varandey in 2002 was 240 thousand tons. The present oil handling capacity of the terminal is thought to be 1,5 million tons per year, but in short time frame (after 2005) the volume of oil shipment is expected to reach 3 million tons per year (Moreinis et al., 2005). The increasing activity in oil and gas exploration, production and transportation in this area of concern presents an increased risk for oil spill incidents. Shipping of oil products is one of the activities that contribute to pollution in the Arctic. It is important to establish robust contingency planning, which include efficient oil spill response strategies to meet the challenges in this vulnerable Arctic region.

In general oil pollution as reported by Semanov (1995) may occur by:

- Discharge of unseparated bilge water due to human error
- Oil spillage during bunkering operations at low temperature due to damaged hoses and leaky flanges
- Escape of oil when transferred within a ship due to valve leakage caused by freezing
- Pipe and valve freezing
- Damage to cargo oil tanks resulting in penetration of oil into the segregated ballast tanks
- Disregard of washing procedures for the cargo oil tanks on oil tankers and fuel oil tanks on other ships
- Failure of limiting oil content (of effluent) alarm
- Inadequate coordination between actions taken by the ship crew and shore personnel during bunkering and cargo oil loading.
- Loading or unloading of tankers (in ice or open waters)
- Tanker accident along the shipping route from Varandey to Murmansk, in ice or in open waters

With respect to the ARCOP transportation scenario it is assumed that the most frequent type of an oil spill will occur during loading or unloading process, i.e. at the terminal in Varandey, or in Murmansk. Most of such spills will likely be small spills (few litres to some cubic meters), caused by all sorts of minor accidents or mishaps. Slightly larger spills could happen during oil loading process due to a breaking hose or an open valve. Spills happening during loading or unloading will be of moderate size. A leakage during transfer of oil will be stopped as soon as the pumping stops after detecting the leakage.

A tanker accident along the shipping route could create a major oil spill. The ARCOP shipping scenario indicates that a maximum damage will break four tanks (due to accident with another tanker, which hits to the tanker's side with high speed and cuts the tanker in two parts). The maximum amount of the crude oil that may be spilled is about 40 000 tons.

A considerable part of the shipping route of concern is covered with ice during several months in the winter and early spring. The western part, towards the Murmansk fjord is all-year ice-free water, while the eastern part towards the Pechora Sea is covered with persistent seasonal ice. Figure 1.1 gives an example of ice coverage and wind fields in the transport area in March (Johansen et al., 2005). Severe ice conditions can occur in March and the shipping route through ice can exceed 700 km with thick ice. In this ice-covered area larger vessels like icebreakers, ice going tugboats and supply vessels are required as carrier for oil spill response equipment.

The ARCOP shipping scenario is characterized by the following main parameters (Evers et al., 2004, Saarinen et al. 2004):

- Cargo: Crude oil from Varanday to Murmansk (year around)
- Tanker alternatives: 120 000 dwt, 90 000 dwt and 60 000 dwt tankers
- Size of the biggest crude oil tank is about 10 000 dwt (in 120 000 dwt tanker)
- Due to design of tankers, the defined ARCOP ice conditions for the shipping scenario are very detailed. Here we only refer some of the parameters:

Ice thickness (average winter max)	1.1 m
Rafted ice with a maximum ice thickness	2.4 m
Average ice pressure intensity	1
Average ice drift speed	0.2 m/s
Ice drift qirection	irregular (wind driven)
Maximum ice concentration	100%
Time of year	March
Minimum air temperature in March	-44 ° C
Typical air temperature in March	-14.4 °C

Based on hydro meteorological station data, average air temperature in the Varandey area in March is -14.4 deg. C (recorded minimum is -44 °C, maximum is +3 °C). Near Murmansk the temperature is slightly higher by about 4 °C. However, this is applicable to the coastal line. Air temperature in this part of the sea is 2 °C to 5℃ higher (depending on location: due to Gulf Stream influence; gradient of air temperature is very significant).

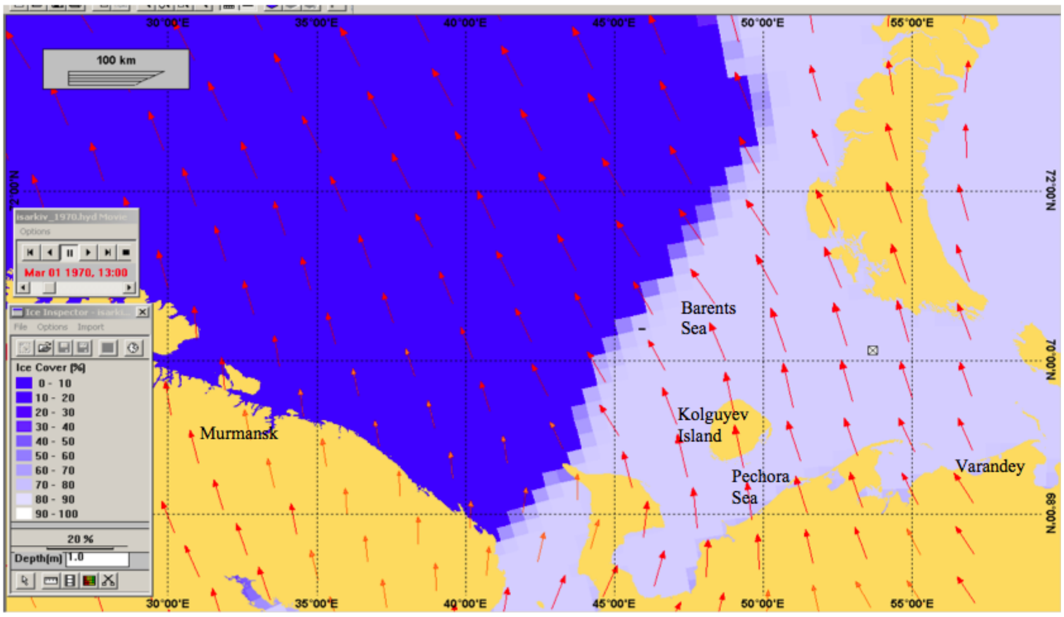


Figure 1.1: Example of ice coverage and wind fields in the transportation area as per March 1. Data at 24 hour intervals in 20 x 20 km resolution. Data provided by the Norwegian Meteorological Institute.

4.6.2 Recommendations for oil spill response strategies

Severe winter conditions represents a challenge to oil spill response such as low temperature, sea ice, lack of daylight and the difficultness of detection, monitoring and surveillance of oil spills. Within the all year round shipping route from the loading terminal in Varandey to the transhipment terminal at Murmansk there are areas with long distances to the mainland which implies longer sailing time for mobilization, transportation as well as support from aircraft stationed on-shore. Long distance to mainland is more inconvenient and can possible increase the oil spill preparedness and the logistic costs, which requires more carefully planning and organization.

The main focus of a contingency planning should be concerned to the following subjects:

- Response time
- Oil spill response techniques (mechanical recovery, in-situ burning, dispersant, bioremediation)
- Combating equipments (booms, skimmer etc.)
- Training (personnel, mobilization and equipment technology)
- Environmental risk analysis
- Mapping natural resources (include use of Net Environmental Benefit Analysis (NEBA) and oil spill risk assessment tools)
- Fate and behaviour of transported oil (properties, type of oil products, amount of oil transported)
- Identifying lack of knowledge concerning the issuses stated above to provide sufficient knowledge which subjects need further documentations/research, improvement and/or developments. Oil spill response concepts in Arctic and ice-infested waters are e.g. described in Singsaas et al., 2005.

The obtained overall knowledge results in an 'operational tool' which improves the possibility to implement a robust contingency plan for operations in open water, ice-infested water and in coastal areas.

Environmental risk analysis such as Oil spill risk assessment and Net Environmental Benefit Analysis (NEBA) should be used in oil spill contingency planning. These analyses are essential within the planning process for instance at the areas around sea port and at oil handling facilities (e.g. loading terminals) to carry out the optimum response options in these areas. NEBA is a methodology for comparing and ranking the net environmental benefit associated with multiple management alternatives, and is a useful tool to evaluate applied response technologies in response to an oil spill, this in accordance to evaluate the benefits and risk of utilize dispersant, in-situ burning and different cleanup technologies. In addition, these analyses can be used to determine the environmental sensitive areas.

Climatic conditions and infrastructure

Climatic conditions will have a considerable influence upon the effectiveness of an oil spill response. As a part of the "A study of consequences of year-round petroleum activity in the area of Lofoten and Barents Sea" (Singsaas et al., 2005), the influence of climatic conditions and infrastructure on the oil spill response in the northern and Arctic areas was discussed.

Wind and waves

Wind and wave statistics for northern areas including the Barents Sea indicate that the conditions both in the summer and winter season is approximately similar to the North Sea or even better. This means that the effectiveness for the oil spill response equipment and the possibility to perform combat actions is not reduced compared to the North Sea. If we define an 'upper limit' on for instance 15 m/s wind speed and/or 4 m significant wave height for use of mechanical recovery equipment, this will give a 'time window' for use based on wind and wave statistics as indicated in Table 6.1, which is comparable for instance to the North Sea.

Table 6.1 'Time window' for use of mechanical recovery in the Barents Sea as a function of wind and wave statistics based defined 'upper limits'.

Area	Month	'Upper limit' 15 m/s wind speed	'Upper limit' 4 m significant wave height
Barents Sea	June January	Ca. 98% of the time Ca. 85% of the time	Ca. 98% of the time Ca. 72% of the time

Darkness

The daylight conditions in the Barents Sea are somewhat poorer than in the North Sea in the winter season, primarily the months from November to February. In the summer season the conditions is better than further south, with midnight sun from May to July. With the present oil spill response there are limitations with respect to operations in darkness. The major challenge is to detect the oil and collect it effectively in a boom and there is a need to develop equipment for better detection of oil spill in darkness and low visibility.

Low temperatures and icing/freezing

Icing of vessels due to low temperatures and sea spray is well known for those who sail in the Barents Sea in the winter season. For the oil spill response it is icing of the oil spill response equipment and the human factor that contributes the major challenge connected to low temperatures and harsh weather. Pumping of high viscous emulsions due to a high degree of weathering and/or low temperatures can cause a problem. For hoses, pumps etc. that can be inactive for periods, freezing and ice creation can become a problem. Also systems for application of dispersants can be subjected to icing/freezing. The viscosity of the dispersant can also increase under low temperatures, changing the spraying pattern or even plugging the nozzles. It is assumed, however, that many of the challenges connected to use of oil spill response equipment during low temperatures can be solved by relative simple practical means.

Infrastructure

To be able to plan and perform an effective oil spill response knowledge and information about the infrastructure in the area/region is very important. It is also important that the oil spill contingency is based on the possibilities and limitations that the prevailing infrastructure gives.

Compared to the areas further south, for instance the North Sea area, the infrastructure in the Barents Sea region is less accessible with long distances from central ports/airports to oil activities/transportation and remote areas. Short response time is often important in oil spill contingency and hence, an accessible infrastructure is important.

Oil spill response in open waters

For an effective oil spill response operation in the open sea it is necessary to use equipment dedicated to operate under rough weather conditions. This means large vessels to be used as a working platform for the equipment and booms, skimmers and other kind of equipment capable of operating in rough seas. In more sheltered areas like e.g. the Kola Bay, less robust equipment dedicated to be utilized closer to shorelines with reduced wave activity can be used. The preferred response options to oil spills in open waters offshore is mechanical recovery in combination with dispersants use. Dispersants could be used as an alternative to mechanical recovery for small oil spills and a supplement for larger oil spills.

Mechanical recovery

The Norwegian Clean Seas Association for Operating Companies (NOFO) is an oil spill response organization established by the operating companies on the Norwegian continental shelf. NOFO has 14 oil spill response systems and each system comprises a boom with a swath of approximately 180 m, referred as 'A' in figure 6.1, towed by two vessels; a main vessel 'C' and a towing vessel 'D'. The maximum towing speed of the system is 1 knot. The Transrec weir skimmer 'B' is connected to the main vessel via a buoyant hose. The nominal pump capacity of the Transrec skimmer is 350 m3/h, but the effective skimming rate during oil recovery operations is presumed to be approximately half of this rate. The main vessel has a 1000 m3 storage tank for recovered oil. The system is found to operate efficiently at sea states up to about 3 m significant wave height.

Figure 6.1: Offshore oil recovery system standardized by NOFO. A: Boom; B: Transrec skimmer; C: Main vessel; D: Towing vessel.

In case of an offshore oil spill in open water along the shipping route from Varandey to Murmansk it is recommended to use similar offshore recovery systems. The systems should be capable of operating under rough weather conditions and the recovery capacity should be large enough to handle fairly large oil spills.

In the oil spill response analysis performed (Johansen et al., 2005) for a spill of 10,000 m3 of oil at two locations, the outlet of the Murmansk Fjord and north-east of Kolguyev Island, 4 such systems were used as input to the analyses (refers to chapter 4). The analyses indicated good effect by use of these systems, but more important than the number of recovery systems seems to be short response time. Obvious place for storage of such systems are the Murmansk area, the Varandey area and Kolguyev Island. In the wintertime, when icebreakers assist the tanker, the icebreakers could form the working platform for such a system, to assure quick response time. However, the icebreakers are dependant on assisting vessel for towing the booms.

Use of dispersants

On the Norwegian continental shelf several oil companies are now including use of dispersants as part of their oil spill contingency. Dispersants can be used as an alternative to mechanical recovery for small oil spills and as a supplement for larger oil spills. The potential use of dispersants is based on a Net Environmental Benefit Analysis (NEBA), which is regularly done as part of the oil spill contingency planning.

The aim of using dispersants is to remove the oil spill from the sea surface to prevent the oil from damaging vulnerable biological resources like e.g. sea birds at sea or vulnerable resources along the shorelines. The concentration of hydrocarbons in the water column will increase by use of dispersants and there is a concern in many countries about the biological effects by use of dispersants. However, the initially high concentrations of dispersed oil and partially water-soluble oil components will be rapidly diluted to concentrations below those that cause negative effects on a wide variety of marine life. Dilution of the oil as small droplets in the water column will increase the biological degradation due to increased surface between oil and water where the microorganisms are active.

According to the Norwegian regulations for use of dispersants, effectiveness and potential environmental damage by use of dispersants shall be evaluated and documented before a dispersing action can take place. This contributes the internal control that dispersants are used within the frames outlined in the Oil Spill Response Plan.

A decision model for use or not use of dispersants has been worked out in Norway (e.g. Singsaas et al., 2005). The decision model is based on the following criteria:

1. Is natural dispersion already a dominating process?
2. Which biological resources are threatened by the oil spill, and how will the use of dispersants influence on these?

3. Can the dispersed oil be effectively diluted in the sea?
4. Will the effectiveness be reduced based on oil type and weathering degree?
5. Will the effectiveness be reduced due to low salinity (brackish water)?
6. Will the effectiveness be reduced due to bad weather conditions (wind/fog)?
7. Application equipment – how to apply the dispersant in a correct way?
8. Application equipment – is there sufficiently short response time and treatment capacity?
9. How will the effectiveness of the dispersant action be monitored?
10. When and to what criteria shall the dispersant action be terminated?

These criteria must be fulfilled in order to evaluate the use of, dispersants in Norwegian waters. Today dispersants can be applied on an oil slick from three different working platforms:

- Aerial application from fixed-wing aircraft. Different systems are in operation. OSRL in Southampton (UK) has 200 tons of dispersants stored in Southampton and Shetland and uses a Hercules aircraft equipped with an ADDS-pack system for application.
- Aerial application by helicopter. In Norway an under sling bucket has been developed for application. This system requires that dispersant for reloading is stored close to the spill site (e.g. a production platform or a vessel) to avoid long flying distances.
- Boat application. Several systems are available. A newly developed system has been successfully tested by Hydro in Norway (figure 6.2). The advantage of such a system is that large amounts of dispersant can be stored on the vessel and normally the response time can be short.

It is recommended that the icebreakers assisting the oil tanker are equipped with application equipment and have some dispersant stored onboard. This will give a fast response and give a high degree of opportunity to combat small oil spills effectively. However, there is a lack about the effectiveness of use of dispersant in ice-infested water.

Figure 6.2: Newly developed system for application of dispersants from a vessel.

Oil spill response in ice-infested waters

Generally, oil spills in ice are far more complicated to combat compared to oil spills in open waters. Apart from the normally long distances from existing infrastructure, the oil is less accessible in ice-covered waters. The oil can be spilled on ice/snow, in open pools between ice floes, in open channels behind vessels or even under the ice as shown in figure 6.3. There are several challenges connected with oil spill response techniques of oils in ice and cold water, which are related to:

- Detection/ monitoring of oil
- Limited access to oil
- Increased oil viscosity
- Contamination of ice with oil/cleaning of ice
- Migration of oil in the ice
- Deflection of oil together with ice
- Limited flow of oil to recovery device
- Separation of oil from ice
- Winterization due to icing/freezing of equipment
- Strength considerations of equipment
- Personnel operating in cold environment

Traditional use of booms and skimmers can be difficult. However, there are also some advantages with oil spills in ice compared to open waters. The weathering rate is normally much slower for an oil spill in ice. This means that emulsification rate and hence viscosity increase may be slowed down resulting in an increased window of opportunity for use of most response techniques (e.g. the Marginal Ice Zone (MIZ) experiment in 1993, Brandvik et al., 2004). The spreading of oil will be normally also much slower resulting in a large oil film thickness that may be favourable for the oil spill response.

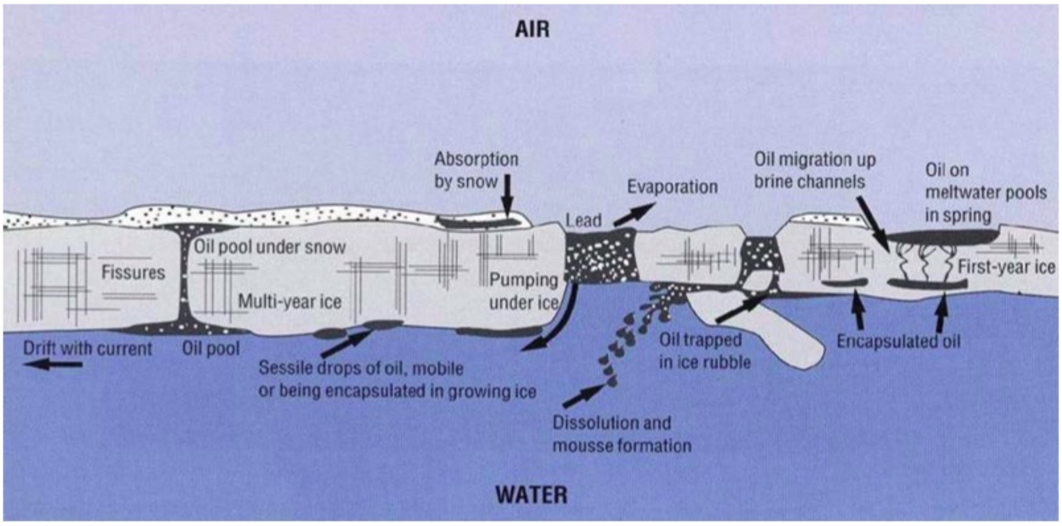


Figure 6.3: Potential oil spreading and behaviour in ice-infested waters.

The ice concentration can become a governing factor in making decisions about equipment selection. The ice can act as a natural containment in a variety of ice features such as floes, snow and ridge. In a case of a spill the oil can be located on ice, among ice floes and oil under ice, which also requires a different approach to the problem.

Table 6.2 gives an indication of expected operational limits of different response methods as a function of ice coverage. Few of these methods have actually been tested in ice-infested waters, so there are large uncertainties attended with the listed technologies. It should also be mentioned that there are major differences in capacity (e.g. amount oil removed per time unit) between the different methods.

Working platform

Table 6.2: Indication of expected operational limits of different response methods as a function of ice coverage

		Ice coverage									
Response method	Open water	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Mechanical recovery:											
- Traditional configuration (boom and skimmer)	—	—	—	···	···						
- Use of skimmer from icebreaker			—	—	—	—	—	—	—	···	···
- Newly developed concepts (Vibrating unit; MORICE)				—	—	—	—	—	···		
In-situ burning:											
- Use of fireproof booms	—	—	—	···							
- In-situ burning in dense ice				—	—	—	—	—	—	—	···
Dispersants:											
- Fixed-wing aircraft	—	—	···								
- Helicopter	—	—	—	—	···	···	···				
- Boat spraying arms	—	—	— ···	···							
- Boat “spraying gun”	—	—	—	···	···						

Along the shipping route from Varandey to Murmansk the maximum ice coverage can typically extend from Varandey to approximately half the distance to Murmansk. Icebreakers assist each tanker and the icebreakers should constitute the main working platform for the oil spill response equipment. In addition it could be beneficial to have some oil spill response equipment stored in onshore bases, e.g. at the Varandey terminal and Kolguyev Island. Helicopters could be used for fast transportation and deployment of equipment.

Recommended response measures

A typical spill scenario for the shipping route in February and March would be dense ice with a shipping lane with smaller and larger ice floes broken by icebreakers. The broken channel will be the potential spill site. Due to the dense ice the weathering of the oil will be slow and hence the ’time window’ will increase for use of in-situ burning and dispersants as potential response methods.

Mechanical recovery could be used without deployment of booms. Testing and use in oil spills have shown that both disc and drum skimmers allow small ice forms to pass the recovery mechanism as oil is being collected (Evers et al, 2004). Rope mop skimmers also have a potential, but this is, as most skimmers, dependent on a certain thickness of the oil/emulsion. Both of these skimmer types (disc/drum and rope mop skimmers) are based on the adhesion principle and show reduced recovery rate for very light oils and/or oil with low weathering degree (e.g. fresh crude oil). Weir skimmers are based on a self-levelling edge over which oil and water flow and are often used for oil recovery in open waters. When oil and water is flowing over the edge, ice will easily follow and can create problems with ice jamming in the pump house. A diverse number of skimmers have been considered for removing oil in ice (Evers et al., 2004).

The Lori Brush Skimmer was found to offer the highest potential for recovering viscous oil in broken ice. Recently Lamor has developed an Arctic Brush Skimmer that has shown to be a promising alternative especially for use in oil loading terminal areas. It must be emphasised that none of these skimmer types have been thoroughly tested in severe ice conditions as can be found in the Pechora and Kara seas, but it can be expected that they could function in high ice coverage as indicated in table 6.2, but probably with reduced recovery rate.

Some novel concepts have shown promising results. The MORICE skimmer was developed through a project from 1995 to 2002. The skimmer has been tested both in basin facilities and in the field and could be used in broken ice with 70% ice concentration on a large scale. So far the skimmer has not been industrialized and only a harbour sized prototype exists. In Finland an Ice Vibrating Unit has been designed by the Finnish Environmental Institute to be used in the presence of broken ice and brash ice in a typical shipping channel in Finnish waters. Two to three units are now being built for use in the Gulf of Finland. However, it has not been demonstrated and no effort has been made to make the Vibrating Unit system suitable also in Arctic conditions.

It appears that no proven system for large-scale oil spills in ice-infested waters exists. The skimmers described above have the potential to work in some ice scenarios, but have not been demonstrated for ARCOP scenarios.

In-situ burning has a potential in ice-infested waters. In general, the applicability of burning can be divided into three broad ice concentration ranges:

- Ice coverage from open water to 3/10. In this low ice coverage the spreading and movement of oil will not be affected by the presence of ice and open water in-situ burning techniques, e.g. fireproof booms can be used. However, the 'time window' can be reduced due to high energetic conditions and a high degree of weathering.

- Ice coverage from 3/10 to 7/10. This range turns out to be the most difficult from an in-situ burning perspective. The use of booms will be difficult, if not impossible. The main challenge is large areas of open water in between the ice floes and the spreading of oil to a thickness below what can be ignited. There are ongoing projects in Canada to study the use of herders to concentrate the oil up to thicknesses where it can be ignited.
- Ice coverage from 6-7/10 to 9/10. At this ice coverage ice floes may contain the oil so the slick gets thick enough to be ignited and burn effectively. Normally the weathering is slow under such conditions and the 'time window' for use of in-situ burning will increase compared to open water conditions.

Oil can also be successfully burned on solid ice, in melting pools, and in snow even with up to 70% snow by weight.

There exist two main types of igniters for in-situ burning:

- Igniters for use from a vessel. Both portable propane or butane torches, or weed burners and rags or sorbent pads soaked in diesel have been used successfully many times to ignite oil slicks on water.
- Igniters for use from helicopter. There are currently two types available, the Dome igniter and the Helitorch igniter.

The icebreakers assisting the oil tanker could carry igniters of the first type or ignition could be carried out by use of helicopter, either from the icebreaker or from an onshore base. The ARCOP study area characterised with dense drifting ice and a shipping lane with typically large ice pieces and which can be closed quite rapidly due to wind and currents could be a relevant scenario for in-situ burning. There must be a sufficient distance between the vessels and the burning area to ensure safety.

Use of dispersants normally requires lower ice concentration than expected to be found in the ARCOP scenario. The weathering of the oil will be slow increasing the ’time window’ for use of dispersants. The main challenge will be to apply the dispersant in an effective manner and helicopter application may be the best method. Another challenge is the low energy condition as an effective use of dispersants, which requires some wave energy to start the dispersing process.

However, studies are ongoing to look upon the potential to apply dispersants for later dispersing when the oil approaches the ice edge. That requires dispersants that have the ability to stay in the oil and not leaking to the surrounding water or ice. Another option under investigation is to use vessels to create artificial turbulence by propellers to initiate the dispersing process.

At the present time, the use of dispersants can not be recommended for the scenario as described in this ARCOP study area. However, later in the spring during the melting period use of dispersants can have a potential and can be an effective response option in lower ice coverage.

Conclusion: Today there is no proven response method for recovery of large-scale oil spills in ice-infested waters. The preferred response for the scenario as described for the shipment in ice from Varandey towards Murmansk may be a combination of mechanical recovery and use of in-situ burning. It is recommended that the icebreakers assisting the oil tanker carry at least one skimmer of the brush type or rope mop type and igniters for in-situ burning. At the same time additional equipment should be stored at the Varandey terminal and/or Kolguyev Island, preferably with helicopters for fast transport and deployment. There is a need for winterisation of existing equipment and field-testing to demonstrate the capability. There is also a need for development of equipment or strategies for systems to handle larger oil spill in ice-infested waters.

Shoreline cleanup

A strategy for shoreline cleanup is an important part of the contingency plan for accidental oil spills in the Arctic region. The contingency plan should primary be focused on the philosophy to minimize the harm caused by an oil spill, not necessarily the needs to provide methods to clean up all the spilled oil. It is important to attain a well documented knowledge about how the natural processes occurs in the different scenarios in a case of an oil spill incident should happen along the coastline or with short drifting time toward the coastline due to wind and/or current. This knowledge about the natural processes in this region can be used with advantage to develop a modelling tool to predict the restitution time of the polluted area in respect of the amount of oil released, type of the oil product, shoreline conditions and duration of the spill, weather and waves.

The disadvantages of most frequent used response techniques are the requirements of logistic and need for much personnel. Several response techniques are in addition tremendously time-consuming. It could be difficult to get access to the contaminated area with massive cleanup equipments and a large group of personnel if an oil spill incident should occur in this vulnerable region.

The strategy and main focus in shoreline cleanup should be addressed to the following subjects:

- Identify the areas with specific concerns along the transport coastline and the areas should be planned based on unique factors. The areas could be divided into sections of major concern, moderate concern and minor concern based on activity of both biological - and human resources (natural recourses).
- Define release scenarios including oil type, the influence of oil type and volume of the released oil. This includes the identification of both, the type and quality of the oil.
- Identify shoreline category possibly influenced by oil.
- Identify the topography and access to the shorelines of concern.

It is recommended to develop and improve in-situ techniques which stimulate the natural processes concerning following techniques:

- Bioremediation /biological degradation*)
- Use of dispersants*)
- Shoreline cleaning agents*)
- In-situ burning*)
- Passive collection with sorbent

- Washing /flushing (variable combination of pressure and water temperature)

The in-situ techniques labelled with *) need a specific approval prior to use. It should be emphasised that Russian regulation prohibits the use of dispersants as a primary response strategy as long as mechanical recovery method can be used. In Western Europe (e.g. Norway) the use of dispersant is an often preferred strategy in the case of relative small oil spills. In-situ burning could for instance have a potential as a countermeasure on remote shorelines or inaccessible mud-flats in Arctic areas. This technique could especially be useful for large quantities of less weathered oil.

Mechanical recovery, manual recovery and natural attenuation (need monitoring) are in addition important tools in oil spill countermeasures on shorelines, but these techniques are not part of in-situ techniques which have the overall objective to stimulate natural processes.

4.6.3 Conclusions

The shipping route from the loading terminal at Varandey to Murmansk sea port has long distance to land which requires that the spill response technology has to stationed off-shore, mainly from larger vessels like icebreakers, ice going tug boats and supply vessels, with possible assistance from helicopters and fixed wing aircraft for monitoring and/or surveillance, dispersant application and ignition of in-situ burning.

If an oil spill incident should occur in the Arctic conditions, the combating strategy will strongly depend on response time, ice conditions, weather/current/wave conditions, availability of equipments, and possibility of assistance e.g. of helicopters. In addition, the properties of the oil, amount of oil spilled and duration of the spill are important aspects in selection of oil spill response methods and technology.

Today there is no proven response method for recovery of large-scale oil spills in ice-infested waters. The preferred response for the scenario as described for the shipment in ice from Varandey towards Murmansk may be a combination of mechanical recovery and use of in-situ burning. In order to secure short response time, it is recommended that the icebreakers assisting the oil tanker carry at least one skimmer of the brush type or rope mop type and igniters for in-situ burning. At the same time additional equipment should be stored at the Varandey terminal and/or Kolguyev Island. The size of the equipment should preferably be tailor-made for fast transportation by helicopters and easy deployment. There is a need for winterization of existing equipment and field-testing to demonstrate the capability. There is also a need for development of equipment or strategies for systems to handle larger oil spill in ice-infested waters.

The strategy with respect to shoreline cleanup is focused on the natural processes and use of in-situ techniques. It is important to attain a well documented knowledge about how the natural processes occurs in the different scenarios in case of an oil spill incident should happen along the coastline or with short drifting time toward the coastline due to wind and/or current. This knowledge about the natural processes in this region can be used to develop a modelling tool to predict the restitution time of the polluted area in respect of the amount of oil released, type of the oil product, shoreline conditions and duration of the spill, weather and waves.

4.7 Biology and Potential Effect of Oil Spills in the Arctic Sea Ice

4.7.1 Introduction

Oil in the Arctic marine ecosystem originates mainly from two sources: drilling activity and oil spills during transportation. Drilling activity causes long-term exposure and thus chronic effects on Arctic marine biota, such as changes in species composition, dominance and biomass, while oil spill effects are acute and can cause severe damage locally. In the scope of the ARCOP project this report concentrates on the latter type of contamination.

Oil in the marine environment affects organisms on all systematic levels: microscopic plankton (phyto- and zooplankton), invertebrates such as crustaceans, molluscs and benthic worms, and vertebrates (e.g. fish, birds, seals, polar bear). To suffer from the negative effects of oil, a given organisms does not need to become directly into contact with the medium: biomagnification is a process where oil is transported within the food web from a lower level to the next one.

Bioaccumulation of oil (concentration of oil into one organism) leads to more pronounced effects than when the organism is in contact with oil only for a short period of time. Petroleum effects on a given organism can vary from mere physical nuisance (such as oil clinging onto the body) to pathological. Oil can affect different organs and physiological functions, and thus lead to changes in e.g. behaviour (feeding, activity and motility, avoidance reactions etc.), growth, and reproduction. The developmental stage of an organism is often crucial; generally, larval and juvenile stages are more vulnerable than adult individuals.

In this report, examples of oil effects on life are given for all Arctic marine habitats: plankton (chapter 2.1.), littoral and benthic communities (chapter 2.2.), and vertebrates (fish, birds, otters, seals, whales and the polar bear; chapter 2.3.). Information is gathered through times mainly by performing experiments in the laboratory and on field (in particular in the 1970's and 1980's), and by sampling the biota during an oil spill.

4.7.2 Biological effects of oil, in particular PAHs

Oil consists of a wide variety of compounds that are toxic to organisms, the worst being the polynuclear aromatic hydrocarbons (PAHs). The effect of PAH compounds on a given marine organism is dependent on numerous factors, which can be both abiotic and biotic (GESAMP 1993). In the arctic environment, important abiotic factors that affect in particular oil spreading and weathering processes include e.g. the presence or absence of ice and snow cover, water temperature, light conditions, and vertical and horizontal water currents (e.g. Mackay et al. 1975, Clark & Finley 1982, Mackay 1985 (and references therein), Payne et al. 1991, Sydnes 1991, Singsaas et al. 1994). Biological events in the Arctic marine ecosystem are strongly linked to specific seasons, thus the possible consequences of a relatively short-lived oil spill depend on the time of the year. Should an oil spill take place after the ice break-up in spring, it would affect the vernal bloom of ice algae and phytoplankton, and thus the rest of the pelagic food chain. Migratory birds would get disposed to oil, which in turn would be transported to coast and thus affect the littoral communities too.

Biochemical processes affecting PAHs in marine ecosystems, and bioavailability of PAH to aquatic organisms are discussed in depth in the works of McElroy et al. (1989) and GESAMP (1993), and are illustrated in Figure 1. Oil is transformed and transported within the marine ecosystem by e.g. metabolism, excretion, incorporation into fecal matter, microbial transformation and degradation, and bioturbation. Numerous laboratory studies have showed that aquatic organisms can accumulate PAH from the water column, from sediments, and from their diet, but that the bioavailability of PAH from these sources is not equivalent (Varanasi & Malins 1977, Neff 1979, McElroy et al. 1989, and references therein). Direct uptake of PAHs from the water column (dissolved PAHs) is the major pathway in bioaccumulation. Trophic transfer of hydrocarbons (biomagnification) is important in aquatic organisms, which have been shown to be capable of accumulating PAH via their diet (McElroy et al. 1989, and references therein). Thus, another important pathway is via food: in cases where uptake from food vs. sediments has been compared, dietary route appears to be more efficient (Corner et al. 1976, Varanasi & Malins 1977 and references therein, McElroy 1985). A good example of this is amphipods, which feed on Arctic phytoplankton in the underside of the ice, and can thus be exposed to toxic components of oil trapped under the ice. Amphipods also consume massive amounts of dead plant and animal material, and in turn serve as an important food source for Arctic cod and other fishes, several species of birds, seals and some whales. Busdosh & Atlas (1977) suggested that oil spills in the Arctic region are likely to cause large-scale local mortality of important amphipod species, resulting in serious ecological changes in detritus decomposing processes and food-web relationships.

Bioaccumulation of oil (accumulation of oil in a single specimen) is positively correlated with physical/chemical properties of the PAHs, such as the molecular weight, and octanol/water partition coefficients (McElroy et al. 1989). By knowing the physical/chemical properties of spilled oil, the degree at which the organism would bioaccumulate PAHs can be predicted. The bioaccumulation factor has been studied mainly for fish and tends to increase with increasing molecular weight (McElroy et al. 1989).

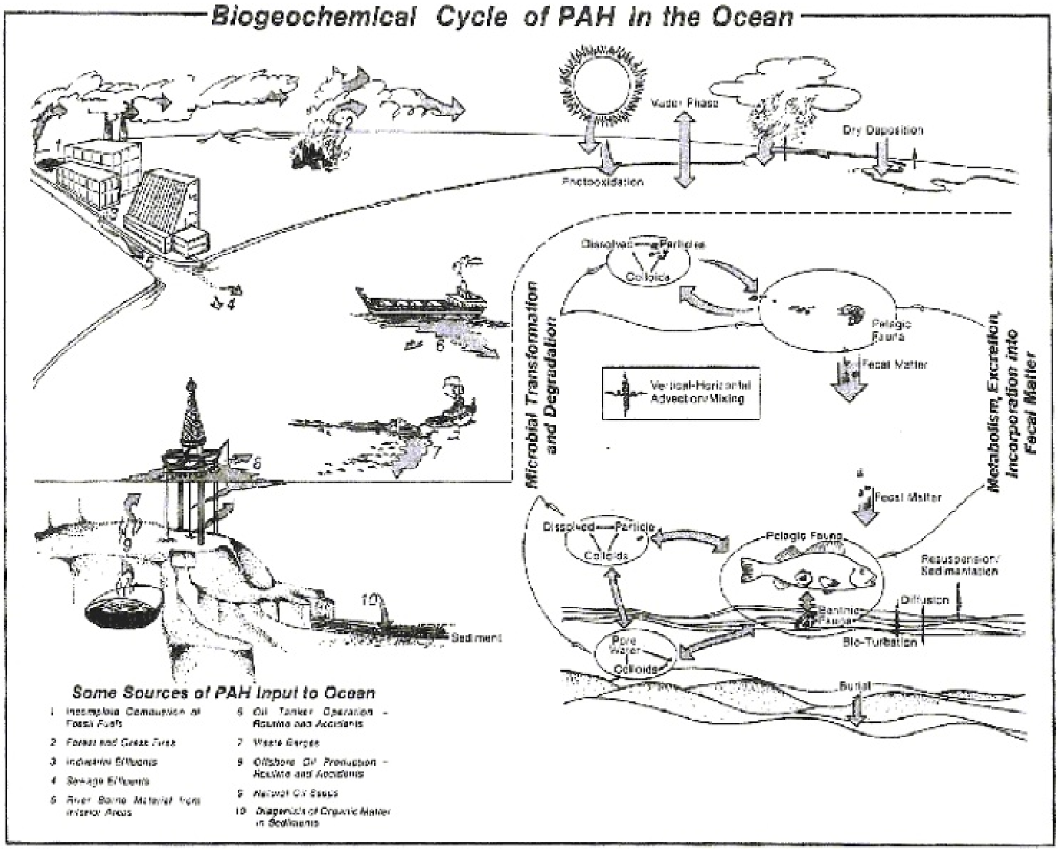


Figure 1. Biochemical processes affecting PAH in marine ecosystems. Source: McElroy et al. (1989).

In toxicity tests, LD$_5$0 concentrations of the tested oil have yielded much information about the tolerance of a given organism to oil and/or dispersant disposition. Typically, oil with a high aromatic content (2- and 3-ringed PAHs, such as naphtalenes, fluorenes, phenantrenes and anthracenes) and fresh crude oil have a greater acute toxicity to marine organisms than oils with more aliphatic nature or weathered oil (e.g. Anderson et al. 1977, Lee et. al 1978). High angular configurations are more carcinogenic than linear or highly condensed ring arrangements (Neff 1979).

Petroleum and its products may have either a mechanical effect, as it is able to penetrate, has a tendency to cling to surfaces and form coverings on objects, or a chemical one, where toxic components (mainly aromatic hydrocarbons of low molecular weight) affect the organism (e.g. Nelson- Smith 1982, Wells and Percy 1985, Robertson 1998). Organisms can become affected by oil by filtration or ingestion, penetration of oil through cell membranes, or through becoming smothered by oil. The sensitivity of a given organism to oil is largely dependent on the severity of contamination, the organism's physiological state, and life cycle. Reproductive and juvenile stages are particularly sensitive to PAH effects. Also, organisms on a higher systematic level generally have a better PAH metabolism, and consequently tolerance, than organisms at lower levels (e.g. Rice et al. 1977a).

In addition to acute toxicity - virtually causing death of an organism, which is tested using LD_50 concentrations of a given compound - PAHs can also cause a multitude of sublethal effects. These may become visible almost instantly after exposure to oil or during later life cycle stages of the organisms (e.g. during maturation or reproduction). Sublethal effects can be expressed in various ways, such as changes in feeding or other behaviour, growth, reproduction capacity, or in the organism's offspring (such as organ abnormalities in the developing embryo). On a cellular level, PAHs can either bind to lipophilic sites in the cell, or affect the DNA creating covalently bound products called adducts (Robertson 1998).

Adducts are thought to be one of the initial steps in tumor development caused by carcinogenic PAHs. Metabolic activation is a prerequisite for carcinogenic effects of PAHs in mammals and fish (Robertson 1998) and is introduced later in this report. In the following chapters, petroleum effects on marine organisms, with particular emphasis on oil spills and arctic species are presented with examples from literature. The report proceeds from plankton (open water) communities to littoral (shorelines), benthos (sea bottom) and, finally, marine mammals.

Plankton

Plankton organisms live in the open water, and comprise of bacteria, fungi and viruses, primary producers (photosynthesising microscopic algae), heterotrophic consumers (e.g. ciliates, rotifers, fish eggs, medusae) and mixotrophic organisms (from several systematic ranks) (e.g. Valiela 1984). Arctic zooplankton consumes phytoplankton and ice algae for food (Runge et al. 1990, Werner 1997). Plankton in general is the foundation of the marine open water food web, and is the primary food source for several macroscopic open water organisms, such as fish and whales. Fisheries, for example is very sensitive to changes in plankton quantity and quality.

In many cases, the comparison of results from oil experiments is difficult, questionable or impossible (for discussion on this issue see e.g. Craddock 1977). Particularly older literature with oil experiments shows that tests were made in various ways, and common guidelines for testing oil effects on plankton were generally missing. This is true not only for plankton, but in commonl for littoral and benthic studies as well. OECD guidelines for e.g. testing of chemicals have later been prepared for some aquatic organisms, i.e. alga (growth inhibition test), zooplankton (Daphnia magna reproduction test) and several for fish (e.g. acute and prolonged toxicity tests, and juvenile growth test) (OECD 1984a, b, 1992, 1998, 2000). The plankton data available derive from three sources: field studies in oil-contaminated areas, studies with enclosed systems - such as mesocosms – with test organisms, and laboratory experiments.

Information about the effects of oil on plankton is much sparser than for littoral or benthic organisms. One reason for this is that oil is regarded to affect sea shores and bottoms more than the open water ecosystem (e.g. Robertson 1998). However, as plankton is the food source for a large variety of organisms even on the top level of the marine food chain, it is vital to know petroleum effects on open water communities. Plankton is generally thought to remain rather unaffected by oil, mainly for its capability to escape the contaminated water area. This is partially true for in particular larger zooplankton and in case of a small scale spill. Also, phytoplankton cells reproduce mainly asexually by cell division, therefore enabling a short recovery time. Local and short-term effects on plankton communities (decreased photosynthetic rates, oiled zooplankton) are likely during even a small oil spill, but have only a temporary dampening effect on plankton productivity. In case of a larger spill, the effects last notably longer and are spread to a larger area (e.g. Teal & Howarth 1984). An oil slick in the water column or associated with sea ice has an effect on the organisms therein, and thus the type and composition of algal material (phytoplankton vs. sea ice algae) sinking to the bottom may affect the food quality of benthic animals (Clough 2005).

Hydrocarbon utilising bacteria (such as Vibrio, Pseudomonas, Micrococcus, Nocardia and Acinetobacter in the Arctic) are long known to be widely distributed in the world's oceans, also in cold marine ecosystems (e.g. Bunch & Harland 1976, Austin et al. 1977, Atlas 1978, Roubal & Atlas 1978, Atlas et al. 1982). Among fungi, Penicillium and Verticillium spp. from the northern Canada oil-producing areas were capable of growth on one or more crude oils tested by Davies & Westlake (1979), and oil-degrading strains of a few other genera were isolated. Several genera such as the truly marine Corollospora, Dendryphiella, Lulworthia and Varicosporina are known (Kirk & Gordon 1984), but their function as hydrocarbon utilisers is still an issue in the Arctic. Microbial degradation of oil by bacteria (bioremediation) and fungi is dependent on several physical, chemical, and biological factors which are extensively studied and discussed by e.g. Leahy & Colwell (1990). A dramatic rise in concentration of planktonic hydrocarbon utilising bacteria in response to acute input of petroleum hydrocarbons has been documented in some cases (Horowitz & Atlas 1978, Johansson 1980, Dahl et al. 1983), but not as a rule. The biomass increase of hydrocarbon degraders can also be extremely slow and take place within months or even years after oil introduction (Haines & Atlas 1982). As for the diversity of bacteria, it may either decrease or increase due to oil exposure (Atlas et al. 1982, Atlas 1983). In sediments, the biomass of oil degraders may be notably higher than in the water column, like in the case of the Arrow oil spill in the Chedabucto Bay, Nova Scotia in 1970 (Stewart & Marks 1978). Generally, hydrocarbon utilisers in sediments seem to increase relatively slowly after the actual spill (e.g. Eimhjellen et al. 1982, Bunch 1987). Hydrocarbons can also cause a temporary change in the behaviour (chemotaxis) of bacteria as evidenced by Mitchell et al. (1972) and Walsh & Mitchell (1973).

Good evidence of effects on plankton derives from field studies of the Tsesis spill in the Baltic Sea in 1977 (Johansson 1980). Phytoplankton species composition was not changed by the oil (concentration 50-60 μg/l after 2-5 days of the accident): microflagellates dominated the community before and after the spill. Phytoplankton biomass and productivity increased after the accident, which was probably largely due to depressed zooplankton grazing. Although planktonic bacteria biomass increased notably after the oil spill, the populations of their grazers (ciliates, rotifers) did not (Johansson et al. 1980). Larger zooplankton abundance changed shortly after the accident, probably due to narcosis effects and/or avoidance reactions. No notable change in phytoplankton communities were detected after the platform Bravo spill either (concentration of aromatic hydrocarbons up to

8 μg/l) in the North Sea in 1977 (Rey et al. 1977), while an obvious retardation of phytoplankton growth, and a considerable mortality of zooplankton was recorded for several weeks in the vicinity of the Amoco Cadiz accident on the NW coast of France in 1978 (Cabioch et al. 1981). Further away, phytoplankton growth was elevated, which was interpreted as a consequence of nutrient release from dead organisms.

Zooplankton was contaminated with oil in proportion to their distance from the wreck. Also the groundings of Arrow in Nova Scotia in 1970, and Argo Merchant on Nantucket shoals in 1976 lead to copepod contamination (Conover 1971, Polak et al 1978): oil droplets had incorporated into their guts. The Potomac spill off Western Greenland in 1977 caused external contamination of plankton (primarily the copepod Calanus hyperboreus and the amphipod Themisto libellilula (syn. Parathemisto libelillula) in the vicinity of the spill, but no oil was found in either copepod or amphipod guts (Maurer & Kane 1978), and thus no severe damage to the zooplankton communities was detected. Thus, field observations at numerous accidental spills show that negative biological effects can occur after a spill, but that the consequences appear rather mild and short-lived.

More detailed information of the effects of oil on plankton organisms originates from laboratory and other experimental studies. The older literature is reviewed extensively by O'Brien & Dixon (1976) and Johnson (1977). Microscopic algae from different systematic ranks may show different responses and tolerance to oil. Pulich et al. (1974) used six phytoplankton species to study experimentally the effects of different crude oils on the growth and photosynthetic rate of microscopic algae. All were inhibited either fully or partially, but significant differences between algal groups were discovered: Thalassiosira pseudonana (a diatom) showed the least tolerance to oil, while blue-green algae (Agmenellum quadlupcanum, Nostoc sp.), green algae (Dunaliella tertiolecta, Chlorella autotrophica) and the dinoflagellate Gymnodinium halli were several times more tolerant to one or all types of oils tested. Hsiao (1978) found that exposure to various crude oils generally inhibited arctic phytoplankton growth, but also some signs of stimulated growth were documented after several days of exposure to 10 ppm of a range of crude oils. The degree of inhibition was temperature dependent: at +15℃ the oils were generally less toxic than at 0 or +10℃. Temperature dependence of oil effects is important in particular in the case of an oil spill accident in the Arctic. Hsiao (1978) further speculated that a major oil spill could cause a change in phytoplankton species composition (from diatoms to microflagellates) and therefore an alteration in the zooplankton communities (species, biomass) that feed on microalgae. Effects of oil on plankton algae may vary even between clones of an algal species as was evidenced for the diatom Skeletonema costatum by Mahoney & Haskin (1980) (an important food source for the eastern oyster Crassostrea virginica). In the same experiment, other algae (chrysophytes Monochrysis lutheri and Isochrysis galbana, chlorophyte Dunaliella euchlora, and the eustigmatophyte Nannochloris oculata) showed generally better tolerance to oil than the diatom. Evidence of differences in oil effects on different phytoplankton groups is published also by Davenport (1982) and Dahl and co-workers (1983).

Sea ice associated (epontic) communities are characteristic to polar regions. They consist of a wide variety of microscopic organisms (size ranges from picoplankton (0.2-2 μm to mesoplankton (20-200 mm) (e.g. Ikävalko 1997, Werner 1997, Thomas 2004). Primary producers, grazers, predators and, finally, degraders are present within sea ice. Sea ice communities consist largely of the same groups of organisms (but often different species) as the plankton, and live trapped in brine channels within ice. Thus they are not capable of escaping oil contamination, and the effects of oil on ice biota can be much stronger than on free-floating plankton in the open water. Ikävalko and co-workers (2005) made experiments on the effects of Statfjord crude oil on sea ice biota by exposing ice algae to oil for 63 days. Oil was practically lethal for dinoflagellates and chlorophytes, while some diatoms survived by forming thick-walled resting stages which are relatively resistant to environmental changes. Vegetative diatom cells survived better in the interior and close to the underside of the ice than in the ice surface where oil was distributed. No negative effects of oil on ice diatom growth or photosynthesis were detected in in-situ experiments by Cross (1987). Conflicting results from experiments on sea ice algae may be explained by several factors, such as differences in study methods (oil type and concentration, duration of predisposition to oil, laboratory vs. field experiments), microalgal species studied, and possibly the physiological state of algae (not measured).

Studies on zooplankton responses to oil are reviewed e.g. by Wells & Percy (1985) and Robertson (1998). Most zooplankters appear to be very sensitive to in particular dispersed and dissolved oil. The acute lethal toxicity of dispersions and water soluble fraction (WSF), usually expressed as 4-day LD_50 values using initial measured concentrations, ranges between 0.05-9.4 mg/litre (Wells & Percy 1985). The major routes of contamination are direct uptake from the water, uptake from food (important for in particular copepods), or ingestion of oil particles that may be the size of the food item Wells & Percy 1985). The capability of detoxifying hydrocarbons varies between different organisms. Oil particles taken up alone, or with food items, seem to pass chemically unchanged through the gut of for example copepods and pelagic barnacle larvae, and may become discharged in fecal pellets. This, in turn, may lead to biomagnification of oil in the arctic foodweb: the transfer of ingested oil to higher predators or coprophages (organisms that eat feces).

Low concentrations of hydrocarbons can cause sublethal effects in zooplankton, such as changes in behaviour, physiology, development, growth and reproduction (Wells & Percy 1985). Further studies are however, required as in earlier experiments there has been much variation in e.g. exposure conditions, life stages of test animals, and oil types used. Field observations are made during oil spills and in chronically exposed areas like in the vicinity of oil platforms. Biological effects seem to be detectable but short-lived. Organisms at spills have suffered from direct mortality (copepods, fish eggs, plankton in general), external oil contamination (crustaceans, fish eggs), tissue contamination by aromatic compounds, abnormal development of fish embryos, altered feeding behaviour in copepods, and changes in metabolic rates of zooplankton. Mesocosm experiments by Vargo (1981) showed several negative effects of chronic low concentrations of fuel oil on temperate zooplankton, in particular changes in respiration and excretion rates.

Wide distribution of zooplankters and rapid change of water masses in the open waters promote the recovery of zooplankton communities after oil contamination, while in enclosed water bodies, such as estuaries and bays, the recovery may take notably longer (Wells and Percy 1985, and references therein).

Dahl et al. (1983) studied the effects of Ekofisk crude oil on a planktonic ecosystem using a simplified mesocosm set-up. While diatoms and copepods suffered from the addition of oil, the rapid stimulation in growth of planktonic bacteria (for which low molecular-weight fractions served as energy sources) was observed. Due to increased food availability (i.e. bacteria) their grazers (mainly heterotrophic choanoflagellates and tintinnid ciliates) increased as well. Very low concentrations of petroleum hydrocarbons (470μg/l) were considered to be the toxic to diatoms. Clear range of oil sensitivity of arctic freshwater zooplankton was detected in experimental studies by O'Brien (1978) and Atlas et al. (1978). As branchiopods (fairy shrimp Branchionecta paludosa) and amphipods seem particularly sensitive, cladoceran Daphnia middendorfiana, the calanoid crustacean Heterocope septentrionalis and isopods in general showed better tolerance to oil.

Copepods are good test organisms in oil experiments: they are easy and inexpensive to access and maintain, and show rapid responses to treatments. Petroleum is acutely toxic, but has also numerous sublethal effects (narcosis, paralysis, decreased feeding and defecation rates, disrupted phototaxis and altered swimming activity) on copepods. The effects of petroleum hydrocarbons on copepods have thus been extensively studied in laboratory set-ups, outdoor enclosure experiments, and at various spilled sites, of which only a few examples are given here (for a careful review of older literature see Wells & Percy 1985). Cross & Martin (1987) examined effects of untreated, solidified and dispersed oil on under-ice meiofauna during the Baffin Island Oil Spill (BIOS) project (for a description of the project, please see Sergy & Blackall 1987). Harpacticoid copepods and polychaete worms showed high sensitivity to oil, in particular the dispersed type, while cyclopoid and calanoid copepod nauplii (juvenile stages) were more tolerant to it. Untreated and solidified oil did not affect nematode, polychaete and copepod densities. The growth of adult harpacticoid copepods and their copepodite (juvenile) stages, and cyclopoid nauplii was, in fact, slightly stimulated by untreated and solidified oil (Cross & Martin 1987). Negative effects of oil on arctic copepods have been evidenced by several researchers. Melbye et al. (2001) studied the effect of low oil concentration on the copepod Calanus finmarchicus, which is an important species in arctic pelagic food web. Oil with very low water-soluble component (and low content of aromatics) had very weak acute toxicity towards the test organism. Furthermore, another arctic copepod, Calanus hyperboreus is considered very resistant to crude oil (Percy & Mullin 1975, Foy 1979) when compared to e.g. amphipods and isopods. Short-term exposures of high concentrations of aromatic hydrocarbons did have profound effects of the copepod Eurytemora affinis as documented by Berdugo et al. (1977): significant reduction in subsequent length of life, total number of eggs produced, mean brood size, and the rate of egg production was evident.

The sensitivity of planktonic cod eggs (Gadus morrhua), and sea urchin eggs and embryos (Strongylocentrotus droebachiensis) to naphatalenes and Ekofisk crude oil was documented by Falk-Petersen et al. (1982, 1983). The locomotory motion and thus swimming of the Arctic medusa Halitholus cirratus is negatively affected by crude oil disposition (Percy & Mullin 1975).

Littoral and benthic communities

The marine benthic habitat can be divided into two areas, the intertidal (here also referred to as the littoral zone) and the sea floor (benthos). Characteristic for the intertidal zone are strong variations in water level, notable stress caused by wave action and, in the Arctic, ice scouring and summertime reduction in surface salinity due to melting of ice and snow. Thus, the marine organisms in the intertidal must be tolerant to e.g. exposition to air and direct sun (desiccation), and fresh/brackish water. The High Arctic intertidal is regarded inhospitable to colonisation (Menzies et al. 1973). In the Eastern Canadian Arctic it is typically colonised by the rough periwinkle Littorina saxatilis and the barnacle Balanus balanoides (Ellis 1955, Ellis & Wilce 1961). Below the intertidal zone is the benthos, which light never reaches. The upper part is the so called barren zone, that typically extends to a depth 3-5 metres, sometimes even 15 metres), which, due to ice scavenging and low surface water salinities, is devoid of infauna (animals partly or completely buried into the substrate) and sessile epifauna (animals attached onto substrates) (Ellis 1960). In the subarctic, ice scouring effect is infrequent and the intertidal communities become notably more diverse. High intertidal zone is inhabited by a variety on invertebrates and smaller macroalgae, such as green and coralline (red) algae. Where ample light for photosynthesis, macroalgae such as kelps (giant brown algae) flourish in deeper intertidal, and offer habitats for diverse invertebrate communities – amphipods, barnacles, mussels, echinoderms, nematodes et cetera (George 1977, Wells & Percy 1985). Much of the polar basin lies beneath the barren zone and thus the permanent ice cover. These zones are called the shelf zone, slope zone and the abyssal (deep sea) (Figure 2. (from Wells and Percy 1985)). The vulnerability of littoral and benthic communities to spilled oil varies due to the environmental factors introduced above, and thus the vertical and horizontal distribution of biological communities (Figure 2.). Oligomixity (high population densities of a single species) is characteristic to the Arctic Ocean in general and particularly true for the benthic communities (George 1977). The most abundant and diverse groups in the arctic benthos include bivalve molluscs, polychaete worms, amphipods and isopods (Marshall 1982). Benthic populations in the Arctic tend to show less fluctuation in abundance than those of warmer seas (Ellis 1960). This is partially due to slower growth and longer life span, but also their altered reproduction strategies: many benthic species have shortened or eliminated the vulnerable pelagic larval stage, and larvae are produced in brood chambers.

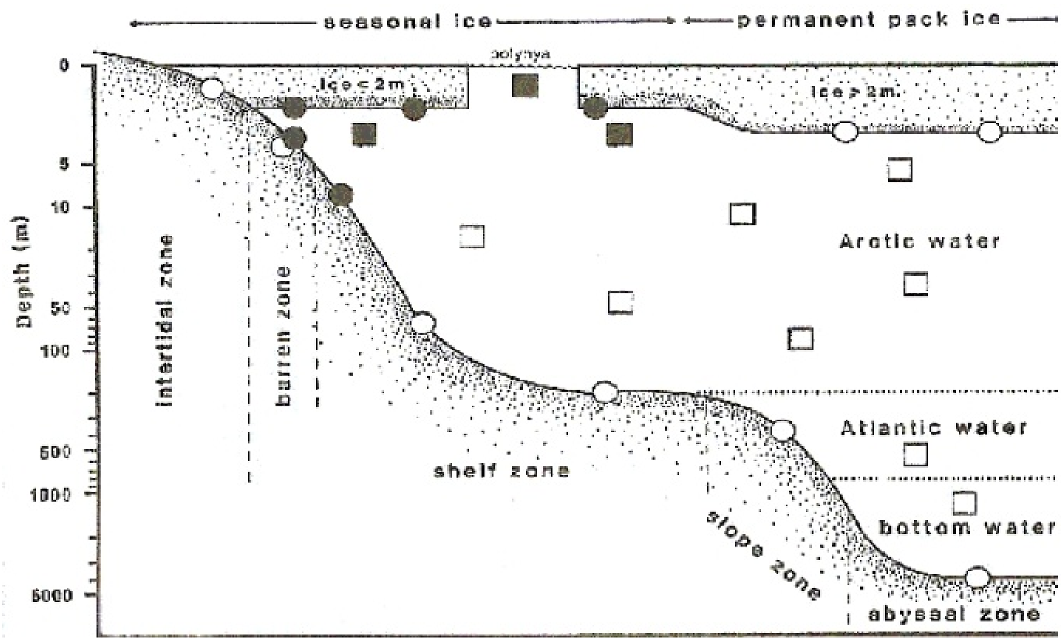


Figure 2. Habitats of Arctic marine invertebrates and their vulnerability to spilled oils (filled circles = possible impacts on benthos, filled squares = possible impacts on zooplankton, open circles = no anticipated impacts on benthos, open squares = no anticipated impacts on zooplankton. Source: Wells & Percy (1985)

Shoreline and shallow subtidal communities are most affected during a coastal oil spill, and oil impacts on sedimentary shorelines have been reported from several accidental and experimental spills at lower latitudes. Also laboratory experiments have been made on various littoral and benthic organisms, and some of them are introduced as examples in this report. In nature, the impacts of an oil spill are dependent largely on the amount of dispersed oil and the type of substratum on the shoreline (e.g. Robertson 1998). On rocky coasts, wave action may remove the oil rather quickly and transport it to the open sea or the benthos, while in sheltered estuaries and on muddy shores the oil effects in the littoral zone are more pronounced. Oil can reach the bottom by various mechanisms: 1) direct mixing of oil with sediments by wave action in shallow water, and consequently transport to deeper water by density currents, 2) sorption onto particulate matter suspended in water column and subsequent sinking, 3) uptake by zooplankton, release in and subsequent sinking of pellets, and 4) take-up of non-volatile aromatic hydrocarbons by phytoplankton, and further sedimentation (Conover 1971, Mackie et al. 1978, Sanders et al. 1980, Teal & Howarth 1984).

Attached algae (seaweeds) and their responses to oil have not been given much attention in the Arctic, although vegetations of macroalgae (in particular green and brown algae) live attached to rocky shores. Production estimates for arctic kelp Laminaria solidungula communities, for example, vary between 7–20 gC/m^2 / year (Dunton et al. 1982, Chapman & Lindley 1980, 1981). The rate of photosynthesis by marine phytoplankton and macroalgae may be stimulated or repressed depending upon the concentration of hydrocarbons and method of exposure (Johnson 1977, and references therein). Oil can form coatings on algae, and thus decrease CO2 uptake and water loss. This has been documented for Laminaria digitata and Fucus vesiculosus (Phaeophyceae, brown algae), Porphyra umbilicalis (Rhodophyceae, red alga) and Enteromorpha sp. (Chlorophyceae, green alga) (Schramm 1972). Intertidal macroalgae are considered relatively resistant to oil due to mucus production, as evidenced e.g. for the giant kelp (Macrocystis sp.). Mucus prevents contact between the petroleum and kelp tissue (Mitchell et al. 1970). During the BIOS project macroalgae were exposed to untreated and dispersed oil (Cross et al. 1987a).

Biomass, number of species and reproductive condition of the most dominant algae did not seem to be adversely affected by neither type of oil. The lack of major effects was explained partially by the mortality of herbivores and thus decreased grazing pressure on macroalgae, and the vegetative mode of reproduction, which is not as sensitive to environmental disturbances as sexual reproduction (Cross et al. 1987a). A heavy oil pollution can cause retarded growth and even death of seaweeds as was evidenced after the Torrey Canyon accident (Ranwell 1968) and a spill of 1000 tons of bunker oil on the Arctic coast of Norway (Wikander 1982). Even in the latter case, in lightly polluted areas the new sprouts of contaminated algae looked healthy the following spring (Wikander 1982). In mesocosm experiments, oil caused growth reduction in macroalgae Ascophyllum nodosum and Laminaria digitata (Gray 1987). Hydrocarbons can also affect reproduction of some fucoid macroalgae (Fucus serratus, F. vesiculosus, F. edentatus) by hindering gamete release, fertilisation, or by altering the behaviour of motile gametes as PAHs produce similar attraction to Fucus sperms as do the egg cells (Cook & Elvidge 1951, Steele 1977).

Sublethal biological effects of PAHs on benthic invertebrates in general are numerous, and include changes in behaviour, physiology, growth and reproduction of coelenterates (corals, sea anemones, hydrozoa, medusae), annelid worms, adult and juvenile arthropods (marine crustaceans such as mysids, and amphipods, isopods, shrimps, prawns, crabs), molluscs (gastropods such as limpets, and bivalves such as oysters, mussels and clams), and echinoderms (e.g. starfish, asteroids, sea urchins) (Straughan 1976, Johnson 1977, Wells & Percy 1985). Generally, long-term effects of petroleum include the development of tumours, neoplasms, diseases caused by bacteria and viruses, and mycoses in invertebrates (Hodgins et al. 1977, Wells & Percy 1985 and references in both works). Benthic invertebrates may also suffer from ostial closure, loss of responsiveness to mechanical stimuli and narcosis (Mageau et al. 1987) which are discussed later in this chapter. Chronic oil predisposition and long-term responses of benthic fauna to hydrocarbons has been monitored in the vicinity of oil platforms by e.g. Menzie 1982, Addy (1987), Kingston (1987), Moore and coworkers (1987a), Gray et al. (1990) and Olsgard & Gray (1995). To summarize, the responses of benthic communities to offshore oil exploration are measurable, complex, often irreversible, and results are presented mainly on the community level (species dominance, competition, and succession). Regarding the scope of the ARCOP project and in particular WP 4 (oil transportation and effects of oil spills on marine biota), oil field monitoring studies will not be discussed here further.

The two classes of marine molluscs which have been studied extensively with respect to petroleum pollution, Gastropoda and Bivalvia, consist of animals with distinctly contrasting adult habits. Most gastropods (e.g. limpets, periwinkles and snails) are free-living epibenthic animals, while most bivalves (mussels, oysters and cockles) are either sessile or sedentary burrowing forms (Fish & Fish 1989).

The literature lists a multitude of oil effects on bivalves and gastropods. They include e.g. mortality, abnormal larval development, and various molecular, biochemical, cellular and physiological responses such as enzymatic hydrocarbon detoxification or elimination, changes in enzymatic activity in general, atrophy of the epithelium, changes in oxygen consumption, feeding, excretion, growth and, finally, ecophysiological consequences like the general reduction in population fitness leading to changes on an ecosystem level, i.e. affecting biological interactions (e.g. Haranghy 1956, Bayne et al. 1982, Lewis 1982, Southward 1982, Stickle et al. 1985, Gray 1987, Moore et al. 1987b, Neff et al. 1987).

During the BIOS project Neff and co-workers (1987) reported several histopathological changes in bivalves Mya arenaria and Macoma calcarea caused by untreated and/or dispersed oil; digestive track necrosis, increase in the number of mucus cells in the digestive track epithelium, granulocytomas, invasive neoplasia (probably cancer), vacuolisation of the digestive tubule epithelium, increased parasitism, and hemocytic infiltration The stress level (indicated by concentrations of glucose, glycogen, trehalose, total lipid and free amino acids) was lower in animals exposed to dispersed oil than for animals receiving oil alone (Neff et al. 1987).

Documented sublethal effects of oil in gastropods only range from simple narcotisation to loss of chemosensitivity, and have been reviewed earlier in depth by (Johnson 1977, and references therein). Narcosis caused symptom is for example the detachment from substrate. The loss of chemosensitivity may change motility and alter the direction of movement, and thus affect food capture. Reduced filtration rates, possibly due to direct inhibition of the cilia by hydrocarbons (Johnson 1977), affect several functions in bivalves and gastropods, including reduced feeding. This has been documented for e.g. the oyster, Crassostrea virginica (Stegeman & Teal 1973), blue mussel Mytilus edulis (Phelps et al. 1981, Widdows et al. 1982), the hard clam Mercenaria mercenaria (Keck et al. 1978), and an arctic bivalve, Yoldiella arctica (Percy & Mullin 1975).

High concentrations of oil can cause shell closure and narcotisation of ciliary surfaces in bivalves, and consequently affect respiration and feeding rates negatively

(Johnson 1977, Bayne et al. 1982 and references therein, Mageau et al. 1987). At low concentrations of oil, rates of oxygen consumption are first increased in bivalves, such as the soft-shelled clam (Mya arenaria), blue mussel (Mytilus edulis), Baltic telling (Macoma balthica) and the gastropod Littorina littorea (edible periwinkle) (Bayne et al. 1982 and references therein).

Metabolic rates increase due to hydrocarbon association in the body tissues, and mucus secretion and excretion increase. As a result, energy expenditure increases while less energy (reduced carbon flux) is available for growth and reproduction (Stainken 1978, Widdows et al. 1982, Bayne et al.1982, and references therein). Other effects are manifested in the structure and development of the eggs and embryos, like anomalies in the gonads of the Baltic telling Macoma balthica (Stekoll et al. 1980). The BIOS project showed different uptake dynamics among species (filter-feeding bivalves Mya truncata and Serripes groenlandicus, and deposit-feeding green sea urchin Strongylocentrotus droebachiensis), but in all cases the effect was immediate, short-lived and resulted in temporary accumulation of hydrocarbons (Mageau et al. 1987). As a consequence of oil exposure, the bivalves suffered from ostial closure, retraction of the siphon (decreased filtration rate and growth), the loss of responsiveness to mechanical stimuli, narcosis, increased enzymatic activities and accumulation of hydrocarbons in tissues.

Low levels of petroleum hydrocarbons can also affect the behaviour of molluscs. The production of the bussys by juvenile and adult mussels may be reduced, leading to weakened attachment on substrate. In mesocosm experiments, oil affected negatively the recruitment of the edible periwinkle Littorina littorea, a common inhabitant on rocky coasts in subarctic, and consequently populations declined over time (Gray 1987). The burrowing behaviour of infaunal bivalves such as Macoma balthica may be impaired, and clams can be stimulated to leave the contaminated area (Lindén 1977, Taylor & Karinen 1977, Stekoll et al. 1980). The crawling rates of gastropods L. littorea and Theodoxus fluviatilis may change (Hargrave & Newcombe 1973, Lindén 1977). During the BIOS project Cross & Thomson (1987) noted that the use of untreated and dispersed oil had very distinct effects on macrobenthic infauna (bivalves Mya truncata, Macoma calcarea, Serripes groenlandicus, Astarte borealis). While untreated oil had practically no effect, dispersed oil caused marked acute effects on infauna, including emergence from the substrate, narcosis and progressive decrease in condition. Neither type of oil release caused any large scale mortality of benthic infauna, neither were significant changes in community structure detected (Cross & Thomson 1987).

Annelids, such as bristle worms (Polychaeta), are common on the shore under stones and rocks, and buried in mud and sand. While the adult worms seem rather resistant to oil pollution (Johnson 1977, and references therein), hydrocarbons can cause narcosis, immobilisation and death of their larvae (Chia 1973, Carr & Reish 1977). Once in sediments, hydrocarbons are taken up by benthic organisms with greater uptake of the heavier relative to the lighter molecular weight aromatic compounds. Uptake from water may occur more readily than from sediments in carnivores and filter feeders, while deposit feeders such as polychaetes with more intimate contact with porewaters could be expected to show a more rapid uptake from substrate (Anderson et al. 1978). Exposure of the polychaete Nereis succinea to oil in a laboratory experiment resulted in a decrease in growth rate and an increase in mixed function oxygenase (MFO) activity relative to unexposed individuals (Lee et al. 1981). MFO is responsible for the metabolic modification of foreign organic compounds in verteberates, such as fish and cetaceans and has been detected also in marine crabs and polychaetes (e.g. Johnson 1977, and references therein, Lee et al. 1981, Rice 1985, Lockhart & Metner 1991, George et al. 1995). Studies on annelids and hydrocarbons are few. Some monitoring on the succession of polychaetes has been made during oil spills. Several years after the Amoco Cadiz and Arrow spills, the lugworm Arenicola marina was very common, in case of Arrow even more abundant than prior to the accident (Gordon et al. 1978, Gundlach et al. 1981). Hydrozoa, corals, and anemones are typical benthic organisms in lower latitudes, where hydrocarbons are known to affect the behaviour, growth and reproduction of these sessile animals (Johnson 1977, and references therein).

Echinoderms include intertidal and benthic, slowly moving invertebrates such as sea urchins, brittle-stars and starfish. Fuel oil and gasoline interfere with the development of boreoarctic sea urchins (Falk-Petersen 1979). In sea urchins oil may stimulate the oxygen consumption, weaken their adherence to the substrate, cause retarded fertilisation, and interfere with the development of the embryo (Johnson 1977, and references therein). A range of behavioural changes in the green sea urchin Strongylocentrotus droebachiensis and the starfish Leptasterias polaris was recorded during the BIOS project caused by a short-term exposure to dispersed oil by Cross and co-workers (1987b) and Mageau et co-workers (1987); unnatural postures (animals upside down), narcosis (i.e. loss of responsiveness to mechanical stimuli), and for sea urchins impairment of the tube foot (resulting in substrate detachment), changes in spine attitude, and frequent shedding of gametes was evident. Furthermore, in starfish the chemoreception system may become partially inhibited, thus affecting food particle sensing and capture (predation) (Johnson 1977, and references therein).

The effects of oil on littoral crustaceans are extensively studied, and earlier literature is carefully reviewed by e.g. Johnson (1977) and Wells & Percy (1985). Evidence shows that these organisms may possess of a variety of responses to hydrocarbons. Physiological responses include changes in e.g. respiration rate (increases and decreases), hormone production (thus reproduction), molting and hatching, development of larvae, chemoreception-mediated behaviour (affecting reproduction and feeding) and disruption of osmoregulation. Behavioural changes are mainly due to narcosis, which in turn affect locomotor activity (and thus feeding and escape reactions), burrowing behaviour, and reception of chemical signals (food particle capture), even shell evacuation. Also physical nuisance is caused: when oil is adhered on the locomotory parts of the crustacean, swimming and feeding is affected. Also, oily coatings on hard substrates hinder the settlement of e.g. pelagic motile barnacle larvae (Straughan 1971). Ingestion of oil droplets tends to decrease feeding rates (Blackman 1972). The arctic marine amphipod Gammarus oceanicus, for example, has showed several negative physiological responses to crude oil (Aunaas et al. 1990). Water soluble fractions of crude oil increased respiration, sodium in haemolymph, and thus water content of the organism. Water emulsions reduced respiratory rates, causing oxygen deficiency due to oil droplet adherence to gill membranes. The use of dispersants reduced the mortality of the amphipods. Low concentrations of crude oil and oil fractions significantly depressed respiration rates of arctic amphipods Boeckosimus affinis and Anonyx nugax, while with high concentrations the depression was reversed (Percy 1977, Busdosh 1978). Baden & Hagerman (1981) and Baden (1982 a, b) exposed the shrimp Palaemon adspersus to water soluble fraction of North Sea crude oil. As a result, the ventilatory behaviour was disturbed, osmoregulation impaired, and a significant increase in oxygen consumption was detected.

A slight stimulation of metabolism at low hydrocarbon concentration followed by a decrease with increasing concentrations was detected for the littoral mysid Mysis litoralis (Wells & Percy 1985). In a behavioural study, arctic amphipods G. oceanicus and Onisimus affinis did not show avoidance of contaminated area in the presence of even high concentrations of crude oil (Percy & Mullin 1975, Percy 1976). Petroleum hydrocarbons interfere also with reproductive processes (e.g. reduced precopulation frequency andnumber of larvae, premature shedding of eggs) of crustaceans such as Gammarus oceanicus and Boeckosimus affinis (Lindén 1976, Busdosh 1978). Differences in response rates to various oil-water mixtures were documented also by Riebell & Percy (1989), by exposing the arctic littoral mysid, Mysis oculata, to oil-in-water dispersions and water-soluble fractions of crude oil. The latter fraction was significantly more toxic, and the species was regarded as exceptionally sensitive to crude oil. Opposed to sessile and slowly moving animals in the littoral and benthos motile invertebrates, like littoral amphipods, are generally capable of avoiding oil slick by escaping it (Bonsdorff & Nelson 1981, Gulliksen & Taasen 1982).

Massive kills and long-term effects can occur when oil reaches the littoral and the benthos in sufficient quantity, as has been evidenced for several oil spills in the past. Within 12 hrs after the Florida spill in West Falmouth, Massachusetts in 1969, the macrobenthos was nearly eradicated at most heavily oiled sites (Sanders et al. 1980). Opportunistic species typically play a vital role in the initial recolonisation of an eradicated area (Teal & Howarth 1984). After the Florida spill the annelid worm Capitella sp.and the nematode Mediomastis sp. increased greatly in abundance, monopolising the otherwise defaunated sediments for months after the accident. The Arrow spill in Nova Scotia in 1970 caused the decline of the bladder wrack, Fucus vesiculosus for five years, while the spiral wrack, Fucus spiralis, disappeared and had not reappeared even six years after the spill (Thomas 1978). Rocky shore animals such as barnacles and periwinkles, however, did not change in abundance or distribution except in areas where their habitat changed. While the Tsesis oil spill in the Baltic Sea in 1977 had virtually no effect on the bladder wrack Fucus vesiculosus (dormant at the time of the accident) it caused a dramatic acute reduction in biomasses of the sediment dwelling amphipod Pontoporeia affinis and the polychate Harmothoe sarsi (Notini 1980, Elmgren et al. 1983). Although heavily contaminated with oil, the Baltic telling, Macoma balthica, and nematodes were more tolerant and showed only little mortality. Recovery in the littoral zone began within two months, but the speed depended on the degree of exposure to oil and the species involved. One year later the animals had returned to their pre-spill condition, except at the most heavily contaminated stations.

Abundance of amphipods, H. sarsi and harpacticoids began to increase, and hydrocarbon concentration in M. baltica decrease during the second summer after the spill. Three years after the accident Pontoporeia and M. baltica biomasses had remained depressed, while H. sarsi showed normal abundance. The recovery of species with long life span, such as M. balthica in this example, require considerably more time than short-lived species (Elmgren et al. 1983). Biological consequences of also other oil tanker wrecks in the Baltic have been monitored. The accidents of Eira in 1984, Antonio Gramsky in 1979 and 1987, and Baltic Carrier in 2001 caused notable effects in particular in the littoral and benthos (The Baltic oil spill 1979, Hirvi 1989, Pécseli et al. 2004). Increased hydrocarbon concentrations in the tissues of e.g. Macoma balthica, Mytilus edulis, Lymnea palustris and Gammarus spp. were recorded, and in some cases decrease in the population sizes of these organisms changed. Furthermore, oiled specimens of zooplankton and dead birds (e.g. black guillemots Cepphus gylle, and eiders Somateria mollissima) were collected. Some fish suffered from morphological abnormalities after exposure to oil. Also, the growth of fish was dampened and in skin diseases were documented (The 1979 Baltic Oil Spill, Hirvi 1989). In the case of Baltic Carrier spill off the Danish coast, hydrocarbon concentration in flounder remained elevated long after the accident (Pécseli et al. 2004).

Oil from the Amoco Cadiz on the northwest coast of France spread over a large area, with highest concentrations found in muddy sediments (Cabioch et al. 1981). Amphipods were virtually eliminated, and in the intertidal massive mortality of e.g. heart urchins and razor clams were observed. The Amoco Cadiz spill caused permanent changes in the shallow water eelgrass (Zostera marina) community, i.e. the total disappearance of filter feeders, and the very diverse amphipod community has been replaced by the dominance of only two species, one of the new to the area (den Hartog & Jacobs 1980). The spill had little effect on polychaete annelids (Chasse 1978). In the intertidal, the knotted wrack, Ascophyllum nodosum (Phaeophyceae, brown alga) was replaced by the much more tolerant bladder wrack, Fucus vesiculosus at sites where it grew in the vicinity (Gundlach et al. 1981). Populations of bivalves, periwinkles, and limpets in the intertidal, heart urchins in the benthos, copepods in the pelagial, and sea birds were most severely affected (Conan 1982).

The Exxon Valdez oil spill in the Prince William Sound in 1989 had relatively mild effects on the littoral communities (Stoker et al. 1992). The survivors were seaweeds (fucoids), barnacles, mussels and periwinkles, which after two years of the accident had re-established themselves and were in a state of prespill condition. A long-time survey of oil effects on sublittoral fine-sand macrobenthic community was made after the Aegean Sea oil spill off the NW coast of Spain in 1992-1996 (Gómez Gesteira & Dauvin, 2005). A short period of high mortality of in particular amphipods was followed by a period of low species diversity and low abundance. Recovery began 3 years after the spill.

Vertebrates: fish, birds, otters, seals, whales and the polar bear

Fish are generally more sensitive to hydrocarbons than invertebrates (Rice et al. 1977a, 1979). Arctic cod (Boreogadus saida), for example, is among the most sensitive fish species to oil that were studied by Rice and co-workers (1979). Most pelagic fish also show response relatively quickly to toxicants, while sedate bottom species react slower. Stress, such as fluctuations in water salinity, temperature, food abundance, disease and parasites depress the fitness of fish and thus reduce its ability to tolerate pollution (e.g. Moles 1980, for a review see Rice 1985). Water temperature affects the toxicity of hydrocarbons; in cold water aromatic hydrocarbons persist longer (decreased biodegradation and evaporation), and extreme temperatures (both low and high) may affect the ability of fish to metabolise or excrete aromatic hydrocarbons and their metabolites (Rice 1985). Fish also possess the ability to 'learn' to tolerate hydrocarbons; previous sublethal exposure to hydrocarbons induces higher levels of hydrocarbon metabolising enzymes in fish (Egaas & Varanasi 1982).

Fish take up oil through ingestion of contaminated food and directly from water (for a review, see Rice 1985). The rate and quantity of hydrocarbon uptake depends on exposure concentration, the molecular weight of the compounds tested, and the amount of lipid in the fish (which, again, is related to fish species, age, season and reproductive stage). Once hydrocarbons are accumulated in fish, many compounds will be metabolised or excreted. Enzymatic metabolising takes place in liver by the mixed function oxygenase systems MFO and the enzyme CYP1A (Rice 1985, Lockhart & Metner 1991, George et al. 1995). The hepatic enzyme CYP1A can be used as a biomarker for petroleum hydrocarbon exposure in the polar cod (Boreogadus saida) (George et al. 1995). Most metabolites are probably less toxic than the parent compound and will be excreted. The effects of oil can be targeted to one or several organs in the fish: liver, gut, pancreas, vertebrae, eye lens, stomach, brain and olfactory (odour sensing) organs (studies are reviewed e.g. by Rice 1985) – all sensed as odd fish flavour or smell by us humans. Tainting of commercial fish by oil has been studied on field and experimentally, and in many cases fish show relatively fast purification after light exposure, i.e. the flavour and odour caused by oil disappear (e.g. Ackman & Heras 1992, Lochart & Danell 1992). Fish exposed to sublethal concentrations of petroleum in the environment show several behavioural, physiological, biochemical and various long-term effects, which are reviewed in depth by Patten (1977), Rice (1985), and in the extensive text book edited by Varanasi (1989). Fish can detect hydrocarbons at different threshold levels (Patten 1977, and references therein) as they have excellent olfaction, which most fish use for detecting hydrocarbons. However, short-term exposures can damage the olfactory epithelia and render these tissues useless (e.g. Solangi & Overstreet 1982).

The detection and avoidance behaviour varies among species and life stages, and fish larvae for example are not always capable of avoiding the contaminated area. There are conflicting records of the avoidance behaviour of fish during oil spills; sometimes fish seem to actively avoid the contaminated area, while in other cases they seemed rather affected to it (discussed by e.g. Rice 1985). Other physiological responses include alteration in metabolism and activity, such as decreased rate of heartbeat, cough responses or convulsive respiratory reactions of fish (possibly due to the aromatic compounds in the petroleum), altered respiration, changes in blood parameters and ion concentrations, and decreased energy reserves (Rice et al. 1977b, reviewed in depth by Rice 1985). Oxygen consumption may either increase or decrease, depending on the type of oil and fish species (Patten 1977, and references therein). Narcosis and consequently cessation of movement and feeding, and changes in activity patterns (swimming movements, gulping at the water surface, erratic motion, hyperactivity) is reported for several fish species and their larvae, and are reviewed by Patten (1977) and Rice (1985).

Effects on fish reproduction is little studied, but evidence shows that oil affects the survival (mortality) of in particular fish eggs and larvae, hatching, and the development of the embryo (Patten 1977, and references therein, Whipple et al. 1981, Teal & Howarth 1984). Eggs and larvae are easily affected by temperature, salinity and pollutants because they have fewer structures and organs capable of detoxifying oil, are intimate with the environment, their mobility is restricted, and many develop at or near the water surface where oil spill can be expected (Rosenthal & Alderdice 1976, Rice 1985). The earlier the juvenile is exposed to oil the more severely it is damaged. When the embryo approach hatching it is more sensitive to oil than after hatching. The sensitivity again increases until its yolk is absorbed and it begins to feed on its own (Rice 1985, and references therein). There is also a negative correlation between hydrocarbon concentration in water and growth, food uptake and thus weight, percent fat and caloric content of adult and juvenile fish (Korn et al. 1976, Moles & Rice 1983, and the review by Rice 1985).

The published literature concerning bird mortality due to oil is large, and reviewed in depth by e.g. Bourne (1968, 1976), Vermeer & Vermeer (1975), Holmes & Cronshaw 1977, Leighton et al. (1985) and Robertson (1998). In many cases the mortality has been substantial, but it is not always clear how estimates were made, as discussed by Leighton and co-workers (1985). Torrey Canyon accident in 1967 caused death of at least 20–30,000 birds but the actual number may exceed even the estimated one (Holmes & Cronshaw 1977). Even very small oil spills can cause similar mass mortality of sea birds (Barret 1979, Robertson 1998). Divers are at high risk, because they spend much of their time sitting on water.

King & Sanger (1979) ranked sea birds in terms of vulnerability to oil pollution, and identified Atlantic puffin (Fratercula arctica), common murre (Uria aalge), thick-billed murre (U. lomvia), razorbill (Alca torda) and northern gannet (Sula bassanus) as particularly vulnerable. Sea birds are at considerable risk because of their social behaviour (Robertson 1998). Large aggregations of birds occur in connection with breeding, molting, overwintering, and preparation for migration. Oil kills birds in many ways, but the main way is by breaking down the bird's waterproofing and thermoregulation. An oiled bird will response by preening itself, and consequently inhale and swallow toxic compounds that damage its liver, lungs, kidneys, intestines and other internal organs. Such poisoning is as lethal as the loss of waterproofing, so hypothermia is the actual cause of death (Holmes and Cronshaw 1977, Leighton et al. 1985).

The embryotoxic effects of oil have been studied experimentally to some extent (e.g. Couillard & Leighton 1989, for review see Leighton et al. 1985). Oil from the feathers may pass through the pores in eggshells and either cause death of embryos, abnormalities or affect hatching success. Ingested petroleum may cause ovarian dysfunction (affecting fecundity) and thus delay the onset and rate of lay (Holmes & Cronshaw 1977, Harvey et al. 1982). Depression of growth rate in young birds ingesting oil is a commonly reported phenomenon for a variety of species (reviewed by Leighton et al. 1985). Marine birds must constantly excrete sodium chloride through nasal glands, as they receive salt in excess through their diet. Such osmoregulation can be affected by oil (e.g. Peakall et al. 1983), lead to ion imbalance in body fluids and thus affect e.g. the function of muscles and the nervous system. Anaemia has been reported by e.g. Leighton and collaborators (1983).

Exposed birds are also more likely to suffer from other pathological effects such as irritation of the gastrointestinal mucosa, lipid pneumonia, fatty degeneration of liver, atrophy of pancreas, toxic nephrosis, enteritis, aspergillosis, and infective arthritis (for review see Holmes & Cronshaw 1977). Other physiological changes in birds caused by oil are e.g. increased basal metabolic rate, changes in hormone production, body temperature and water flux (Harvey et al. 1982, Hughes et al. 1990).

The Arctic seas are a habitat for a large proportion of marine mammals in the world, in particular whales, seals, sea otters and polar bears (Engelhardt 1985, GESAMP 1993). All marine mammals need to remain in contact with the air-water interface as they are dependent on air breathing, and the polar bear feeds on fish and seals it catches from the surface water. Thus, they may come in contact with a surface oil slick, in particular in sea ice covered areas where the open surface (such as breathing holes) is limited (Engelhardt 1985, Robertson 1998). Oil causes problems to mammals through coating by oil and inhalation of volatile hydrocarbons. Inhalation can be life threatening in the case of prolonged exposure (Geraci & St. Aubin 1980). Certain marine mammal species may additionally be vulnerable through the food vector, e.g. bivalves and crustaceans that have a potential to bioaccumulate hydrocarbons (Engelhardt 1985). The information of effects of oil on whales is quite limited, but generally whales are anticipated to remain unharmed by contact with oil (Engelhardt 1985, and references therein, Robertson 1998). There are no records of oil fouling of the skin of free-living whales, suggesting either that oil may not stick to the skin surface due to its quality, or that contact with oil is rare because whales avoid slicks.

Whether active avoidance occurs remains uncertain, but observations in spill situations suggest that whales do not take notice of oil spills (Engelhardt 1985, and references therein, Robertson 1998). However, in experiments exposure of cetacean skin to oil has caused cell damage in epidermis (Geraci & St. Aubin 1982). The unique structure of cetacean skin and the fact that it contains lots of vitamin C may serve to protect against harmful effects of oil (Geraci & St. Aubin 1980). There is some suggestion that whales may take up petroleum derived hydrocarbons (Engelhardt 1985). The presence of MFO and a hydrocarbon marker enzyme P-450 has been demonstrated in the liver of several cetacean species (Geraci & St. Aubin 1982), indicating that cetaceans should be capable of detoxifying oil. Spilled oil may interfere with feeding behaviour, in particular filtering efficiency, through effect on baleen function as oil becomes trapped onto baleen hairs (Geraci & St. Aubin 1982, Braithwaite et al. 1983). However, the development of offshore petroleum and gas resources seems to present more threats to marine mammals than accidental oil spills in the Arctic (Geraci & St. Aubin 1980). Seismic activities, noise (affecting physiology and behaviour), and long-term accumulation of petroleum fractions through the food chain in the vicinity of oil platforms are thus more of concern.

Behavioural consequences and thermal effects of oil fouling have been noted for pinnipeds and sea otters (Geraci & St. Aubin 1980). Davis & Anderson (1976) noted reduced growth rate in oiled seal pups, but could not detect changes in nursing behaviour as a result of oiling. Experimentally oiled sea otters spend more time underwater trying to clean them selves, and seals show variable signs of aggression and arching of the back (Geraci & Smith 1976a, Geraci & St. Aubin 1980). After removal from oiled experiment tanks, animals' behavioural and physical signs disappeared rather quickly. Thermal effects are noted for sea otter pups (Enhydra lutris), and the Weddell seal (Leptonychotes weddellii) (Kooyman et al 1977). Most true and phocid seals, sea lions and walrus, however, have a relatively coarse and short fur and thick blubber. The danger of heat loss due to oil fouling is therefore small, but the fouling may cause a physical hindrance to swimming (Davis & Anderson 1976, Kooyman et al. 1977, Robertson 1998).

Sea otters are peripheral in their occurrence in the Arctic and may therefore be more sensitive to oil effects, in particular thermal effects, than the 'true' arctic mammals (Kooyman et al. 1977). Oiling and consequent washing of sea otter furs caused oxygen consumption increase and weakened thermoregulation (Costa & Kooyman 1981). The vulnerability of sea otters was documented clearly during the Exxon Valdez oil spill in Prince William Sound in 1989, where estimated 2000-3000 animals perished (Waldichuk 1990). Some anticipated effects of surface contact with oil are irritation and inflammation of eyes, skin, and sensitive mucous membranes (Geraci & Smith 1976a). In experiments acute organ damage has not been recorded even after ingestion of relatively large quantities of oil in ringed seals (Phoca hispida) (Geraci & Smith 1976a), but such findings cannot be extrapolated to greater quantities of oil and other marine mammals.

Ringed seals rapidly absorbed crude oil hydrocarbons to body tissue and fluids, ultimately excreting the compounds via bile and urine (Engelhardt et al. 1977). Experimental exposure of adult ringed seals to hydrocarbons increased the mixed function ogygenase (MFO) activity, indicating the enzymatic break-down of hydrocarbons in these animals (Engelhardt 1981). Furthermore, studies in ringed seals showed that volatile hydrocarbons and likely to become absorbed through respiratory tract (Geraci & Smith 1976b). Kidney and liver lesions were observed, but no associated lung pathology. Effects of prolonged inhalation may cause disturbance of the central nervous system, pneumonia and death (Carpenter et al. 1978). Oiling of grey seal pups (Halichoerus grypus) did not affect the body weight development as the oil typically disappeared when the white lanugo fur was moulted (Jenssen et al. 1991).

Regarding polar bears, severe heat loss and elevated compensatory metabolism have been observed after experimental oiling of their fur (Hurst et al. 1982). Extensive grooming causes ingestion of oil leading to tissue elevation of hydrocarbons and gradual development of dysfunction, and lethal damage in several internal organs. Renal failure may be the ultimate cause of death (Øritsland et al. 1981).

4.7.3 Discussion

Petroleum hydrocarbons affect organisms in a variety of ways, ranging from death to biomolecular, pathological and cellular effects to merely physical nuisance. The effect on organisms, and whether it is reversible or not, depends on numerous physical and biological factors, that also affect oil spreading, weathering (including biodegradation), and absorption of toxic compounds into organisms. These are for example the volume and type of spilled oil, water temperature and water currents, the presence of sea ice and snow cover, season (in particular in the Arctic), location of the spill (open water vs. shore line) and oil combating measures taken. At least some effects seem temperature dependent and are more pronounced in warmer water, thus not likely in the Arctic.

For long-lived organisms, such as kelps and vertebrates, the developmental stage can be crucial; reproductive organs, embryos and juveniles are at most risk. Thus, we cannot nominate only a single species in the Arctic that could be determined as particularly sensitive to oil and consequently an indicator species of the severity of oil pollution. Sublethal effects are numerous and can become manifested in various ways in the organisms' reproduction, behaviour (e.g. feeding, mating) and thus growth, and physiology (general fitness). The apparent complexity of e.g. the metabolic response to petroleum is hardly surprising in view of the broad range of physiologically active compounds present in crude oil and physiological processes that are undoubtedly affected in different aquatic species.

An evaluation of the consequences of the environmental contamination requires an understanding of the extent to which it is responsible for changes in individuals and populations in the affected area (discussed in depth by e.g. Clark 1982, Jones 1982). Population change is not solely related to mortality which may be observed, but depends also on the population dynamics (e.g. migration, age structure and reproduction patterns of a given population), stock size, survival strategy of the species affected, and other possible disturbances in the area. Furthermore, while individual organisms may die to oil effects, on a population level the outcome may not be dramatic. At open sea, plankton is likely to be transported from one area to another by wave action and water currents, and thus the contaminated part of the plankton population may become substituted with 'fresh' material from elsewhere. In such an example, the actual sufferers may be found in the benthos; organisms whose food quality and uptake is dependent on the quantity and quality of settling material from above (here dead, oil contaminated plankters).

In the littoral, most severe effects of oil spills are documented for soft bottoms and sheltered bays. Oil penetrates and readily remains between the tiny pores of mud and silt, where it will have more time to stay in contact with benthic organisms. On hard bottoms, such as rocky shores, wave action is usually stronger, and thus capable of transporting even large masses of oil to the open sea. The clinging of oil onto hard surfaces is much less than oil penetration into soft substrates. In general, field studies of the biological consequences of oil spills show good agreement with the experimental data: intertidal and subtidal benthic communities are affected and can take a long time to recover, undergoing slow and subtle changes.

Oil does not need to affect directly all organisms on every level of the food web, and yet with time the consequences of an oil spill may be discernible in the entire system (Figure 3.). Such is a consequence of biomagnification; when littoral and benthic crustaceans for example are contaminated by oil, the negative effects will soon be observed in their predators, such as polar cod, seals and, finally, the polar bear, i.e. animals than migrate to the contaminated area from elsewhere. Another example is from the open water ecosystem. Divers and whales will bioaccumulate hydrocarbons by consuming pelagic fish and invertebrates exposed to oil, and consequently develop various hydrocarbon related symptoms (Figure 3.).

Fishery is always one of the main concerns when an oil spill happens. Field studies after oil spills have generally failed to document the widespread effects of oil on fish. In Argo Merchant, Ekofisk Bravo and Amoco Cadiz accidents effects on

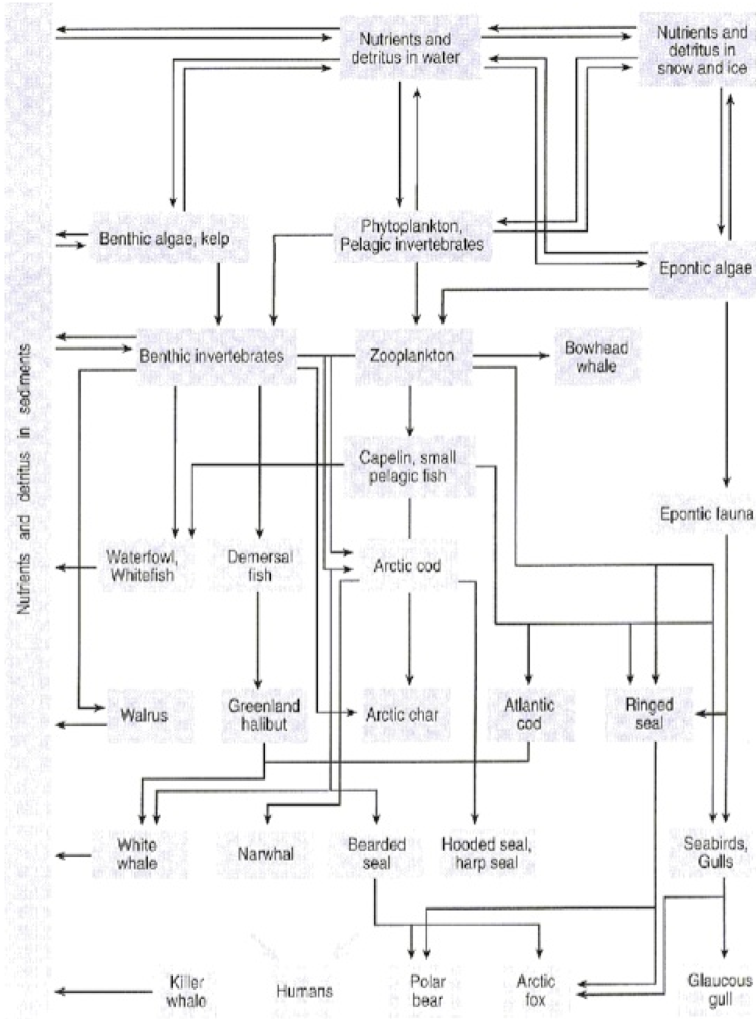


Figure 3. A generalized marine food web in the Arctic. Souce: de March et al. (1998).

fish stocks were negligible (e.g. Rice 1985 and references therein, Teal & Howarth 1984). Although adult fish can be killed by oil spills, this probably poses less of a threat to commercial fisheries than do damage to eggs and larvae, or changes in the ecosystem supporting the fishery (Teal & Howarth 1984). Ecosystem changes in the lower levels of the food chain and thus long-term effects on fish are more likely than acute effects. However, such interactions are poorly studied, as is discussed e.g. by Vandermeulen (1982) and Teal and Howarth (1984). One of the reasons for this is that long-term spill effects are generally local phenomena. Fish have been exposed to oil in many studies, but the methods have varied considerably among studies. Thus, direct comparison between studies is not usually valid.

There is a general impression of the exceptional sensitivity of Arctic ecosystems to oil. Sensitivity of Arctic zooplankton and benthic organisms to oil contamination, for example, is discussed by Wells and Percy (1985), and it seems to be a consequence of several biotic and physical factors. In cold water zooplankton has lower uptake, metabolic and excretion rates, possibly leading to lower inputs of oil into organisms, but also to longer detoxification and depuration times. Low temperature can influence the availability of oil by changing its solubility, physical form and the stability of different fractions, or by extending the exposure time by retarding the loss of hydrocarbons from the medium, and extending the predisposition time of organisms to oil. It can also delay the onset of e.g. criteria of death like immobilisation. Based on extensive experimental data set Rice and co-workers (1976, 1977a) concluded, that Alaskan marine invertebrate species may be slightly more sensitive than similar species in lower latitudes. However, our knowledge of the species specific sensitivity of Arctic organisms to oil is still patchy. In the past a number of arctic benthic species have been subjected to acute lethal tests with petroleum hydrocarbons (Wells & Percy 1985) but the taxonomic coverage has been uneven: of the 24 species listed by Wells and Percy (1985) almost 90% are crustaceans and at least 50% are amphipods. Also, comparison of results is complicated by differences in oil types, methods of preparation, exposure regimes and criteria of death. In general, amphipods and decapods seem relatively sensitive to oil, while isopods are more resistant. As noted earlier, the polar cod seems to be particularly sensitive to oil (Rice et al. 1979).

Avoidance is one way of minimising the negative effects of oil. However, avoidance of oil by motile organisms is not a universal type of behaviour, as was evidenced for the isopods, and fish such as the juvenile English sole (Parophrys vetulus, syn. Pleuronectes vetulus) by Percy (1976) and Weber and co-workers (1979). Isopods did not seem to exhibit any particular attraction or repulsion responses when confronted by oil masses. The effects that the oil in the sediments may have on fish can depend on overall amount, composition (age) of the pollutant, and the season (activity level of the fish) (Fletcher et al. 1981). Whether fish in nature avoid, ignore or are attracted to an area with an oil spill largely remains unanswered. There are several cases where field observations have been conflicting, as evidenced during past oil spills, where both avoidance behaviour and attraction of in particular fish has been recorded (Teal & Howarth 1984).

Non-avoidance behaviour of animals when confronted with crude oil may play a crucial role in determining the subsequent impact upon organisms and thus populations. Burrowing species, like the much studied arctic species, the Baltic telling Macoma balthica, rarely venture onto the surface, although most extend their siphons into the overlying water for feeding and respiration. The impact of oil on burrowing species depends largely upon how it is introduced to the habitat. The response of the animal to dispersed oil in the overlying water and to oil within the sediment is to emerge onto the surface, not to burrow deeper into the substrate, and usually in proportion to the dose (Taylor & Karinen 1977, Wells & Percy 1985). Although the sediment depth may affect the surface speed, chronic contamination will force animals to eventually surface (Wells and Percy 1985, and references therein). Not all animals would become killed by oil, at least in the short term, but high concentrations (3 mg/l) and long-term exposure would no doubt be lethal. Reburying is not possible for as long as the oil prevails (Taylor & Karinen 1977, Engelhardt et al. 1983).

Altogether, it seems that long-term effects of oil spills on open water ecosystem, including cetaceans may be less important than generally assumed, and restricted to a relatively small area. However, there is uncertainty about the effect of oil in restricted environments, such as in polynyas and ice leads. In the littoral and benthos, where organisms are often either sessile or slowly moving, and the motility of the spilled oil is weaker than in the open water the effect is likely to be more pronounced, including consequences on an individual and population level, and expanding the time of disturbance. Observed effects of long-term and chronic discharges in marine ecosystem have not been discussed in this report.

However, to summarise the existing literature, effects of e.g. oil drilling activities are sooner local than widespread, but the chronic exposure of organisms to oil and drill muds, for example, can cause pronounced, permanent changes in species composition, fitness and diversity of benthic communities (e.g. Sharp & Appan (1982), Addy (1987), Kingston (1987), Moore and co-workers (1987a), Gray et al. (1990) and Olsgard & Gray (1995). The temporal changes seen after oil spills are comparable with the spatial changes observed around chronic discharges, in particular in case of an ecosystem with dominance of only a few species.

4.7.4 Summary and conclusions

Oil spill effects on Arctic marine organisms and ecosystems can locally be dramatic. The severity of contamination is not only dependent on the type of organisms exposed to oil, but also on the type and volumes of spilled oil, the speed of oil weathering processes (e.g. evaporation, dispersion, degradation by bacteria), oil combating measures taken, and the location of the spill. Large spill of oil with a high aromatic fraction is worse to marine life than oil with less aromatic compounds. Weathering of large oil spills require more time than that of smaller spills, and the use of oil dispersants (not discussed in depth in this report) has usually more severe consequences on organisms than the mechanical and/or biological oil combating.

Organisms in the littoral and benthos, particularly sessile and slowly moving invertebrates such as molluscs, snails, and crustaceans suffer the most from oil exposure. Seaweeds (macroalgae) attached to hard substrates seem to have a fairly good potential for recovery after oil exposure. In the open water, contaminated plankton can be replaced by 'fresh material' transported from sea areas outside the spill site. Avoidance of oil is typical for fish and larger vertebrates (seals, whales), but sea birds, in particular divers are at risk in the pelagial. Oil associated with sea ice may have a notable effect on the ice biota, particularly as oil tends to become trapped between ice platelets and floes, and within brine channels in ice, and thus lengthens the contamination time. Recovery of marine life may be complete, nearly complete or only partial.

Complete recovery is more likely in the open water ecosystems where water currents disperse oil both horizontally and vertically. Partial recovery is typical of littoral and benthic ecosystems, and is dependent not only on the factors described above, but also on the type of the original community (species composition, dominance, biomass), the organisms' potential of adjusting to changes (abiotic and biotic) in the habitat, and thus the ability of recolonising the deserted area. Even after several years of an oil accident, the recovery process of a littoral or benthic ecosystem may still be incomplete and, in the worst case, may not ever reach the original state.

5. WP5 Validations

5.1 Validation Voyage

The northern oil deposits of the Timan-Pechora oil-and-gas-bearing provinces (developed: Varandejskoye, Toraveiskoye and explored: Romana Trebsa, named A. Titov, Yuzno-Hilchuyuskoye, Toboiskoye etc.) are located relatively close to the southern coast of the Pechora Sea.

Here by Cape Varandej at a depth of 12 m the underwater road terminal has been in operation since September, 2002. The underwater oil pipeline, 3.4 km in length, comes up to the terminal; the pipeline is designed to service tankers (with a draft of up to 10 m) joined by means of a strong hose-mooring line. Here tank vessels such as "Astrakhan" with a cargo capacity of about 18 thousand tons were used [16, 17].

Total amount of crude oil shipped from Varandej in 2002 is 240 thousand tons. The present oil handling capacity of the terminal is thought to be about 1.5 million tons per year, and now the volume of shipment is limited by oil production rate of the deposits linked to the terminal, but in short-term outlook (after 2005) the volume of oil shipment is likely to run into 3 million tons.

This report presents the description of components and functioning of Varandey oil offloading system.

Work under WP 5 "Experimental Voyage" has been carried out according to the memorandum on the results of the meeting of ARCOP Working Packages leaders.

1. The description of Arctic Submerged Loading Terminal (ASLT) operation is represented in the report. ASLT includes using of Single anchor loading (SAL) developed by APL for oil and gas production from fields located in North Sea.

The general arrangement of ASLT includes: long-shore tank farm (STF), Oil pipeline, submarine manifold (PLEM), hose – hawser – a flexible loading hose, Equipment for pipeline pressure-testing and its cleaning, supply icebreaker, specialized shuttle tankers (ST).

STF involves 6 cisterns, each in capacity 10000 m^3 and 2 operating pumps with productivity 300 m^3 / h. STF is built apart 1 km from a water edge. The marine oil pipeline (OP) with length of 3,6 km and diameter 250 mm is used with bottom penetration on 8,5 m. An inlet pressure in a marine section of an oil pipeline24 atm.

PLRM – a gravitational anchor with a manifold and oil swivel mounted on a sea bottom on depth equal to 12m.

A hose – hawser consists of 8 sections each one is equal 12 m. On its end the hatchway for connecting with the cargo reception facility of the tanker places. There were built two tankers in type "Astrakhan" with dead weight of 20 thousand tons and ice class UL on stocks of FGUP «the Admiralty shipyards» for oil transportation on route Varandey-Murmansk. The tankers re equipped with the bow loading device (BLS) by APL.

The icebreaker «Kapitan Nikolaev» and the icebreaker «Kapitan Ignatyuk» provide loading operations during winter period. In summer, the motor ship «Agat» provides loading operations.

2. In the summer mooring and loading is allowed under the following conditions: heaving – up to 5 balls, wind – up to 15 m/s; in winter the conditions are: thickness of fine broken ice – up to 0.7 m, level of ice consolidation – 10 balls, drift velocity – up to 1.0 m/s. Air temperature must be not lower than a minus 20 degrees.

3. The accomplished evaluation of the cargo voyage Varandey-Rotterdam shows that there is an ice section on this route during 7 months and its length can be 220 miles in spring period. The time of loading varied from 36 hours in summer to 60 hours in summer.

4. In accordance with reported data of 2000–2002 tanker preparation time for loading varies from 2 to 15 days and averages to 97,3 hours (4 days). Cargo pumps working time varies from 25 to 65 hours and averages to 38,5 hours.

Timing of duration of operational cycles during loading "Kaliningrad" tanker in December 2001 – January 2002 showed that maneuvering operations (arrival, departure, hose-mooring) took 77,3%, pure time of loading operations – 18,8%, paper work – 3,9% of the general loading time was 10,8 days.

Time structure of "Kapitan Nikolaev" loading work of tanker "Kaliningrad" was equal to the time structure of loading the tanker.

5.2 Guiding Large Tankers in Real Ice Conditions in the Gulf of Finland

General characteristic of the 2004–2005 winter navigation on the Primorsk fairway and icebreaker support

The winter navigation of 2004–2005 and icebreaker campaign over the water area of the Gulf of Finland was opened on 24 November 2004 and its closure was declared on the 1st of May 2005.

Escorting of tankers to the sea trading port of Primorsk was provided by icebreakers "Ermak" and "Kapitan Sorokin" being on the balance of the State Enterprise "Rosmorport" and by icebreaker "Admiral Makarov" of the same type as icebreaker "Ermak" leased by "Rosmorport" with the Far East Shipping Company (FESCO).

Passage of a tanker under ice conditions was, as a rule, ensured by icebreaker "Admi- ral Makarov" and in the case of necessity one of two icebreakers – "Ermak" or "Kapitan Sorokin" (fig. 1 and fig. 2) – in. Escorting of loaded tankers was carried out along the recommended deep water route, escorting of tankers in ballast (depending on ice conditions) – outside the recommended route at the discretion of icebreaker captain.

Simultaneously two tankers were loaded with oil in the port of "Primorsk". In the course of twenty four hours (on the average) two tankers approach the Primorsk terminal and two icebreakers are led to the ice edge. At the beginning of Feb-

Fig. 1 Icebreaker "Kapitan Sorokin"

ruary, before the arrival of icebreaker "Admiral Makarov" this daily conveyor was provided by icebreakers "Ermak" and "Kapitan Sorokin" the latters operating together or separately. Table 1 shows principal characteristics of icebreakers.

Characteristic of icebreaker	**"Admiral Makarov" / "Ermak"**	**"Kapitan Sorokin"**
Principal dimensions: Length, m Beam, m Draft, m	 130.0 25.6 11.0	 130.2 30.5 8.5
Displacement (DWL), t	20,240	17,270
Type of propulsion plant	Diesel-electric	Diesel-electric
Type of main engines	Medium-speed	Medium-speed
Number and power of main engines, kW	9x3,380 / 7x3,380	6x3 050
Shaft power, kW	26,500	16,200
Number and type of propellers	3 FPP	3 FPP
Speed in calm water, kn	19.5	18.0
Icebreaking capability, m	1.8 / 1.65	1.9
Endurance as to fuel capacity, days	28	28

Icebreaker "Admiral Makarov" began working on the Primorsk fairway on 11.02.05

after the scheduled repair at the Kanonersky shipyard. Further in the text, if not otherwise stated, the escorting by icebreaker implies using icebreaker "Admiral Makarov" for this purpose.

First two escorting operations were made by icebreaker "Admiral Makarov", when icebreaker "Ermak" was a leader with the purpose of transferring experience of work with large tankers under conditions of the strict Primorsky fairway.

Unlike the previous navigation, in winter 2004–2005, mostly tankers with a deadweight of about 100 000 t were admitted to the port of Primorsk. The throughput of the port of Primorsk during winter navigation (from 24.11.04 to 25.04.05) amounted to 482 tankers in comparison with 419 ones for the same period of the previous navigation. Freight turnover of the port was 23 633.6 thousand tons, that is 1.5 times as much as in the previous year for the same period.

Throughout the period of the introduced restrictions as to the ice navigation of ships the ice class of which would not meet the restriction requirements there practically were no such ships with the exception of period from 02 March to 09 April 2005, when the restrictions by ice class LU2 were put into effect. During this period, out of 59 tankers providing for the transportation of oil, 14 tankers with ice class LU 2 called at the port these latter tankers having "Recommendations on ice safety" developed by CNIIMF for the given ice conditions (these tankers made 35 calls). For the indicated period, export of oil was 5994.5 thousand tons out of which 3452 thousand tons were transported by ships with ice class LU 2 (14% of the total cargo throughput of the port for winter navigation).

Conclusion

1. According to data of the "North-Western interregional territorial department on hydro- meteorology and monitoring of the environment", ice conditions of 2004–2005 winter navigation in the Gulf of Finland were estimated as typical for temperate winter.

2. For the transportation of crude oil from the port of Primorsk predominantly tankers with a deadweight of about 100000 t were used.

3. Principal work on the escorting of tankers in ice was performed mainly by

one icebreaker and since February 2005 linear icebreaker "Admiral Makarov" was used for this purpose.

4. Most of escortings were realized by scheme: "one tanker – one icebreaker". Tanker escorting by two icebreakers was carried out extremely seldom (only two cases). As the tanker traffic intensity increased, two tankers were escorted by one icebreaker.

5. During the most severe period (February-March) of 2004–2005 winter navigation it was possible for the majority of escortings of large tankers to maintain average speed of about 10 knots this being confirmed by master reports of icebreaker "Admiral Makarov" (for instance, in March, total tanker escorting distance was 3442 miles and the time spent – 353 hours) as well as by data of the present report for separate cases of escorting.

6. The power used of the propulsion plant of icebreaker "Admiral Makarov" changed with changes of ice conditions: from diesel scheme "1x2x1" in mid-February and "2x2x2" in the first ten-day period of March up to "2x3x2" (i.e. seven diesel sets out of nine available ones) from 11 to 29 of March.

7. During winter navigation of 2004–2005 (153 days) the port throughput amounted to 482 tankers and the intensity of visits by tankers of the port of Primorsk was 1.6 tankers a day.

6. WP6 Workshop Activity

The workshop activity during the ARCOP project was maybe the most successful part of the whole project. The workshops were an efficient tool to bring together the different interest groups from industry, science and authorities. And although ARCOP was a EU-project, the workshops brought a circumpolar dimension into the work.

The following pages give the detailed program of each of the workshop lists the statistics of the participants to the workshops. All the actual workshop reports are available on the ARCOP web-site www.arcop.fi

Listed below are the workshop programs and participation statistics.

ARCOP Workshops 1-3

March 25-27, 2003
Helsinki

Program

March 25th	**Legal and administrative issues**	
Chairman: Nikolay Matyushenko, Ministry of Transport of the Russian Federation		
8.30	Registration	
9.00	Opening remarks	Minister Kimmo Sasi, Ministry of Transport and Communications
9.15	Legal status of the NSR	Central Marine Research and Design Institute, Irina N. Mikhina *Comment: The Fridtjof Nansen Institute*
10.00	International agreements regarding marine transportation	The Fridtjof Nansen Institute, Douglas Brubaker *Comment: Central Marine Research and Design Institute*
10.45	Coffee break	
11.15	New ice rules of the Russian Maritime Register	Russian Maritime Register, Vladimir I. Evenko *Comment: Lloyds Register*
12.00	Lunch	
13.00	Insurance related questions for the NSR operations	The Fridtjof Nansen Institute, Douglas Brubaker *Comment: Central Marine Research and Design Institute*
13.45	Coffee break	
14.15	Rules to be followed on the NSR	Northern Sea Route Administration, Anatoly G. Gorshkovsky *Comment: The Fridtjof Nansen Institute*
15.00 – 16.00	Discussion and conclusions	
17.40	Bus departs from Scandic Hotel Continental for the Ministry of Trade and Industry, address Ratakatu 3	
18.00 – 19.30	Reception at Ministry of Trade and Industry	Minister for Foreign Trade Jari Vilén

March 26th	**Industry Needs**	
Chairman: Jaakko Ihamuotila, The Finnish Academies of Technology		
8.30 -	Registration	

9.00	Opening remarks	Chairman Jaakko Ihamuotila
9.15	Review of the Arctic Oil and Gas reserves	Ministry of Natural Resources of the Russian Federation, Andrei A. Gagelgants *Comment: Fortum E&P*
10.00	Importance of direct marine transportation (canceled)	
10.45	Coffee break	
11.15	Role of marine transportation in Russia's energy export	Ministry of Transport of the Russian Federation, Nikolay I. Matyushenko *Comment: Stena Bulk*
12.00	Lunch break & Press conference	
13.15	Experience from regular traffic	Murmansk Shipping Company, Nikolay Babich
14.00	Experience from loading systems	Murmansk Shipping Company, Vsevolod Garulin Tecnomare SpA, Giovanni Busetto
14.45	Coffee break	
15.15	Proposed ARCOP scenario	Kvaerner Masa-Yards, Kimmo Juurmaa *Comment: Central Marine Research and Design Institute*
16.00	Discussion and conclusions	

March 27th	**Technology & Environment**	
Chairman: Joachim Schwarz		
8.30	Registration	
9.00	Opening remarks	Chairman Joachim Schwarz
9.10	Integrated transportation system	Kvaerner Masa-Yards, Kimmo Juurmaa *Comment: Central Marine Research and Design Institute*
9.50	Ice service capabilities	Arctic and Antarctic Research Institute, Vladimir Smirnov *Comment: Finnish Institute of Marine Research*
10.30	Coffee break	
10.50	Use of satellites to serve the traffic	Nansen Environmental and Remote Sensing Center, Sandven *Comment: Arctic and Antarctic Research Institute*
11.25	Traffic management systems	Hamburg University of Applied Sciences, Jens Froese *Comment: Central Marine Research and Design Institute*
12.00	Lunch	
13.00	Training requirements	Wagenborg Shipping, Anniek Platzer *Comment: Central Marine Research and Design Institute*

13.40	Environmental impact assessment	Alpha Environmental Consultants, Kjell Moe *Comment: Arctic and Antarctic Research Institute*
14.20	Coffee break	
14.40	Oil spill management	Central Marine Research and Design Institute, Gennady Semanov *Comment: SINTEF*
15.10	Social impact	University of Lapland / Arctic Centre, Nina Messthyb *Comment: Arctic and Antarctic Research Institute*
15.30	Discussion and conclusions	
16.10	Bus departs from Finlandia Hall for Masa-Yards Arctic Technology Centre, address Kaanaankatu 3A	
16.30 – 19.00	MARC – 20th Anniversary Reception	

ARCOP Workshop 4: Technologies and Environment

June 8-9, 2004
Brussels

Program

June 8th Technologies and Environment, Integrated transportation system for Arctic oil and gas (WP 3)		
Chairman: Kimmo Juurmaa, KMY		
8.30	Registration	
9.00	Welcome to the 4th workshop of ARCOP "Technology and Environment"! - practical arrangements	WP6 leader Ministry of Trade and Industry of Finland, Liisa Laiho
9.30	Opening address: Goals and progress of WP3	WP3 leader Kvaerner Masa-Yards (KMY), Kimmo Juurmaa
10.00	Coffee break	
10.15	Design of cargo vessels for the Arctic • Design considerations • Design conditions • Operational principles • Examples of LNG and container vessels • Tanker alternatives for ARCOP scenario	Kvaerner Masa-Yards (KMY), Sami Saarinen
11.00	Assisting large tanker in ice • Convoy practice • Propulsion systems • New challenge to guide large cargo vessels	Hamburg Ship Model Basin (HSVA), K-H. Rupp
	Discussion on presentations "Design of cargo vessels for the Arctic" and "Assisting large tanker in ice"	
12.00	Lunch	
13.00	Loading facilities for Arctic areas • Design aspects of pipelines • Thermo-hydraulic conditions of the fluid to be transported • Methods and problems for pipeline installation	Tecnomare, Giovanni Busetto

13.45	Traffic management systems - basic requirements • Analysis of state of the art VTS/VTMIS • Surveillance and support areas, services, vessels, ports and terminals	Technical University Hamburg-Harburg, Maritime Logistics (ISSUS), J. Froese & K. Bruns-Schüler
	Comment	VTT Technical Research Centre of Finland, Jorma Rytkönen
14.30	Coffee Break	
14.45	Training for arctic navigation • Availability of training • Types of training, types of vessels • Trading areas • Basis and goal of training	Wagenborg Shipping (WS), Anniek Platzer
	Comment	Maritime Safety Training Centre Meriturva, Leif Baarman
15.30	Impact of climate change on transportation environment	US Arctic Research Commission, Lawson W. Brigham
16.15 – 17.00	Discussion and conclusions	
18.00 – 19.00	Evening programme: Wine and Snacks	
June 9th Technologies and Environment, Environmental protection and Management system for the Arctic (WP 4)		
Chairman: Karl-Ulrich Evers, HSVA		
8.30	Registration	
9.00	Opening address, Goals and progress of Work Package 4	WP4 leader Hamburg Ship Model Basin (HSVA), Karl-Ulrich Evers
9.30	Keynote address, Ecological safety of oil transport and terminals in the Baltic Sea • Environmental control and protection measures	Ministry of Transport, State Marine Pollution Control, Salvage & Rescue Adm. of RF, Nataljia Kutaeva
10.15	Coffee break	
10.30	Characteristics of shipping and navigation in the northern seas • Technical characteristics of tankers for the White Sea, Barents Sea and Kara Sea	Central Marine Research and Design Institute (CNIIMF), V.I Peresypkin

	• Operational requirements • Seasonal and year-round operations • Total fleet simulations	
	Characteristics of shipping and navigation in the northern seas in Environmental Risk Analysis (ERA) perspectives • Identification of impact factors; regular activities and accidental events • Selection of priority factors; input to ERA • Calculation of risk – integration of accidental events and likely impact	Alpha Environmental Consultants, Odd W. Brude
	Comment	Canadian Coast Guard, Victor Santos-Pedro
11.30	Oil weathering and oil spill countermeasures • Fate and weathering of oil in Arctic waters • Oil spill response – alternatives for ice covered waters; mechanical methods, burning, dispersants • Potential improvements	Hamburg Ship Model Basin (HSVA), Karl-Ulrich Evers & SINTEF, Hans Jensen
	Comment	Norsk Hydro, Dag K. Onshuus
12.30	Lunch	
13.30	Biological degradation of oil in sea ice • Knowledge of biological oil degradation • Sea ice – ecosystem, description of the environment with biological, physical and biogeochemical parameters • Laboratory and field experiments, preliminary results and future plans	Alfred Wegener Institute for Polar and Marine Research (AWI), Birthe Gerdes
13.50	Sea ice Biota • Organisms living within and associated with Arctic sea ice • Effect of sea ice biota on the processes in open water • Consequences of oil spill in biological communities and processes in water column	Finnish Institute of Marine Research (FIMR), Johanna Ikävalko
14.10	*Comment on presentations "Biological degradation" and "Sea ice Biota"*	David Thomas, University of Wales-Bangor

14.45	Coffee break	
15.00	Social impact of Arctic transportation • The peoples in Arctic and sea transportation - the peculiarity of interrelationship • Mass media and public opinion about perspec-tives of the marine Arctic transportation • Case study of the consequences of the marine transportation in Nenetsky Region	University of Lapland/ Arctic Centre (AC), Nina Messhtyb
	Comment	Administration of the Nenets Autonomous Okrug, Jana Kislyakova
16.00 17.00	Discussion and conclusions Closing the Workshop	

ARCOP Workshop 5: Legal and Administrative Issues of Arctic Transportation

September 7-8, 2004
Marina Congress Center, Helsinki

Program

September 7th **Legal and Administrative Issues, Ice Rules and Classification**		
Chairman: Vsevolod Peresypkin, CNIIMF		
08:30	Registration	
09:00	Opening Remarks	Arnaud Revel EU/DGTREN
09:10	Opening address: Industry Interests in Legal and Administrative Issues	Kimmo Juurmaa Project Coordinator Kvaerner Masa-Yards
09:30	Keynote address: NSR Rule Development	Alexander Ol'shevskij RF Ministry of Transport
10:00	Coffee	
10:30	Consistency of NSR Rules with other National and International Rules	Loly Tsoy CNIIMF
	Comment: Canadian Rules and Practices	Victor Santos-Pedro Transport Canada
11:30	Lunch	
12:30	IACS Harmonized Requirements	Robert Bridges Lloyd's Register
	Comment	Øyvind Solem Bergesen
13:30	Project of New RS Requirements for Propulsion Machinery of ice Going Vessels and Icebreakers	Alexander Andryushin Russian Maritime Register
14:00	Coffee	
14:30	Problems of Equivalency Between Different Ice Rules	Igor Stepanov Arctic and Antarctic Research Institute
15:00	HELCOM's Recommendations for Safe Winter Navigation	Roy Jaan Swedish Maritime Administration
	Comment: The Adequacy of the Baltic Sea Rules	Anita Mäkinen WWF
16:00-17:00	Discussion and Conclusions	
18:00-19:30	Cocktails	Hotel Grand Marina

September 8th **Legal and Administrative Issues at and Beyond the Border**		
Chairman: Arild Moe, The Fridtjof Nansen Institute		
08:30	Registration	
09:00	Opening address: The EU Acquis on Trade in Shipping Services and the Russian Arctic Marine Oil and Gas Export to EU Ports	Edgar Gold The Fridtjof Nansen Institute
09:30	Immigration and Customs Procedures	Erkki Kotiranta Fortum Shipping
10:00	Practical Problems Encountered at an Oil Terminal	Stena
10:30	Coffee	
11:00	Marine Insurance Coverage for Oil and LNG Tankers on the Northern Sea Route: An Update on Insurance Market Interest	Edgar Gold The Fridtjof Nansen Institute
	Comment	Sten Göthberg Swedish Association of Marine Underwriters
12:00	Lunch	
13:00	Consequences of Different Fee Systems	V.I. Peresypkin CNIIMF
	Comment	Markku Mylly Finnish Maritime Administration
14:00- 15:00	Discussion and conclusions	

ARCOP Workshop 6: Industry Interests in the Northern Sea Route

October 12-13, 2004
St. Petersburg, Hotel Dostoevsky, Vladimirsky Avenue 19

Program

October 12th **Industry Interests in the NSR**		
Chairman: Nikolay Matyushenko, Norilsk Nickel		
09:00	Registration	
09:30	Opening address: Russian Interests in the NSR	Alexander Olshevsky RF Ministry of Transport
10:00	Progress of the ARCOP Project	Kimmo Juurmaa Kvaerner Masa-Yards / MARC
10:45	Coffee	
11:15	Experiences of Production Plants in Using the NSR as an Export Route	Nikolay Matyushenko Norilsk Nickel
12:00	Lunch	
13:30	Service Transportations to Population Centres in the Russian Arctic: view of a shipping company	Vsevolod Garulin Murmansk Shipping Company MSCO
14:00	Service Transportations to Population Centres in the Russian Arctic: view of Sakha Republic	Olga Alexeyeva RF Republic of Sakha
14:30	Coffee	
15:00	Polar Station Activity, Experiences and Future Plans	Alexander Danilov and Vladimir Sokolov Arctic and Antarctic Research Institute
15:30-16:30	Discussion and Conclusions	Chairman
18:00-19:30	Evening reception and Cocktails, hosted by Finland's Consulate General Address: ul. Tshaikovskogo 71	
October 13th **Industry interests in the NSR**		
Chairman: Erkki Kotiranta, Fortum Shipping		
09:00	Registration	
09:30	Experiences and Future Prospects of Oil Transport in the NSR	Andrey Aprelenko FEMCO / Rosneft
10:30	Benefits of Marine Transportation	Erkki Kotiranta Fortum Shipping

11:00	Coffee	
11:30	Perspectives of the Development of Oil and Gas Fields in the Arctic Region	Ivan Shestakov Gazprom
12:00	Future Prospects of Liquified Natural Gas (LNG) Transports in the NSR	Nikolay Bogachev Tambeyneftegaz
12:30	Lunch	
14:00	Use of the NSR for Through Passage - Russian views	Loly Tsoy and Anatoly Yakovlev CNIIMF
14:30	Use of the NSR for Through Passage: Views of the German Shipping Industry	Joachim Schwartz German Association for Marine Technologies
15:00	Coffee	
15:30	Noncommercial Partnership of the Coordination of Northern Sea Route Usages	Vladimir Mikhailichenko
16:00-16:30	Discussion and Conclusions	Chairman

ARCOP Worshop 7

Concluding workshop:

Legal and Administrative Issues of Arctic Transportation

September 28-29, 2005
Hotel Norlandia Karl Johan, Oslo, Norway

Program

September 28th **The Legal and Administrative Framework for NSR transportation**		
Chairman: Arild Moe, The Fridtjof Nansen Institute		
08:30	Registration	
09:00	Opening address	Chairman
09:30	Legal status of the NSR and westover • UNCLOS Article 234 effects • Norwegian developments • Civil Liability Convention • UNCLOS Article 76 clarification	Douglas Brubaker, The Fridtjof Nansen Institute FNI
10:15	Discussion	
10:30	Coffee Break	
11:00	EU regulations - WTO/GATS	Douglas Brubaker, The Fridtjof Nansen Institute FNI
11:30	The International Shipping Industry and Oil Transportation in the North: Expectations and Requirements	Sverre Björn Svenning Feanley Consultants
12:15	Discussion	
12:30	Lunch	
13:30	Rules and Regulations • The new NSR guidelines content • The new RMRS rules • Interrelation of NSR, LU, PC rules • Applicability of PC rules to NSR	Loly Tsoy Central Institute of Marine Research and Design CNIIMF Andrey Andryushin Russian Maritime Shipping Registry RMRS
14:15	Arctic Shipping Rules	Victor Santos-Pedro Transport Canada
15:00	Discussion	
15:15	Coffee Break	

15:45	Panel discussion: Rules development • Robert Bridges, Lloyd's Register • Lasse Norhamo, Det Norske Veritas • Jorma Kämäräinen, Finnish Maritime Administration • Victor Santos-Pedro, Transport Canada • Alexander Andryushin, Russian Maritime Shipping Registry RMRS • Loly Tsoy, CNIIMF	
16:45	Discussion and Day 1 Conclusions	
17:30	Cocktails hosted by The Fridtjof Nansen Institute	
September 29th **The Economic Framework of Arctic Transportation**		
Chairman: Herbie Battye, Shell Shipping		
08:30	Registration	
09:00	Opening address	Chairman
09:30	Risk Management for NSR Navigation • Basis for Insurance Cost Estimation	Peter L. Wright
	NSR Risk Management	Loly Tsoy Central Institute of Marine Research and Design CNIIMF
10:15	Discussion	
10:30	Coffee Break	
11:00	Immigration and Custom Procedures at Russian Oil Terminals • Review of the current practices and plans for the future	Anton Nikulin Central Institute of Marine Research and Design CNIIMF
	Fee Policy • The proposed new fee policy for the NSR	Anton Nikulin Central Institute of Marine Research and Design CNIIMF
11:45	Finnish Fee Policy Development	Markku Mylly Finnish Maritime Administration
12:15	Discussion	
12:30	Lunch	
13:30	Effect of the Legal and Administrative Framework on the Economics of the Transportation System	Kimmo Juurmaa, Aker Finnyards

15:00	Discussion and conclusions Future work	
	Excursion	The Maritime Museum

ARCOP Worshop 8

Concluding workshop:

Technologies and Environment

October 19-20, 2005
Finland's Consulate General, St. Petersburg, Russia

Program

October 19th **Integrated Transportation System for the Northern Sea Route**		
Chairman: Esko Mustamäki, Finstaship		
08:30	Registration	
09:00	Opening address Operating Strategy and Experiences of a Commercial Icebreaker Operator	Esko Mustamäki Finstaship
09:45	Loading Facilities • Review of existing experience • Design of the loading facility • Performance, costs • Recommendations for feasibility evaluations	Giovanni Busetto Tecnomare
10:30	Discussion	
10:45	Coffee Break	
11:15	Arctic Cargo Vessels and Assisting Fleet • Alternative designs • Costs, performance	Kimmo Juurmaa Aker Finnyards
12:00	Discussion	
12:30	Lunch	
13:30	Ice Information System • Ice Ridging Information System (IRIS) development • Application to NSR	Risto Jalonen Helsinki University of Technology Robin Berglund Technical Research Centre of Finland
14:15	Vessel Traffic Management and Information System (VTMIS)	Angel León Technical University Hamburg-Harburg
15:00	Discussion	
15:15	Coffee Break	

15:45	Particularities of Icebreaker Support in Operation of Large-capacity Tankers and Gas Carriers	Valery Belyashov Krylov Shipbuilding Research Institute
16:15- 17:00	Discussion and Day 1 Conclusions Future Needs	
	Cocktails hosted by the Finnish Consulate	
October 20th **Safety of Arctic Shipping**		
Chairman: Gennady Matishov, Murmansk Marine Biological Institute		
08:30	Registration	
09:00	Opening address	Chairman
09:30	Training for Arctic Navigation • Recommendations for training of arctic navigation	Bob Derks Wagenborg Shipping
10:00	Ice Navigation Training for Pilots and Deck Officers at Admiral Makarov State Maritime Academy	Vladimir Kuzmin Admiral Makarov State Maritime Academy
10:30	Discussion	
10:45	Coffee Break	
11:15	Environmental Risks Assessment for Arctic Shipping • review of work • future development needs	Odd Willy Brude Det Norske Veritas
11:45	Biology and Potential Effect of Oil Spills in the Arctic Sea Ice • Marine biological experiments • Improvement of technologies to expedite biological degradation of oil	Birte Gerdes Alfred Wegener Institute Johanna Ikävalko Finnish Institute of Marine Research
12:30	Lunch	
13:30	Oil Weathering	Ivar Singsaas SINTEF Applied Chemistry
14:00	Oil Spill Countermeasures • Evaluation of methods and devices, potential for improvement • Oil spill response concepts	Karl-Urlich Evers Hamburgische Schiffbau-Versuchsanstalt GmbH
14:30	Forecasting the Properties and Behaviour of Oil in the Arctic Waters	Mikhail N. Grigoriev Gecon Ltd.
15:00	Discussion	

15:15	Coffee Break	
15:45	Oil Spill Response Analysis	Øistein Johansen SINTEF Applied Chemistry
16:15- 17:00	Discussions and Workshop Conclusions Future Work	

ARCOP Worshop 9

Concluding workshop

November 16-17, 2005
Marina Congress Centre, Helsinki, Finland

Program

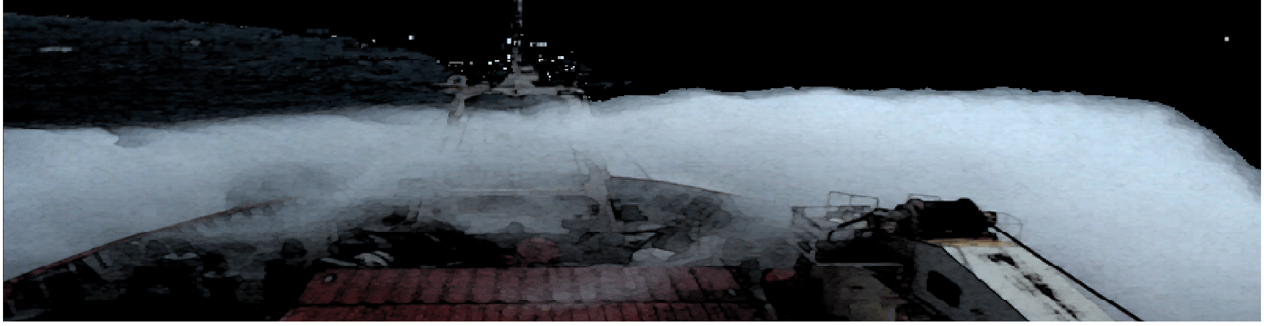
November 16th		
Chairman: Project coordinator Kimmo Juurmaa, Aker Finnyards		
08:30	Registration	
09:00	Opening address	Erik Ulfstedt Ministry of Foreign Affairs, Finland
09:30	Summary of the ARCOP Project • Technical solutions, economics, safety and policy issues	Kimmo Juurmaa Aker Finnyards
10:15	Coffee Break	
10:45	Experience in Icebreaker Maintenance and Ship Traffic Management in the Seas of the Northern Arctic	Nikolay Babich Murmansk Shipping Company
11:45	Discussion	
12:00	Lunch	
13:15	Environmental Protection Processes in Oil and Gas Projects	Gennady Matishov Russian Academy of Science
14:45	Coffee Break	
15:15	Oil Transportation Plans and Needs in Murmansk Area	Alexander Selin Murmansk Regional Government
16:00	Discussion and Conclusions	
16:30	Excursion (two possibilities to choose from) • Finnyards shipyard, Norilsk Nickel's DA vessel • Aker Arctic's new ice laboratory	
18:30	Cocktails at Hotel Grand Marina	
November 17th		
Chairman: Project coordinator Kimmo Juurmaa, Aker Finnyards		

08:30	Registration	
09:00	Future Trends in the Development of Seaborne Cargo Transportation in the Arctic Region of Russia and its Icebreaker Support for the Period up to 2020	Nikolay Monko RF Ministry of Transport
09:30	Shipping Through the Northern Sea Route: Navigational and Hydrographic Support	Victor Medvedev RF Ministry of Transport
10:00	Discussion	
10:15	Coffee Break	
10:45	Development of Transport Streams Through the Baltic and Barents Seas • Future freight flows • Impacts of infrastructure projects • Environmental considerations	Mikhail N. Grigoriev Gecon Ltd.
11:30	Discussion	
11:45	Lunch	
13:00	Nenets AO - A Growing Oil Province • Plans and needs to develop oil reserves and transportation • On-going projects and views for their future • Impact of the developing oil industry on other means of livelihood	Vladimir M. Shibeko NAO Administration
14:00	Other ongoing work and plans for the future • Arctic Marine Shipping Assessment (AMSA) • Program of the Russian chairmanship of the Arctic Council	Lawson Brigham US Arctic Commission
14:45	Discussion	
15:00	Coffee Break	
15:30	Concluding Panel Session: The Challenge Remains	Speakers and Sergey Aysinov, Admiral Makarov State Maritime Academy
16:45	Project closing address	The European Commission, Directorate General of Energy and Transport

ARCTIC OPERATIONAL PLATFORM

ARCOP WORKSHOPS 1-9

WS 1	Legal and Administrative Issues	Helsinki, March 2003
WS 2	Industry Needs	Helsinki, March 2003
WS 3	Technology and Environment	Helsinki, March 2003
WS 4	Technology and Environment	Brussels, June 2004
WS 5	Legal and Administrative Issues of Arctic Transportation	Helsinki, September 2004
WS 6	Industry Interests in the Northern Sea Route	St. Petersburg, October 2004
WS 7	Legal and Administrative Issues of Arctic Transportation	Oslo, September 2005
WS 8	Technologies and Environment	St. Petersburg, October 2005
WS 9	Concluding Workshop of ARCOP project	Helsinki, November 2005



ARCTIC OPERATIONAL PLATFORM

WORKSHOP PARTICIPANTS

	ORGANISATIONS	%	PERSONS	%
Arcop participants	20	22,5	216	54
Other organisations	69	77,5	185	46
Total	89		401	

ARCTIC OPERATIONAL PLATFORM

PARTICIPATING PERSONS

	WS1	WS2	WS3	WS4	WS5	WS6	WS 7	WS 8	WS 9	WS 1-9
Industry	14	19	14	8	17	22	15	14	19	142
Research	15	13	15	15	10	20	9	32	19	148
Government	8	8	8	13	13	7	8	9	20	94
Other	2	2	2	1	2	3	1	2	2	17
Total	39	42	39	37	42	52	33	57	60	401

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ARCTIC OPERATIONAL PLATFORM

PARTICIPATING ORGANISATIONS

	WS1	WS2	WS3	WS4	WS5	WS6	WS 7	WS 8	WS 9	WS 1-9
Industry	9	14	9	7	9	18	11	11	12	39
Research	10	9	10	13	7	5	4	15	12	22
Government	6	6	6	8	8	4	4	5	13	22
Other	2	2	2	1	2	3	1	2	2	6
Total	27	31	27	29	26	30	20	33	39	89

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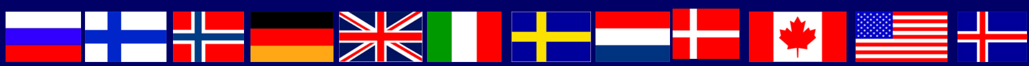
ARCTIC OPERATIONAL PLATFORM

WORKSHOP PARTICIPANTS

Russian Federation	136
Finland	135
Norway	46
Germany	26
Great Britain	17
Italy	8
Sweden	7
Netherlands	6
EU representatives	5
Denmark	5
Canada	4
USA	4
Iceland	2

EU 52 %
Russian Federation 34 %
Other 14 %



ARCTIC OPERATIONAL PLATFORM

WORKSHOP PARTICIPANTS

Female 67 **Male 334**

Male business ?


The ARCOP project team of the Ministry of Trade and Industry in Finland wishes to thank all stakeholders, project partners and workshop participants for their co-operation during the project.
The challenge remains!