MINISTRY OF TRADE AND INDUSTRY, FINLAND (KTM)

GROWTH Project GRD2-2000-30112 "ARCOP"

Technologies and Environment

WP6: WORKSHOP ACTIVITY

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DELIVERABLE SUMMARY SHEET

Short Description
The workshop 8 report consists of the presentation abstracts and slides, a record of the discussions as well as the conclusions and recommendations.

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PREFACE

Arctic Operational Platform ARCOP is a research and development project co-funded by the Directorate General Energy and Transport of the European Commission under the 5th Framework Programme for Research and Technological Development. The project coordinator is Aker Finnyards.

The project aims to develop efficient and environmentally safe oil shipping by the Northern Sea Route. The three-year (2003-2005) project has been participated by 21 organisations from the EU, Russia and Norway. The work has been divided into 6 parts:

- Development of collection methods for ice information and ice forecasts in view of choosing transport routes (WP1)
- Assessment of the rules and regulations on transport by sea and of insurance and payment systems (WP2)
- Development of an integrated transport system for Arctic oil and gas transport (WP3).
- Development of the environmental impact assessment method and the environmental hazard management system (WP4)
- Trial in practice of the solutions developed and recommendations given during an actual transport assignment (WP5)
- Organisation of expert meetings between industry, authorities and representatives of technology to direct the project, to assess the results and to give recommendations (WP6)

Every year, during the three years of activity, the project has organised three workshops in which the results have been presented to representatives of industries, authorities and scientifical organisations. The participants of the workshops have given guidelines for the project and also evaluated the achievements.

The workshops have been arranged by the Ministry of Trade and Industry of Finland. During 2005, 109 participants, representing 92 organisations from all over the world, attended them. In 2004, the meetings were participated by 102 persons from 55 organisations, and in 2003 the figures were 57/35, respectively.

In the course of time, the workshops have formed a popular forum for the experts to meet and discuss the topical issues of Arctic transportation. The eight workshop of ARCOP, the third meeting baring the title “Technologies and Environment”, was held in St. Petersburg, in October 2005. The meeting focused to discuss the effect of the technological solutions on the overall transportation economics, environmental protection and oil spill response. The meeting gathered 57 experts representing 33 organisations.

This workshop report consists of the presentation abstracts and slides, a record of the discussions during the event as well as the conclusions and recommendations. The conclusions and recommendations have been compiled by the project coordinator and the workshop organisers based on the presentations and the discussions heard during the workshop.

We wish to thank the chairmen, speakers and panellists for their valuable input to the successful and interesting eight ARCOP workshop.

In Helsinki, 16.2.2006

Liisa Laiho
Piia Nordström
Kimmo Juurmaa

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EXECUTIVE SUMMARY

Technological advances and investments in training go hand in hand in developing environmentally sound Arctic shipping, concluded the experts at the eight workshop of ARCOP.

The goal of the ARCOP project is to develop the cost efficiency and environmental safety of Arctic shipping. The environmental research conducted in the project has revealed several new areas and questions, which need to be studied further to form a unified view of the environmental risks and accident prevention. The training of crews and the implementation of new, environmentally sound technologies are key issues when ensuring safe growth of traffic by the NSR.

New solutions for organising icebreaker services

In Finland, the icebreaking operations were separated in the beginning of 2004 from the Finnish Maritime Administration FMA to a commercially operated company Finstaship. The FMA charters icebreakers from Finstaship, whose services will after 2005 become commercially available to any interested client. It was noted, that a similar arrangement or services could be a working solution to the looming icebreaker shortage at the Northern Sea Route as well.

Along with the decreasing availability of the NSR icebreaker services, the costs of the services have been a key issue when studying the economical efficiency of the NSR transports. A calculation of transportation economics based on the costs analyses of each workpackage reveals that marine transportation of oil can be made cost-effective through optimisation. The difference in costs between an un-optimised transportation system and the most favourable optimised configuration was as high as 50%. The economic analysis ended up with a total cost of 12€ per ton of oil for the route Varandey-Rotterdam. This figure is based on the use of independently operating cargo vessels, the double-acting tanker concept, and assumes direct transportation between the ports. It also assumes that in the future, the transport flows will grow according to the industries estimations, to 100 mln tons annually.

The escorting tactics for large tankers, in addition to safety of sail, play a large role also in the economical efficiency of a transportation system. It was concluded, that it was indeed very beneficial to design the cargo and assisting fleet as a versatile system, according to the needs of the transportation task and the local environmental conditions. This requires, that no particular escorting tactic is favoured, but the requirements of all tactics are considered, enabling adaptable escorting.

Challenges of developing loading facilities, ice information system and VTMIS

In the chain of the maritime transportation system, the the loading terminal constitutes a point where activities are accumulated and considerable delays possible, if the facilities are not fit for the purpose. In Arctic Seas, the harsh environment plays a great role. In the NSR, the growing traffic and increased volumes of a cargo affect the efficiency of a loading system. The study conducted in ARCOp shows, that an efficient loading system can be developed for Arctic conditions as well, but the effect of the larger cargo volumes must be further looked into in the future.

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. On board route optimisation is possible to perform but reliable results require accurate and up-to-date information on ice conditions and ship resistance in ice. The experts estimate, that in the Baltic conditions, efficient route optimisation can save up to 20% in sailing time. The same can be expected for the NSR as well. In Arctic conditions ice information service and information on icebreaker service are an essential part of the VTMIS.

Environmental safety through training and risk analysis

The human factor prevails as the main cause for marine accidents. Thus, the connection between the skills and the knowledge of the seafarers and the environmental conditions is the key issue. Ice-infested waters and acting in harsh environmental conditions is unfamiliar to most of today's seafarers. The ARCOP experts were pleased to note the advanced cooperation between Admiral Makarov State Maritime Academy AMSMA and the oil companies in developing route specific ice training. They also noted, that in addition to learning to navigate a vessel, the today's seafarers also need to be trained for the routines related to environmental protection.

ARCOP scientists have been active in the field of oil spill response research. In ARCOP, the risk studies focused to study the phase of transport, when a tanker is sailing at open sea. It was reminded, that most accidents occur near the terminals, where the traffic is dense. The experts recommended conducting a study about the risk factors related to the terminal activities to form a uniform view.

The relations of spilled oil on the microorganism communities confirm, that although biodegradation is a viable method in certain conditions, in arctic environment there are limitations to its effectiveness. In this light, the importance of other oil spill response methods should be emphasised. In ice conditions, the practicability of these methods is also limited. The experts mentioned the Arctic skimmer as the most efficient mechanical oil spill combat tool.

The generally unfavourable conditions of the Arctic seas and the oil weathering processes make oil spill preparedness measures and short response times decisive. Also efforts of advance measures grow significantly in importance. Developing the environmental monitoring systems of the Barents areas facing the growing oil traffic could efficiently support preparedness.

The research made within ARCOp shows that the marine transportation can be economically feasible. The technology can still be further developed to reduce the cost for icebreaking. Practice has shown that the problems that were foreseen in the beginning of the ARCOP project, can be solved.

PROGRAM, 19th October 2005 Integrated Transportation System for the Northern Sea Route	
Chairman: Esko Mustamäki, Finstaship	
Opening address: Operating strategy and experiences of a commercial icebreaker operator	Esko Mustamäki, Finstaship
Loading Facilities	Giovanni Busetto, Tecnomare
Economic impacts of the technology issues	Kimmo Juurmaa, Aker Finnyards
Ice information system	Risto Jalonen, Helsinki University of Technology Robin Berglund, Technical Research Centre of Finland
Vessel traffic and management information system (VTMIS)	Angel León, Technical University Hamburg-Harburg
Particularities of icebreaker support in operation of large-capacity tankers and gas carriers	Valery Belyashov, Krylov Shipbuilding Research Institute
PROGRAM, 20th October 2005 **Safety of Arctic Shipping**	
Chairman: Gennady Matishov, Murmansk Marine Biological Institute	
Opening address: Present Status Of Environmental Protection in the North	Gennady Matishov, Murmansk Marine Biological Institute
Training for Arctic Navigation	Bob Derks, Wagenborg Shipping
Ice navigation training for pilots and deck officers at Admiral Makarov State Maritime Academy	Vladimir Kuzmin, Admiral Makarov State Maritime Academy
Environmental Risks Assessment for Arctic Shipping	Odd Willy Brude, Det Norske Veritas
Biology and potential effect of oil spills in the Arctic sea ice	Birte Gerdes, Alfred Wegener Institute Johanna Ikävalko, Finnish Institute of Marine Research
Oil Weathering	Ivar Sinsgaas, SINTEF Applied Chemistry
Oil Spill Countermeasures	Karl-Ulrich Evers, Hamburgische Schiffbau-Versuchsanstalt GmbH
Forecasting the properties and behaviour of oil in Arctic waters	Mikhail N. Grigoriev, Gecon Ltd.
Oil Spill Response Analysis	Øistein Johansen, SINTEF Applied Chemistry

1. OPERATING STRATEGY AND EXPERIENCES OF A COMMERCIAL ICEBREAKER OPERATOR

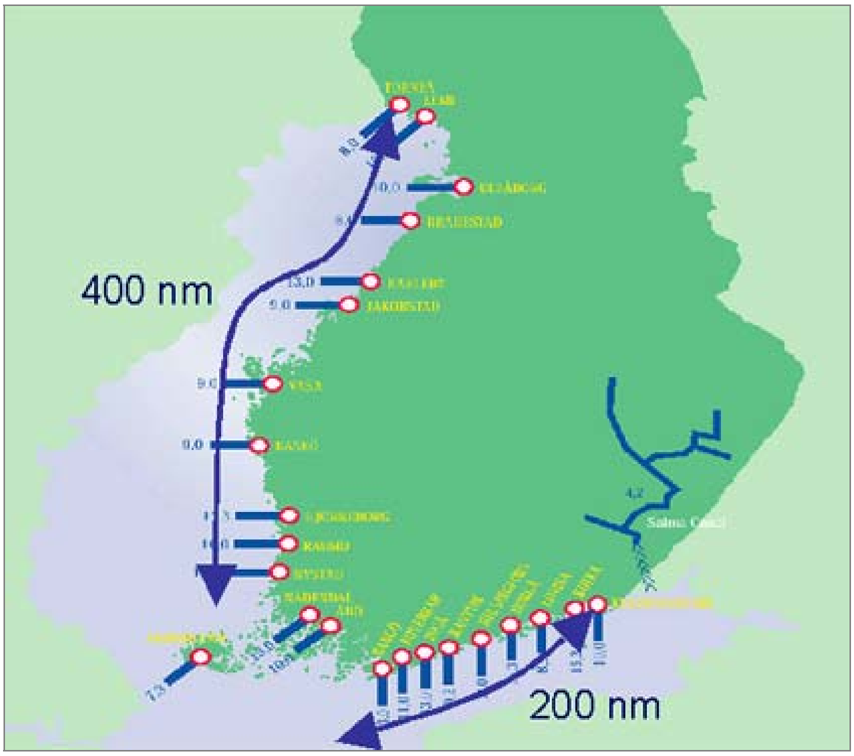
Esko Mustamäki, Finstaship

Abstract

Finstaship offers icebreaking and fairway services for shipping needs as well as special services for the offshore and marine construction industry. In addition Finstaship offers ferry and ship management services.

The presentation describes the current organisation of the Finnish icebreaking services. The role of these services in enabling year round passenger transportation and export and import of goods is considerable.

The annual turnover of the company consists mainly of the icebreaker services and the offshore operations. With 9 icebreakers Finstaship is the leading commercial icebreaker operator in the Baltic Sea.



The Finnish winter ports and the distances navigated in ice

Currently all nine icebreakers have been chartered by the Finnish Maritime Administration FMA for the winter season until the end of year 2005. Six icebreakers are booked by the FMA for the following winter and three multipurpose icebreakers have been in offshore tasks during summer seasons. The multipurpose vessels will be partly free for operation outside Finland during the coming winter.

Discussion

The Finnish Maritime Administration and Finstaship have a charter agreement on 6 of the 9 icebreakers for 2006. It was inquired, whether the Administration is planning to lower the service level from 2006. Mr. Mustamäki explained, that there was no official information on such move and that in Finland there has been a strong consensus on having the minimum 9 icebreakers to assist the traffic.

Conclusions

The Finnish concept to open the icebreaker service for competition was considered interesting. The FMA charters icebreakers from Finstaship, whose services will after 2005 become commercially available to any interested client. It was noted, that a similar arrangement or services could be a working solution to the looming icebreaker shortage at the Northern Sea Route as well.

Finland is currently planning to invest in new icebreaking vessel with oil recovery abilities. Multi-purpose icebreakers are an efficient way to reduce the costs of icebreaking, for the vessel can be utilized for other work during summer months.

2. LOADING FACILITIES: EXPERIENCE, DESIGN, PERFORMANCE AND COST ASPECTS

Giovanni Busetto, Tecnomare

Abstract

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.

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.

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.

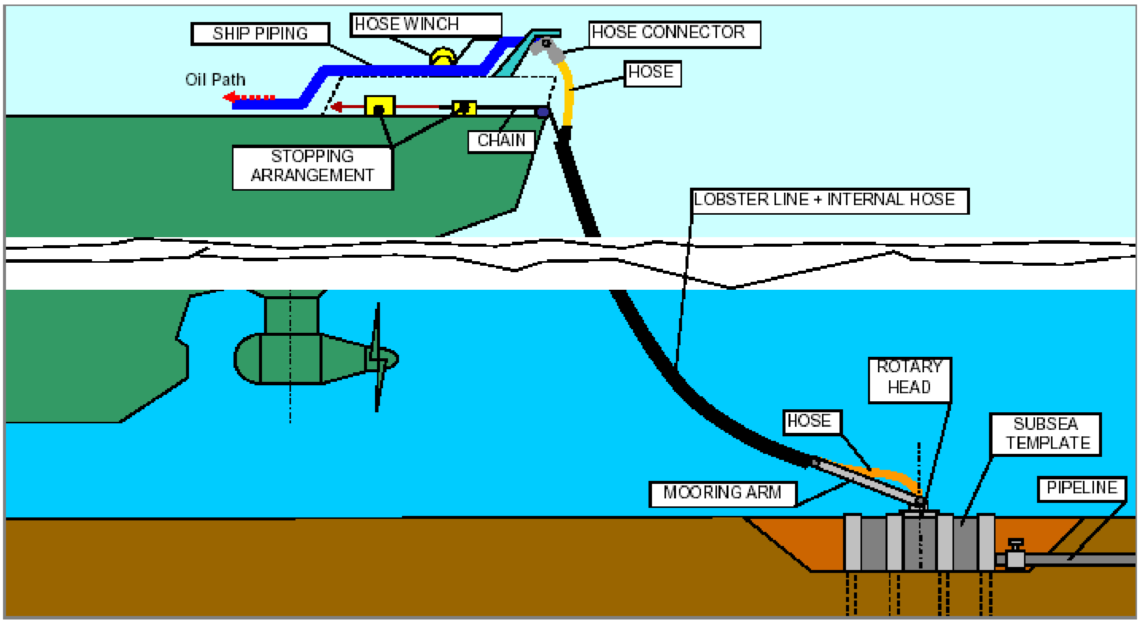
The main components of the Arctic SBAM system are:

- 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.

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.

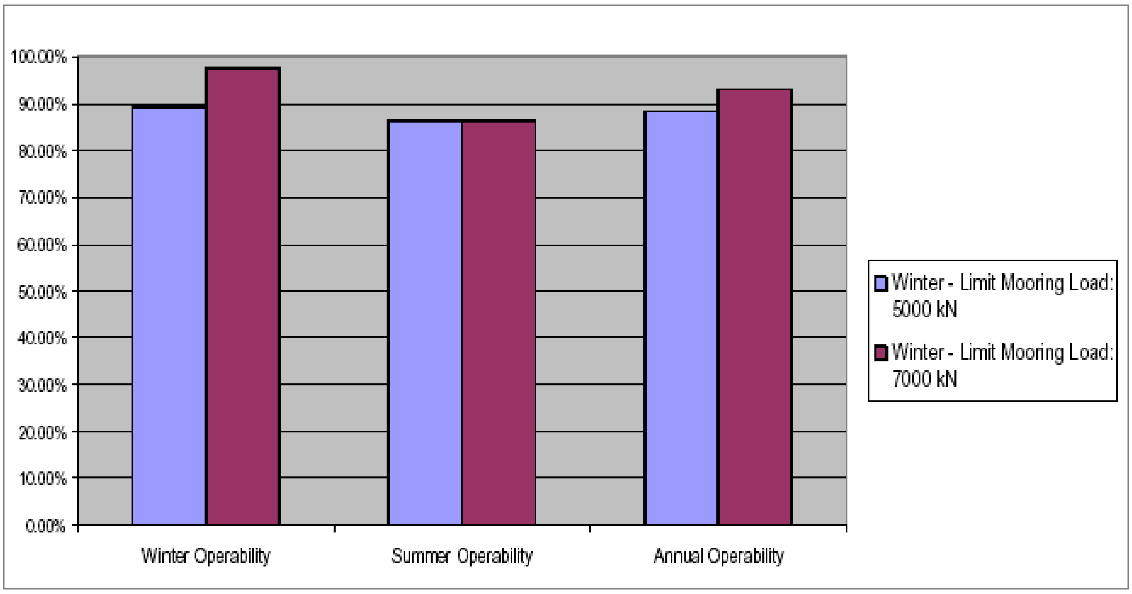
Considering the difference in the ‘summer’ (wave, wind, current) and ‘winter’ (ice) scenarios, separate calculations of operability have been performed and then combined accounting for the relevant durations.

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.)

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.

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, additional 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.

Discussion

Mr Busetto explained that when preparing the study regarding the loading facilities, the Varandey loading system has been carefully analysed.

The loading facilities' capability to endure emergency situations like high tidal waters and storms was discussed. Mr Busetto explained, that the designed facility has a low sensitivity to water level for the only element that is sensitive to water level changes is the lobster line. Other area-specific characteristics, such as seismic activities, can be well taken into account in the design basis. In this case there was no need for that. Ice and wave loads on the structures were taken into account. In ARCOP the study was limited to the conceptual and not detailed design.

Mr Busetto commented that model tests can and should be utilised in planning loading facilities. One cannot rely on analytical predictions, but practical experience must be combined to the analysis.

It was noted, that due to the changes in the climatic conditions all over the world, any oil production related structures should be designed so that future anomalies in climatic conditions would be taken into account.

The emergency disconnection of the lobster line was brought up. In an emergency situation the chain stopper is disconnected first and then the loading system, first the hose and then the mooring chain. Estimate for the duration of the disconnection is 30 minutes. Mr Busetto reminded that a tanker is not permanently attached. In case of a tsunami warning or some other emergency, the tanker and structures can be moved.

Conclusions

The objective of this workpackage was to develop a representative scenario and at a conceptual design level, a concept of loading system, which can permit most reliable, environmental friendly and economical operations of loading icebreaking tankers.

The study proves that low cost offshore loading facilities can be developed for Arctic as well. For year round loading of large volumes a number of details must further investigated.

3. ECONOMIC IMPACTS OF TECHNOLOGY ISSUES

Kimmo Juurmaa, Aker Finnyards

Abstract

The evaluation was made using the selected ARCOP scenario, where 15 million tons of oil per year is transported from Varandey 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 and from the data presented at the ARCOP workshop 6, which has been reported in the report D6.6.

The report describes the impact of following factors:

- mode of operation (independent versus assisted)
- direct transportation versus transshipment in Murmansk
- size of the tankers used
- type of the icebreakers used
- type of winter

The results show that there are some interrelations between the factors, but the general tendencies are similar with all of the alternatives. The cost level as such can be within the target that was set at the beginning of the project, so that the actual costs for the transportation are in best cases below the 15 USD per ton. However the difference between the best and worst cases is close to 100%, which equals to 12 USD per ton. In the scenario this is 180 million USD per year and 3.5 billion USD over the expected lifetime of the operation.

The optimum alternative is the use of 120.000 tdw tankers capable to operate independently and sailing directly from Varandey to Rotterdam. Only in case of transhipment in Murmansk it seems that somewhat smaller tankers would be more feasible. Also it seems that the development of the icebreaker technology towards more cost effective solutions can be bring the costs close to the costs of independently operated tankers. It should also be taken into account that this study does not take into account the selected fee policy. If the fee system is as it is today, the overall costs would be double and for the ship-owner the alternative with the icebreaker assistance would be the most feasible one.

Discussion

The performance of the double-acting tanker concept was discussed. In the economical evaluation Mr Juurmaa had found the DAT concept beneficial especially with regard to icebreaking. Some participants questioned the independent operation in the difficult ice conditions often seen at the Pechora Sea. Mr Juurmaa explained, that even though ice ridges are an obstacle, they are a problem also for any vessel, including icebreakers. The calculation method takes into account the calculation of the performance of an icebreaker in ridges. The transportation speed of a DAT and an assisted conventional tanker was taken into account by a certain factor.

The difficulty in the economic analysis of the DAT concept is that in some extreme conditions, the DAT might also need icebreaker assistance. The economic analysis did not consider this possibility, but it was assumed that with the DAT concept, the transport task would only carry the costs of the fairway infrastructure.

The DAT's ability to assist conventional vessels (which has been witnessed at the Baltic Sea) was not taken into consideration in the economic analysis.

The chosen fleet optimisation "boundaries" included fixed freight rate for Murmansk-Rotterdam, 60 cents per barrel. Ship size or type was no considered.

Mr Juurmaa explained the philosophy behind the economic calculations. When optimizing the transhipment, the influence of the winter is relatively bigger than in the case of direct shipment, for in the direct shipment the section Murmansk-Varandey is relatively short. The calculation also aimed to minimize oil in storage, which is why during the summer months June-October the number of chartered vessels was 5,4,3,2,1 respectively. It was commented, that once the investment on the storage capacity has been made, the cost of the storage is the same both when the storage is full or completely empty.

Finstaship was asked to comment the number of icebreakers by the NSR and their annual cost $120 mln. The figure comes from the maintenance and operation of the nuclear powered vessels, which are thus not comparable to the diesel powered ones in Finland. In Finland the overall cost of the icebreaker fleet is 30 mln €.

Mr Juurmaa concluded that the results from the economic evaluation were in the range of what had been expected. Some assumptions in it are pessimistic, for instance having tanker down time of one month every second year. Downtime estimate for the loading system is also quite pessimistic.

The fees, on the other hand, are on the optimistic side. Today the fee only is 16 dollars per ton. Also the insurance costs might be optimistic. These values come from the workpackages of ARCOP.

Conclusions

The marine transportation is a competitive alternative for oil transportation from the Pechora Sea, but the development of the fleet is a complicated problem of optimisation. Along with the decreasing availability of the NSR icebreaker services, the costs of the services have been a key issue when studying the economical efficiency of the NSR transports. A calculation of transportation economics based on the costs analyses of each workpackage reveals that marine transportation of oil can be made cost-effective through optimisation and the difference in costs between an un-optimised transportation system and the most favourable optimised configuration was as high as 50%. The economic analysis ended up with a total cost of 12€ per ton of oil for the route Varandey-Rotterdam.

Direct transportation to Europe can be more cost effective than the use of transhipment, and the researchers encourage the shipping companies to investigate this option as well. Icebreaker technology should be developed further to make the use of icebreakers competitive.

4. NSR ICE INFORMATION SYSTEM – STATE-OF-THE-ART AND VIEWS TOWARDS FUTURE

Risto Jalonen, Helsinki University of Technology

Abstract

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.

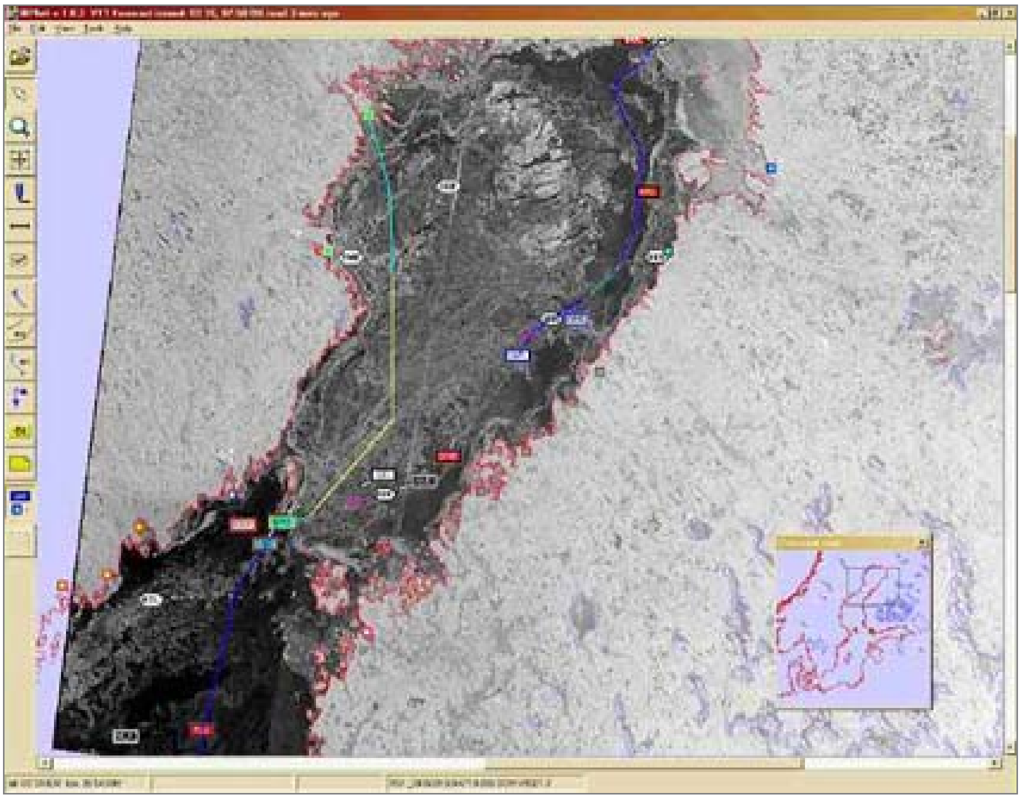
Long experience of Arctic navigation in Russia has proved the importance of ice information and other hydro-meteorological support providing safety and efficiency of sea operations. The currently available ice information system is based on combined processing and analysis of non-homogeneous information 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 onboard 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 hydrometeorological 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.



Screenshot from the routing system software

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 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 will be included in the last deliverable of this workpackage.

Commentary presentation:
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

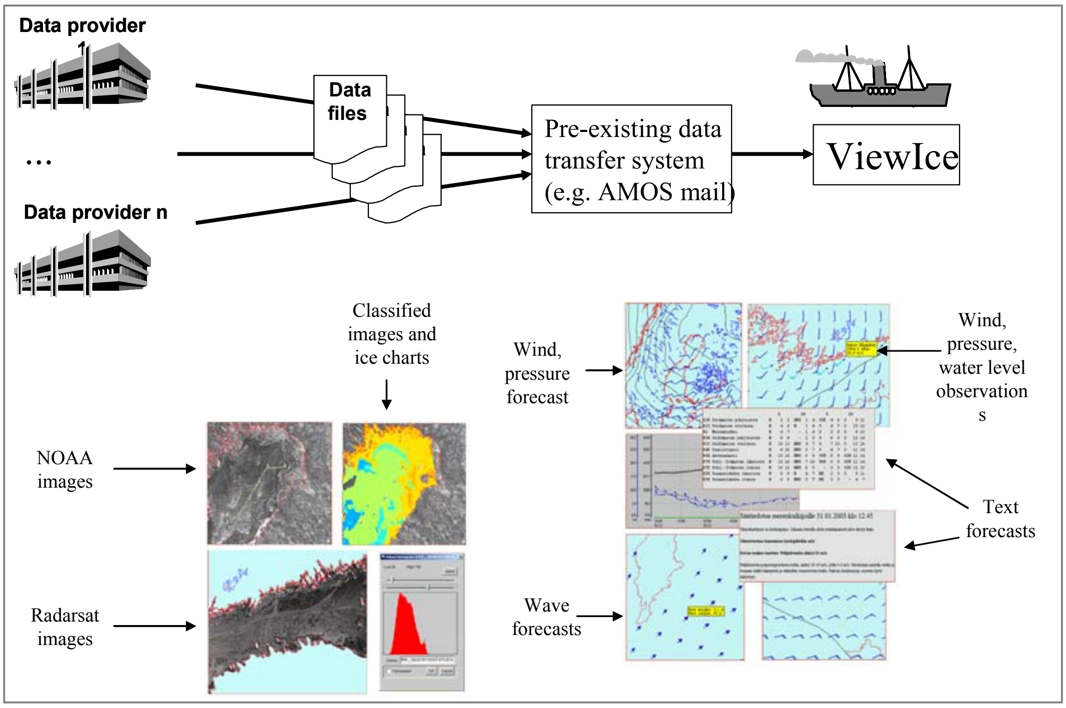
ViewIce functionality

- 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:

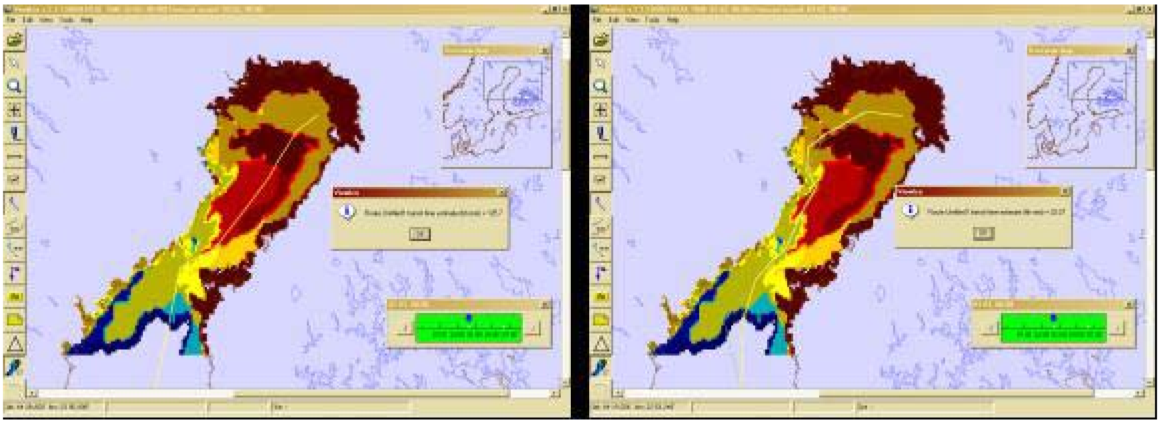


ViewIce in IRIS

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 certain 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, certain 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.

5. VESSEL TRAFFIC AND MANAGEMENT INFORMATION SYSTEM (VTMIS)

Angel Leon, Technical University Hamburg-Harburg

Abstract

A VTS (vessel traffic service) is a service implemented by a competent authority designed to improve the safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and respond to traffic situations developing in the VTS area. A VTMIS (vessel traffic management information system) gathers, evaluates and distributes vessel traffic and waterborne transport data to improve the safety and efficiency of transport and to better protect the environment. There are several operating options for a VTS to be considered for the ARCOP VTS as information service, navigational assistance service, traffic organisation service and co-operation with allied services and adjacent VTS.

The recommendations are based on the recommendations given by IALA in its VTS Manual – 2002 and considering state of the art technologies of VTS Systems.

Discussion

Mr Leon explained that the manufacturers are unwilling in providing cost estimates for their equipment, since the costs depend largely on where the equipment is built, among other reasons.

The possibility to utilise radar networks for ice monitoring was discussed. Mr Leon commented that in this case the radar network was for traffic surveillance only.

Conclusions

The objective of this workpackage was to develop a concept for a wide area VTMIS under the extreme conditions of the Russian Arctic seas.

The study shows that modern technology and the AIS (automatic identification system) open new possibilities for the whole VTMIS concept. In Arctic conditions ice information service and information on icebreaker service are an essential part of the VTMIS.

6. PARTICULARITIES OF ICEBREAKER SUPPORT IN OPERATION OF LARGE-CAPACITY TANKERS AND GAS CARRIERS

Valery Belyashov, Krylov Shipbuilding Research Institute

Abstract

In the recent years the structure of sea cargo flows has been changing both quantitatively and qualitatively. Their volumes quickly grow both on the Baltic, and in the Arctic regions, and, obviously, this tendency will continue. Since 2000 the year-round oil export from Varandey offshore terminal in the Pechora Sea has been carried out, construction of offshore ice-resistant platform Prirazlomnoye is nearing completion. In the coming years the volume of oil export with commissioning of fixed terminal on Varandey, ice-resistant platform on Prirazlomnoye oil field as well as some others can reach 20-25 million tons per year.

Nowadays all Russian shipping companies are actively involved in modernizing tanker fleet and, first of all, with reference to ice conditions of the Baltic, Barents, Kara seas and Sakhalin Island offshore.

The possibilities of transporting liquefied gas from Shtokmanovskoye field in the Barents Sea, from gas fields of Yamal peninsula and the Ob-Yenisei region as well as from Sakhalin Island are also considered.

Oil and liquefied gas transportation requires large-capacity vessels with the width from 30 to 50 m, what significantly exceeds the width of existing icebreakers. The proportional increase in width of icebreakers is economically unprofitable and technically inexpedient. Therefore, there are two alternatives of modern transport system development.

The first one consists in providing high icebreaking qualities directly to cargo vessels. In this case icebreakers will play auxiliary role.

Another one consists in studying possibilities of escorting vessels with significant width by icebreaker of essentially smaller width. In support of studying this approach the Krylov Shipbuilding Research Institute has performed model tests on the order from LUKoil Arctictanker.

According to modern navigation safety requirements transport vessels should have propulsive power sufficient to move with icebreaker escort in specification conditions. This requires knowing ice resistance forces acting on vessels under these conditions.

The report presents comparative analysis results for two variants of large-capacity vessel navigation tactics:

- in the narrow channel behind the icebreaker with additional breaking of the channel edges and
- in parallel to the channel, moving behind the icebreaker,

on the basis of preliminary experimental studies of ice forces affecting the hull, performed in the Krylov Institute's ice test tank.

The obtained materials can serve as a basis for prediction of required propulsive power for large-capacity vessels.

Discussion

The escorting tactics were noted to differ from each other by the performance they require from the assisted vessel. In real life situation all tactics may be used, depending on the ice conditions. Krylov institute is currently working on showing the ways of escorting high tonnage tankers using only one icebreaker. This tactic requires the hull of the tanker to be designed in a proper way. For instance, when using the tactic in which the vessel goes parallel to the broken channel, the hull form should be designed so that it is easy to keep the vessel at the side of the channel without it pushing back to the channel.

In this tactic the icebreaker works as a cutter and disintegrates the ice. Mr Belyashov commented that finding the optimum ratio of the width and breath of tanker has been a subject to debate for a long time. In arctic all possible ways of escorting are be used. The optimum ratio can vary according to the shape of the vessel. But, when travelling parallel to the channel, there's no optimum ratio for the width and breadth. It was noted, that although the problems related to the proportions of a cargo vessel in comparison with the width of the icebreaker is not solved by the parallel to channel movement, it is still the first attempt at this direction.

The hull reinforcements were discussed. In one of the tactics widely used, two assisting icebreakers produce ice floes, and the tanker cuts it with its stem. Mr Belyashov suggested that in case of just one icebreaker escorting the ice floes will be bigger. This would mean, that the loads on the bow would increase and the hull would need more reinforcement. It was commented that actually when moving in a channel behind an icebreaker, the ice floes will be smaller than behind two icebreakers, because they will be destructed by the sectors of the vessels. The floe size also depends on the distances between the vessels. The problem of the strength of the bow part is widely known. The flow of ice pieces from the icebreaker propeller comes with a high speed. The mass of them is not big. In case of a parallel channel the bulb of the tanker should be strong enough. It was noted that the problem is interesting, and there are several opinions considering this.

Conclusions

Arctic navigation contains large variety of ice conditions and operational situations.

The escorting tactics for large tankers, in addition to safety of sail, play a large role also in the economical efficiency of a transportation system. It was concluded, that it was indeed very beneficial to design the cargo and assisting fleet as a versatile system, according to the needs of the transportation task and the local environmental conditions. This requires, that no particular escorting tactic is favoured, but the requirements of all tactics are considered, enabling adaptable escorting.

7. INTEGRATED TRANSPORTATION SYSTEM FOR THE NORTHERN SEA ROUTE: CONCLUDING DISCUSSION

Open discussion

Representatives of Central Marine Research and Design Institute commented the escorting tactics. Mr Tsoy expressed doubt regarding the hull-lines. If the testing has been in ice tank only, then the fracturing of the ice might have been modelled poorly, he said. In natural, strong ice, there are secondary fracturing of ice. The following vessel can be cracking pieces of ice from the side of the channel. This is also the case for the ice-class enforced bulb vessels. In the model experiments, where the sides of the ice are cut, the ice forms a monolith. Wedging of ice between the edge of the channel and the hull of the vessel can occur.

Mr Tsoy continued to say that CNIIMF has got some doubts regarding hull size based on the field experiments that have been ran. The optimum ratio of the vessel and channel has not been found in CNIIMF’s experiments. Concerning the bulbous bows, finding a ratio is even more difficult.

Exxon Mobil organized a field experiment in 2002. The different channel width could be experimented, for there were two icebreakers of a different beam. A narrow channel was cut with one icebreaker with 20m width and a wider channel of 26m with a bigger icebreaker. The widest channel was produced by using two icebreakers. In this case of bulbous bow vessel, the wedging effect could be seen because its bulb part was cylindral. The experiments showed, that it’s inappropriate to use these bulbous bow type tankers in the Arctic. This finding has been put down in the NSR navigation regulations.

Mr Tsoy continued to comment the towing of vessels in severe ice conditions. He said that there is no need for any analytical studies, but the rich navigation experience of mariners shows that in the case when the mass of the towed tanker is a lot bigger than the mass of the icebreaker, then all of the caravan can hardly be controlled. So in a case of a “tandem operation” of a tanker, then the pushing scheme is the only option. A specially fitted stern can be designed for these purposes.

The experience shows that in the case in which some ice hummocks or ice ridges were encountered, the cargo vessel stopped and then the icebreaker could push it. The scheme saves towing time. CNIIMF recommends this practice to the ship owners. CNIIMF also recommends strengthening the stern of the high tonnage tankers and gas carriers so that an icebreaker can help it.

Speaking about power and strength, it's also not always that simple, because for example the Titanic, in open water you can also run into an iceberg. It is clear that when sailing in ice the hull has to be enhanced. The question is, to what extent should the reinforcements be made.

It was noted that there have been a lot of discussion about how expensive the nuclear icebreakers are. The diesel-electric option was discussed. Mr Tsoy commented that it is a topical technical-economical question. The atomic icebreaker is a huge advantage. Their mobility, their autonomous manoeuvrability is sovereign. The atomic icebreaker, after leaving the port, it can work in the arctic full year round without refuelling. And a diesel-electric icebreaker has to refuel every month. It causes losses.

So where is the border between the feasibility of a diesel-electric and atomic icebreaker? Mr Tsoy said that CNIIMF started to study the issue already in the Soviet times. It's more efficient to build diesel-electric icebreakers of size 35 MW. The Taimyr nuclear icebreaker is within these limits. These are the assessments that were made before. Hydrocarbon fuel, diesel fuel is getting more expensive. But respectively the nuclear fuel grows in price because to produce it, you have to consume some energy as well. The topic remains a subject of a specific study.

Chairman Mr Mustamäki commented that now that the route can be optimised, loading in ice conditions is possible, optimising tanker-icebreaker combinations is sorted out and we can optimise the transport economically. We have cargo vessels in building. The question is, do we have enough icebreakers?

Mr Tsoy replied that there are enough icebreakers for today. But everybody knows that some of the icebreakers are outdated. Russia is solving these issues at the state level and constructing new-generation icebreakers, and also the number of needed icebreakers. We will prepare such a report and be ready to present it in the next workshop.

Project Coordinator's comments

Project-coordinator Juurmaa noted that when listening to the discussions of these last topics, one could feel that we are at the beginning of a project and not at the end of one. He reviewed the day's presentations in short.

The presentation by Finstaship described how the icebreaker fleet has been organized in Finland today. This is really something quite interesting that in this way Finstaship actually starts creating an international market for icebreaking and icebreakers. Unfortunately the Russian partners did not comment whether this is something that could happen in Russia. Already some oil companies have started building their own icebreakers for their own operations. This may lead to the creation of a privately owned icebreaker company.

The second topic of today was dealing with the loading facilities. The work that has been done and reported by Tecnomare, quite well fulfils the needs. If there is something still to be done, it relates to the downtime analyzes and how those impact on the economics.

The third presentation was about economic tools and economic calculations of these overall transportation costs. Certainly, that is a complicated task to optimize the whole transportation system, and there is still a lot of work to be done. The situation, which is being created in the arctic is something that has never been created anywhere in the world. There will be a lot of big vessels operating in very difficult conditions. That means that when doing these analyzes, one has to make a lot of assumptions on where the development is leading. There should be a system where experience from the first transportation systems could collected. This has been attempted at the Baltic conditions where automatic identification systems have been utilized. That system will just record the movement, and a lot of different analyzes can be made and a lot of statistics can be created. This kind of data collection could be a topic for future cooperation.

Project coordinator commented next on the work regarding ice information systems for the NSR. The group has worked quite efficiently, but some kind of cost-efficiency analyzes are still lacking. And also there the data collection and collecting experiences from the first transportation systems that have been created would be important. This also relates to the next presentation, which was about the Vessel Traffic Management System, VTMIS. The basic ideas on how this system should be constructed, are well structured but how to realize this to practice is still an open question.

The last presentation is a really interesting topic. The different assisting tactics have been looked into, which is a good sign. This is something that really will be changed when cargo vessels will grow in size and icebreakers will still be relatively much smaller in size. There will be a lot of work to be done.

8. PRESENT STATUS OF ENVIRONMENTAL PROTECTION IN THE NORTH

Gennady Matishov, Murmansk Marine Biological Institute

Abstract

The presentation describes the current status of environmental studies and monitoring in the Barents Sea region. It also reviews some of the topical issues of environmental protection in the area.

The Barents Sea is facing the changes caused by the expanding human activities in the region. Over-fishing, increasing sea transportation of hydrocarbons, alien species, radioactive waste among many other problems, threaten the sea.

The scientists hope, that the environmental monitoring routines could be strengthened to receive more information of the current status and thus be more prepared for accidents.

Conclusions

There is a lot of data available regarding the status of the environment, especially the Barents region. Continuous monitoring of the changing situation of the Barents environment and transportation activities was considered essential.

9. TRAINING FOR ARCTIC NAVIGATION

Bob Derks, Wagenborg Shipping

Abstract

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.

		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

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**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

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**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*

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.

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

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

Commentary presentation:

ICE NAVIGATION TRAINING FOR PILOTS AND DECK OFFICERS AT ADMIRAL MAKAROV STATE MARITIME ACADEMY

Vladimir Kuzmin, Admiral Makarov State Maritime Academy

Since 1996 shipping companies train their Masters and Deck Officers using full mission bridge simulator “Navi-Trainer Pro 4000” which is integrated with GMDSS simulator and VTMIS training complex. Visualization system uses 57 ship models and 65 sailing areas including approaches and ports of Primorsk, Vysotsk, St. Petersburg, Vladivostok and many others. At the end of March, 2003 Ice navigation module was installed – new training program was started - ice passage to the port of Primorsk.

This module was thoroughly tested and approved by the Representatives of Russian Maritime Administration on 17th of April 2003.

Makarov Training Centre developed training program for Ice Navigation in cooperation with Saint-Petersburg Pilots, Primorsk Pilots, Ice Masters from Harbour fleet of St. Petersburg and Murmansk Shipping Company. Instructors of Makarov Training Centre have good experience in ice navigation.

Since then Ice Model was significantly improved.

- Ice Field is entered from the Instructor Station as a polygonal zone with properties. Maximum quantity of these zones is technically not limited and depends on hardware capabilities.
- The zone properties could be adjusted both before and during scenario run. Changing the zone properties during the scenario run allows simulating changing of the weather conditions affecting ice navigation conditions.
- Ice Fields could overlap. Ship model will be affected by both fields when sailing within zones of overlap.
- Concentration of the broken ice in the channel is visually represented by means of dynamic texture changing
- Concentration of the broken ice in the channel increases linearly from an initial value (specified in the properties) to the maximum (100%).
- Thickness of the broken ice in the channel is equal to the thickness of an initial ice field.
- “Crosspiece” parameter specifies the widest ice field that would be broken between two moving icebreakers.
- Thickness of the broken ice in the channel is equal to the thickness of an initial ice field.
- “Crosspiece” is visually represented by a polygon with a specific photorealistic texture.
- “Freezing” parameter specifies the time (in minutes) that takes broken ice to get maximum concentration (become solid) in the channel
- “Compacting” parameter specifies the speed (cm/sec.) of the ice channel closing from its edges.
- Ice channels could be made by multiple ice breaking models.

- Ice channels can have any configurations including interactions with each other and self-interactions.
- Interaction between a ship and a solid ice edge (channel effect) has been adjusted in accordance to the recommendations of the experienced ice navigating seafarers.

Ice model includes changeable ice conditions, various types of ice: ice fields, fast ice, ice belt, brash ice, broken ice, broken ice. Ice thickness could be changed from 0,1 to 2 meters.

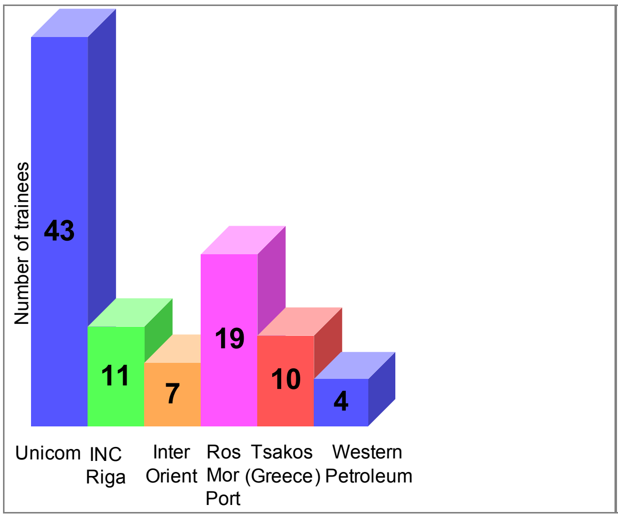
All types of ice are visually represented on the screens. During exercise trainees could observe impact of ice conditions on manoeuvring characteristics of the ship and ship - ice interaction.

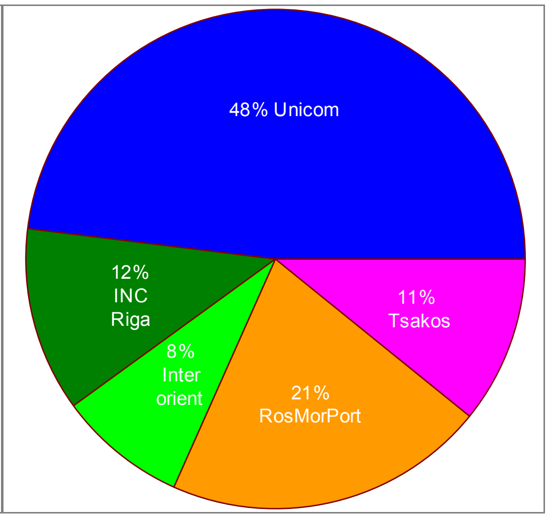
Ice navigation training on the integrated simulators complex allows imitating any operations and mistakes (which is impossible in case of training on board the ship), to develop the skills of ice navigations. In exercises 150,000 t and 72,000 t models of oil tankers are used.

Initially this course was started as a short goal-based course - Ice Navigation to the port of Primorsk - according to Unicom request. Later on, some other companies requested extended course, and now one-week course of Ice Navigation, including both Primorsk and Vysotsk areas are available. The training is offered both in the English and Russian languages. The course consists of theory classes combined with practical exercises using the simulator. All exercises include bridge watch keeping during unassisted passage of tanker in ice, entering an ice area, passage with icebreaker assistance. Convoy passage and ice passage in broken ice, manoeuvring in ice channel, rudder and engine operations, safe port operations procedures in low temperatures. To make course more realistic, senior pilots from Primorsk are involved in the training program.

On May, 2003 3 groups of Unicom Deck Officers were scheduled for simulator training on ice passage to the port of Primorsk

Since then, 92 deck officers had been trained from different companies.





Number and distribution of ice simulator trainees

Nowadays, further development of the ice navigation program is planned. In late February simulator software is to be upgraded. Only for last 9 months 57 deck officers and masters were trained at Admiral Makarov State Maritime Academy. Several more courses are already scheduled. And we are ready to provide company specific training courses upon request.

Discussion

Mr Kuzmin was asked to comment on the use of mathematical models in the simulation. He explained that AMSMA did not make the actual models. The models were developed by a company called Transas. AMSMA has focused on the training part and has only participated in the ice conditions modelling.

He explained that the simulator developers are continuously planning upgrades, e.g. a version including hummocks, which would be installed in the next version.

The director of the training centre described the training concept the partners have developed. It is based on three parts: training program and the methodics, the simulator and the equipment and the mathematic models regarding the ice conditions' impact on the ships. The first is the business of AMSMA. The board of the Academy is developing the courses according to the requests from industries, Ministry of Transport and shipping companies.

Transas is the main provider for the training instruments. Ship models were previously developed by a company called Navis. The Academy has recently started to develop their own ship mathematical models. Transas is also the main contractor in ice-mathematical modelling. Transas is working with AARI and CNIIMF. The model contents and features are developed in cooperation between AMSMA and Sovcomflot. The training model is a combination of these three.

It was commented that a model can always be provided with the actual performance of a vessel, so that the model requirements are not an issue. In reality, accidents often happen in dense traffic situations. It would be useful to model different kind of situations, such different modes of assisting large tankers in ice conditions.

AMSMA was recommended to visit ice tanks, which would bring new realistic touch to the simulation training. Also emergency situations in which rudders and other equipment is not working, was hoped to be included in the training.

Conclusions

The aim of the work was to produce recommendations for specialised training program for navigation in ice in general and in particular for the Arctic transportation system.

The ARCOP experts and stakeholders remain worried about the state of the ice navigation training, but were pleased to note the advanced cooperation between Admiral Makarov State Maritime Academy AMSMA and the oil companies in developing route specific ice training. AMSMA's efforts in developing ice-training simulations were discussed and it was concluded, that the existing experience of AMSMA should be utilised in formulating the training requirements for Arctic Navigation.

10. ENVIRONMENTAL RISKS ASSESSMENT FOR ARCTIC SHIPPING

Odd Willy Brude, Det Norske Veritas

Abstract

Environmental Risk Assessment is about integrating probability of accidental events and the possible environmental consequences of this event. Events dealt with are serious oil spills from tanker traffic and accidental frequencies have been calculated based upon tanker traffic intensity in 2003, and prognoses for the years 2012 and 2020.

Environmental consequences

Two overall criterias has been considered for 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), seabirds, seals and walruses may be significantly affected.
- Ecological significance; this means that effort has been placed on the most important resources, e.g. large populations of fish, seabirds, seals etc. Resources of minor ecological importance are not compiled

Source data has been documented in the Environmental Atlas (D.4.1.3.1)

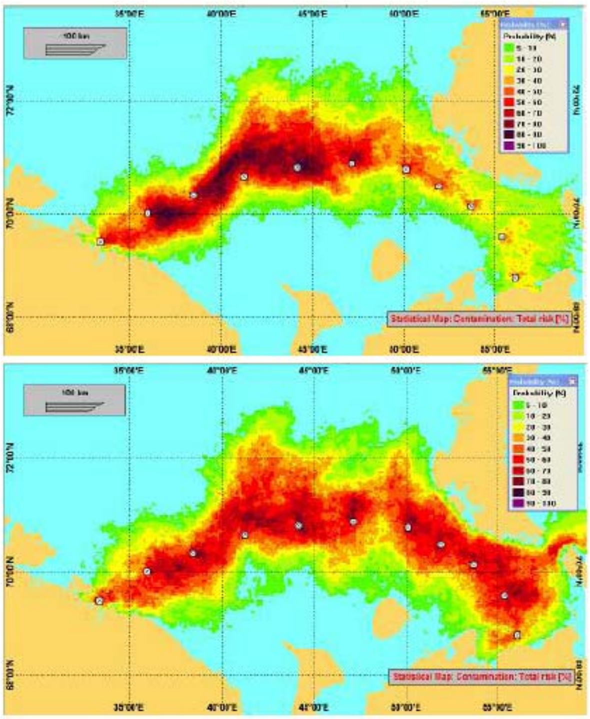
Regarding the vulnerability assessment, specific vulnerability to oil pollution has been given a factor value 1-3 together with an assessment of the significance of areas related to various species/stocks (also factor value 1-3). The vulnerability index has been calculated for each ecological species group like seabirds, marine mammals, fish eggs/larvae, benthos and shoreline.

Each group will have a seasonal score of 0-9 giving a max sensitivity index value of 36 in a given season.

The sensitivity index is presented for each season.

The risk assessment has been conducted by combining the accidental frequency with the sensitivity index and also taking into account the spread of an oil spill. Within workpackage 4, SINTEF has modelled the simulation of drift and spreading of the oil in open and ice infested water at different spill sites:

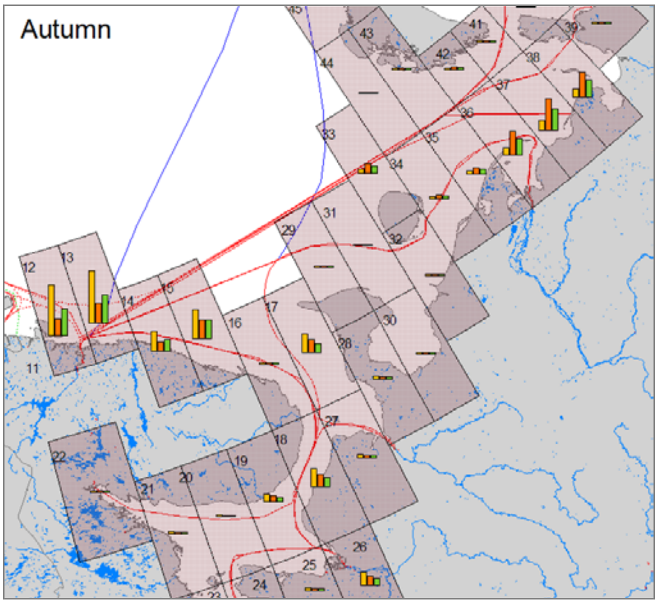
- Western spill site: Murmansk Fjord; E 33º 24’ 00”, N 69 º 27’ 00”
- Eastern spill site: Pechora sea; E 53 º 41’ 30”, N 70 º 07’ 30”
- Possible tanker route (11 spill sites)



The modelling has been performed with a release of 10 000 m3 crude oil (Troll oil), released over a 10 hour period for two seasons; spring (March, April and May) and autumn (August, September and October). Each statistical simulation includes three oil drift scenarios per year in the period covered by the hind cast wind data set (23 years), i.e. a total of 69 oil drift scenarios (3 per year in 23 years).

The overall risk index has further been calculated by multiplying the following parameters:

Risk index = accidental frequency * sensitivity index * contamination probability (oil drift)



Risk values indicate that the risk in the eastern part of the Barents Sea and in the Pechora sea are of order a magnitude less than the risk from Murmansk along the Norwegian coast.

Low risk index values may be explained by

- Limited traffic
- Limited exposure during periods of ice cover
- Apparently lower resource index values
- Regime with icebreaker assistance

Main concerns regarding the environment in future operation in ice infested waters are mostly aimed towards tankers without icebreaker assistance and the balance between

- Regularity vs. security and economical demands
- Speed vs. Ice conditions

Important risk reducing measures in this context would include

- Ship specific issues (icebreaking abilities, double acting tankers, propellers)
- Oil spill response
- Ice monitoring and forecast

Discussion

The Russian experts inquired, what kind of data had been utilized to define oil spill risks for the Barents Sea, for damage data for the NSR has not been available. Mr Brude explained that experiences from the Canadian Arctic have been used, although some presentations during ARCOP have shown that the accident risk at the Barents Sea would be considerably lower. Some assumptions on the risk levels have also been made. All these information is documented in the reports regarding the environmental risk assessment.

Mr Brude commented that icebreakers are an important factor when discussing the environmental risks at the Barents Sea. In the absence of an icebreaker the risks are higher. Contingency is important even though the risk values are low, especially when there are vessels without icebreakers.

Mr Brude was asked whether the terminals in the Barents Sea had been included in the study. He explained, that only the transportation phase was considered, and not terminals. He admitted, that the risk at the terminals would be much higher. He continued to say that terminal activities have also not been included in the traffic frequency estimates. For instance, the Snohvit field platform maintenance transports have not been considered, but only cargo transport from the platform. Also the spill that might occur in the production of oil has not been considered. It was commented that there is an ongoing integrated project to study the impacts of petroleum industry, transport and fishing on the environment. This work will be completed soon.

Conclusions

In this workpackage, the ARCOP experts have assessed environmental damage risks. Impact significance has been be assessed qualitatively and quantitatively, and ranked with regard to geographical areas and periods of time. The study has focused on the sea part of the transportation, excluding terminal operations.

It was recommended that in the future, the risk related to presence of terminals would be studied, for the terminals are points where activities are accumulated.

The risks related to the presence of ice should be studied more in detail.

11. BIOLOGICAL DEGRADATION OF CRUDE OIL IN ARCTIC SEA-ICE

Birte Gerdes and Gerhard Dieckmann, Alfred-Wegener-Institute (AWI)

Abstract

The sea transportation of Arctic oil and gas from the Pechora and Kara Sea region will increase the risk of oil spills in ice-covered regions of the Northern Sea Route (NSR). The alternative oil spill response method of the bioremediation technique is a sensitive method appropriate for the highly vulnerable sea-ice ecosystem. Bioremediation is the acceleration of the natural degradation process of a contaminant such as crude oil, through the stimulation of the indigenous microbial population by the addition of fertilizers and through the addition of exogenous microbes. Nutrients such as nitrogen (N) and phosphorus (P) are essential for the respiration and conversion of hydrocarbons into bacterial biomass. Former studies showed that the addition of fertilizers increased the degradation process significantly even in cold environments. In Arctic seas, nitrogen and phosphorus are, however, often limiting factors.

Oil degradation test site at Svalbard

The bioremediation experiments were carried out in the laboratory as well as in the field to expedite biological degradation of crude oil in sea-ice and melt water pools on sea-ice surface to develop and improve the bioremediation technology. The impact of crude oil on changes of bacterial communities in Arctic and Antarctic sea-ice and melt water pools was investigated using the molecular method DGGE (Denaturing Gradient Gel Electrophoresis). In the bioremediation experiments, the natural degradation of oil by autochthonous sea-ice bacteria was stimulated through the addition of different fertilizers. Two different organic fertilizers were tested, Inipol and fishmeal, as well as inorganic nutrients under natural sea ice conditions and in the laboratory. More than 500 oil-degrading bacteria of 15 different genera were isolated from bioremediation experiments and 26 representative isolates were studied for their potential to degrade hydrocarbons at different temperatures. A consortium of hydrocarbon-degrading cold-adapted sea-ice bacteria was prepared and tested for the application of effective bio augmentation in the field. Degradation of hydrocarbons was determined by oil analysis using GC/MS to assess the effectiveness of the bioremediation technique.

Molecular and cultivation methods revealed a strong shift in community composition toward the g-proteobacteria and gram-positive bacteria in sea-ice and melt pool samples with crude oil. *Shewanella* spp., *Pseudomonas* spp., *Pseudoaleromonas* spp. and *Marinobacter* spp. were the predominant phylotypes of the g-proteobacteria and *Dietzia* spp. and *Rhodococcus* spp. of the gram-positive bacteria in the oil-treated experiments. Oil analysis revealed that in the experiments with sea-ice, incubated at -3°C, no significant degradation of oil hydrocarbons occurred. Whereas the experiments with sea-ice melt water, incubated at 0°C, showed significant degradation through bioremediation treatments. Melt pool samples fertilized with inorganic nutrients showed a significant biodegradation of n-alkanes. In the nutrient fertilized samples, which were also inoculated with hydrocarbon-degrading bacteria, n-alkanes up to a chain length of C27 were completely degraded. Branched alkanes where also biodegraded while hydrocarbons in the control with oil only were not degraded.

It appears that biodegradation of oil hydrocarbons comes to a halt at temperatures below freezing. However, when temperatures rise above 0°C and melt water pools begin to develop bioremediation could be applied as a sensitive alternative oil spill response method. Future bioprospection and the culturing of more specific PAH-degrading cold-adapted bacteria should improve the prospects of oil remediation in sea ice.

Discussion

Dr Gerdes was asked about the rate and speed of the biodegradation. She responded that to give some absolute quantitative figure would be impossible. This is why the ratios are used. There are always compounds that are not degradated so then it is possible to compare the degradated and not degradated and assess the overall success of the degradation process.

Conclusions

The aim of the work was to study the practicability of the technologies based on the application of reproducing hydrocarbon-degrading (also genetically altered) bacteria under nutrient supply (specifically to stimulate the autochthonous sea ice microbial communities) in oil spill combat.

It appears that biodegradation of oil hydrocarbons comes to a halt at temperatures below freezing. However, when temperatures rise above 0°C and melt water pools begin to develop, bioremediation could be applied as a sensitive alternative oil spill response method.

Future bioprospection and the culturing of more specific PAH-degrading cold-adapted bacteria should improve the prospects of oil remediation in sea ice.

12. AN EXPERIMENTAL STUDY OF THE EFFECTS OF STATFJORD CRUDE OIL, AND APPLICATION OF INIPOL AND FISH MEAL ON THE SEA ICE BIOTA IN SVALBARD IN FEBRUARY-APRIL 2004

Johanna Ikävalko, Finnish Institute of Marine Research

Abstract

For the study of crude oil and nutrient addition effects on arctic sea ice biota, a field experiment was carried out in Van Mijenfjorden, Svalbard, during 22.2. -25.4.2004. During the 63 day long experiment, three different compounds (Statfjord crude oil, Inipol and fish meal) were added in different combinations onto snow-free sea ice surface. In February the sea ice biota consisted solely of diatoms. In the end of the experiment the natural sea ice community consisted of both diatoms and euglenid flagellates (abundance ≤3400 cells 100 ml^{-1} melted sea ice). The treatment with oil only, oil+Inipol, and oil+fish meal lead to a general decrease in protist diversity and abundance. The most dramatic decrease in the abundance of all protists was caused by the addition of oil only, and throughout the ice cover, while the addition of oil+Inipol, and oil+fish meal lead to the disappearance of all other protist groups than diatoms. The negative effects of Inipol and fishmeal were most severe in the ice surface, while the interior and the bottom parts of the ice cover were less impacted by the treatments. Heterotrophic flagellates seemed to be able to migrate downward from the ice surface when only oil was added onto the ice. Also, the use of oil only, and oil+Inipol induced the formation of diatom resting spores. In control samples, the addition of fishmeal only caused a notable increase of heterotrophic flagellates (≤25 000 cells 100 ml^{-1} melted ice).

Discussion

The vulnerability of different types of microorganisms was discussed. Dr Ikävalko explained that in a case of an oil spill in ice the microalgae would suffer first. But there are differences in the vulnerability between the groups of biota as well. The ones that are not vulnerable are the ones that can protect themselves. Flagellates can move and the ones that have a thick cell wall, like diatoms, can protect themselves from the harmful substances. Those, that form resting stages, can survive through difficult times in inhospitable environment.

Conclusions

Arctic sea ice is inhabited by a highly diverse community of unicellular and invertebrate organisms. The occurrence and e.g. nutrition of these organisms depend on the presence of ice and the physical and biological processes associated to it.

The impact of oil on sea ice communities varies according to the organism in question. Some die, some form resting stages and some migrate away from the contaminated area. The impacts remain local, especially if the ice cover does not melt. It is presumed, that melting periods intensify oil degradation processes and impacts on sea ice organisms.

The effects of an oil accident on Arctic sea organisms depend on the species and their development stage, the season of the year and the intensity of the exposure. The impacts on an individual-, population-, and even on a community level can be very dramatic, and sometimes it is not even possible for the community to return to the state it was in prior to the accident. On the other hand, in a larger, ocean scale, the impacts can still to some extent be considered local.

13. WEATHERING OF OILS AT OPEN SEA AND IN ICE-INFESTED WATERS

Ivar Singsaas, SINTEF Materials and Chemistry, Marine Environmental Technology

Abstract

Sea transportation of oil and gas products from the Pechora and Kara Seas region as well as oil/gas exploration in arctic waters will increase the risk of oil spills in this highly vulnerable environment.

The general fate and weathering of oils spilled in open/ice-infested waters have been described in a "state-of-the-art" study. This study also reveals eventual needs to perform (at a later phase) a more specific oil weathering study according to standardized methodology on relevant types of oil in connection to the planned transportation from the Pechora Sea and Kara Sea region, (including both crude oils produced in the area and representative heavy bunker fuel oils (HFOs) used by the shipping industry). Reliable documentation of the oil weathering properties is of fundamental input for doing reliable Environmental Impact Assessment (EIA), Environmental risk Assessment (ERA) and response analysis of oil spill scenarios.

This presentation gives an overview of the methodology developed at SINTEF for oil weathering studies. It focuses on the difference in weathering degree between open waters and ice-infested waters, showing some examples from experiments performed in Norway. It also focuses on the need to perform weathering studies on Russian crude oils and oil products, seen from a Norwegian perspective connected to the oil shipment along the Norwegian coasts.

Discussion

Mr Singsaas noted, that there had been hopes of building a database containing information on oil types and their weathering properties. It was commented, that such a database would be an unfeasible task for oils are often mixes of different types of oil. There is pure oil from certain sources like Prirazlomnoye but all other exports are mixtures. Useful information would include sulphur content, viscosity, density and other characteristics. Mr Singsaas commented, that though oil is often a mix, mixes are often stable in their qualities. This might be the case for Varandey oil. It should be quite stable, as well as oil from Kolguev Island and other offshore fields should be.

Conclusions

The objective of the study was to study the present status of weathering properties of oil types spilled in open/ice-infested waters, and to identify needs for eventual specific laboratory studies to generate more relevant weathering data on the specific oils transported.

The monitoring and forecasting of the qualities of the transported oil or oil mixes were considered essential. The generally unfavourable conditions of the Arctic seas and the oil weathering processes make oil spill preparedness measures and short response times decisive.

14. OIL SPILL COUNTERMEASURES

Karl-Ulrich Evers, Hamburgische Schiffbau-Versuchsanstalt GmbH

Abstract

The future increase of sea transportation of oil and gas products from the Barents Sea, Pechora Sea and Kara Sea region to western Europe as well as oil/gas exploration in arctic waters is associated with an increase of risk of oil spills in this highly vulnerable environment. To be prepared for oil spill response in remote areas, vessels, oil recovery device, and oil combat techniques are required. Oil spill response systems and methods used in open water (vessels, skimmer, booms, dispersants, etc.) are in general state-of-the-art, however not always successful applicable in ice covered water.

Oil spill response in Arctic regions is much more complex than in open water, consequently there is a challenge for improvement of existing device and development of new systems and combat methods. Four main important subjects with respect to oil spill countermeasures in ice-covered waters are considered: mechanical recovery, *in-situ* burning, use of dispersants and bio-remediation.

Discussion

Ranking the oil spill response methods was discussed. It was noted that the efficiency of a response method depends on the type and the size of the spill. In each situation one has to consider which measures might be effective in the given situation. For instance in a case of a larger spill a mechanical response is not possible. Then you have the possibility to consider burning. But when the spill occurs near to terminal, burning is not a possibility. So ranking methods is not possible, but rather all methods should be taken into account and decide according to situation.

Krylov institute suggested the use of a separation method. In this method an assisting vessel can make a channel to localise the spill and then prepare favourable conditions to a known method. Mr Evers commented that ice management is indeed often used. The oil is pushed and separated with a boom. After these preparations are made, a skimmer can be used.

It was noted that if only mechanical methods were used, the Lamor arctic skimmer seems quite efficient, even though it is very small and limited. CNIIMF experts commented that CNIIMF has tested the arctic skimmer and recommended it for all Russian ports, for it is the only product that works efficiently in broken ice.

Conclusions

The objective of the study was to perform quantitative scenario-based Oil Spill Response by the use of modern numerical model tools.

Oil spill contingency plans should consider all methods of response (in-situ burning, bioremediation, mechanical methods). There is still no proven technology for large-scale mechanical oil recovery.

It is proposed to make efforts on new design and further development of existing open water recovery systems to make them usable also for conditions in cold environment. More laboratory and field tests of oil spill response equipment under real conditions are necessary to optimize the functionality and efficiency. Icebreaking multi-purpose vessels with oil combat capabilities should be provided at oil loading terminals, in harbours and along main shipping routes in order to be in short time at the spill site. Training programmes and exercises under realistic conditions should be performed in order to keep the tanker crew and contingency personnel skilled. The balance of economy and ecology must be carefully considered when doing any environmental control and protection measures in the Arctic.

15. FORECASTING THE PROPERTIES AND BEHAVIOR OF OIL IN ARCTIC WATERS

Mikhail Grigoriev, Gecon Ltd.

Abstract

The forecast of transport streams of oil and oil products through the territory of Northwest of Russia - shelves of the Barents and Baltic seas - should be considered in the general context of schemes of transportation of the Russian hydrocarbons to the foreign markets.

Prompt growth of an oil production in Russia in 2000-2004 was replaced by a one-year period of stagnation, which proceeds now.

Growth of extraction has enabled the development of transport export capacities, and the greatest growth has occurred in northwest of Russia, mainly, due to development of the Baltic pipeline system and the terminal in Primorsk. This scheme allows the exporting of about 60 million tons of oil per year.

In 2004 91 % of the export of oil and products on the shores of Barents and Baltic seas (160 mln t. including IMP&EXP flows in Finland)) was concentrated at the Baltic Sea ports (42 % on through the Russian ports). The share of the Barents Sea was 9 % of the freight traffic.

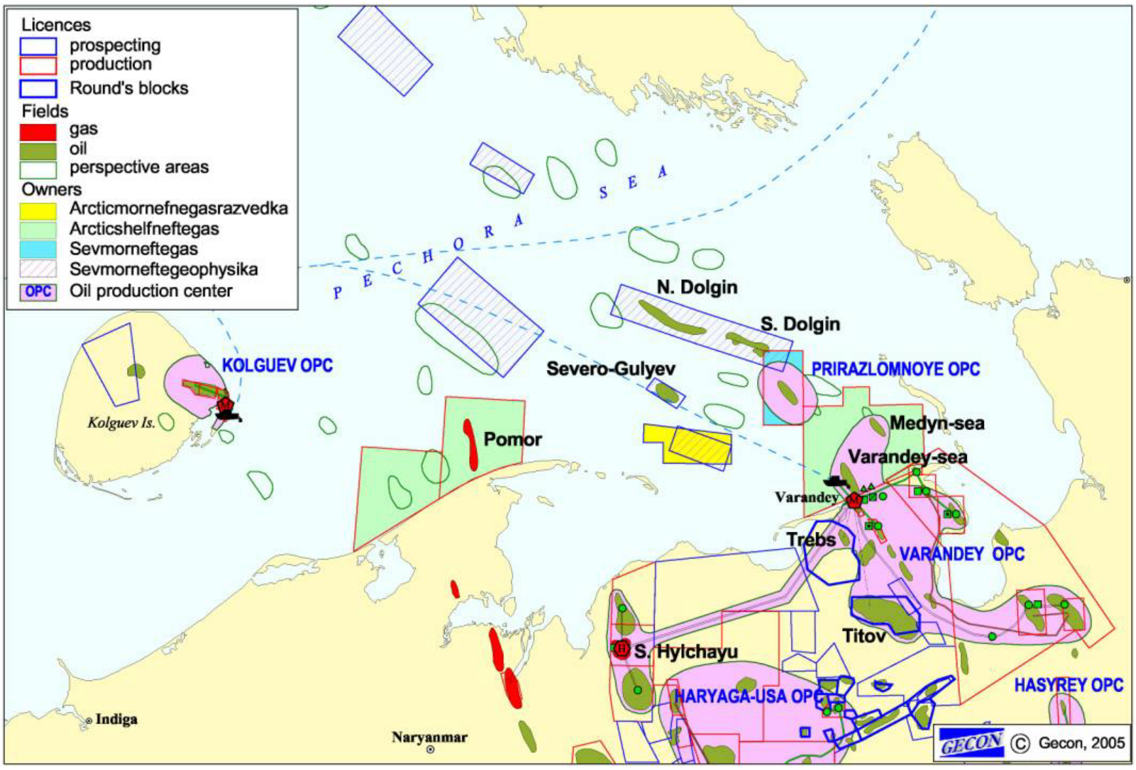
The development of the export of oil and products through the ports Barents sea (Arkhangelsk, Murmansk) provides not only a growing oil production in the Arctic regions, but also relieves the pipeline capacity deficiencies in the central regions of Russia.

Currently the turnover of goods at the Murmansk transport hub includes the following cargo streams:

- from Volga region by railroad directly to Kola and Murmansk
- mainly from Volga region by railroad to station Beloe More (White Sea) with reloading in Vitino for the shuttle tankers for Murmansk BOB terminal
- mainly from Timan-Pechora by railroad to Archangelsk with reloading for the shuttle tankers for Murmansk BOB terminal or exported directly
- from Varandey and Kolguyev sea terminals
- from Numgi (West Siberia) river-sea terminal

Development of the future transportation includes the strengthening of the current streams and the new routes (Prirazlomnoye, Medyn-Varandey offshore etc.).

In connection with the rise of the oil prices, the tax of production and the export duty have lowered the efficiency of export of oil by rail with reloading through the port terminals. During the second half of the year the volume of oil export by rail has catastrophically fallen (a similar situation has developed at some Baltic sea terminals as well). Now it is more favorable for oil companies to export oil products or gas condensate. The higher price of the products and condensate provide a comprehensible level of profitableness for railway export schemes. The change is reflected in the change of the structure of the freight traffic through seaports.



Licences and producing fields and their owners in the Varandey area, Russia.

At the same time, the traffic of oil on Northern Sea Route (NSR) grows. It is connected with the development of the utilisation of the deposits at coast of the Arctic seas. Sea transport is the only possible form of export for these regions (Varandey, Kolguyev, Ob River).

It is necessary to emphasize, that the NSR development is not a separate aim by itself, but it enables the hydrocarbon field development projects in the Russian and Norwegian arctic not having access to the major pipeline systems. Its core is to provide an arena for the oil and gas business development.

Conclusions

The report focuses to discuss the possibilities to forecasting transport streams of oil and oil products through the territory of Northwest of Russia.

It seems possible to predict the quality of oil mixtures loaded in different terminals but continuous monitoring is needed. It is expedient to consider the Arctic oil transport channels not only within the limits of formally allocated NSR (to the east from Vaigach Island), but in a wider sense: within the limits of all transport schemes from the mouths of the rivers Ob and Yenisei in the east up to the Northern sea in the West. These together form a line of transportation for both Russian and Norwegian oil, gas condensate and LNG on their way to the markets of Europe and the USA.

16. OIL SPILL RESPONSE ANALYSIS FOR THE VARANDEY – MURMANSK TANKER ROUTE

Øistein Johansen, SINTEF Marine Environmental Technology

Abstract

This presentation deals with simulations of oil drift and oil spill response for possible spills from tanker transport from the 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 hind cast 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 cannot 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 hind cast 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 hind cast 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 hind cast 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.

Discussion

It was commented, that it would have been very useful to simulate the spreading of oil in ice conditions. It was also noted that before drawing conclusions it would be better to make a rehearsal regarding the response possibilities. Modelling is not useful, for there are too many uncertainties. Mr Johansen replied that simulations regarding spreading in ice without oil spill combating have been carried out and this could be used as a kind of worst-case scenario. Weather conditions were also included in the simulations for the recovery techniques etc. depend on the weather.

If one wants to study the fate of oil in a longer run, it is possible to simulate a longer period of time during which the ice melts. While the oil is in ice, the tracking is easy but if you continue beyond ice melting, the situation will be more complicated. Mr Johansen continued to say that the model has mainly been used for making virtual analysis, but recently Norwegian oil companies have been helped to make their response plans as well.

The oil companies abilities for independent action in responding to oil spill situation was discussed and doubted.

The worst case of oil spreading understandably occurs in open water situation. Oil companies are interested in the most dangerous scenario. Currents should be taken into consideration, and not bottom currents but surface currents, in the area of consideration. Mr Johansen commented, that his worst-case scenario selection was the one, which carried most oil to shore. The model uses background current along with winds. The simulation period was chosen to be 30 days, for after 30 days there normally is only minor amounts of oil left in the water. In ice, on the other hand, the situation is very different.

It was also commented that work regarding oil drift simulations was done in cooperation with AARI, who prepared a similar analysis.

Conclusions

This study uses the OSCAR 2000 Model System to generate quantitative information (mass-balances, exposure areas etc.) of alternative spill response strategies for the relevant spill scenarios.

The two different methods (AARI's and SINTEF's) used for oil drift simulations gave more or less similar results. As a conclusion, the researchers note that short response time seems to be more important than high recovery capacity for near shore spills.

17. SAFETY OF ARCTIC SHIPPING: CONCLUDING DISCUSSION

Open discussion

Project coordinator Juurmaa commented that training centre AMSMA presented interesting information about their capabilities. Wagenborg commented, that with the help of CNIIMF the new information could be reflected in the final report.

Meriturva commented that the features that were presented by AMSMA, are still a prototype, and have not been launched commercially. These features were also listed in the report of 3.7. The features are certainly a welcomed addition to the current simulators. In any case the practical application of the software has both are weaknesses and strengths in it. Convoy operations are already modelled and we are capable to train those with simple ice model.

It was noted, that since AMSMA has an active training program, the final report should describe the experience the Academy has from their clients. The report should include comments from the oil companies and shipping companies, which have used the AMSMA services.

Also some more doubtful comments were heard. Specialists cannot sort out clear understanding on which mathematical model for movement of level ice is the best. Adjusted models bring errors when we use new hull lines. Model tests are necessary when defining the correct formula model. The training centres should also be interested in different scenarios: oil loading, approaching terminals etc. These kinds of simulations are of need.

The environmental risk assessment was discussed. It was noted that only very little information on ice damages exists. The statistical data is quite limited. CNIIMF has been active in this field, and Helsinki University of Technology and also Technical Research Centre of Finland have been active at the Baltic. Developing a solid database is something that needs to be done in the future.

It was reminded that the number of traffic has decreased. The database should be updated constantly.

IMO Marine Environment Protection Committee, by the request of Russia, has assigned a risk assessment study. The study will include response methods as well. A draft plan will be completed by 3/06. In IMO there are not many participants dealing with transportation in ice infested areas. ARCOP program could also bring something in to this work as well.

Comments regarding the oil spill response analysis were given. It was commented that ARCOP is considering Russian areas and transport inside Russian borders and thus response and preparedness recommendations should comply with the Russian norms. Modelling of oil spill behaviour like stranding or spreading have not been recognized by the national authorities. These results developed in ARCOP could however be utilized in the Russia legal documents in the future.

Project Coordinator’s comments

The second day of the workshop consistsed of three main topics. First we learned about training and possibilities to minimize the risk of a human error. It seems that the importance of training has been recognized both by authorities and private ship operators. The authorities have expressed their concern in form of general requirements. The private sector has taken concrete steps in starting the training for their own purposes. Hopefully in the near future these two can be combined in form of specific requirements or at least recommendations for training the crews of vessels operating in the Arctic areas.

The second main topic was dealing with the impacts of oil in the Arctic sea. It seems that the knowledge we have is limited. With the experiments we can show what happens to individual species and to some of the biological processes. What still remains unclear is what happens on the ecosystem level. How vulnerable the Arctic marine ecosystems are and what it takes to make them recover after a major oil spill? These questions will require further research in the future so that we would understand the actual risks that the increased traffic in the Arctic creates.

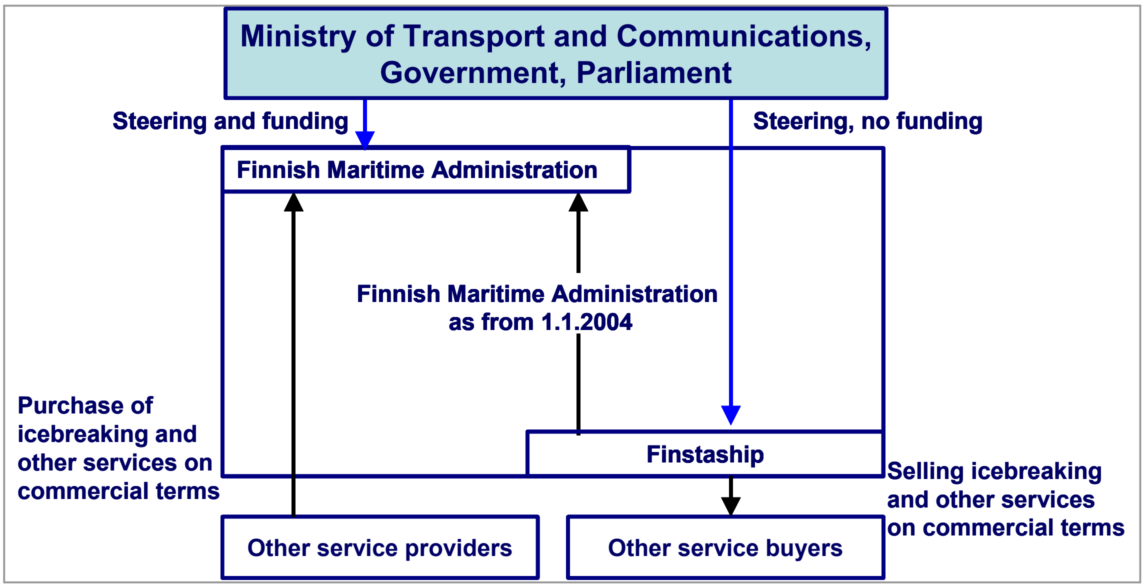
The third main topic was on the ways to minimize the amount of oil in the sea after a major spill. It seems that we can predict the risk for a major spill. Also we can predict what happens to the oil after the spill has taken place. But it seems that there is uncertainty in the technologies for collecting the spilled oil. The simulations show the importance of these technologies. We have been lucky that technologies that have been developed have never been in real test in connection of a major spill. But this also creates the uncertainty among the specialists. Some technologies have proven to be efficient in limited scale and limited areas like the terminals. But these technologies have been developed for minor spills. Can they be developed to work efficiently also in larger scale remains to be seen.

If we look at the work done within ARCOP for the environmental protection, we can say that we achieved what we wanted. We were not aiming at solving all the problems. The main purpose was to learn where we stand and what will be needed in the future. And now we know that with current level of knowledge and with current technology the major increase in transportation volumes includes unknown risks. This means that continuous monitoring and development work are needed from the very beginning of the large volume transportation operations.

OPERATING STRATEGY AND EXPERIENCES OF A COMMERCIAL ICEBREAKER OPERATOR

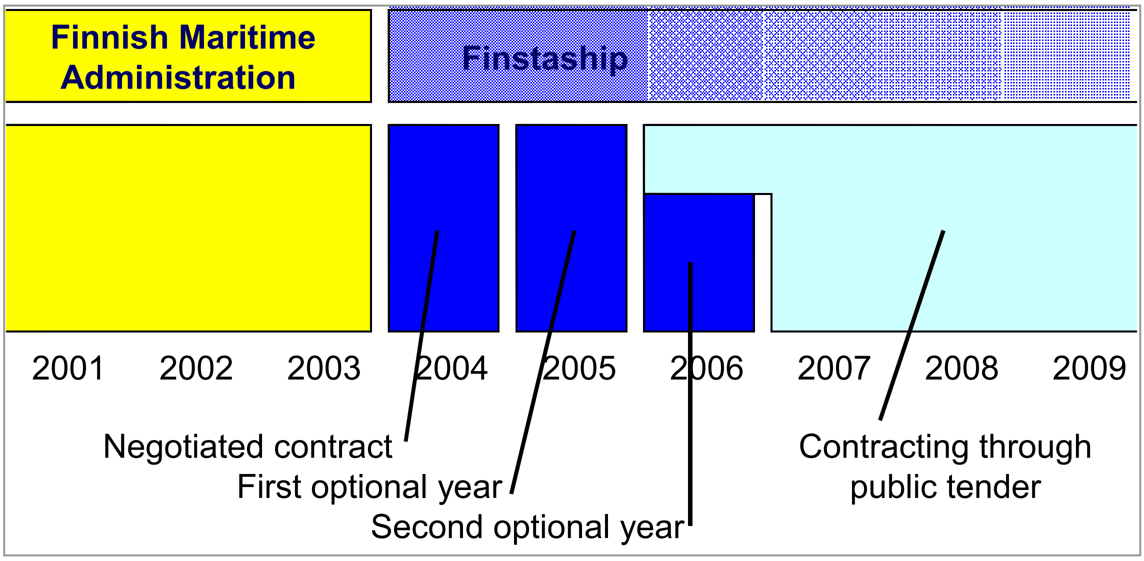
by Esko Mustamäki, Finstaship

FINSTASHIP DEMERGED FROM FINNISH MARITIME ADMINISTRATION 1.1.2004



CHANGED ICEBREAKING SERVICE PRODUCTION PATTERN

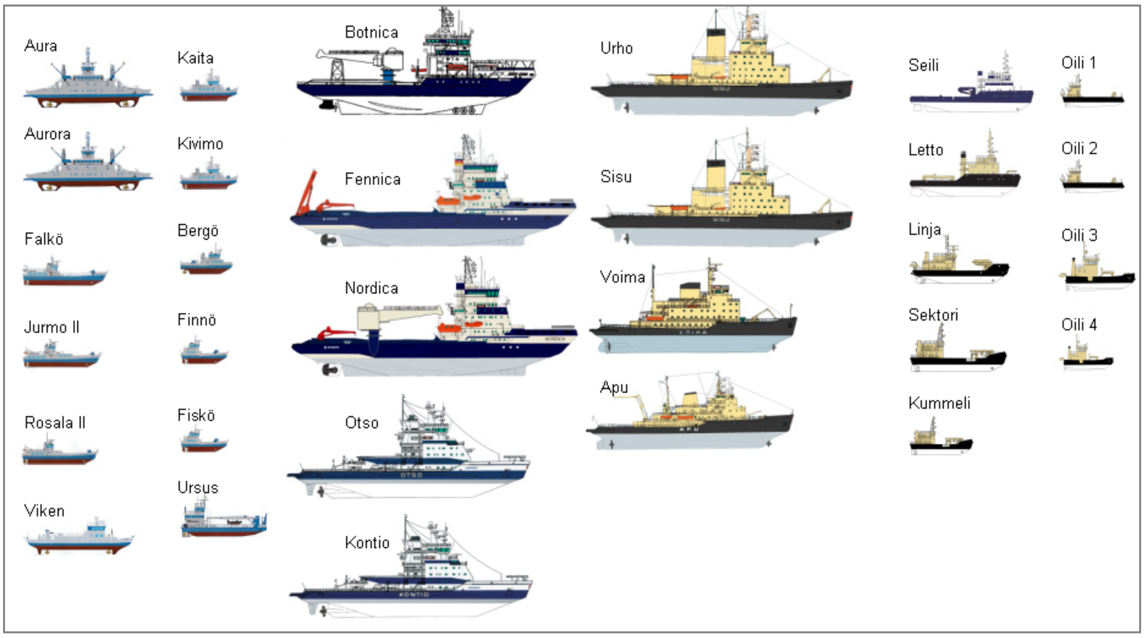
- From service produced by the administration to services purchased through public tender



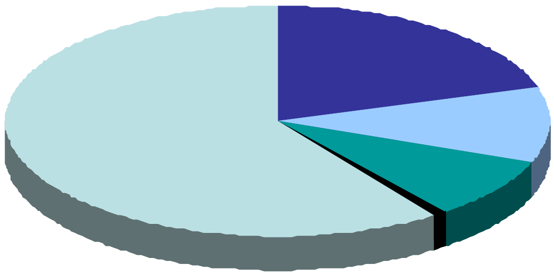
MISSION AND BUSINESS IDEA

- We offer icebreaking and fairway services for shipping needs as well as special services for the offshore and marine construction industry
- In addition we offer ferry and ship management services

FINSTASHIP FLEET 31.12.2004



TURNOVER DISTRIBUTION (2004)



	mill. euro
Icebreaking	31,8
Offshore	10,8
Ferry services	5,7
Fairway maintenance	4,5
Others	0,5

FINLAND AND THE BALTIC SEA

- 85 % of Finnish export and import goods are transported by sea
- There are 23 ports kept open year around in Finland
- The one way distances navigated in ice can be 200 to 400 nm when the ice coverage is normal
- Nine icebreakers are needed to ensure smooth traffic during the winter
- In Finland icebreaker assistance is free of charge for vessels

FINNISH WINTER PORTS

THE DISTANCES NAVIGATED IN ICE

ICEBREAKER OPERATORS IN THE BALTIC SEA

- With 9 icebreakers Finstaship is the leading commercial icebreaker operator in the Baltic Sea
- Sweden has 7 state owned icebreakers
- Estonia has 1 state owned icebreaker
- Russia has 3 large liner icebreakers and 9 smaller icebreakers operating in the Baltic Sea

STRATEGY

- Finstaship is investing in vessels supporting its present or new fields of business. The investment may be new buildings, second hand tonnage or acquisition of businesses or similar arrangements.
- In investments the emphasis is on ice strengthened tonnage and off-shore vessels or shipping business connected to these areas
- Where applicable we aim to move towards service agreements in stead of traditional chartering agreements

FUTURE TARGETS OF FINSTASHIP

- We are growing profitably while fulfilling our service requirements
- We offer best service concepts for the needs of our customers
- We have efficient working models and long term partnerships
- Our personnel is well trained and motivated and meets our strategic needs

ICEBREAKING ACTIVITIES SO FAR

- All nine icebreakers have been chartered by Finnish Maritime Administration for the winter season until end 2005
- Six icebreakers are booked by Finnish Maritime Administration for next winter
- Three multipurpose icebreakers have been in offshore tasks during summer seasons
- The multipurpose vessels will be partly free for operation outside Finland during the coming winter

FUTURE POSSIBILITIES

- To grow in new areas and invest in new icebreakers
- To grow in new areas and invest in new ice-going tonnage
- We are prepared to invest in new tonnage against a long term chartering

LOADING FACILITIES
Experience, design, performance and costs
by Giovanni Busetto, Tecnomare S.p.A

1. Importance of the loading facility
2. Review of existing experience on arctic loading
3. Conceptual design of the loading facility
4. Performance
5. Costs
6. Recommendations for further development work

IMPORTANCE OF THE LOADING FACILITY

- A Loading Terminal is a *bottleneck* in the chain of the Maritime Transportation System for hydrocarbon field exploitation and, due to the nature of the environment, 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 one, tested in operation.
- The Loading Facilities have an *important weight in the economics* of the transportation system:
  - CAPEX: large capital investments are needed, to create the infrastructures,
  - OPEX: large operating costs, to maintain operability and adequate safety.
- Looking at possible *risks* during Arctic marine transportation, the loading operations are the most important issue, due to:
  - challenging environmental scenario (low temperature, ice, wave, wind exposition, current) and uncertainty on long term data,
  - high distance from existing infrastructures,
  - large quantities of products, at high transfer flowrates, to be handled,
  - need to keep the product parameters within defined limits,
  - movement of a number of vessels in proximity of fixed infrastructures, in exposed locations,
  - higher risk of human errors (approach, communication, operation control),
  - higher risk of equipment failure (vessel, cargo circuit, control system)
  - limited experience of arctic loading and significant research and development work is needed from the technological and organisational points of view.

THE PAST EXPERIENCE WITH ARCTIC LOADING

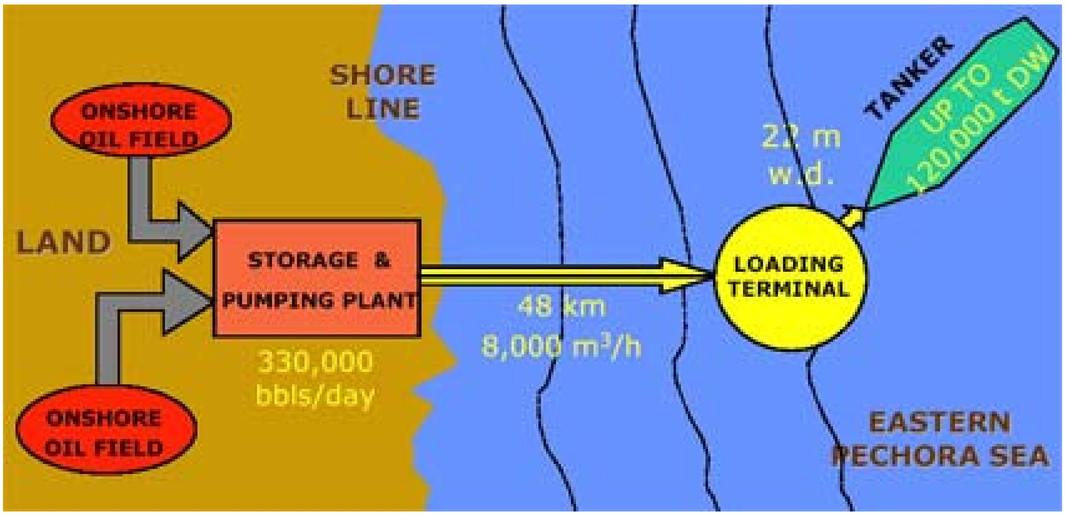
- Petroleum activities in the *Canadian Arctic (Beaufort Sea),* in the Seventies: many wells were drilled from gravel islands, floaters and caissons, but offshore production never became a real scenario;
- Year-round operations, with freighters of limited size, as well as with escorted tanker operations, in the *Pechora Sea*, for a number of years: year-round tanker transport is considered feasible and safe,
- Export operations, on an extended seasonal basis, related to oil production in the *Russian Far East (Sakhalin),*
- Freighters operations in the *Baltic Sea, Bothnia Gulf* and, on seasonal basis and for limited quantities, in the *Canadian and Russian Arctic,*
- Large number of *studies* carried out in the latest 20 years, mainly sponsored by Oil and Gas Companies, with the substantial help from the *Russian Design and Research Institutes*.

THE PRESENT SITUATION

No year-round, large scale loading operations of tankers are maintained in the Arctic offshore yet, but the situation is riper, as there are plans to make infrastructures ready and larger and ice capable vessels start to be available or will be completed in the next future:

- a project is in progress for extension of the existing temporary terminal of Varandey, to increase exported oil volume and size of received tankers,
- ongoing 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.
- research projects create a platform of knowledge for Russian Arctic operations

SCENARIO FOR THE CONCEPTUAL DESIGN: Export from onshore fields of Varandey Area



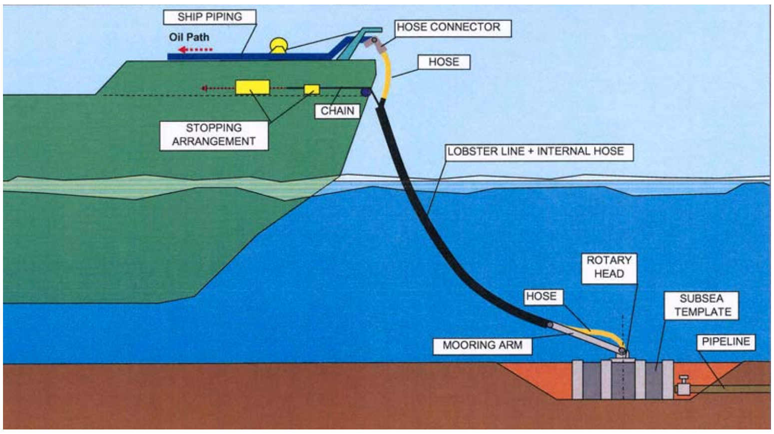
CONSIDERED TYPE OF LOADING SYSTEM:

The Arctic **S**ea **B**ed **A**nchor **M**ooring (SBAM)

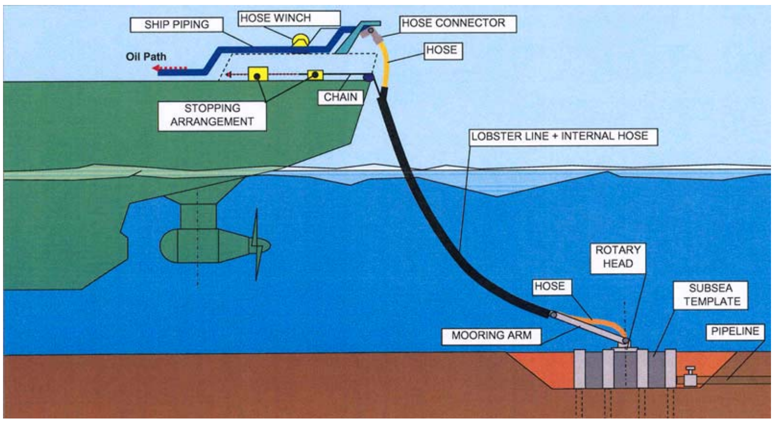
- Developed by Tecnomare in 1996, it offers unique safety characteristics compared with other massive Single Point Mooring concepts, which expose critical elements to risks of damage for tanker impacts.
- A preliminary comparison of four methods for loading, made within ARCDEV Project, revealed an appreciable advantage for the SBAM and considered it a promising solution for Arctic and Sub-Arctic applications.

FUNCTIONAL CHARACTERISTICS OF THE ARCTIC SBAM SYSTEM

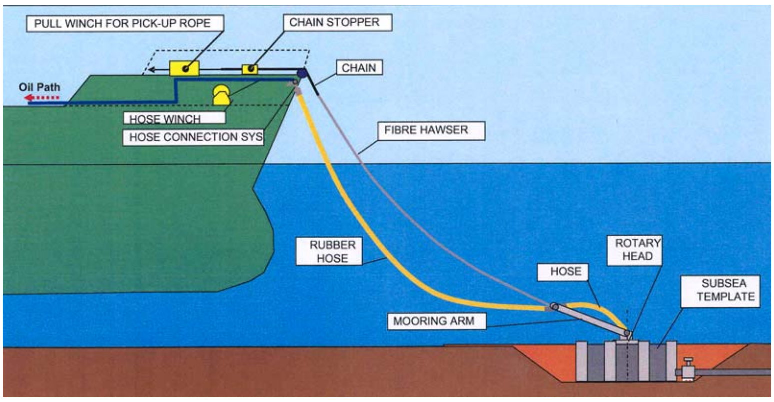
1. All crucial structural and mechanical components for mooring and loading are integrated in a *subsea template*. The only element piercing the sea surface is the '*lobster line'*, a hollow mooring line consisting of modular steel elements and protecting the hoses.
2. *Remote actuation* of the subsea valves permits to control the loading operations, to prevent any significant oil spill, also in case of accidental damage to the hoses,
3. *Remote control* of the basic parameters of the system and of the product is performed from shore,
4. All crucial system *components can be temporarily removed,* if needed, for exceptional inspection & maintenance operations,
5. Interchangeable 'winter' and 'summer' seasons arrangements, to permit *optimal performance* with both seasonal scenarios.



Operation in winter (ice) season with Conventional Arctic Tanker



Operation in winter (ice) season with Double Acting Tanker

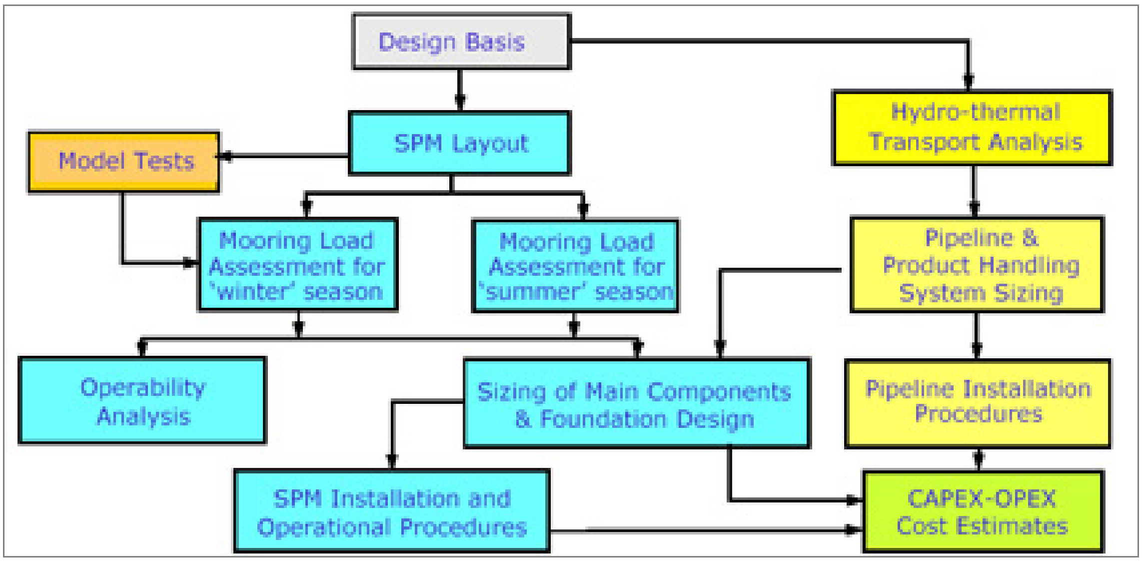


Operation in summer (ice free) season with Conventional or Double Acting Arctic Tanker

PREVENTION MEASURES AGAINST OIL SPILLAGE INCORPORATED IN THE SBAM SYSTEM

- Use of well tested and certified products and equipment,
- Multiple sealing on swivel and rotating head,
- Monitoring of sealing tightness (via lub oil pressure monitoring),
- Protection of swivel and bearing in an optimum environment,
- Ball valves to remotely isolate pipeline and SBAM circuits,
- Double carcass hoses with leak detection system,
- Possibility to isolate the circuit, for removal of the rotary head.

CONCEPTUAL DESIGN PROCESS OF THE LOADING SYSTEM



MOORING LOADS ASSESSMENT

"Winter" Season (ice):

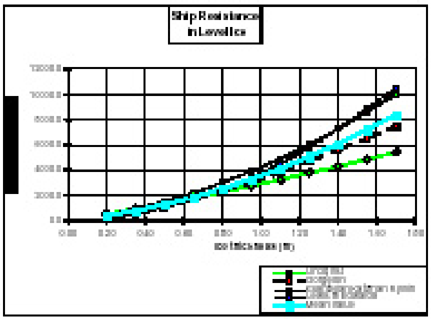
- STEP 1: Preliminary calculation with static approach, by using analytical methods for ship ice resistance and f.e. programme,
- STEP 2: Empirical method based on combined use of model test results, analytical formulations and f.e. programme

"Summer" Season (eave, wind, current):

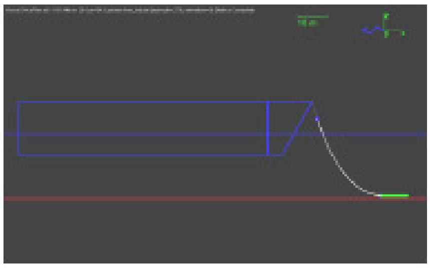
- Dynamic Analyses in Time Domain of Tanker and Mooring Line.

→ Input for the Operability Analyses

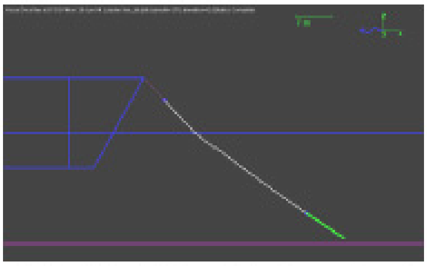
STEP 1 : Preliminary Mooring Loads Assessment



Analytical formulations for Ice Resistance



Static Simulation - No Load



Static Simulation - Maximum Load

Model Tests with a 90.000t DW stock Tanker
(HSVA, 2004, within the IHP Programme of the EU)

- Ship Resistance Tests: no 1 ice thickness
  no 2 drift speeds
- Level Ice Tests: no 2 ice thicknesses
  no 2 drift speeds
  no 3 ice drift directions
- Ridge Tests: no 2 ridge keels
  no 2 drift speeds
  no 3 ice drift directions

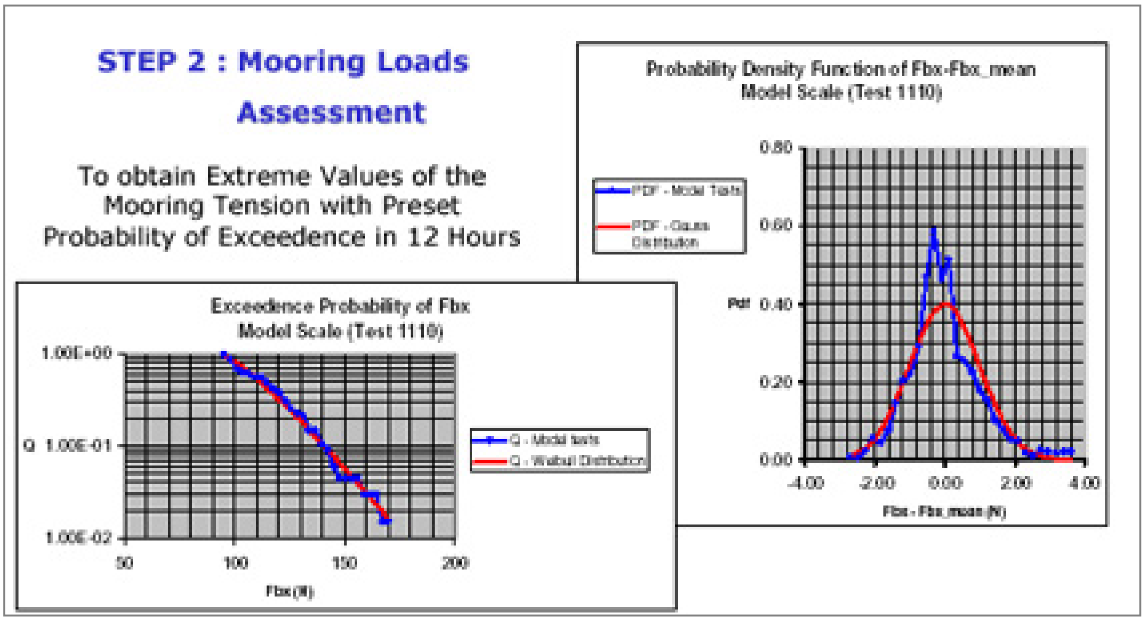
MODEL TESTS

Tests with moderate level ice

Tests with moderate size ridge

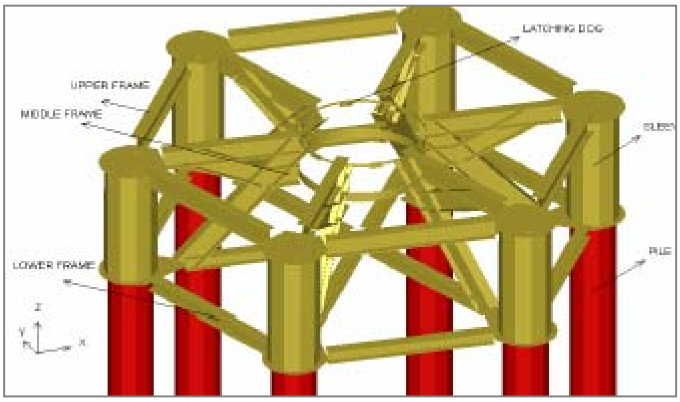
Tests with thick level ice

Tests with angled ice drift



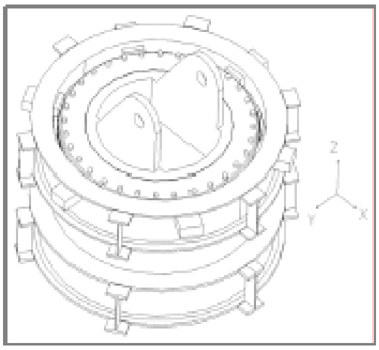
STRUCTURAL ANALYSIS OF
SUBSEA TEMPLATE

- Structural Model
- Load Conditions
- Soil Constraints
- Stress and Stability Checks in accordance with Codes

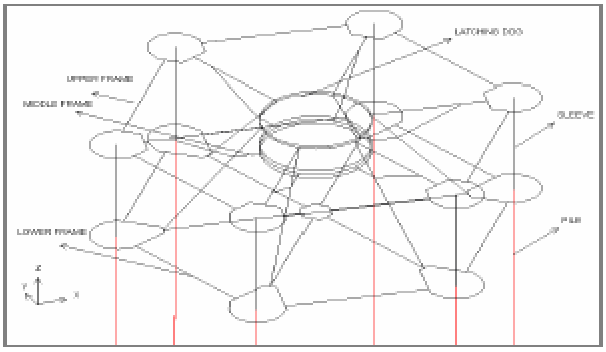


Structural Model of the Subsea Template

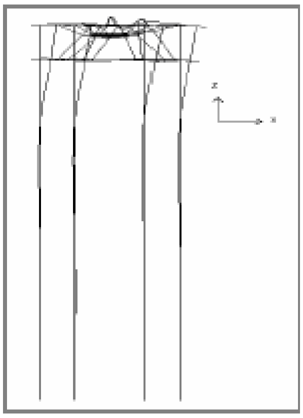
STRUCTURAL ANALYSIS OF ROTARY HEAD AND FOUNDATION ANALYSIS



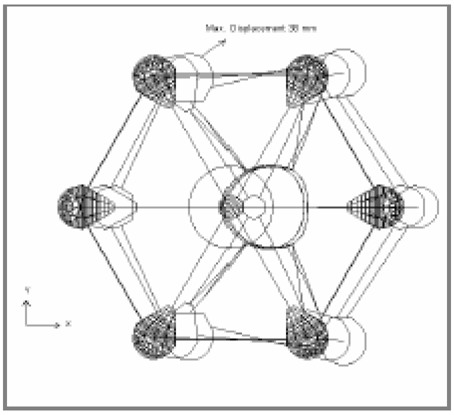
Rotary Head Model



Isometric View of Wireframe Model

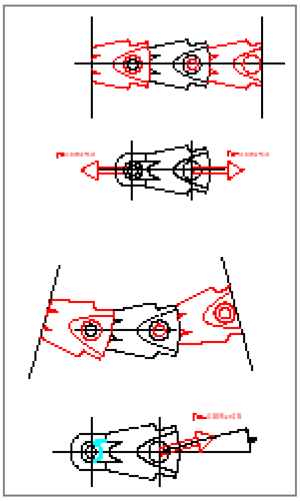


Deformed shape for Load Case 1
Lateral and Top View



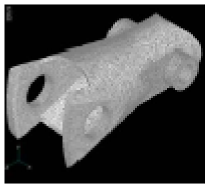
Deformed Shape for Load Case 1
Isometric View

F.E. ANALYSIS OF THE LOBSTER LINE

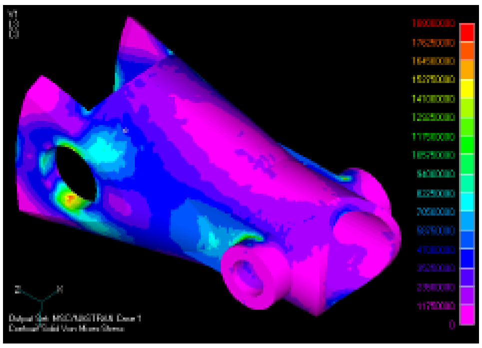


Aligned Configuration

Rotated Configuration

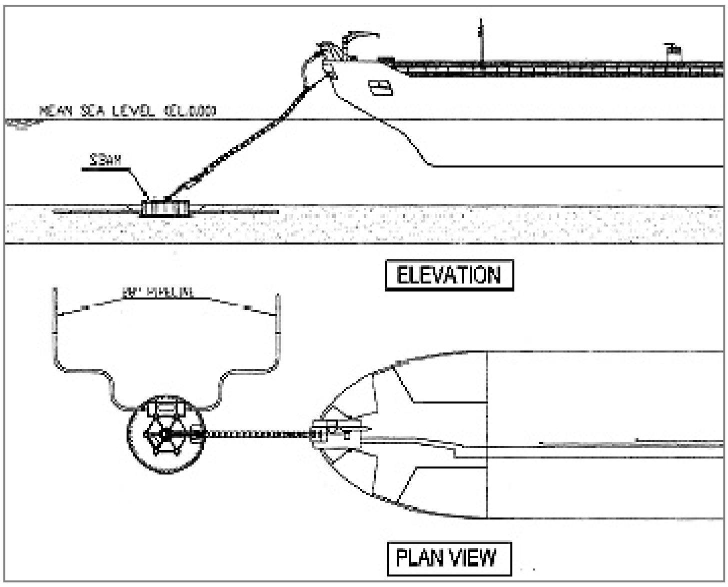


Structural Mathematical Model

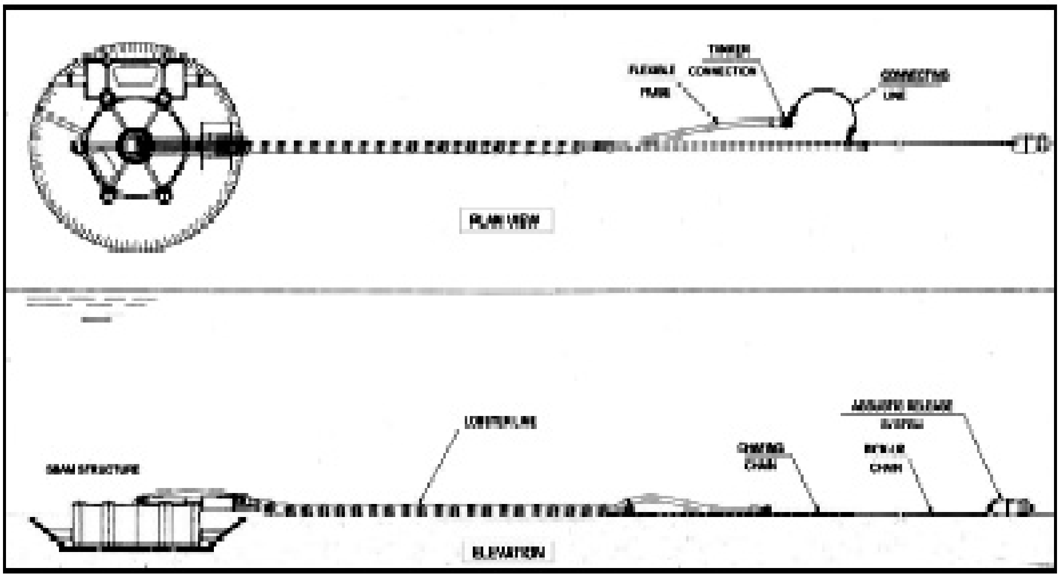


Von Mises Stress Representation

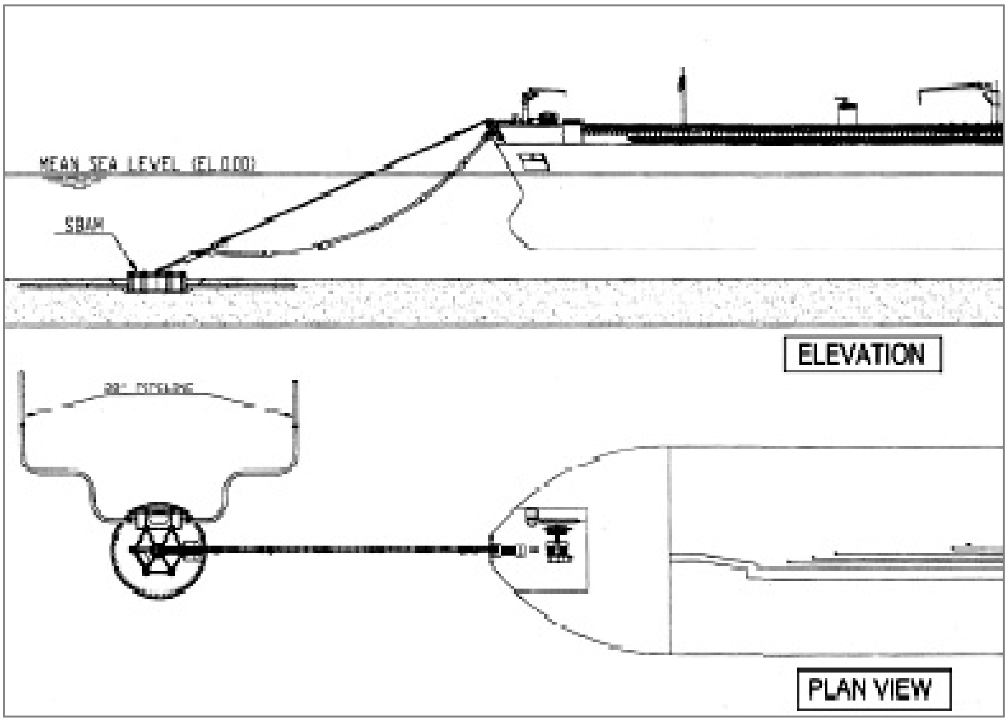
LAYOUT OF THE SBAM



“Winter” Operating Conditions (with ice)

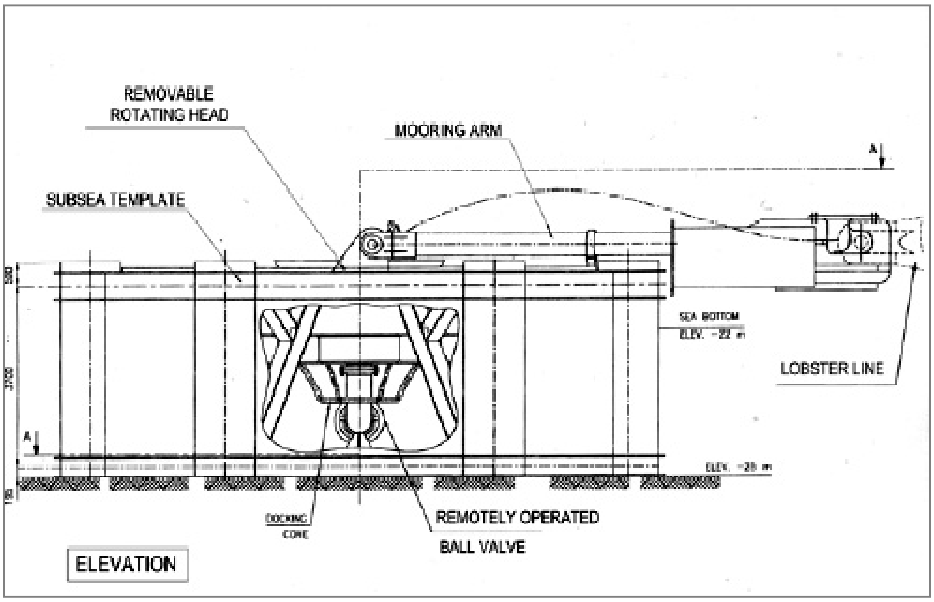


"Winter" Idle Conditions (with ice)

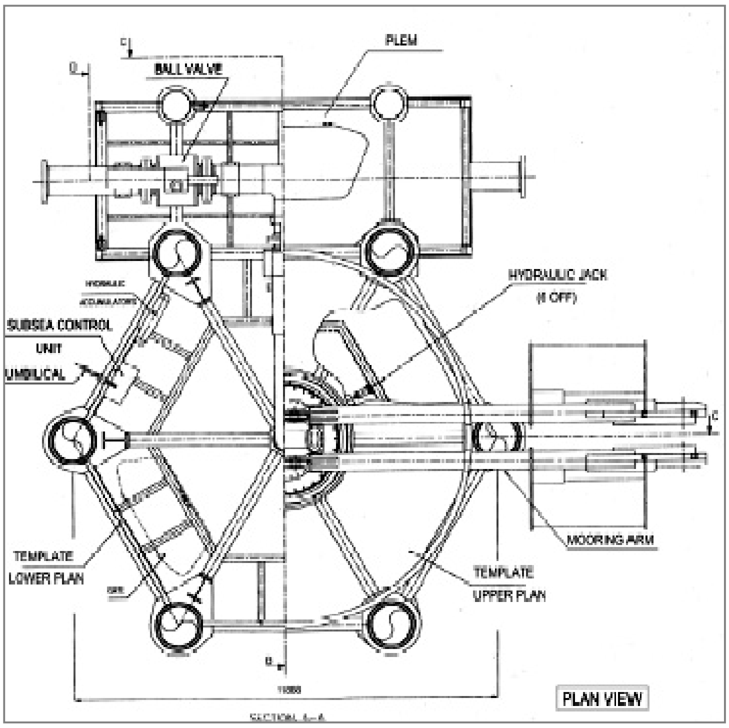


"Summer" Operating Conditions (no ice)

SBAM STRUCTURAL LAYOUT

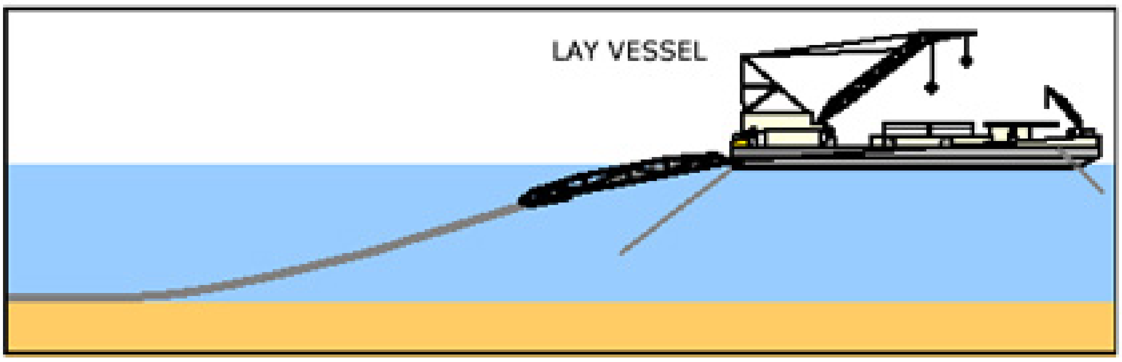


Profile

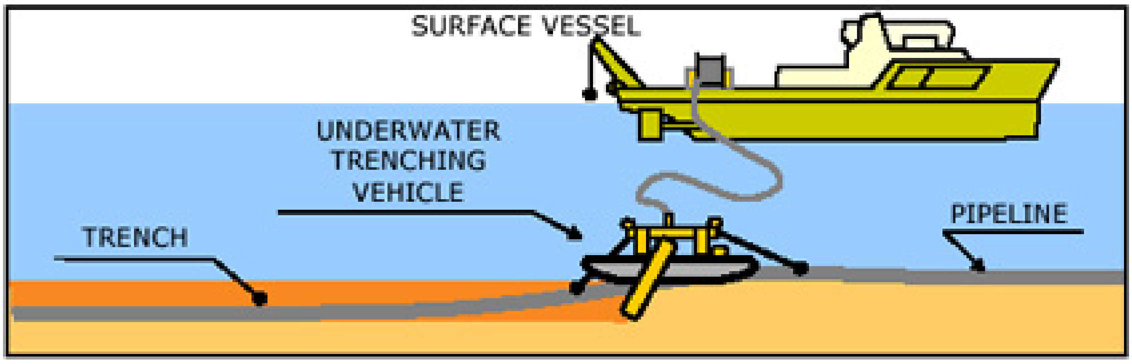


Plan

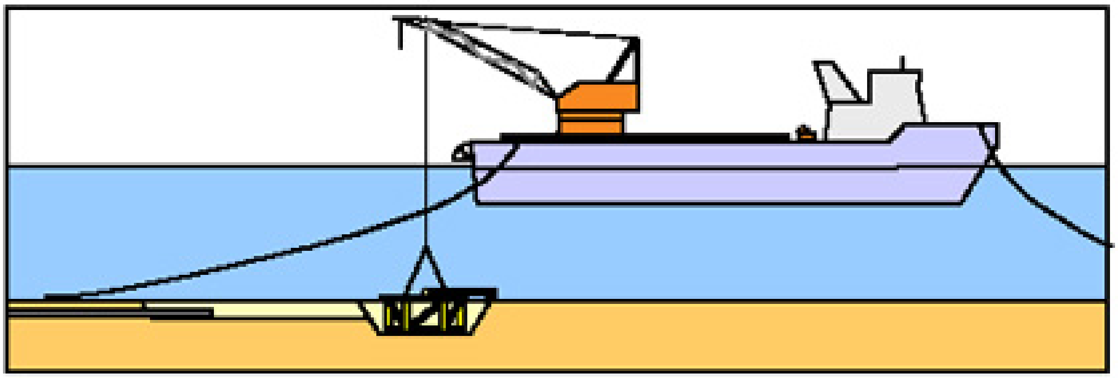
INSTALLATION SEQUENCE



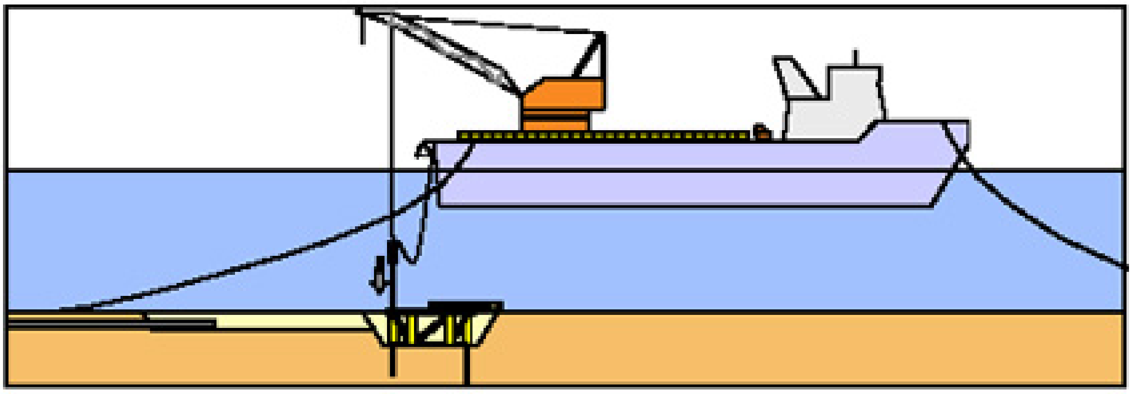
1. Laying of the pipeline



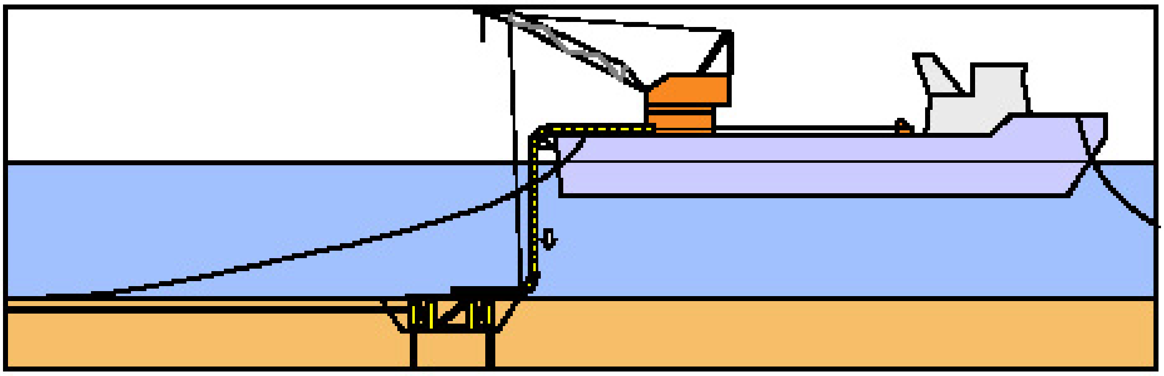
2. Post-Laying Mechanical Trenching



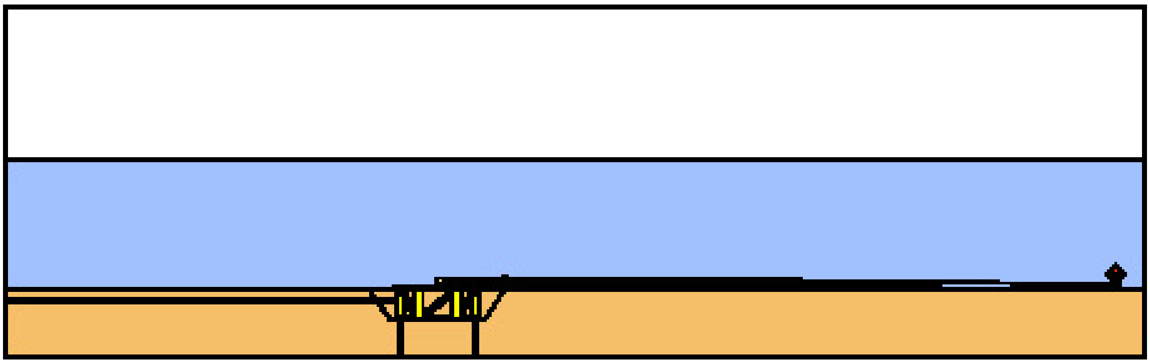
3. Base Template Positioning on Seabottom



4. Foundation Piles Installation

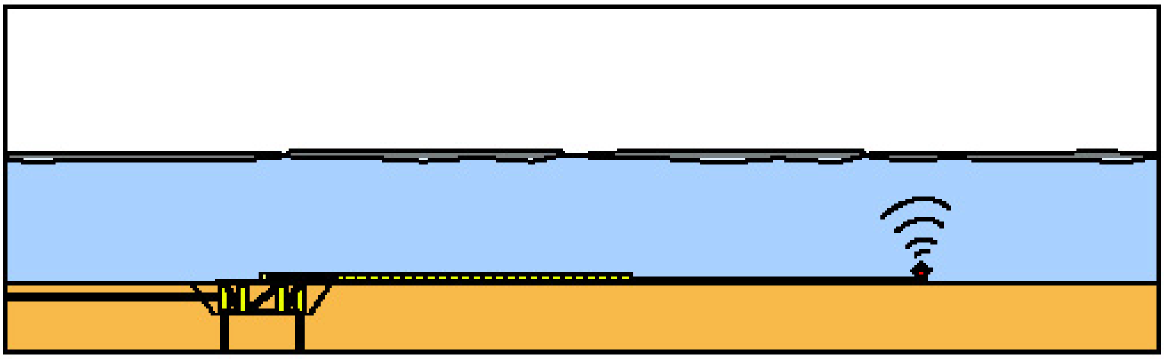


7. Lobster Line Lowering, Mating and Connection

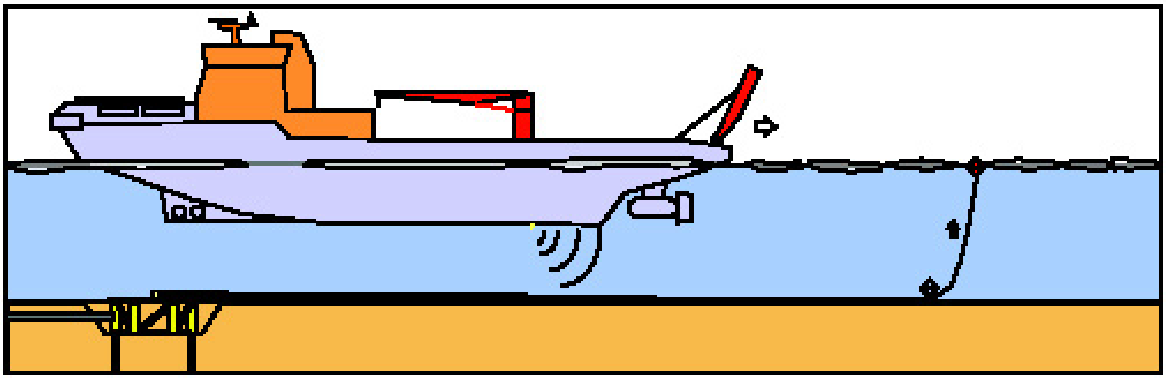


8. Completed Installation

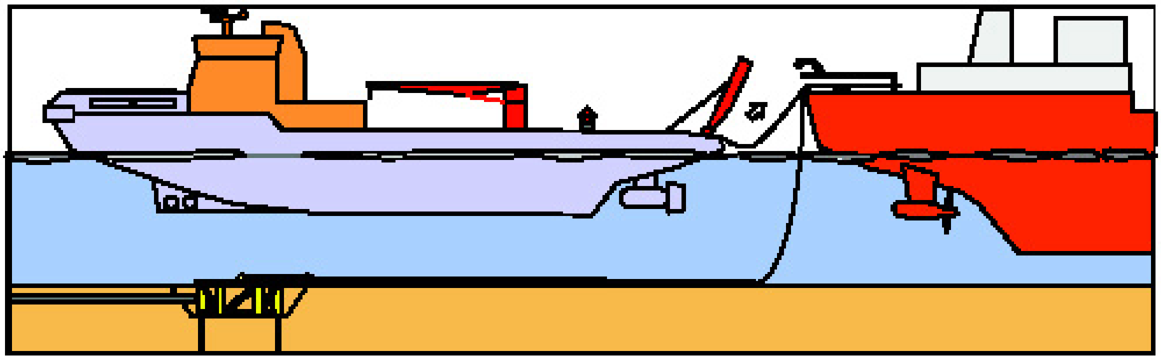
OPERATION (ICE SEASON)



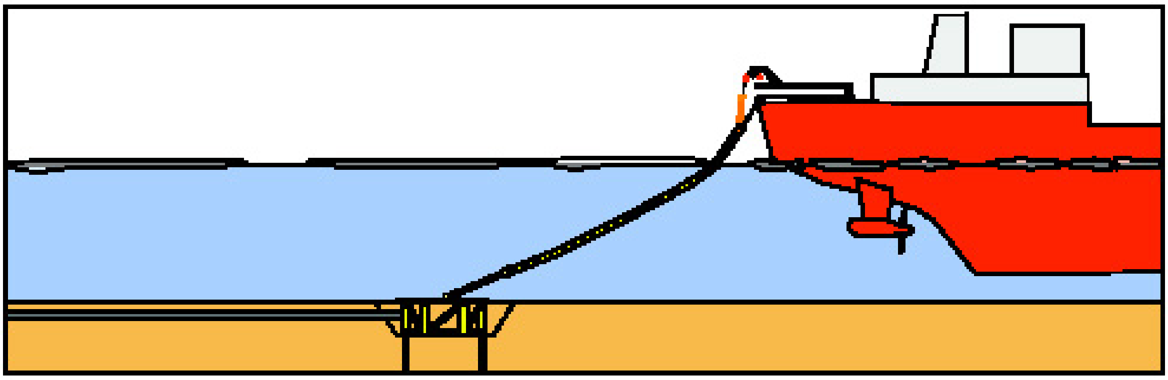
1. Stand-by Condition



2. Support Icebreaker Approach and Acoustic Release Buoy Surfacing



3. Approach of Tanker and Transfer of Pick-up Chain



4. Pull-in and Latching of Chafing Chain, Hose Connection and Loading

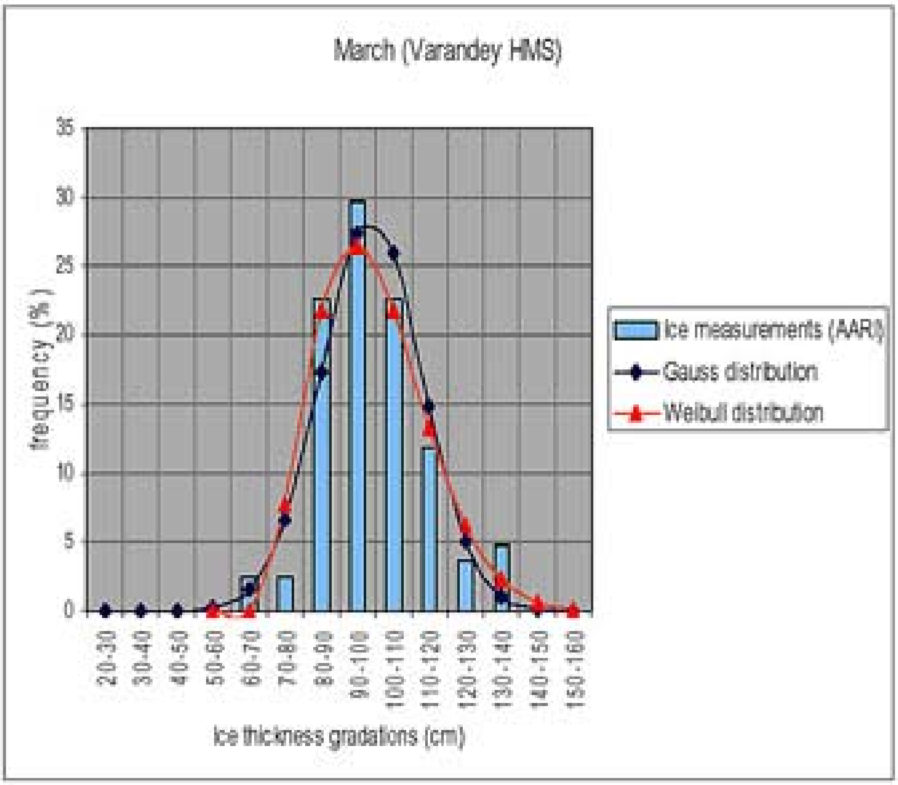
PERFORMANCE OF THE LOADING SYSTEM

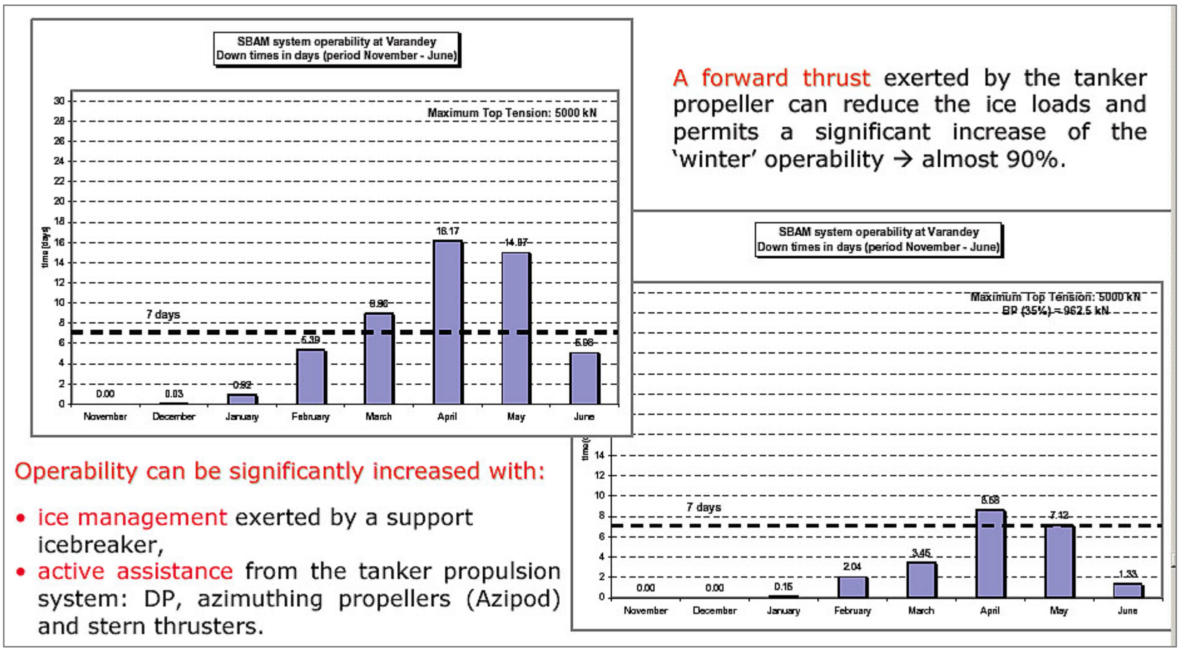
Availability of the Terminal = Time Percentage of *Operability* of the System

Downtime= 100% - Availability (%)

Operability during the "winter" season:

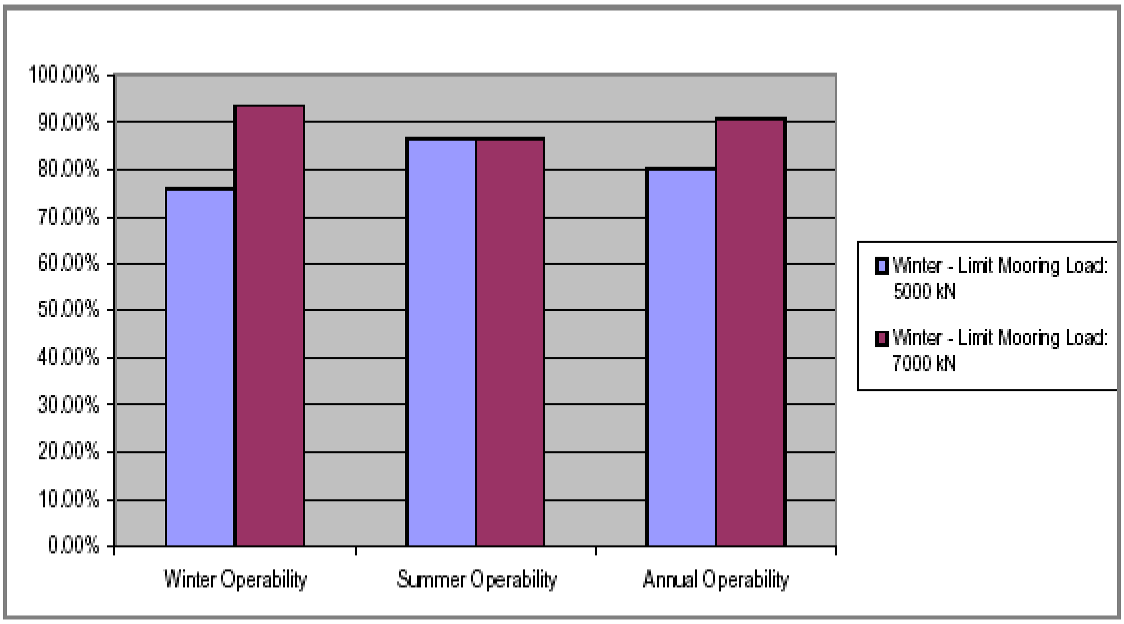
- Selection of *threshold values* for the mooring loads.
- Identification of the *limit ice conditions* from the relationships mooring tension vs. ice thickness and ice drift speed (from mooring load analysis).
- Weibull *distribution functions* to model the occurrence frequencies of the limit ice thickness and ice drift speed.


March (Varandey HMS)
frequency (%)
Ice measurements (AARI)
Gauss distribution
Weibull distribution
20-30 30-40 40-50 50-60 60-70 70-80 80-90 90-100 100-110 110-120 120-130 130-140 140-150 150-160
Ice thickness gradations (cm)

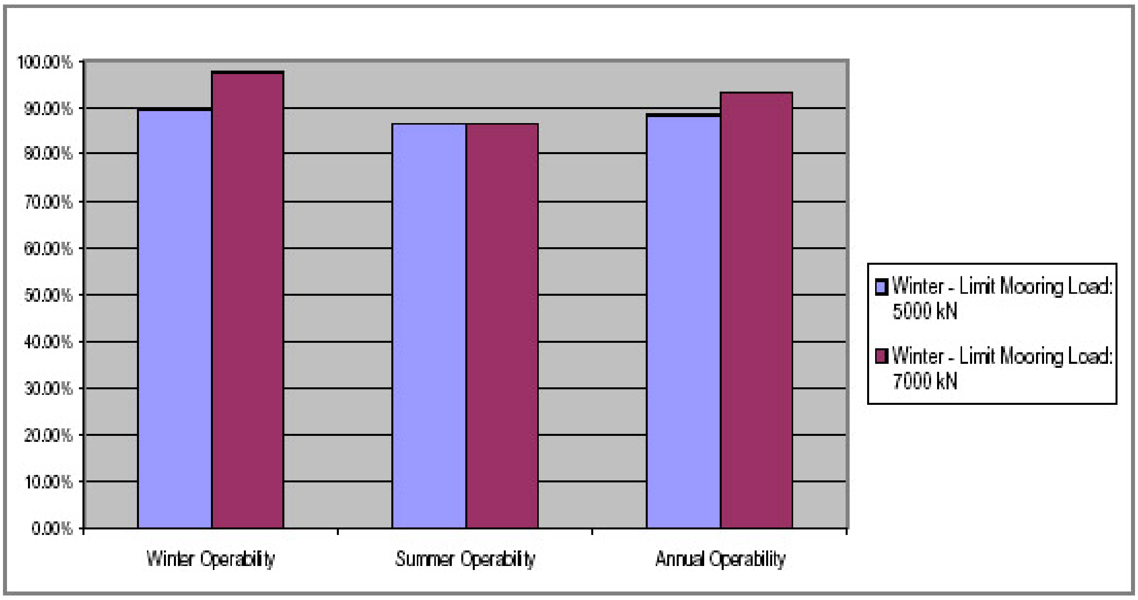

SBAM system operability at Varandey
Down times in days (period November - June)
Maximum Top Tension: 5000 kN
7 days
November December January February March April May June
A forward thrust exerted by the tanker propeller can reduce the ice loads and permits a significant increase of the 'winter' operability → almost 90%.
SBAM system operability at Varandey
Down times in days (period November - June)
Maximum Top Tension: 5000 kN
BP (35%) = 962.5 kN
7 days
Operability can be significantly increased with:
• ice management exerted by a support icebreaker,
• active assistance from the tanker propulsion system: DP, azimuthing propellers (Azipod) and stern thrusters.

OPERABILITY OF THE LOADING SYSTEM

- No Forward Thrust -



- Forward Thrust (35% of B.P.) -



CAPEX ESTIMATE - MAIN COST ITEMS

1.0 - Engineering

2.0 - P.M., Superv., Planning, Logistic Organisation

3.0 - Classification & Certification

4.0 - Model Tests

5.0 - Insurance for Marine Operations

6.0 - Pipeline System:

6.1 - Material & Procurement

6.2 - Construction, Assembly & Installation
6.3 - Testing, Commissioning & Start-Up

7.0 - SBAM System:
7.1 - Material, Procurement & Fabrication
7.2 - Loadout & Marine Transportation
7.3 - Installation
7.4 - Final Commissioning & Start-Up

8.0 - Spare Parts

Estimated CAPEX: about 350 Million Euro

OPEX COST ESTIMATE - MAIN COST ITEMS

1.0 - SBAM System
1.1 – Periodical Inspection and Maintenance
1.2 – Arrangement for Operation in Ice-free Season
1.3 – Arrangement for Operation in Ice Season
1.4 – Periodical Planned Replacement of Components

2.0 - Pipeline System
2.1 – Condition Monitoring
2.2 – Maintenance and Minor Repairs

Estimated Annual OPEX: about 1.7% of CAPEX

RECOMMENDATIONS FOR FURTHER DEVELOPMENT WORK, TO SECURE A RELIABLE AND PROVEN SITE -SPECIFIC SOLUTION SPECIFIC SOLUTION

- To establish a sound and, to the maximum extent, comprehensive design basis, to clearly define available data, assumptions, functional requirements and other requirements:
  - *Environmental data* on a long term basis, covering the whole year. Occurrence frequencies for ice, wave, wind, current with directional statistics.
    Tide, air and water temperature ranges, visibility.
    Directional extreme values for return periods between 100-years and 1-year;
  - *Terminal process data*, with indication of operating requirements such as pigging, simultaneous handling of products, heating and in general treatment requirements;
  - *Tanker data* and, in particular maneuvering and propulsion control capabilities, strength capability of the arrangements for mooring and data on the loading arrangements;
  - *Support fleet data*, with availability and extent of icebreaker support, as well as achievable ice management capabilities;
  - *Geophysical and geotechnical soil data*, seismic data, occurrence of ice scouring, 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 investigate, for successive steps in the design of the terminal, additional aspects relevant to:
  - *Testing of operational procedures* for approach to the terminal, mooring and loading, safe and expedient disconnection, 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;
  - *Evaluation of the suitability of off-the-shelf materials and equipment* for the intended service at low temperatures and possible qualification of the same;
  - *Risk assessment*, 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 for risk reduction and mitigation.

ECONOMIC IMPACTS OF TECHNOLOGY ISSUES

by Kimmo Juurmaa, Aker Finnyards Inc.

BASIC ASSUMPTIONS

- The purpose is to illustrate how some of the technology issues influence the cost per transported cargo ton
- The study case is transportation from Varandey to Rotterdam
- The base vessels are 90.000 tdw conventional and DAT
- The base winter type is average year

ECONOMIC TOOL

- For transit time calculations AARC simulation tools have been utilised
- Dedicated fleet simulation tool was developed within ARCOP workpackage 3.5
- Excel worksheet utilising data from:
  - WP 3.1 Transportation scenario
  - WP 3.2 Tanker designs
  - WP 3.3 Icebreaker designs
  - WP 3.4 Loading terminal
- Information from following WP's was also used:
  - WP 2.3 Immigration and customs prcedures
  - WP 2.4 Risk management and insurance coverage
  - WP 2.5 Fee Policy
  - WP 5 Demonstrations

TRANSPORTATION SCENARIO

- Route Varandey-Rotterdam
- Volume 330.000 barrels per day (15 million tons per year)
- Onshore production and offshore loading
- Onshore storage

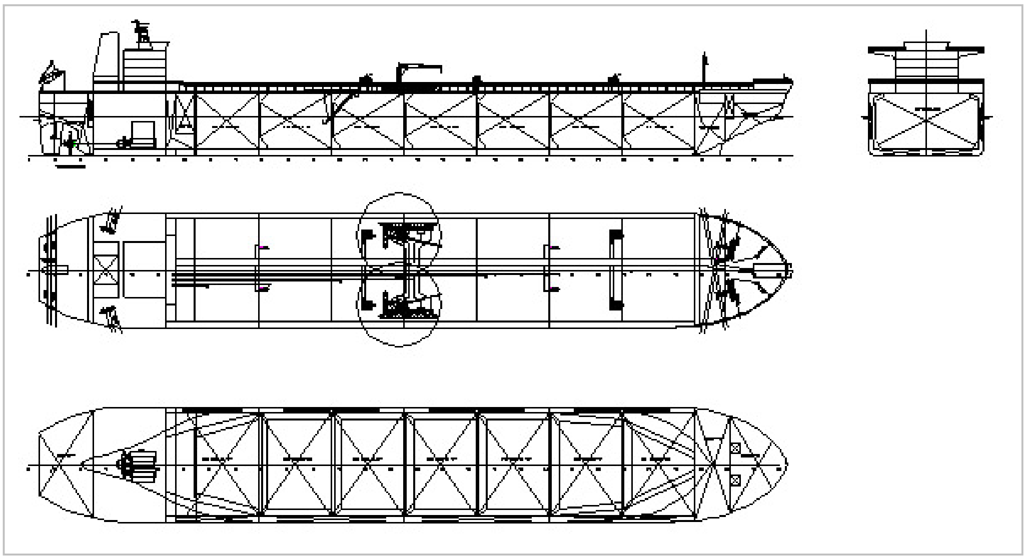
OPERATIONAL ASSUMPTIONS

- The variation of transportation performance is balanced by storage and by chartering open water tankers during summer months
- Downtime for each tanker is 1 month in every second year
- Delays for terminal approach, mooring etc. considered as 15 hours per roundtrip
- Cost for building the dedicated vessels are based on European cost level
- Fixed fee per ton for transipment in Murmansk
- Fixed fee for transport between Murmansk and Rotterdam for large open water vessels
- Chartered vessels during summer time are Aframax size, ice class 1A when needed

CONVENTIONAL TANKERS

- Ice class DNV Ice 10
- Capable to follow the icebreaker
- Diesel-mechanic, CPP propulsion

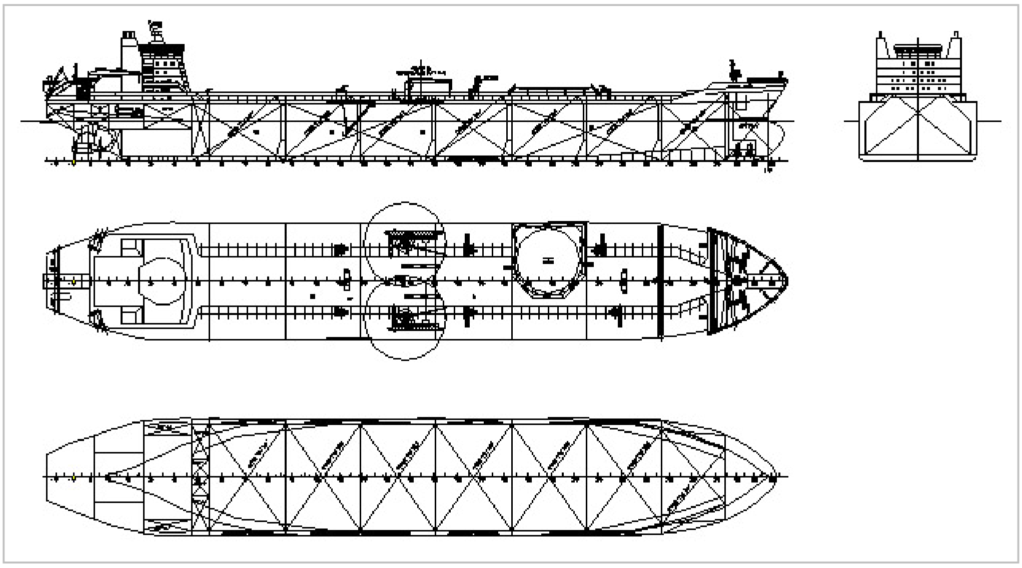
90000 TDW CONVENTIONAL ARCTIC TANKER



DOUBLE ACTING TANKERS

- Designed for independent operation
- Bulbous bow to make best performance in open water
- Diesel-electric propulsion

90000 TDW DOUBLE ACTING ARCTIC TANKER



HALF ACTING ARCTIC CONTAINER VESSEL

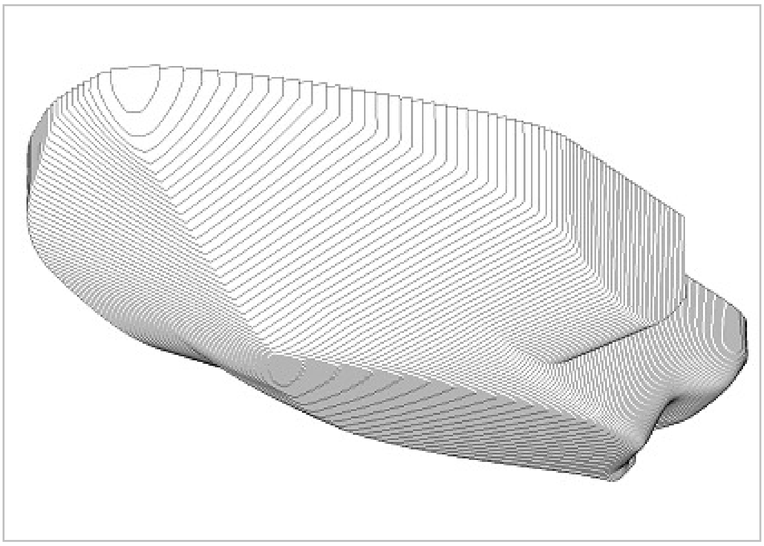
- Icebreaking bow increases flexibility in ice operations
- There will be some losses in open water performance

ICEBREAKER ASSISTANCE

- For large tankers traditionnally two icebreakers are needed
- Speed of convoy depends on slowest icebreaker
- Two 18 MW vessels are the base case

GUIDING the AFRAMAX TANKER PRIMORYE with the ICEBREAKERS KRASIN and MAGADAN

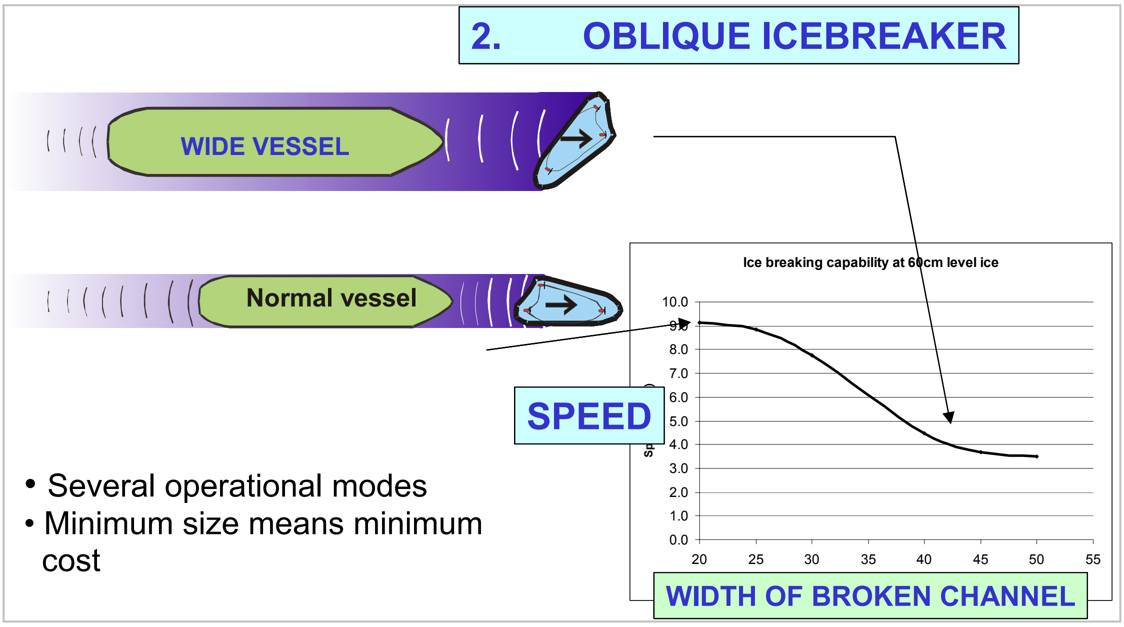
ALTERNATIVE ICEBREAKER DESIGNS



VERSION 2 WITH WIDE REAMER

- One icebreaker to make wide enough channel
- Hull form and power to be optimised

TAIMYR BEAM wl		**=**	**28.0 m**
VERSION 1	**BEAM wl**	**=**	**34.0 m**
VERSION 2	**BEAM wl**	**=**	**44.0 m**

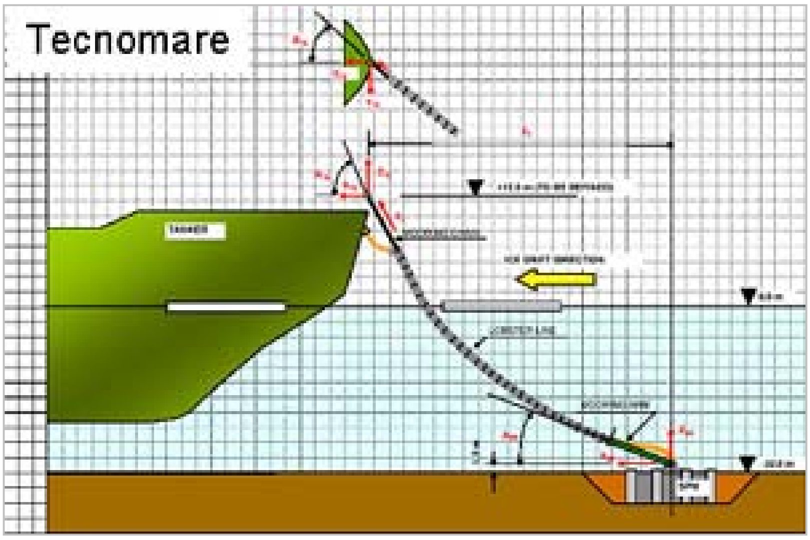


NEW THINKING IN RUNNING A VESSEL

OBLIQUE ICEBREAKER (artists impression)

LOADING SYSTEM

- Tecnomare SBAM
- Costs include subsea pipeline
- Maintanence costs including mobilisation costs for supporting fleet
- Downtime estimates without ice management



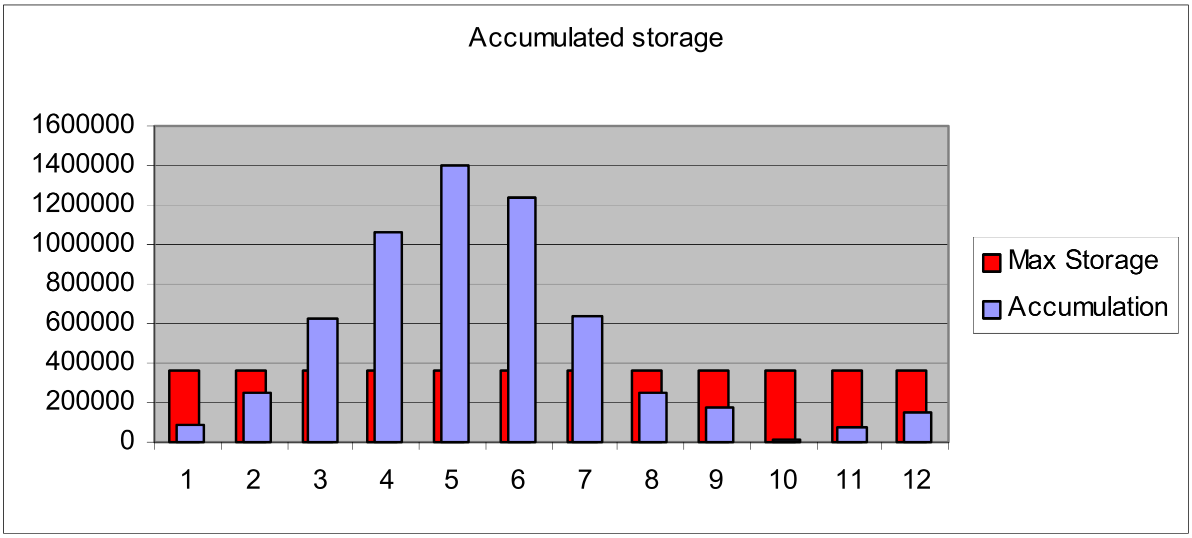
BASIS FOR THE FEES

- To cover the costs for icebreaking and fairway infrastructure (120 million Euro + ? annually)
- Alternatives:
  - Actual costs
  - Even fees to all winter traffic
  - Even fees to all traffic in the area
  - Limited yearly maximum
- The assumed overall cargo volume 100 million tons/year

ASSUMPTIONS FOR ACTUAL COSTS

- The fairway infrastructure cost is 120 million Euro per year (equal to icebreaker cost)
- The infrastructure cost is evenly distributed over all the cargoes, which means 1.2 Euro per ton
- The icebreaker costs are based on actual usage of icebreakers

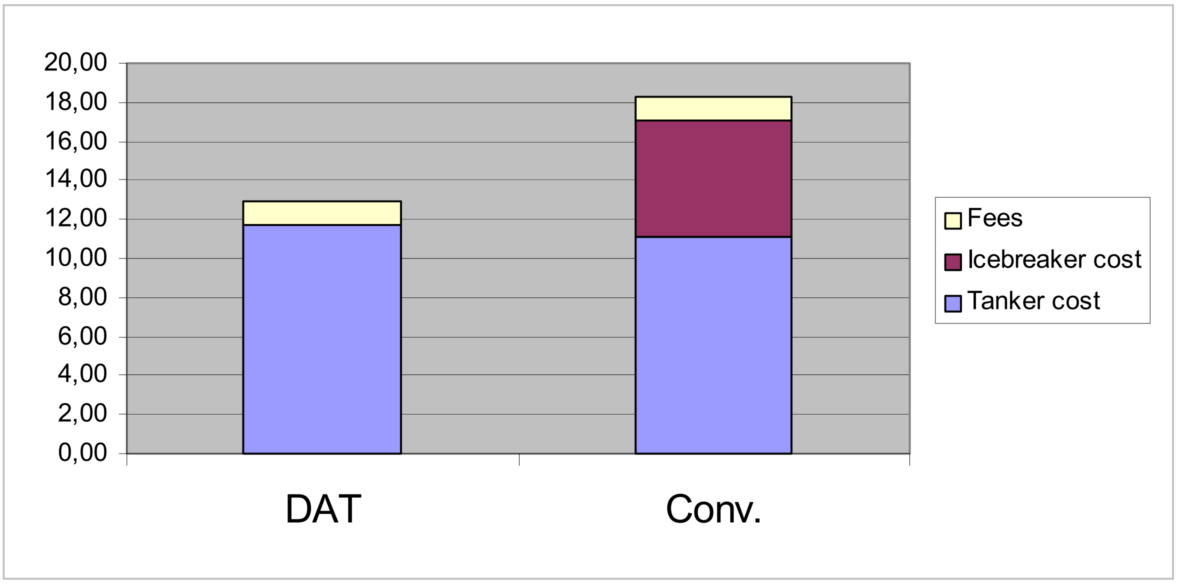
EXAMPLE OF RESULTS FOR DAT



- Basic fleet is 8 vessels
- Aframax size open water vessels:
  - 5 in June
  - 4 in July
  - 3 in August
  - 2 in September
  - 1 in October
- Max storage 1.4 million m3

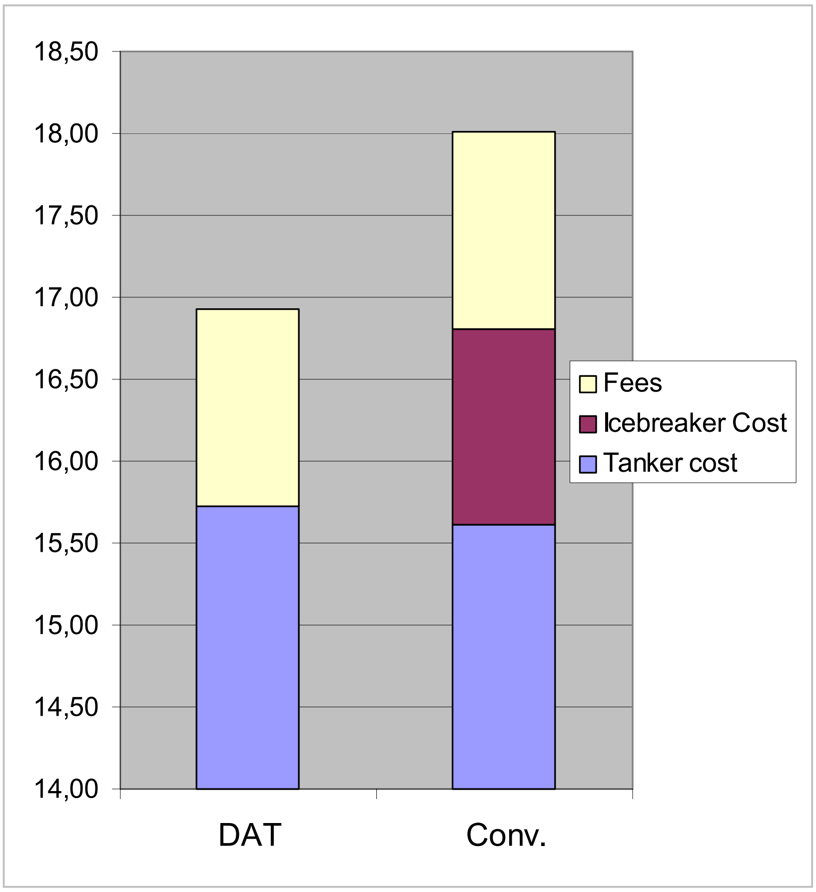
INDEPENDENT OR ICEBREAKER ASSISTED DIRECTLY TO ROTTERDAM?

- Two LK-18 for each tanker
- Year round cost for 6 icebreakers
- Independent operation is more feasible



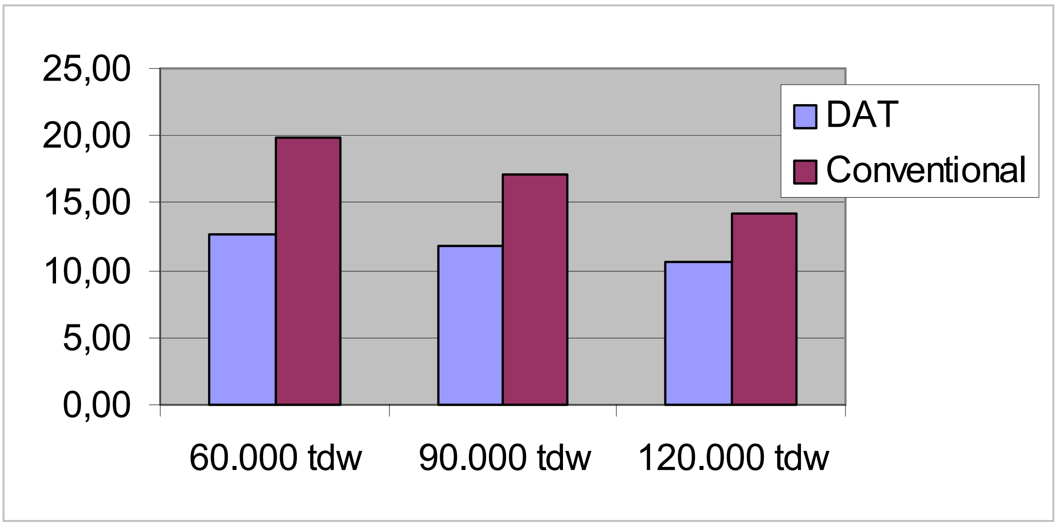
INDEPENDENT OR ICEBREAKER ASSISTED WITH TRANSHIPMENT AT MURMANSK

- 4 LK-18 icebreakers are needed
- The independent operation is still more feasible



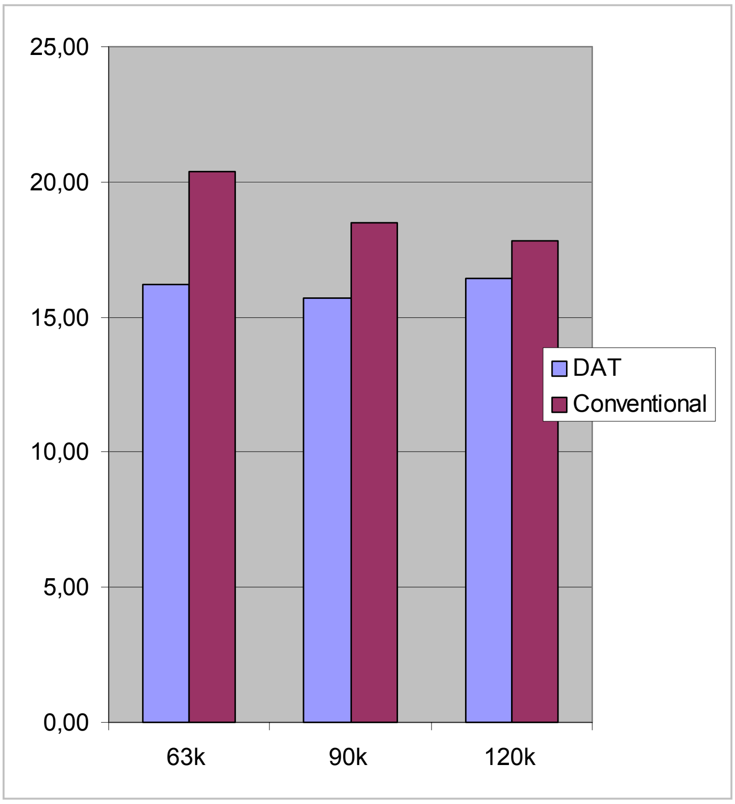
WHAT SIZE DIRECTLY TO ROTTERDAM?

- The cost decreases with increasing size
- With smaller size the number of icebreakers increase



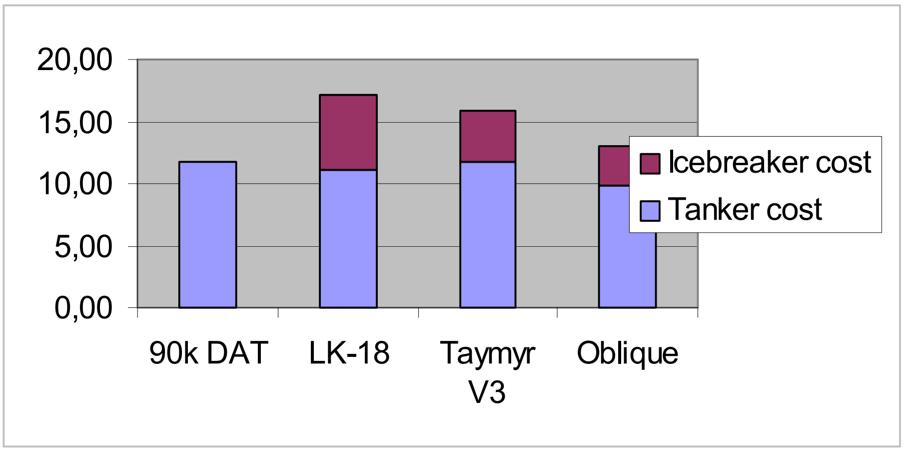
WHAT SIZE WITH TRANSHIPMENT TO ROTTERDAM?

- With bigger vessels the storage cost will increase
- For shorter distances the optimisation of all components becomes important



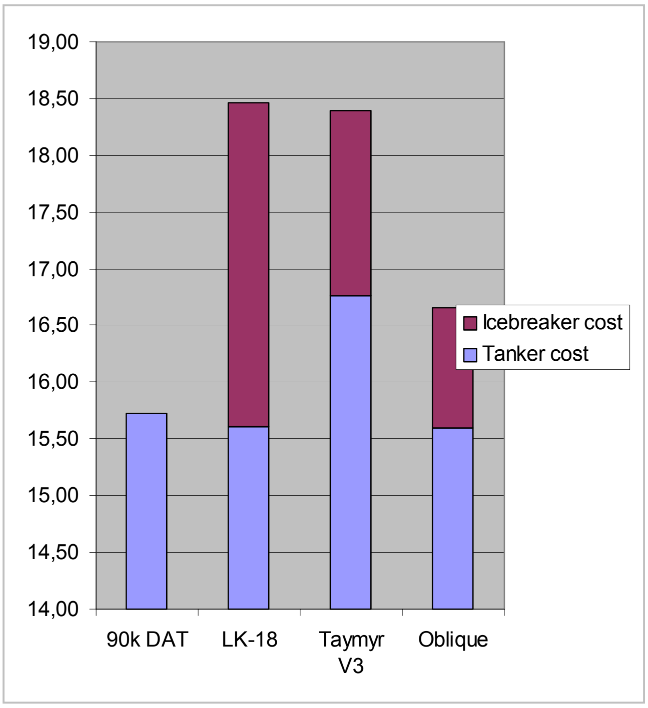
WHAT TYPE OF ICEBREAKER WHEN DIRECTLY?

- Development in icbreaker technology creates cost savings
- Independent operation is hard to beat

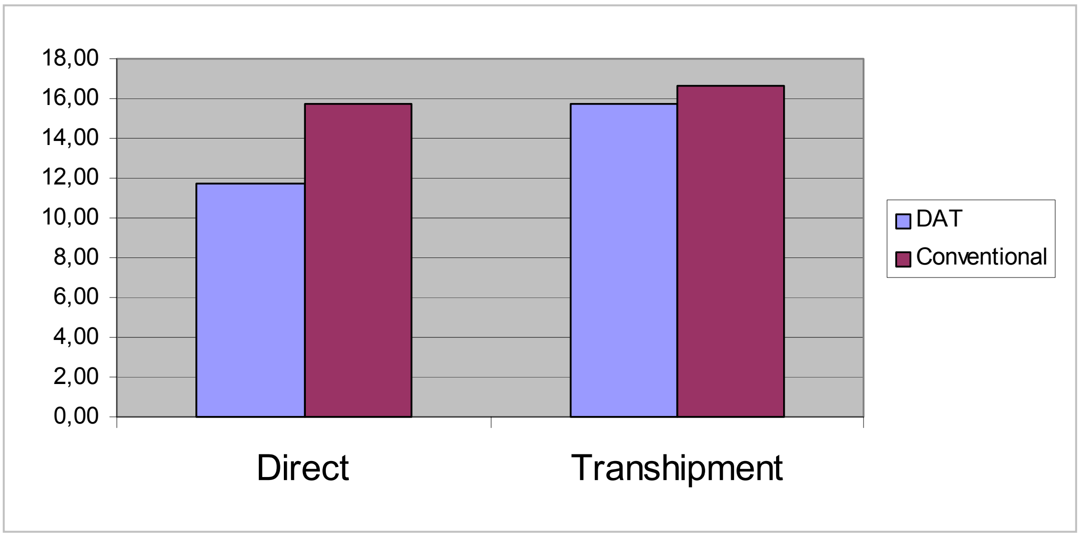


WHAT TYPE OF ICEBREAKER WHEN TRANSHIPPING?

- The performance of the icebreaker fleet is important cost factor
- There must be clear understanding how to share the costs between all the interested parties

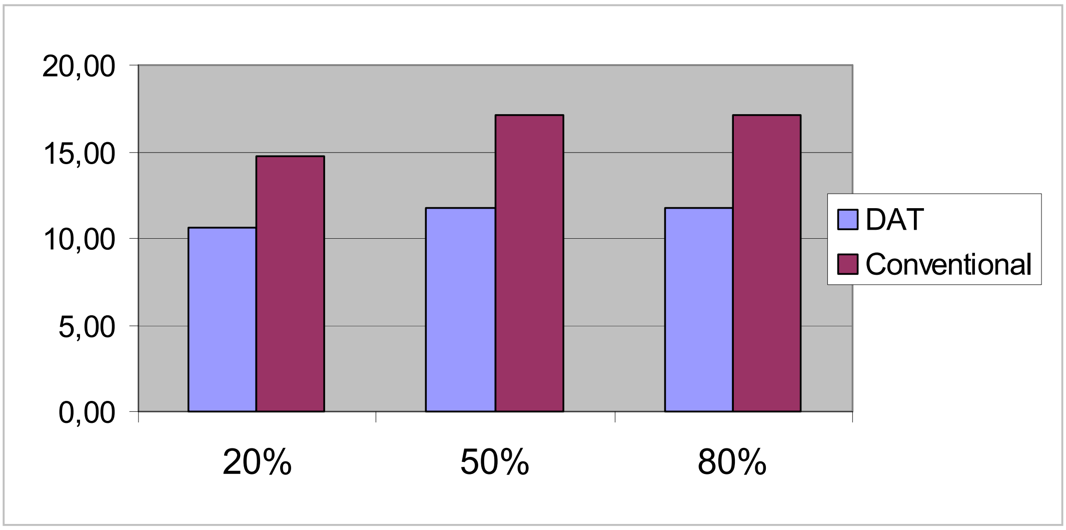


SO, WHAT IS THE BEST ROUTE?



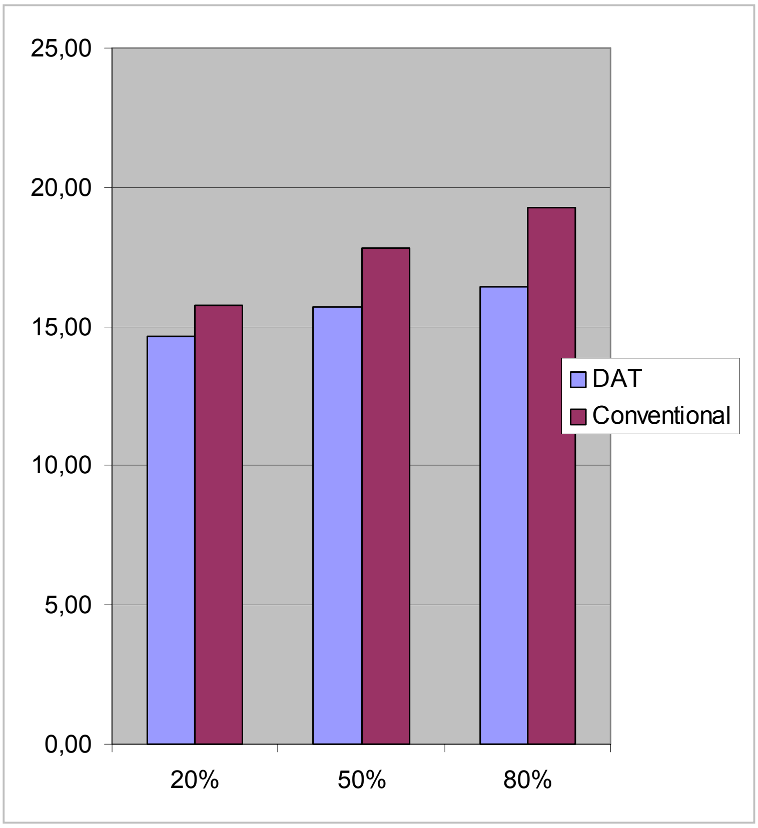
- Direct transportation to Europe
- For other destinations with longer open water leg the transipment may be more cost effective

HOW DOES THE WINTER EFFECT DIRECT TRANSPORTATION?



Direct transportation is not very sensitive to the type of the winter (<10%)

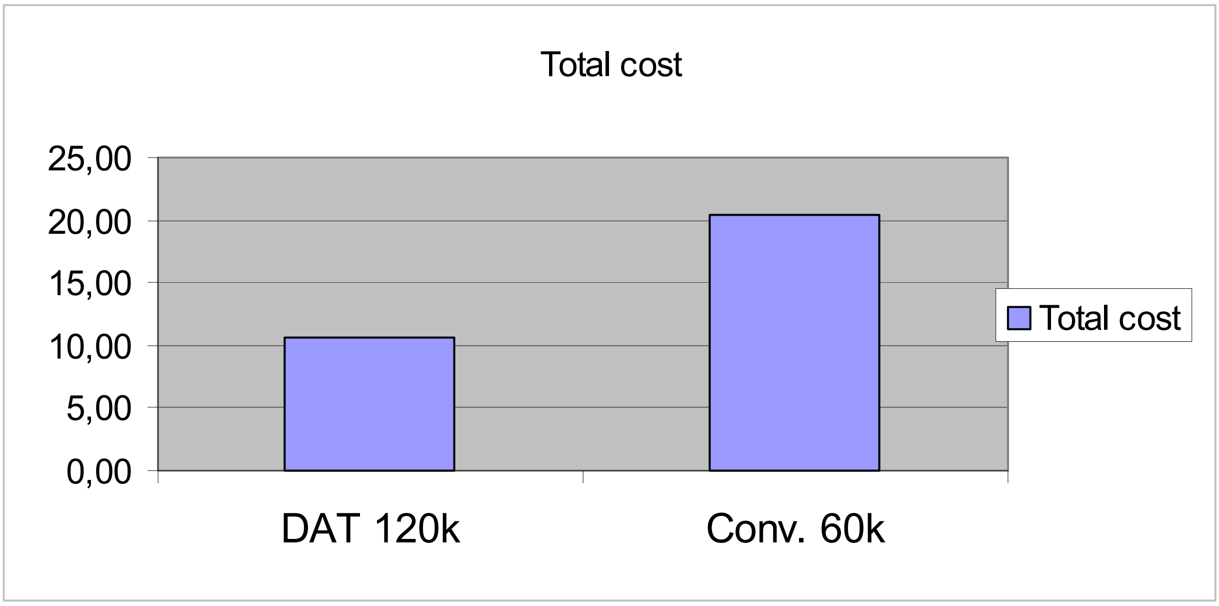
HOW DOES THE WINTER EFFECT THE TRANSHIPMENT ALTERNATIVE?



The cost difference between mild and severe winter if more than 20 %

CONCLUSIONS

- The development of the fleet is a complecated problem of optimisation
- The marine transportation is a competitive alternative for oil transportation from the Pechora Sea
- Direct transportation to Europe can be more cost effective than the use of transhipment
- Independent transportation is today the most cost effective alternative
- Icebreaker technology should be developed further to make the use of icebreakers competitive



- The cost saving with optimised design can be upto 50 %

IRIS ICE INFORMATION SYSTEM

Ice ridging information for decision making in shipping operations

by Risto Jalonen , Helsinki University of Technology

THE THREE TARGETS OF THE IRIS PROJECT:

1. Include ridging parameters into ice forecast models, develop methods of determining the parameters from satellite imagery, and verify the results by ground truth experiments.

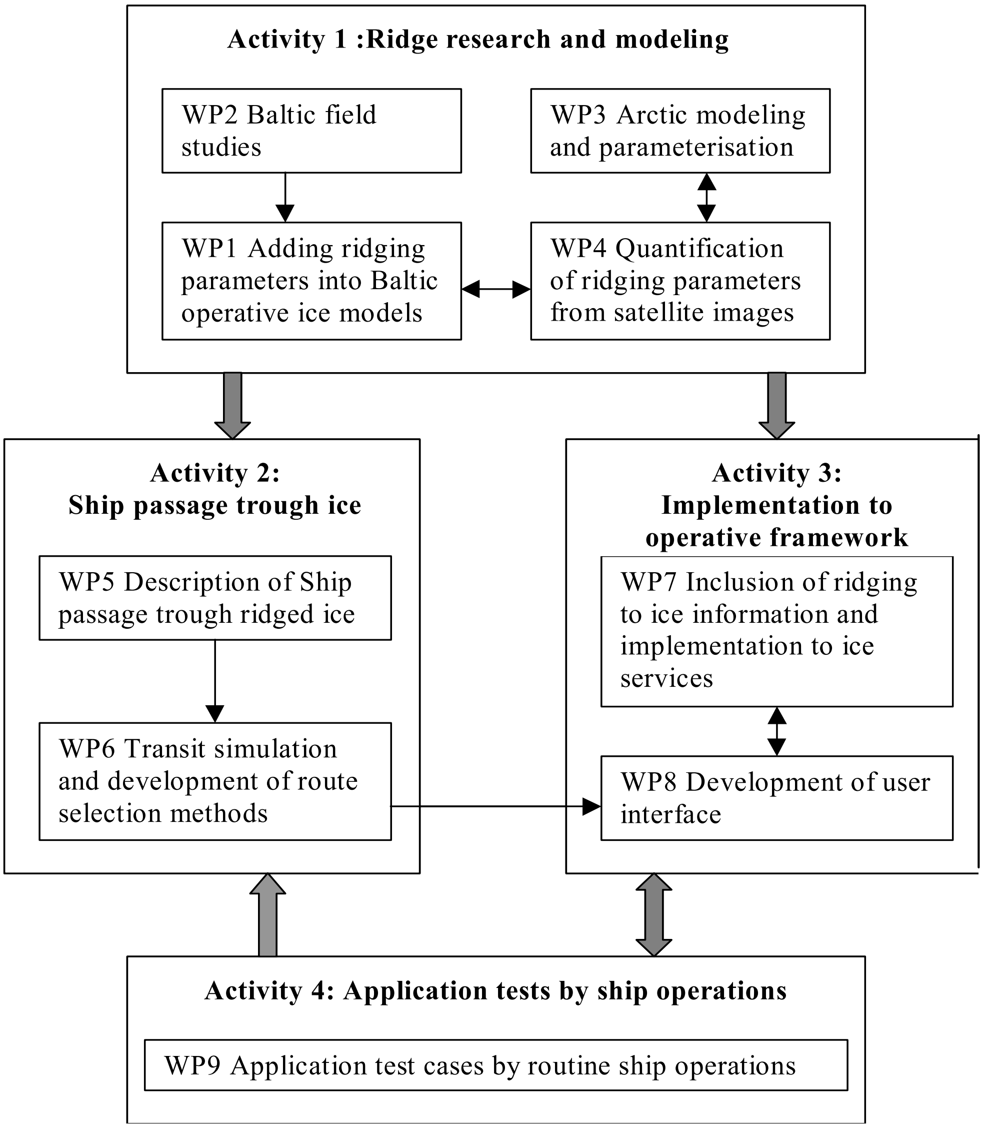
2. Determine the effect of ridging to ship transit, use this knowledge to describe the ship passage in variable ice cover, and develop tools that can be used in route selection and assist decision making in shipping operations.

3. Include ridging parameters to ice charts and ice model forecasts, supply this ice information to ships and display it with a terminal software, implement the routeing tools as an integral part of the software, and verify the applicability by routine ship operations.

TO ATTAIN THE TARGETS THE IRIS PROJECT IS DIVIDED INTO FOLLOWING WORK PACKAGES:

- WP1 Adding the description of ridging to ice models
- WP2 Baltic field studies
- WP3 Arctic field studies and model parameterisation
- WP4 Quantification of ridge density from satellite images
- WP5 Description of ship passage through ridged ice cover
- WP6 Transit simulation and development of route selection methods
- WP7 Inclusion of ridging to ice information products and implementation in ice services
- WP8 Development of user interface
- WP9 Application test cases by routine ship operations
- WP10 Project conclusion

THE INTERCONNECTIONS BETWEEN ACTIVITIES AND WORK PACKAGES IN IRIS



IRIS PROJECT PARTICIPANTS:

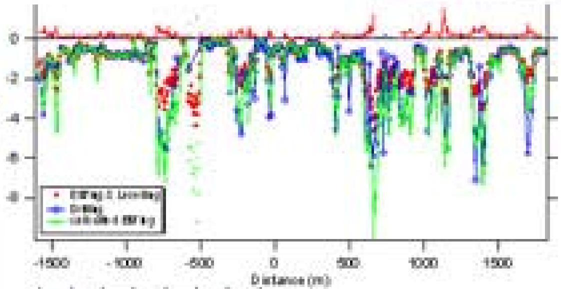
HUT	Helsinki University of Technology
AWI	Alfred Wegener Institute
FIMR	Finnish Institute of Marine Research
FOG	Neste Oil Oyj (ex. Fortum Oil and Gas)
KMY	Aker Finnyards Inc. (ex. Kvaerner Masa-Yards)
SAMS	The Scottish Association for Marine Science
SMHI	Swedish Meteorological and Hydrological Institute
VTT	Technical Research Centre of Finland; Information Technology
WS	Wagenborg Shipping

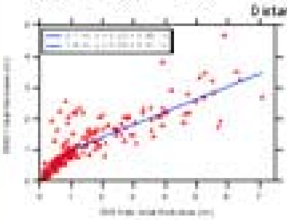
Note! IRIS is a research project funded by the European Commission (with a 100%/ 50% contribution)

RESULTS (1)

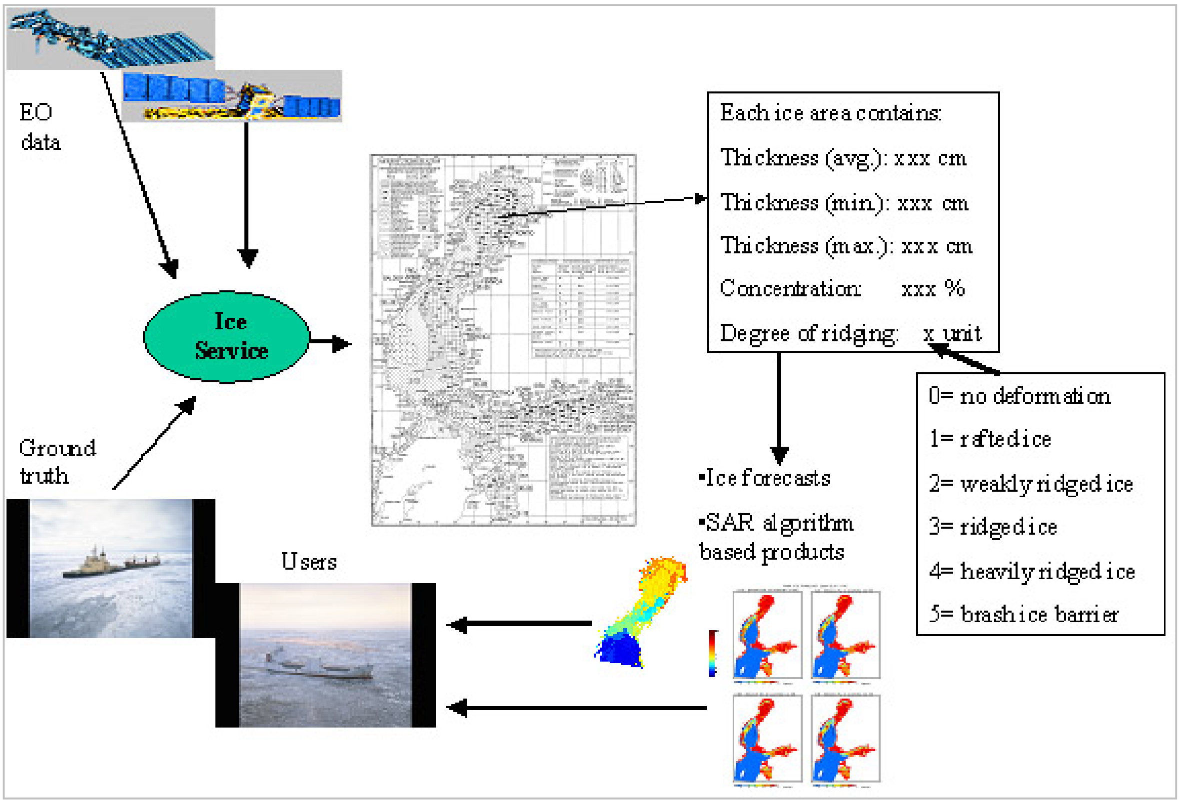
New ice models: see the separate presentation from FIMR

- Field tests & EM-data validation in 2003-2005

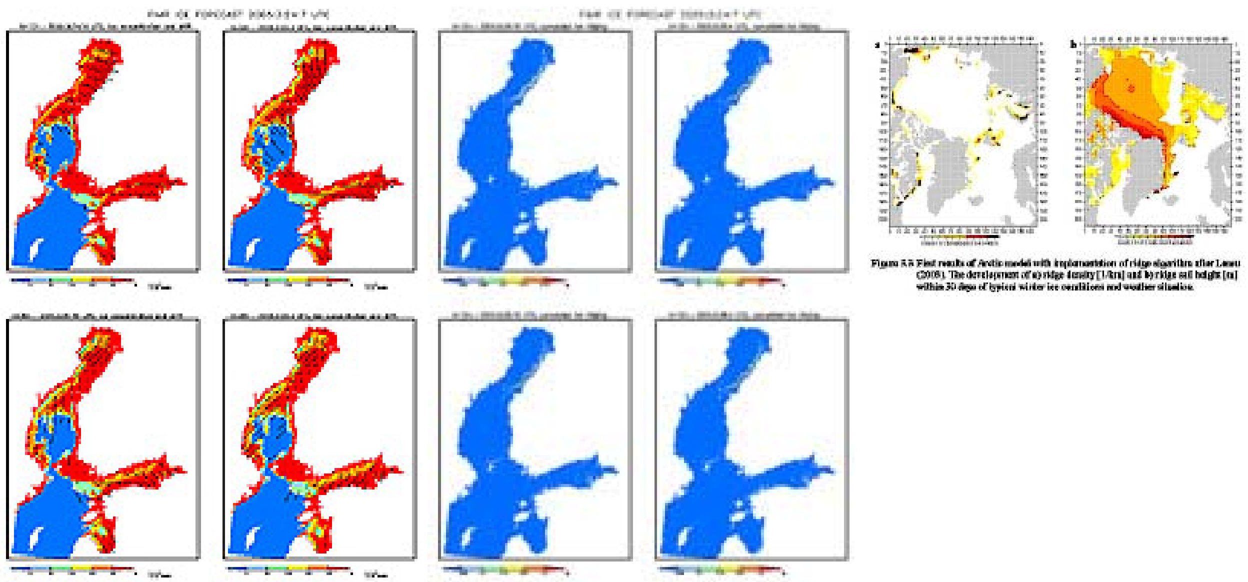




In the ice chart for each ice area manual ice parameters a put in:
a) minimum, average and maximum ice thickness,
b) ice concentration, and
c) degree of ridging
(0=no deformation, 1= rafted ice, 2= weakly ridged ice, 3= ridged ice, 4= heavily ridged ice, 5= brash ice barrier).
This information is used as input to models.

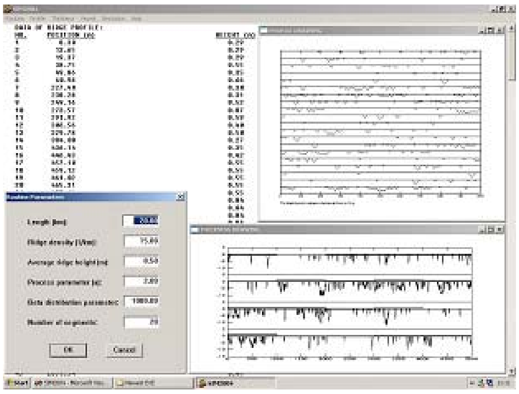


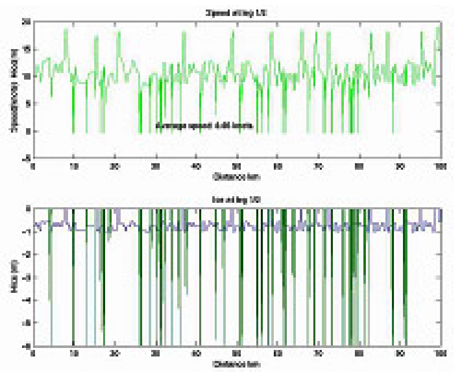
Predicted ice motion: Predicted ice ridging:

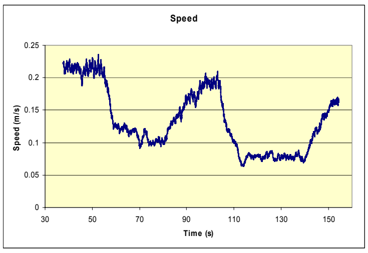


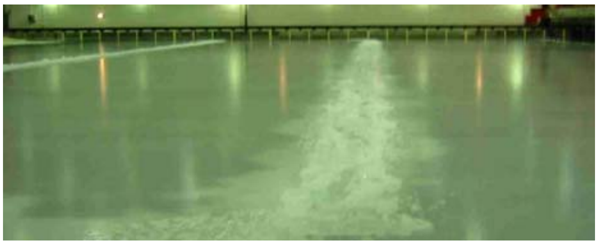
RESULTS (2):
Better understanding of ship behaviour in ridged ice based on:

- Model test results
- Ship transit simulations



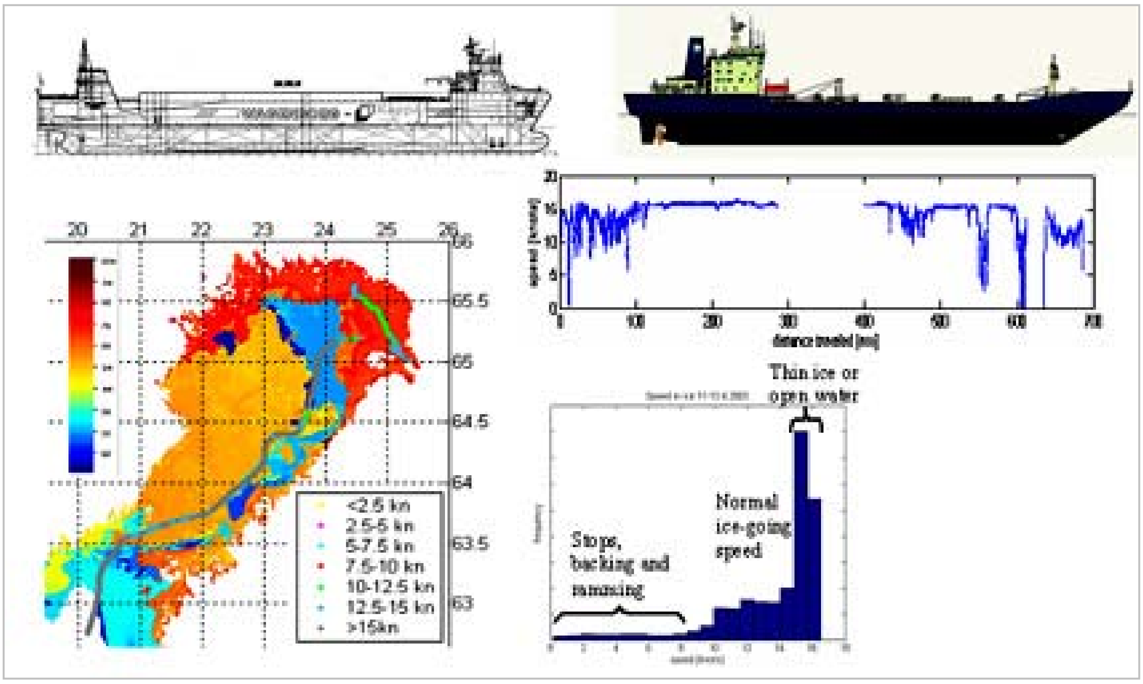






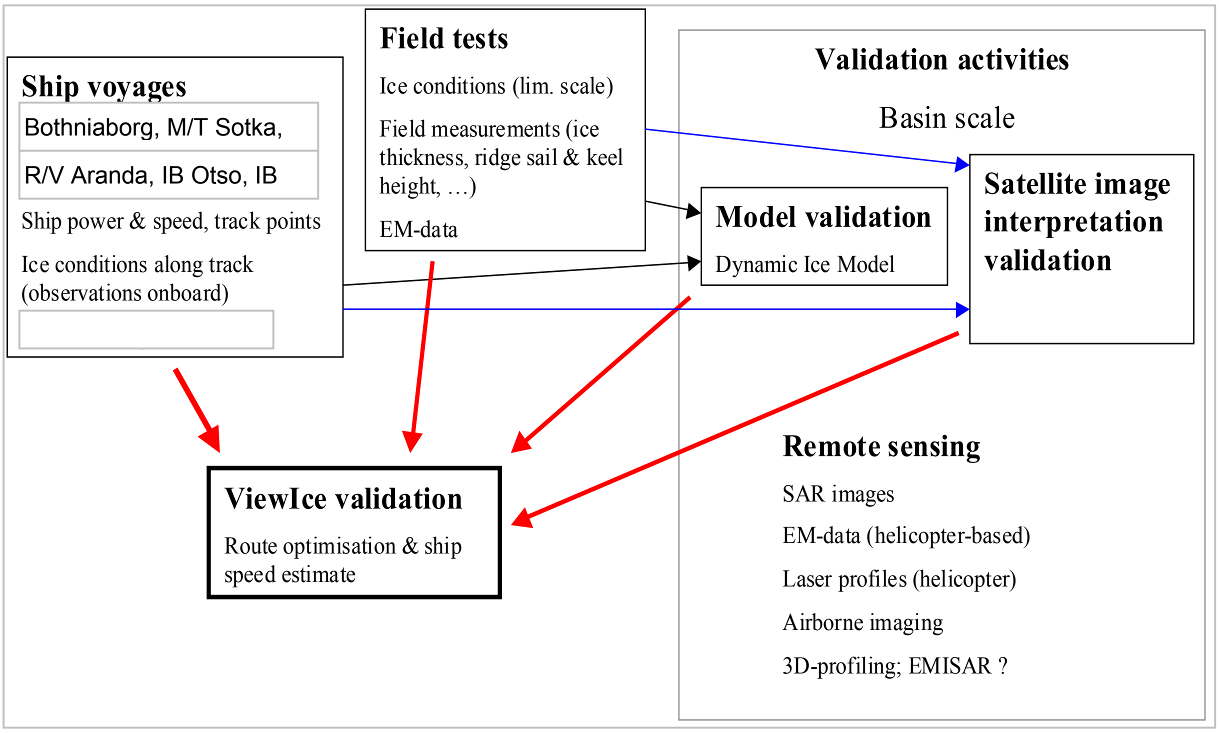
RESULTS (3):

- Ridge clustering effects, Lensu (2003)
- Data from several field campaigns in 2003-2005
- Data from several ship validation voyages in 2003-2005



SHIP VALIDATION CAMPAIGN 2005 INCLUDED (1):

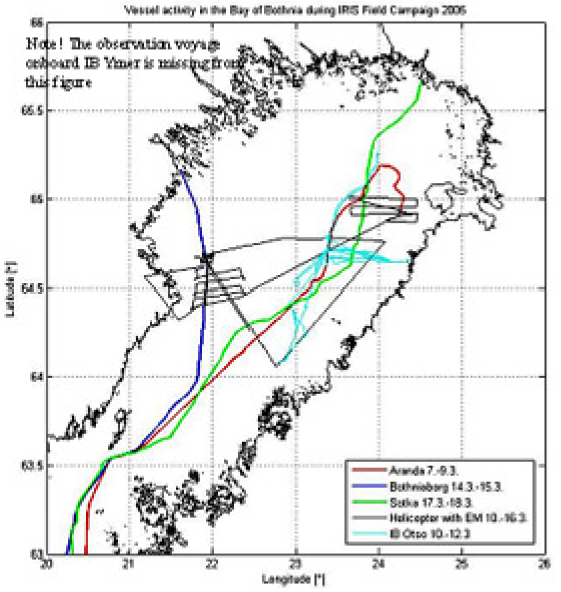
Voyages to the Bay of Bothnia and observations of ice conditions and validation of IRIS ice model data, observation of ship performance in ice, validation and feedback of ViewIce ice information and of the use of this kind of user interface onboard R/V Aranda, MS Bothniaborg and MT Sotka as well as icebreakers Otso and Ymer.

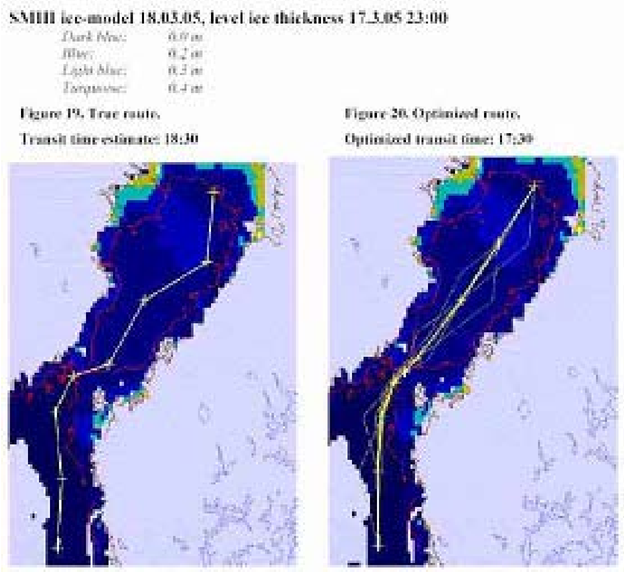


SHIP VALIDATION CAMPAIGN IN WINTER 2005 INCLUDED (2):

Iris voyages & helicopter EM-flights and field work at r/v Aranda:

- Based on the analysis of IRIS voyage onboard M/T Sotka the ptimised transit routes were assessed to be approximately ~ 1-1.5 hours faster than the realised route

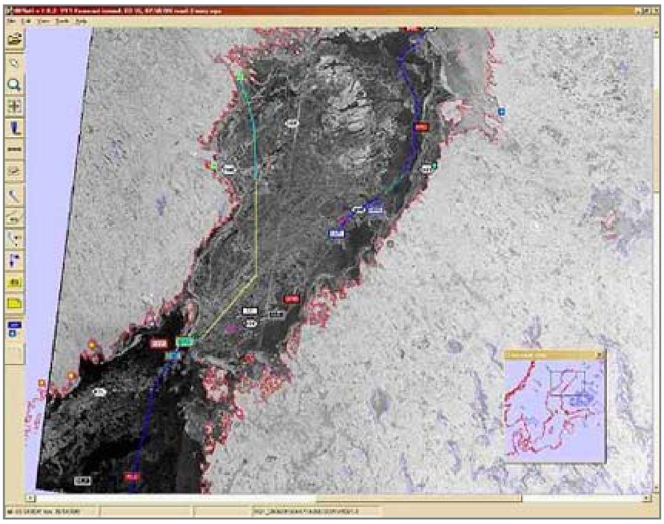




RESULTS (4):

The end result of IRIS is the user interface which presents the ice information (current data and forecasted information) and the suggested, optimised route to the operator who makes the final route planning decisions

- ViewIce A separate demonstration of the Ice information presentation and route optimisation tool ViewIce is arranged by Robin Berglund / VTT



The IRIS project will end in the end of year 2005.

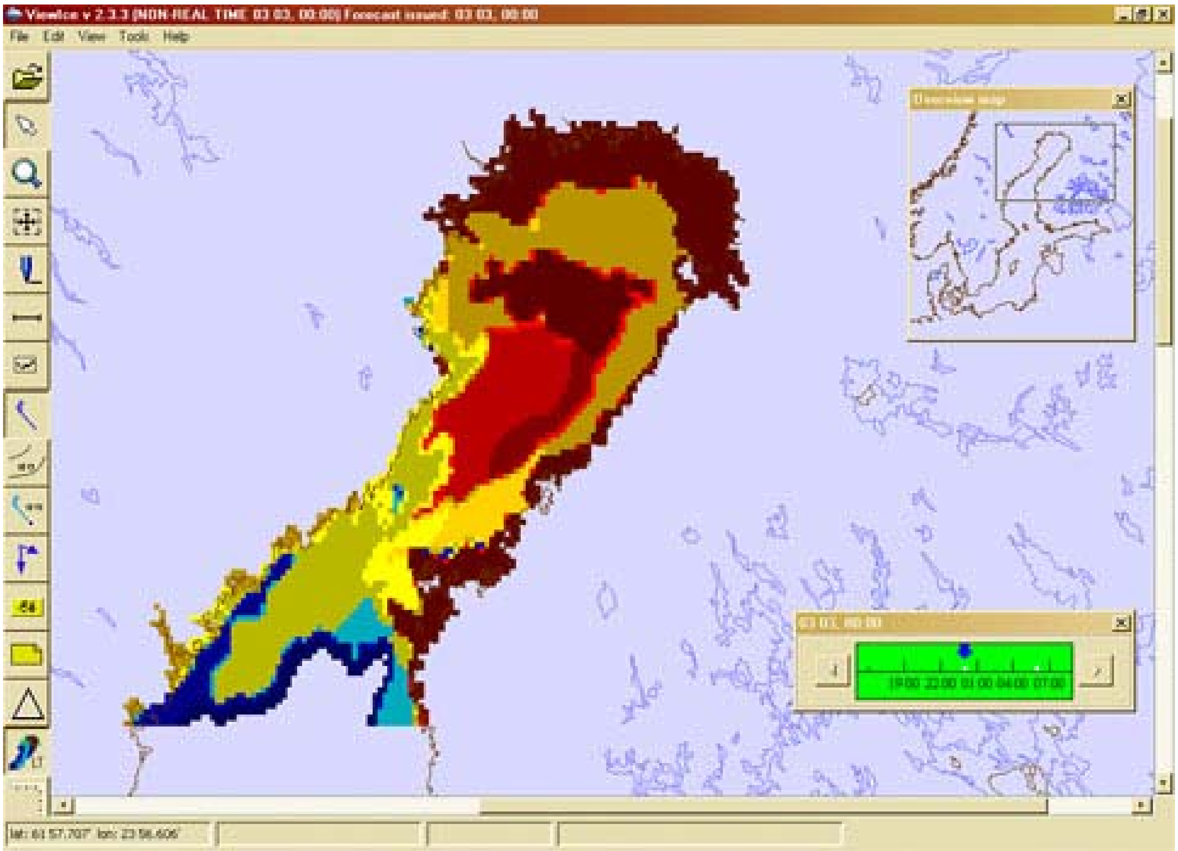
TRANSIT TIME OPTIMISATION

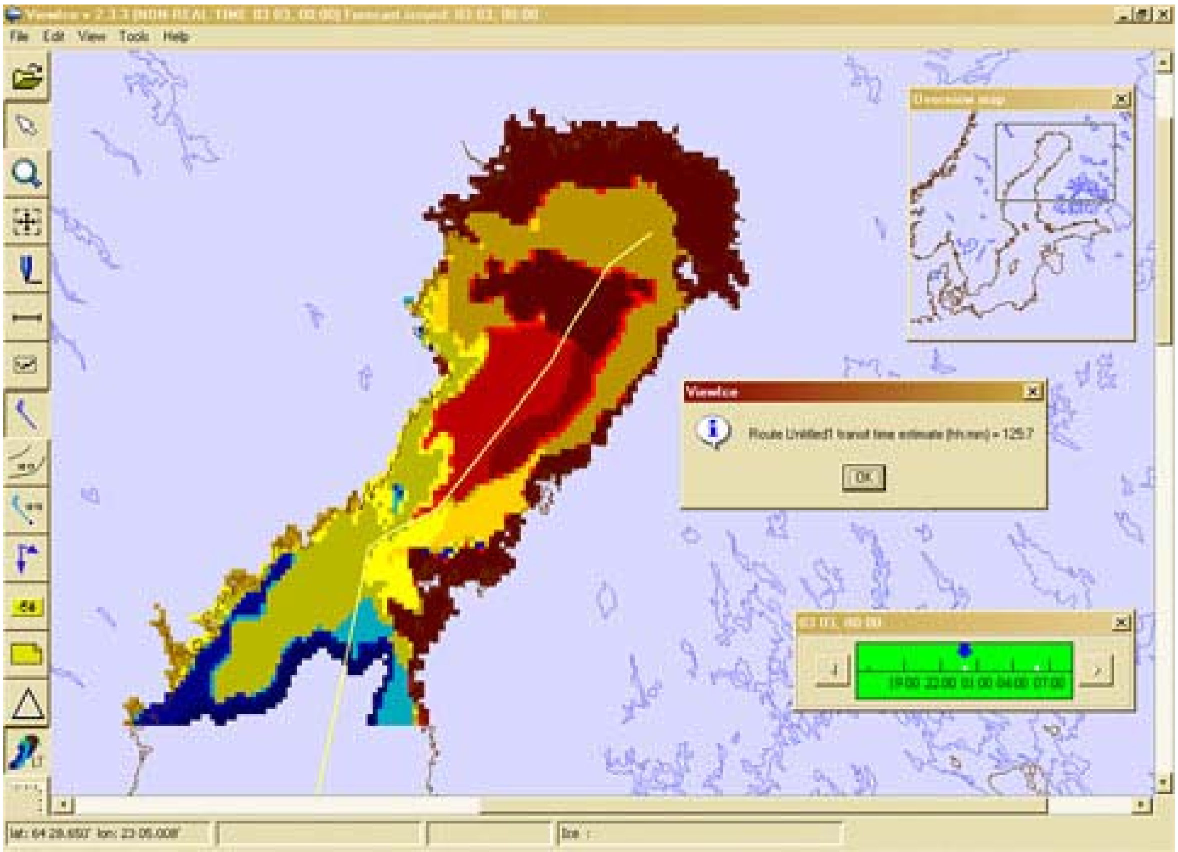
ViewIce demo

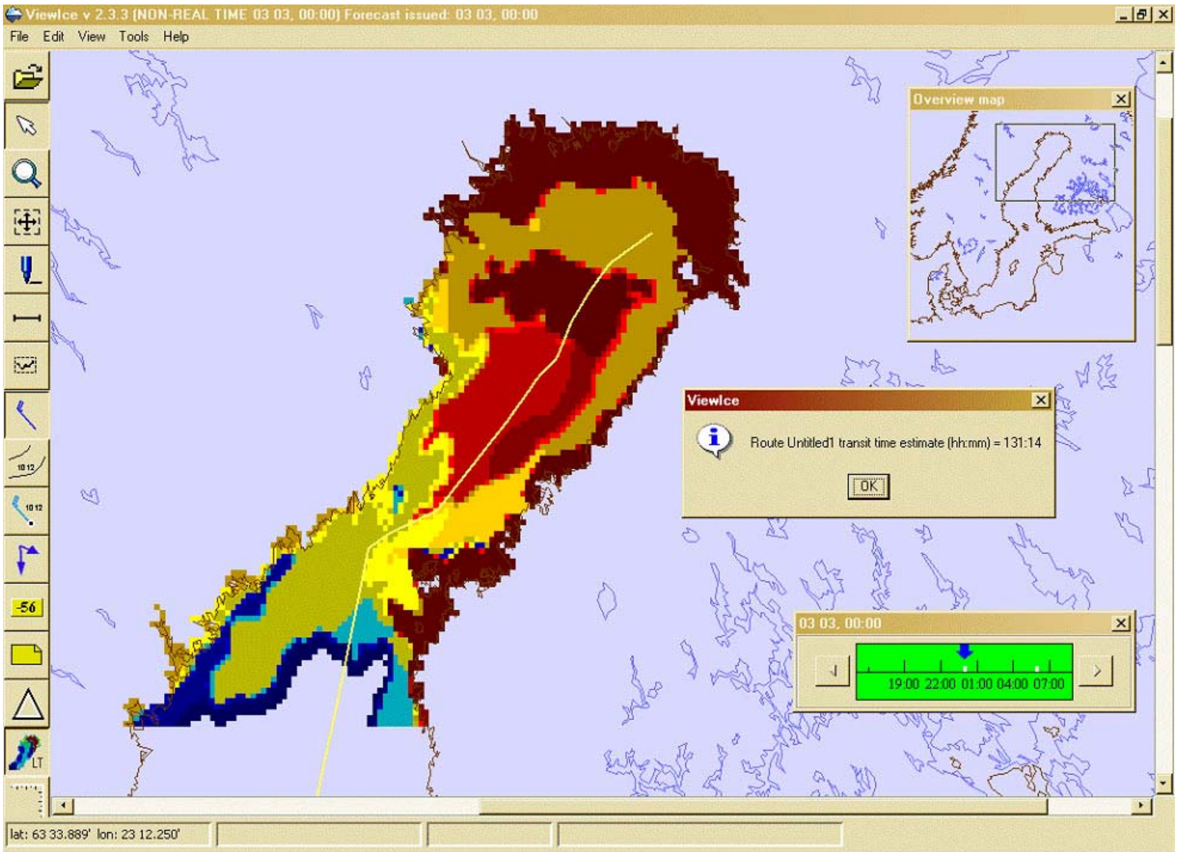
Robin Berglund, Helsinki University of Technology

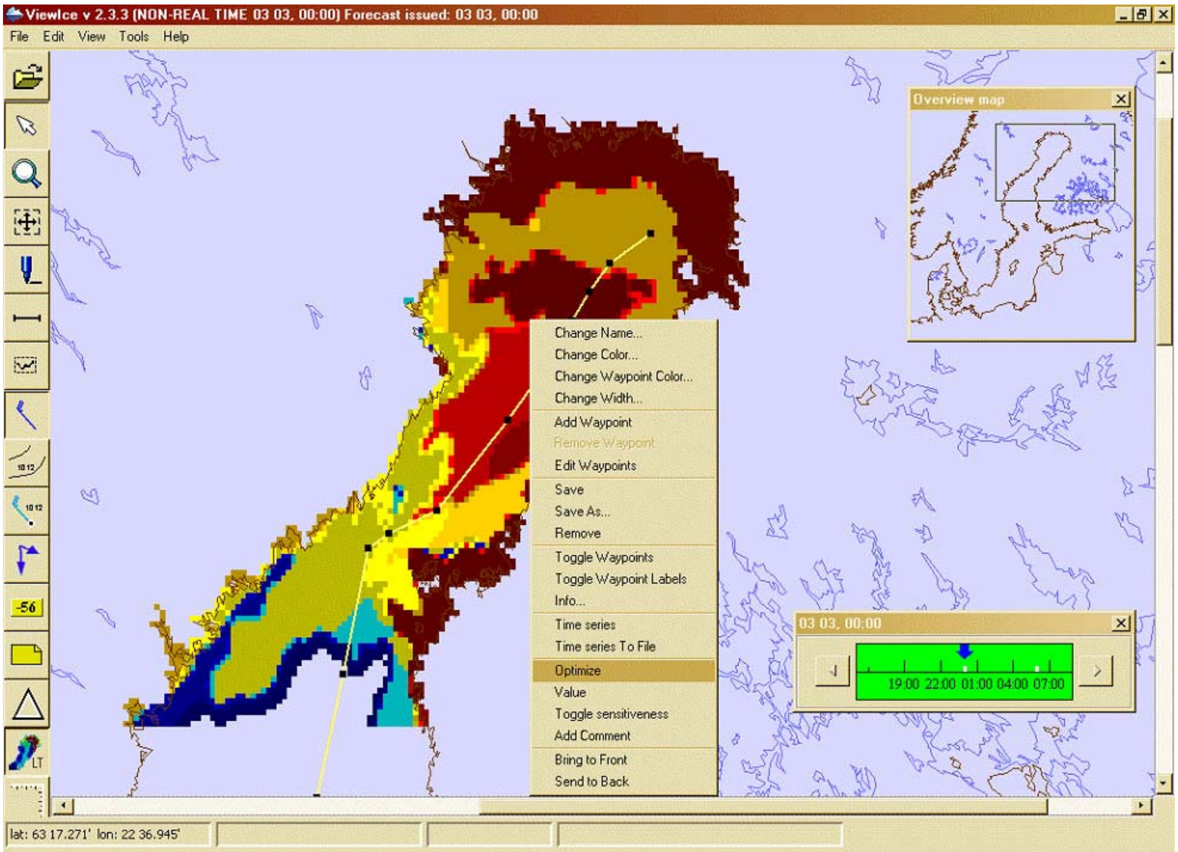
Short demo of route optimisation based on model output.

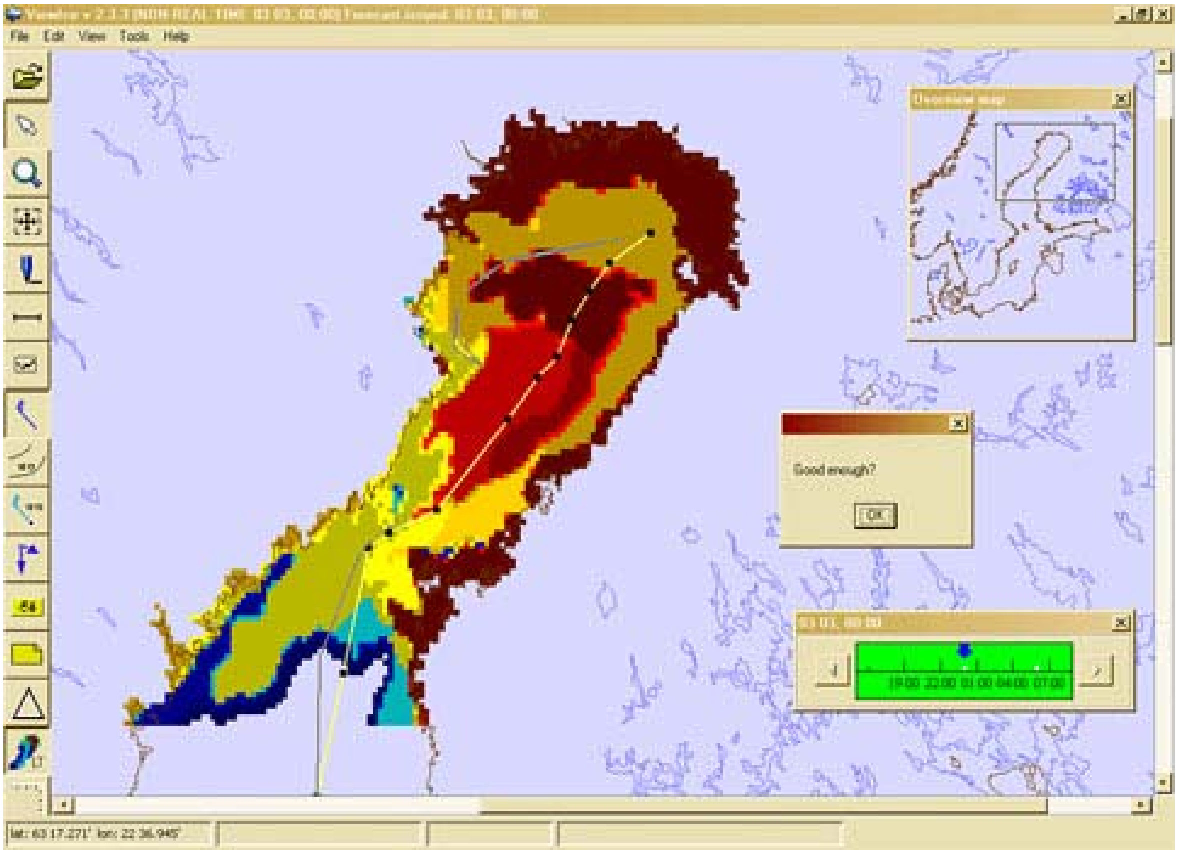
- Ice thickness exaggerated, but taken from the situation 3 – 4 March 2005 in the Bay of Bothnia
- Level ice thickness displayed

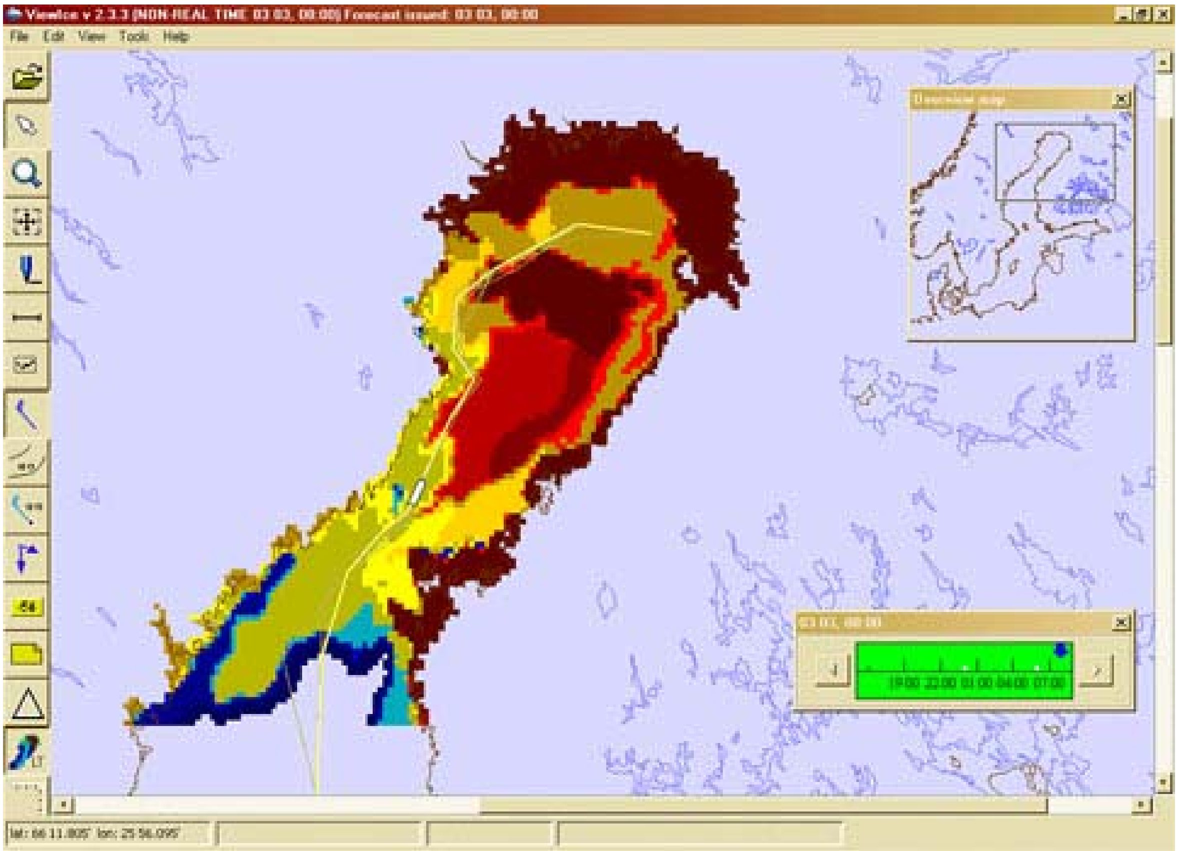


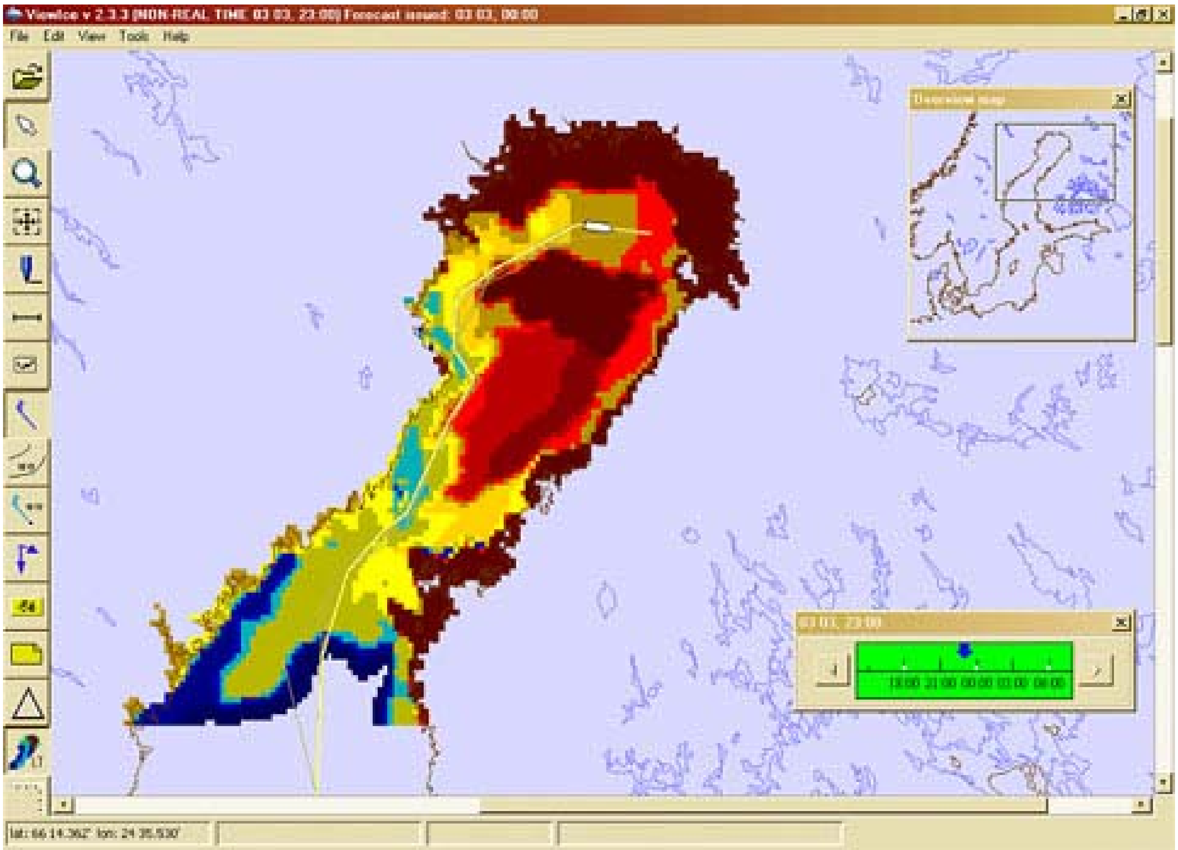

File Edit View Tools Help
Overview map
ViewIce
OK
19:00 22:00 01:00 04:00 07:00


ViewIce v 2.3.3 (NON-REAL TIME 03 03, 00:00) Forecast issued: 03 03, 00:00
File Edit View Tools Help
Overview map
ViewIce
Route Untitled1 transit time estimate (hh:mm) = 131:14
OK
03 03, 00:00
19:00 22:00 01:00 04:00 07:00
lat: 63 33.889' lon: 23 12.250'


ViewIce v 2.3.3 (NON-REAL TIME 03 03, 00:00) Forecast issued: 03 03, 00:00
File
Edit
View
Tools
Help
Overview map
Change Name...
Change Color...
Change Waypoint Color...
Change Width...
Add Waypoint
Remove Waypoint
Edit Waypoints
Save
Save As...
Remove
Toggle Waypoints
Toggle Waypoint Labels
Info...
Time series
Time series To File
Optimize
Value
Toggle sensitiveness
Add Comment
Bring to Front
Send to Back
03 03, 00:00
19:00 22:00 01:00 04:00 07:00
-56
lat: 63 17.271' lon: 22 36.945'


File
Edit
View
Tools
Help
Good enough?
OK
19:00 22:00 01:00 04:00 07:00
lat: 63 17.271' lon: 22 36.945'


ViewIce v 2.3.3 (NON-REAL TIME 03 03, 00:00) Forecast issued: 03 03, 00:00
File Edit View Tools Help
Overview map
03 03, 00:00
19:00 22:00 01:00 04:00 07:00
lat: 66 11.805' lon: 25 56.095'


ViewIce v 2.3.3 (NON-REAL TIME 03 03, 23:00) Forecast issued: 03 03, 00:00
File Edit View Tools Help
Overview map
03 03, 23:00
18:00 21:00 00:00 03:00 06:00
lat: 66 14.362' lon: 24 35.930'

ARCOP RECOMMENDATIONS OF VESSEL TRAFFIC MANAGEMENT AND INFORMATION SERVICES (VTMIS)

by Angel León / Maritime Logistics / ISSUS / Hamburg University of Technology

VESSEL TRAFIC SERVICE (VTS)
A VTS is a *service* implemented by a *Competent Authority*, designed to improve the *safety* and *efficiency* of vessel traffic and *to protect the environment.*

The service should have the capability *to interact* with the traffic and *respond to traffic situations* developing in the VTS area.

FROM VTS TO VESSEL TRAFFIC MANAGEMENT AND INFORMATION SERVICE (VTMIS)

Vessel Traffic Service (VTS)
- traffic information
- navigational assistance
- traffic organisation

\+ *transport related* information to allow for co-operative resource management in intermodal transport.

A VTMIS gathers, evaluates and distributes vessel traffic and waterborne transport data to improve the safety and efficiency of transport and to better protect the environment.

ARCOP CONDITIONS
Differences to a normal VTS:
- Low traffic density;
- Weather conditions;
- Area of coverage is huge;
- Rules for sailing in the NSR already exist.

RECOMMENDED VTMIS SERVICES

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

INFORMATION SERVICE

- 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
- Legal information
- Ice service/ice reconnaissance
- Hydrometeorological support

NAVIGATIONAL ASSISTANCE SERVICE

- Remote guidance of vessels,
- Ice pilotage,
- Navigational assistance, advice and operative navigation information
- Ice breaking support.

TRAFFIC ORGANISATION SERVICE

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

RULES AND REGULATIONS

- Regulations within the VTS area,
- Communication rules and procedures
- Enhancement of onboard equipment such as ECDIS and data communication.

CO-OPERATION WITH ALLIED SERVICES

- Ice clearance before berthing; harbour breakout
- Tugboat support of berthing operations
- Lighters
- Port services, repair
- Emergency services
- Passengers conveyance
- Supply
- Medical assistance

- Legal support
- Organisation support
- Other services

LIMITATION OF SERVICES
- Weather restrictions
- Severity of ice season
- Physical restrictions
- Safety restrictions
- Availability of resources

RECOMMENDATIONS FOR STRUCTURING THE ARCOP VTMIS
Organization of traffic:
- geographical division
- distance separation
- time separation / time slot

INFRASTRUCTURE ASPECTS
Operational aspects:
- centralised VTS System
- lower costs
- in case of total power failure difficulties to provide limited VTS Services

Technical aspects:
- radars,
- AIS base stations,
- network and
- satellite link

RECOMMENDATIONS FOR VTS SYSTEM
- Open System Architecture
- Modular System
- Standard Interfaces
- Hardware and Software
- Built-in Redundancy
- Digital nautical VTS documentation

RECOMMENDATIONS FOR EQUIPMENT

- Automatic radar tracking
- VTS display units
- Functional elements (radar, video presentation, radar signal processing, ECDIS, multi-sensor fusion)
- AIS

AUTOMATIC IDENTIFICATION SYSTEM (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

- Automatic Vessel Identification
- VHF communications
- Improved Vessel Tracking
    - Wider geographical coverage
    - Positional accuracy
    - Absence of radar shadow areas
    - Traffic image accuracy
    - Real time manoeuvring data
    - Weather effects on tracking performance
    - Precise navigational advice
    - Electronic transfer of port passage inf.
    - Electronic transfer of safety messages
    - Automatic indication of Voyage Related Information
    - Archiving data
    - System redundancy
    - Potential for interaction within regional AIS network
    - Improved SAR management

INSTALLATION OF AIS

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

AIS AND AtoNs

AIS transponder can provide information that can serve to:

- complement or replace an existing aid to navigation;
- provide identity, state of "health" and other information;
- provide the position of floating aids;
- provide information for performance monitoring;
- as a supplement to radar transponder beacons (racons); and,
- as a data gathering tool.

AIS FOR METEOROLOGICAL AND HYDROLOGICAL INFORMATION

Options:

- Connecting a measuring station directly to a local AIS-unit.
- Several measuring stations can be connected to a base station network.
- A measuring station can be co-located with an AtoN equipped with AIS.

Examples of information:

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

COSTS

Investment costs :

- planning
- building works
- equipment purchase and installation
- organisation set-up
- project management and administration

Operation costs:

- maintenance and repairs of the building works
- maintenance and repairs of the equipment

- personnel
- consumables
- insurance cover

EQUIPMENT COSTS

- VTS stations
- radar posts
- VHF masts
- AIS base stations
- Satellite link
- power/water/telephone connections
- Radar
- VHF and other communication
- Computers and software
- VTS work consoles
- vessels/vehicles

RECOMMENDATION V-103 ON STANDARDS FOR TRAINING AND CERTIFICATION OF VTS PERSONNEL

- job descriptions
- selection and recruiting
- training
- qualification and certification
- competence charts

ОСОБЕННОСТИ ОБЕСПЕЧЕНИЯ ЛЕДОКОЛЬНОЙ ПРОВОДКИ КРУПНОТОННАЖНЫХ ТАНКЕРОВ И ГАЗОВОЗОВ

Ю.А.Симонов, В.А.Беляшов, В.И.Шлячков, А.П.Тумашик, К.Е.Сазонов / ФГУП ЦНИИ им.акад.А.Н.Крылова

PARTICULARITIES OF ICEBREAKER SUPPORT IN OPERATION OF LARGE-CAPACITY TANKERS AND GAS CARRIERS

Yu.A.Simonov, V.A.Belyashov, V.I. Shlyachkov, A.P.Tumashik, K.E.Sazonov / FSUE Krylov Shipbuilding Research Institute

ЦЕЛИ:

- обсуждение альтернативных способов проводки крупнотоннажных судов в арктических ледовых условиях,
- определение основных особенностей взаимодействия крупнотоннажных судов со льдом при движении в узком канале и при движении параллельно каналу
- представление предварительных данных для оценки требуемой пропульсивной мощности крупнотоннажных судов ледового плавания на базе сравнительных экспериментальных исследований в ледовом бассейне ЦНИИ им. акад. А.Н.Крылова при исследовании ледовых сил, действующих на судно в присутствии канала

OBJECTIVES:

- Discussion of alternative ways of escorting large-capacity vessels in Arctic ice conditions,
- Determination of basic particularities of large-capacity vessels interaction with ice when moving in the narrow channel and when moving in parallel to the channel
- Presentation of preliminary data for large-capacity ice-going vessels required propulsive power prediction on the basis of comparative experimental studies in the ice test tank of Krylov Institute with studies of ice forces acting on vessel due to channel presence

Характеристики ледоколов

Наименование ледокола	«Арктика»	«Ермак»	«Фенника»	“Oden”	“Polar Star”
Длина по КВЛ, **L**,м	136.0	130.0	108.0	116	121
Ширина по КВЛ, B,м	**28.0**	**25.6**	**26.0**	**29/25**	**24.5**
Осадка, **T**,м	11.0	11.0	8.5	7.5	9.0
Мощность ЭУ, **Np**, МВт	55.2	30.4	20.3	18.0	44.7

Characteristics of icebreakers

Name of icebreaker	Arctica	Yermak	Fennica	Oden	Polar Star
Length, DWL, **L**, m	136.0	130.0	108.0	116	121
Breadth DWL, B, m	**28.0**	**25.6**	**26.0**	**29/25**	**24.5**
Draught, **T**, m	11.0	11.0	8.5	7.5	9.0
Power, **Np**, MW	55.2	30.4	20.3	18.0	44.7

Характеристики крупнотоннажных танкеров (2005-2007 гг.)

Характеристика судна Компания	Дедвейт D, тыс. тонн	Длина L, м	**Ширина B, м**	Осадка Т, м	Количество судов/ледовый класс
« Fortum»	106	252	**44**	14.5	2/ 1ASuper
«Sovcomflot»	100	240	**42**	15.0	2 / 1A
«Sovcomflot»	159	274	**48**	17.2	4 / 1C
«Prisco»	170	-	**-**	-	2-4/1A
«Prisco»	108	-	**-**	-	2/1C
«Prisco»	100	-	**-**	-	3/1A

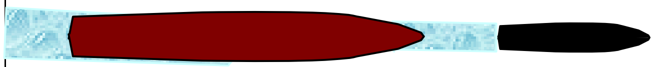
Characteristics of large-capacity tankers (2005-2007)

Vessel's characteristics Company	Deadweight DW, thousand tons	Length L, m	**Breadth B, m**	Draught T, m	Vessels quantity/ice class
Fortum	106	252	**44**	14.5	2/ 1Asuper
Sovcomflot	100	240	**42**	15.0	2 / 1A
Sovcomflot	159	274	**48**	17.2	4 / 1C
Prisco	170	-	**-**	-	2-4/1A
Prisco	108	-	**-**	-	2/1C
Prisco	100	-	**-**	-	3/1A

ТАКТИЧЕСКИЕ СХЕМЫ ПРОВОДКИ ТАНКЕРОВ
TANKER ESCORTING TACTICAL CONFIGURATIONS

а) движение т/к в канале за ледоколом
а) tanker movement in channel following the icebreaker

риск навала / fall foul risk

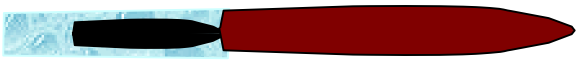


т/к
tanker

л/к - снабженец
supply icebreaker

Тандем «на усах»
Tandem "on whiskers"
риск навала / fall foul risk

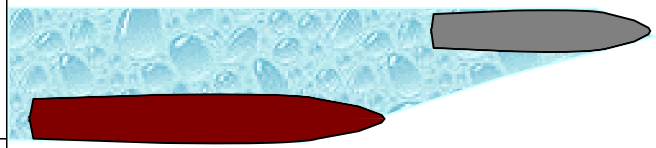
Тандем-толкание
Tandem-pushing
ледовое усиление танкера / tanker ice strengthening



б) движение т/к параллельно каналу
б) tanker movment in parallel to channel

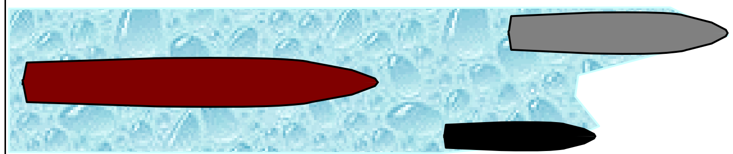
нет риска навала
no fall foul risk

л/к «Арктика»
"Arctica" icebreaker



в) движение т/к в широком канале
в) tanker movement in wide channel

увеличение стоимости проводки / escort cost increase



мысл тактики использования канала / Channel use tactics sense

Самостоятельное движение–малая толщина льда - дешевизна судна	**Тактика использования канала - Уменьшение ледового сопротивления**	возрастает ледопроходимость при заданной мощности пропульсивной установки возрастает скорость движения при заданной толщине льда
Independent movement–small ice thickness - vessel's low cost	**Channel use tactics - Reduction of ice resistance**	Ice-going capability increase at specified power of propulsive plant Speed increase at specified ice thickness

Экспериментальные и расчетные исследования особенностей движения по каналам
Experimental and calculation studies of particularities of movement in channels

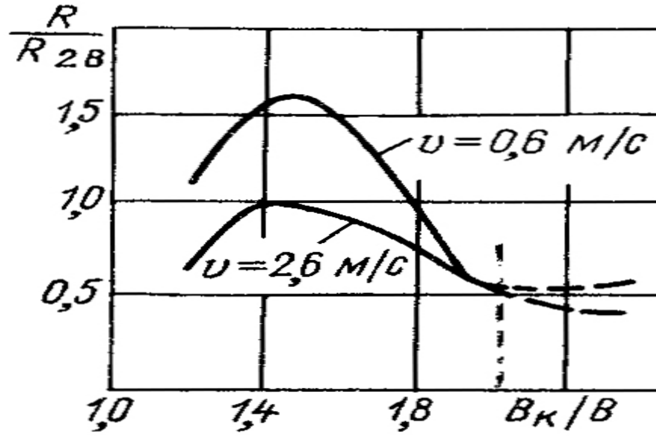


Рис. 1. Влияние ширины канала на величину силы сопротивления судна. Появление «буферного эффекта».
Fig. 1. Channel width effect on vessel resistance force value. "Buffer effect" occurrence.

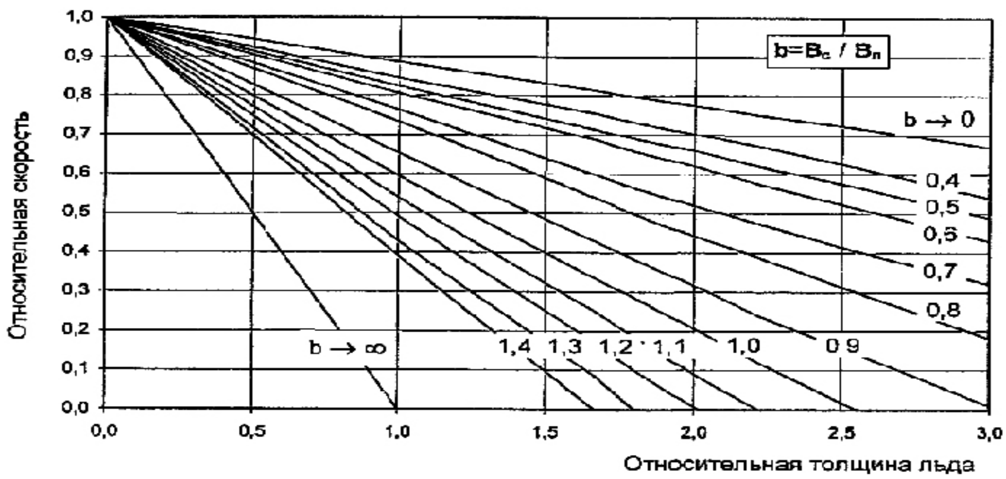
Метод В.А. Зуева (Zuev V.A method)

$$\mathbf{R = \rho g B h^2 (c_2 B/h + c_3 Fr_h + c_4 Fr_h^2) S^2 (2\text{-}S)/(\underline{\textit{B}_{канал}/\textit{B}_{судна}})^{0.75}, \quad \underline{B_{канал} \geq} B_{судна}}$$

Метод Л.Г. Цоя (Tsoy L.G method)

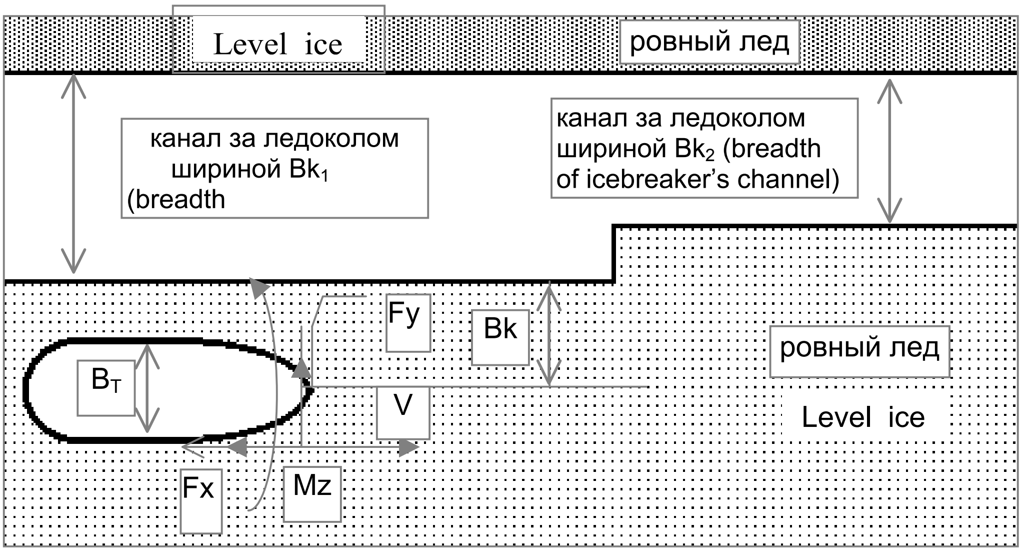
$$\mathbf{V_I = V_{OW} (1\text{-} K_C h_I (V_{OW}\text{-}2)/h_O V_{OW}),}$$

$Kc = 0.116 + 0.278\ \mathbf{b}^{-2.29}$, при $b<1$
$Kc = 0.390 + 0.523\ \mathbf{(b - 1)}$, при $1 \leq b<1.4$
$Kc = 1.0 - 0.56/\ \mathbf{b}$,при $1.4 \leq b$,
где $b = Bc/Bi$,
Bc – ширина судна (vessel width), Bi – ширина ледокола (icebreaker width).
$h_I = h_0 / Kc$

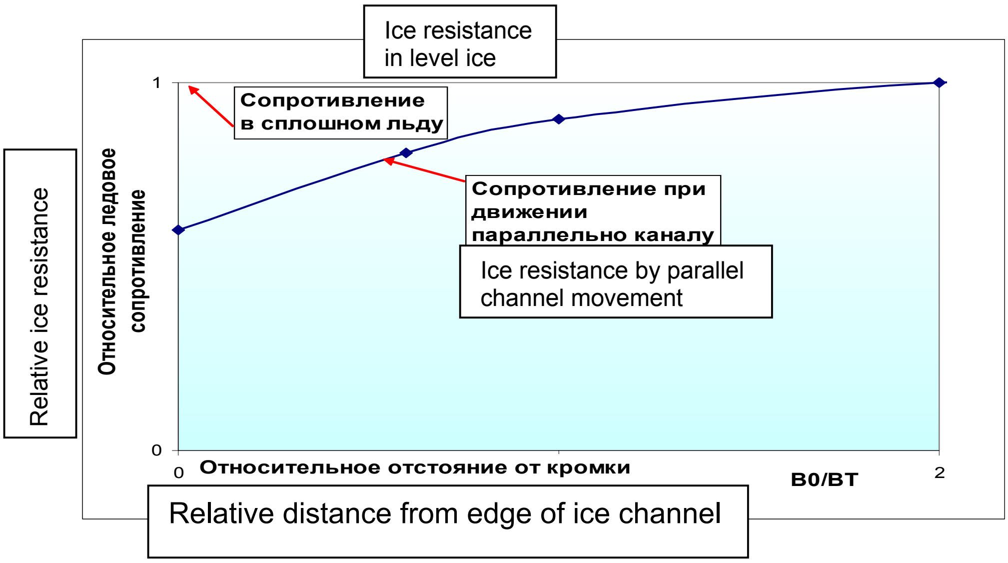


Составляющие ледового сопротивления при движении в канале	Ice resistance components when moving in channel
$R_{CH} = R_0 + R_1 + R_2 + R_3 + R_4 + R_5$	
- **R_0** - сопротивление разрушения кромок канала, - **R1** - импульсное сопротивление, обусловленное потерей кинетической энергии судна при ударах о льдины, - **R_2** - диссипативные силы сопротивления, связанные с рассеиванием энергии движущегося судна и обусловленные сопротивлением воды раздвиганию льдин и трением льдин между собой, - **R_3** - сопротивление притапливанию и поворачиванию льдин, - **R_4** - сопротивление деформированию льдин при раздвигании, - **R_5** - сопротивление, вызванное затиранием льдин между бортами и кромкой ледяного поля - «буферный эффект».	- **R_0** - channel edges breaking resistance, - **R1** - impulse resistance, caused by vessel's kinetic energy loss due to ice-floe hits, - **R_2** - dissipative forces of resistance related to moving vessel's energy dissipation and caused by water resistance to ice-floes separation and friction between ice-floes, - **R_3** - resistance to ice-floes submergence and rotation, - **R_4** - resistance to ice-floes deformation in separation, - **R_5** - resistance caused by ice floe jamming between vessel sides and ice field edge – "buffer effect".
Определение необходимого уровня пропульсивной мощности **Required propulsive power level prediction**	
$P_{min}=f_1\ f_2\ [f_3R_i]^{3/2}\ K_e\ /D$ $R_{CH} = F(B, L, b_K, h_i, \varphi, \alpha, \beta, v)$ $\quad h_{эф} = h_i \cdot [1 + A \cdot (K_{торос} - 1)]$	

Движение судна параллельно каналу, проложенному ледоколами
Vessel moving in parallel to channel made by icebreakers

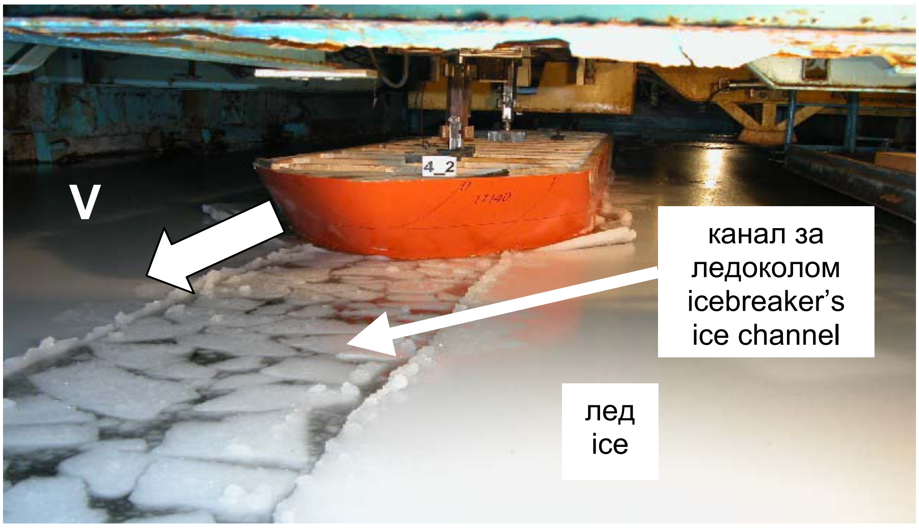



V
Кромка канала за ледоколом
Icebreaker's edge ice channel


Ice resistance in level ice
Сопротивление в сплошном льду
Relative ice resistance
Относительное ледовое сопротивление
1
0
Сопротивление при движении параллельно каналу
Ice resistance by parallel channel movement
0
Относительное отстояние от кромки
B0/BT
2
Relative distance from edge of ice channel

ДВИЖЕНИЕ ТРАДИЦИОННОГО ТАНКЕРА В КАНАЛЕ

CONVENTIONAL TANKER MOVEMENT IN CHANNEL



Движение танкера DAT в канале
DAT tanker movement in channel

ВЫВОДЫ

1. ТАКТИКА ПРОВОДКИ КРУПНОТОННАЖНЫХ СУДОВ ВО ЛЬДАХ С ДВИЖЕНИЕМ СУДНА ПАРАЛЛЕЛЬНО КАНАЛУ БОЛЕЕ БЕЗОПАСНА ПО СРАВНЕНИЮ С ДВИЖЕНИЕМ ПО УЗКОМУ КАНАЛУ ЗА СЧЕТ УМЕНЬШЕНИЯ РИСКА НАВАЛА СУДНА НА ЛЕДОКОЛ И БОЛЕЕ ЭФФЕКТИВНА ПРИ СЖАТИЯХ ИЗ-ЗА ОТСУТСТВИЯ ДАВЛЕНИЯ ЛЬДА НА БОРТА СУДНА.
2. ПРИ ДВИЖЕНИИ СУДНА ПО УЗКОМУ КАНАЛУ СУЩЕСТВУЕТ ОПТИМАЛЬНОЕ СООТНОШЕНИЕ ШИРИН КАНАЛА И СУДНА, ПРИ КОТОРОМ СОПРОТИВЛЕНИЕ ДОСТИГАЕМ МИНИМУМА. ЕГО АБСОЛЮТНАЯ ВЕЛИЧИНА ЗАВИСИТ ОТ ФОРМЫ КОРПУСА СУДНА
3. ПРИ ДВИЖЕНИИ СУДНА ПАРАЛЛЕЛЬНО КАНАЛУ ЕГО СОПРОТИВЛЕНИЕ МОЖЕТ БЫТЬ УМЕНЬШЕНО ДО ЗНАЧЕНИЯ, СООТВЕТСТВУЮЩЕГО МИНИМУМУ СОПРОТИВЛЕНИЯ ПРИ ДВИЖЕНИИ ПО УЗКОМУ КАНАЛУ.
4. ПРИ ДВИЖЕНИИ СУДНА ПАРАЛЛЕЛЬНО КАНАЛУ ВОЗНИКАЮТ ЗНАЧИТЕЛЬНЫЕ ЛЕДОВЫЕ СИЛЫ И МОМЕНТЫ, СПОСОБСТВУЮЩИЕ СНОСУ СУДНА В КАНАЛ. ДЛЯ УДЕРЖАНИЯ СУДНА НА КУРСЕ ТРЕБУЮТСЯ ВЫСОКОЭФФЕКТИВНЫЕ СРЕДСТВА УПРАВЛЕНИЯ
5. ЦНИИ ИМ. АКАД. А.Н. КРЫЛОВА ОБЛАДАЕТ ЭКСПЕРИМЕНТАЛЬНОЙ И МЕТОДОЛОГИЧЕСКОЙ БАЗОЙ ДЛЯ РЕШЕНИЯ ВОПРОСОВ РАЗРАБОТКИ КРУПНОТОННАЖНЫХ СУДОВ, ПРИСПОСОБЛЕННЫХ ДЛЯ ПРОВОДКИ ЛЕДОКОЛАМИ

CONCLUSIONS

1. TACTICS OF ESCORTING LARGE-CAPACITY VESSELS IN ICE WITH MOVEMENT OF VESSEL IN PARALLEL TO THE CHANNEL IS MORE SAFE IN COMPARISON WITH MOVEMENT IN THE NARROW CHANNEL DUE TO REDUCED RISK OF VESSEL FALLING FOUL OF ICEBREAKER AND IT IS MORE EFFECTIVE IN NIPPING DUE TO ABSENCE OF ICE PRESSURE ON VESSEL'S SIDES.
2. WHEN VESSEL MOVES ALONG THE NARROW CHANNEL THERE IS AN OPTIMUM CHANNEL/VESSEL WIDTH RATIO, AT WHICH RESISTANCE REACHES MINIMUM. ITS ABSOLUTE VALUE DEPENDS ON THE VESSEL'S HULL FORM.
3. WHEN VESSEL MOVES IN PARALLEL TO THE CHANNEL ITS RESISTANCE CAN BE REDUCED TO THE VALUE CORRESPONDING TO A MINIMUM OF RESISTANCE REACHED WHEN MOVING IN THE NARROW CHANNEL.
4. WHEN VESSEL MOVES IN PARALLEL TO THE CHANNEL THERE ARE SIGNIFICANT ICE FORCES AND MOMENTS PROMOTING VESSEL'S DRIFT INTO THE CHANNEL. FOR STEERING A STEADY COURSE THE VESSEL NEEDS HIGHLY EFFECTIVE CONTROLS
5. KRYLOV INSTITUTE HAS EXPERIMENTAL AND METHODOLOGICAL BASIS FOR SOLVING THE PROBLEMS OF DESIGNING LARGE-CAPACITY VESSELS SUITABLE FOR ICEBREAKER ESCORT

PRESENT STATUS OF ENVIRONMENTAL PROTECTION IN THE NORTH

by Gennady Matishov, Murmansk Marine Biological Institute

MMBI RESEARCH DIRECTIONS

Ministry of Education and Science of Russia
Complex investigations of processes, characteristics and resources of the Russian seas of North European basin, Black Sea and the Sea of Azov, Caspian Sea (Programme «The World Ocean»)

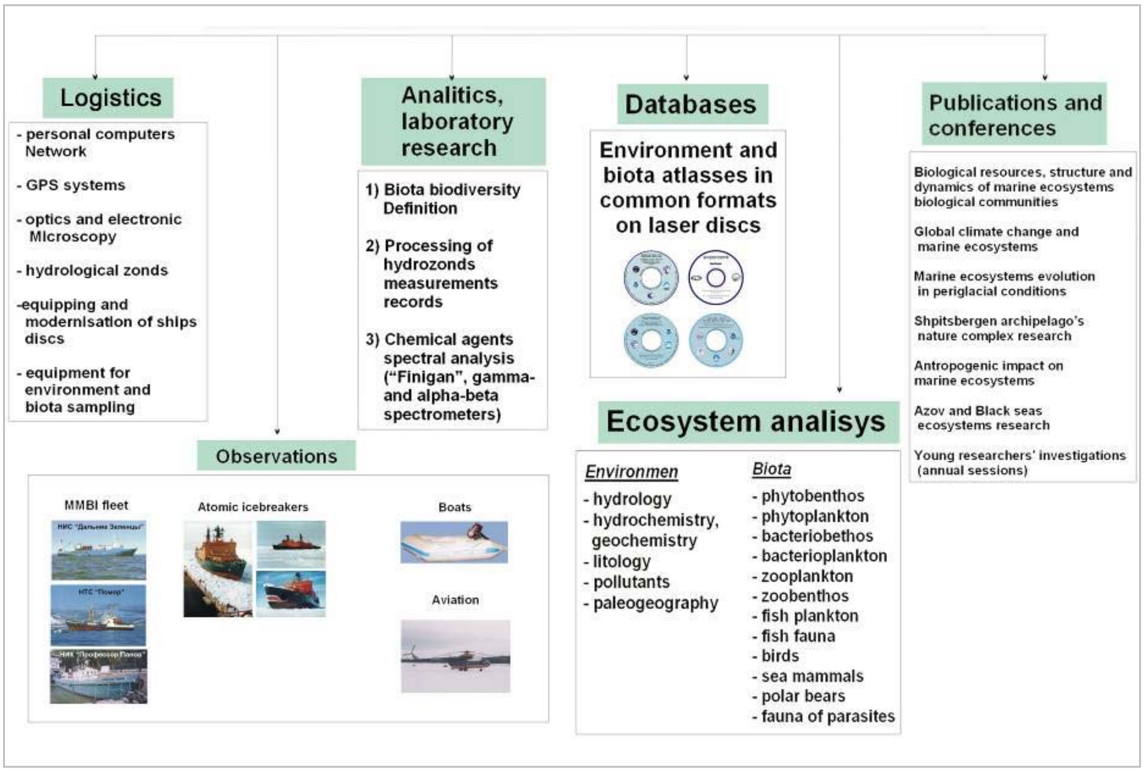
Development of natural processes monitoring new technologies in the environmentally vulnerable zones of fresh and marine waters interaction with the use of biological indicators (Programme «New Technologies»)

Russian Academy of Sciences
Monitoring technologies development, ecosystem modeling and forecasting while studying the natural resources under conditions of arid climate

Ministry of Oil and Gas of Russia
Engineer-ecological surveys for the construction of Stockman Gas Condensate Deposit development objects («Sevmorneftegaz»)

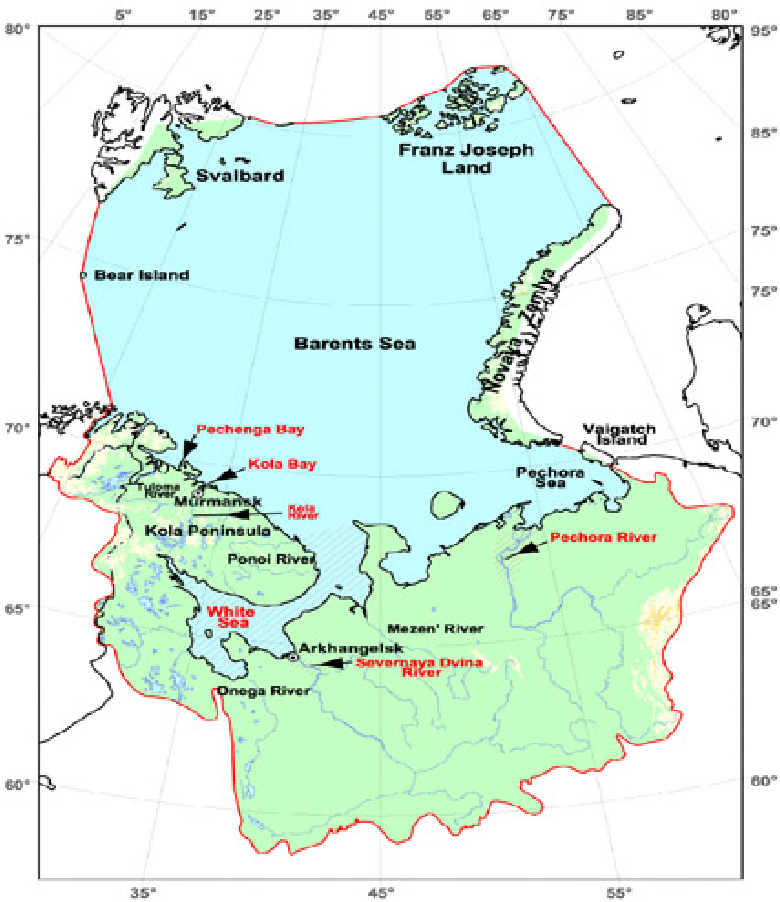
Determination and mapping of environmentally vulnerable zones of the open water area of the North Caspian Sea on the basis of created electronic data base of the region («LukOil»)

MARINE ECOSYSTEM RESEARCH COMPLEX AND LOGISTICS IN MMBI



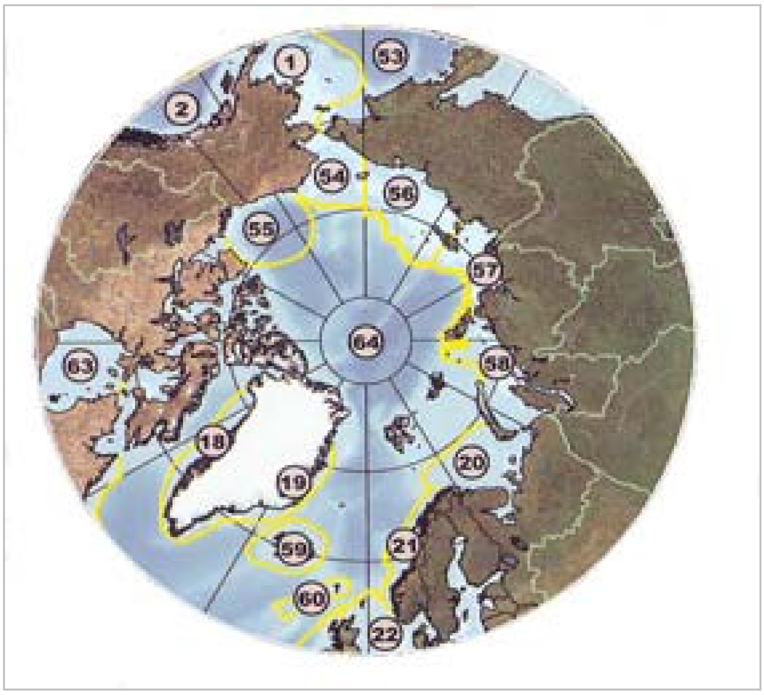
Global International Waters Assessment (GIWA) sub-region 11, Barents Sea

Large Marine Ecosystem

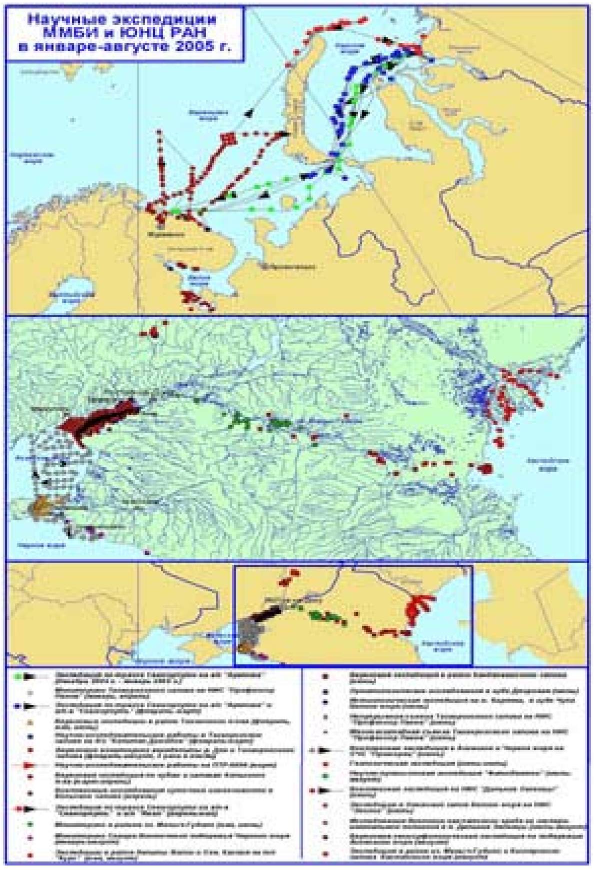


North Polar Region LMEs

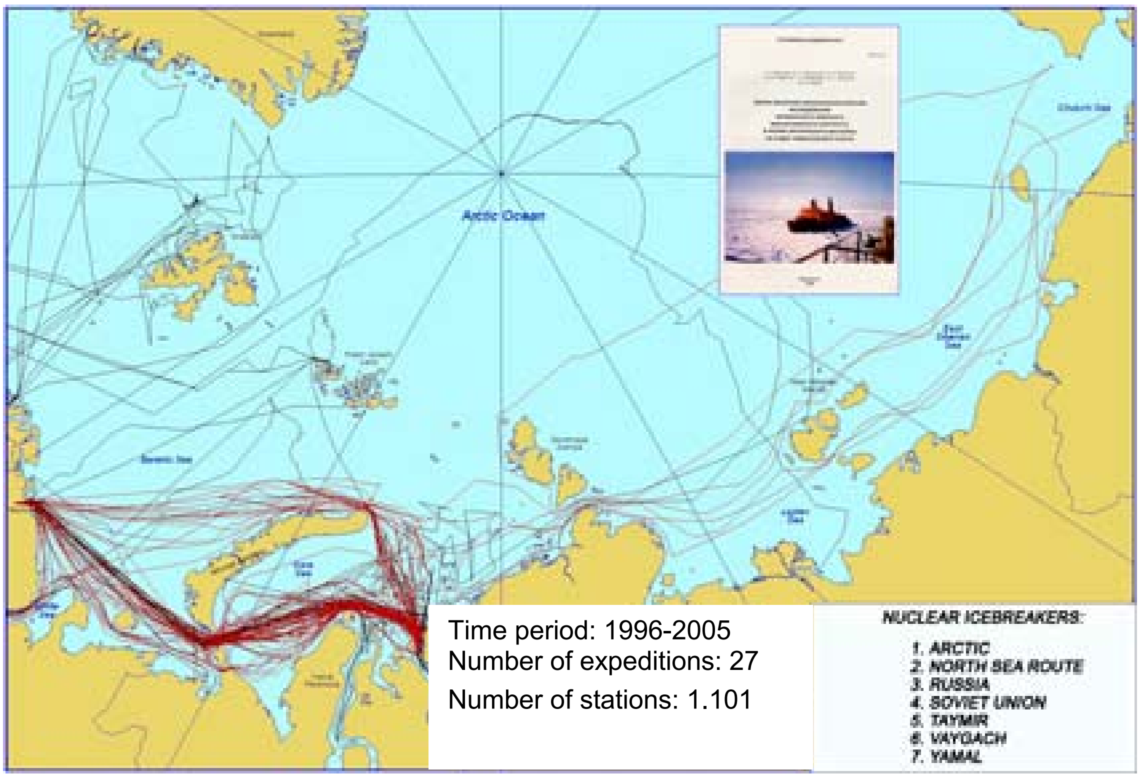
1	East Bering Sea
2	Gulf of Alaska
18	W.Greenland Shelf
19	E. Greenland Shelf
20	Barents Sea
21	Norwegian Shelf
22	North Sea
53	W. Bering Sea
54	Chukchi Sea
55	Beaufort Sea
56	East Siberian Sea
57	Laptev Sea
58	Kara Sea
59	Iceland Shelf
60	Faroe Plateau
63	Hudson Bay
64	Arctic Ocean



Scientific Expeditions of MMBI RAS and SSC RAS in January – August 2005



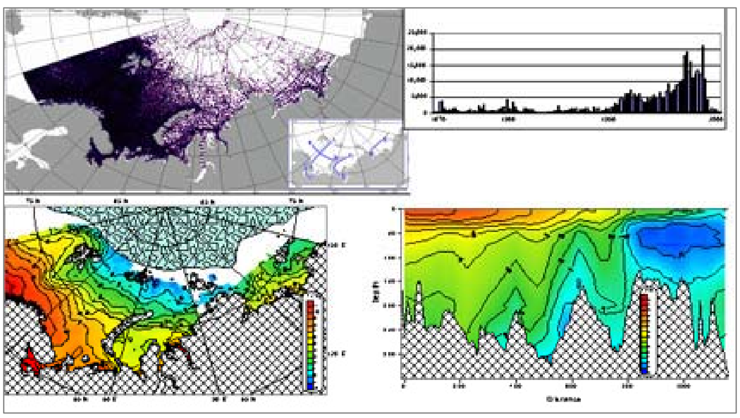
ALL-SEASON ECOSYSTEM MONITORING FROM BOARD OF ATOMIC ICE-BREAKERS IN DIFFICULT TO ACCESS ARCTIC REGIONS



CLIMATIC ATLAS OF ARCTIC SEAS 2004: PART 1. DATABASE ON BARENTS, CARA, LAPTEV AND WHITE SEAS – OCEANOLOGY AND MARINE BIOLOGY

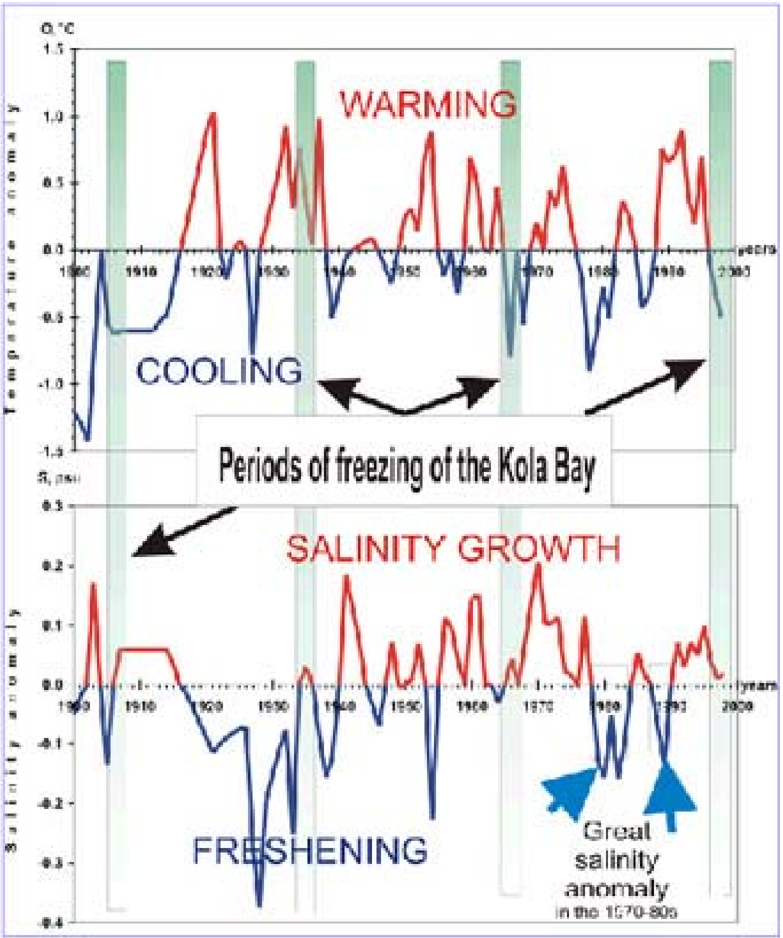
The total 10 years work of the institute in the field of applied marine informatics and, at the same time, is the base for further development of integrated hydrobiological research in oceans and seas.

Meteorological, oceanographical and hydrobiological primary data on arctic seas are presented on DVD including 478 thousands of oceanographical stations in 1810-2001 period.

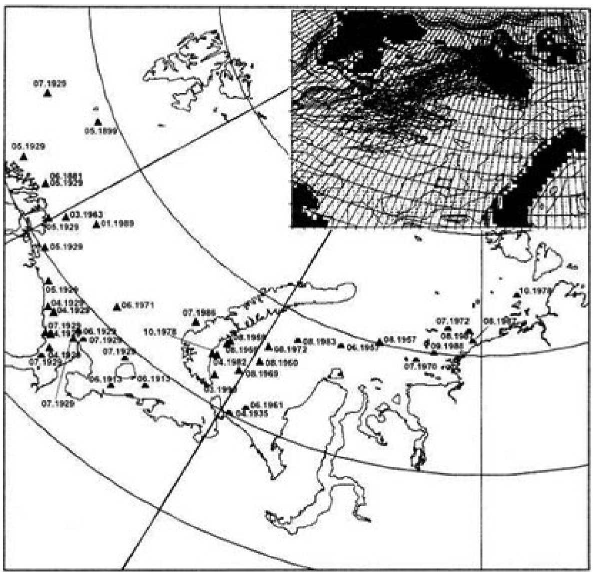


ANOMALIES IN FOCUS OF MODERN OCEANOLOGY

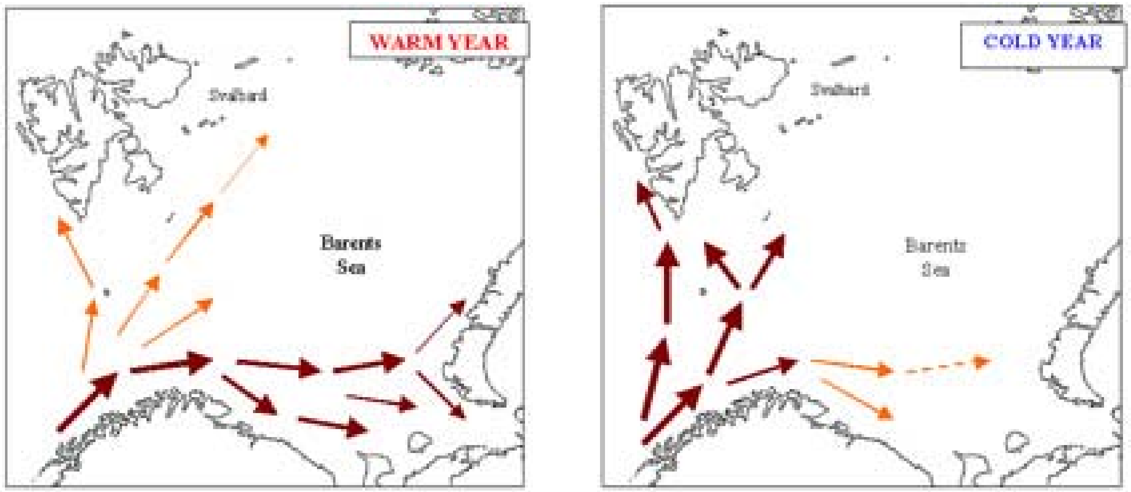
Century temperature and salinity trends in Barents sea.
0-50 m layer



DRIFT DIRECTIONS AND IRREGULAR CASES OF ICEBERGS APPEARANCE IN THE SOUTHERN PART OF THE WESTERN ARCTIC (according to: Abramov V. A., 1995)



CLIMATE, PRODUCTIVITY AND NATURAL MORTALITY OF FISH

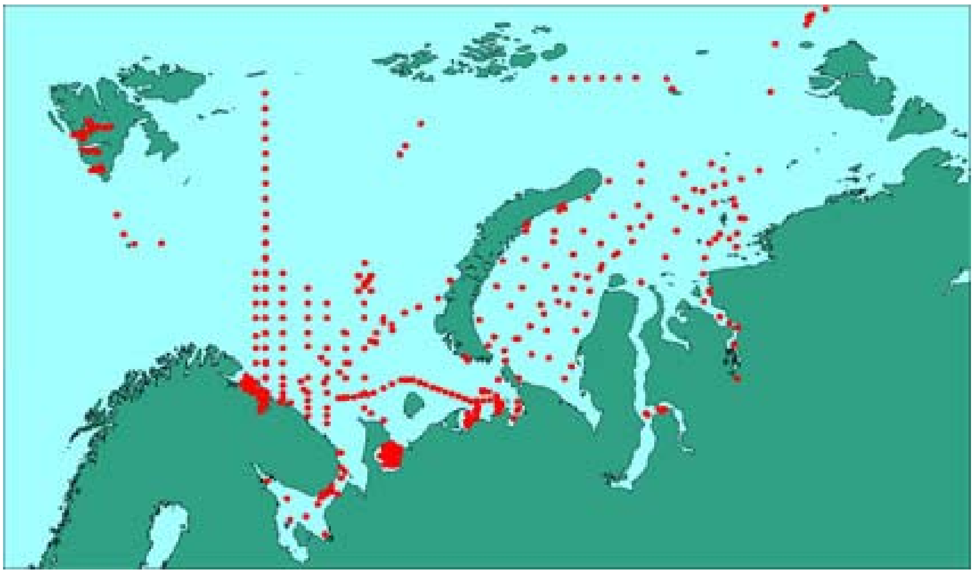


Primary route
Secondary route

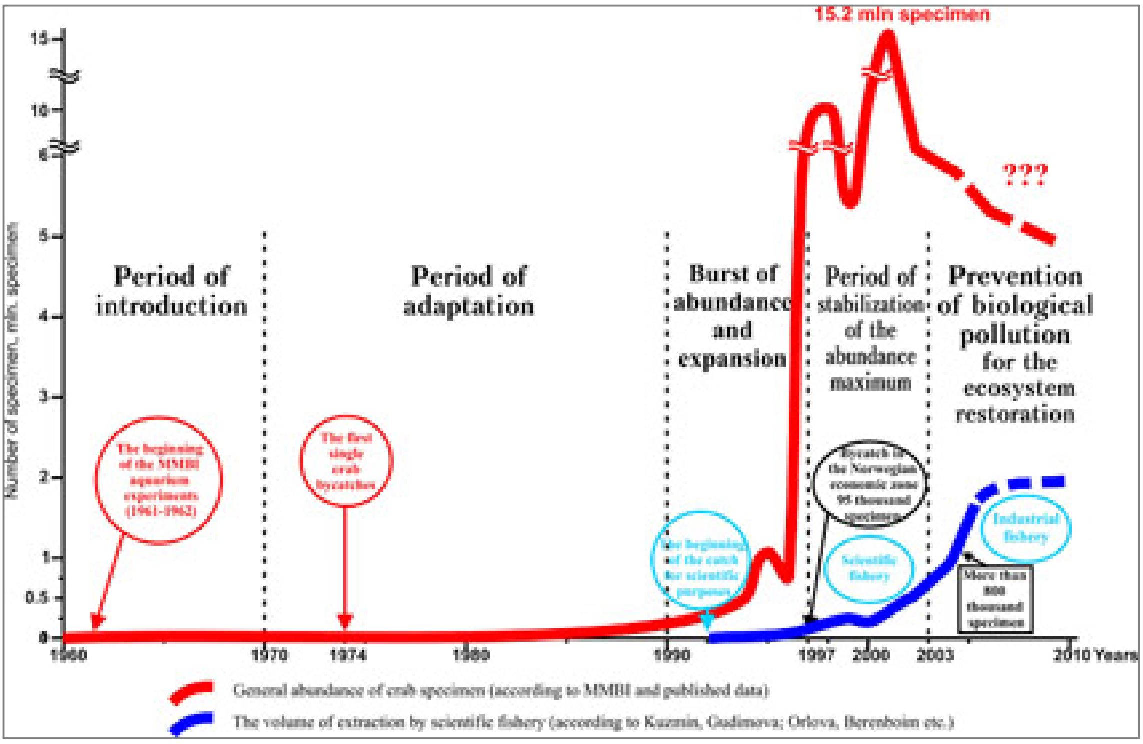
PHYTOPLANKTON DOMINANT SPECIES IN ARCTIC SEAS

phytoplankton

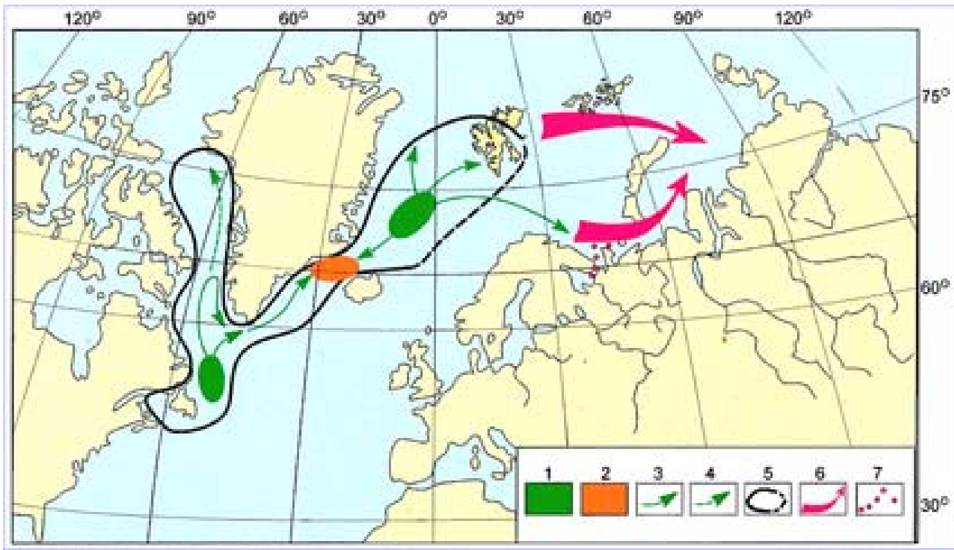
SCHEME OF BENTHOS STATIONS, CARRIED OUT BY MMBI IN 1994 – 2004



THE STAGES OF RED KING CRAB ACCLIMATIZATION
(BIOLOGICAL INVASION) IN THE BARENTS SEA (1960-2003)



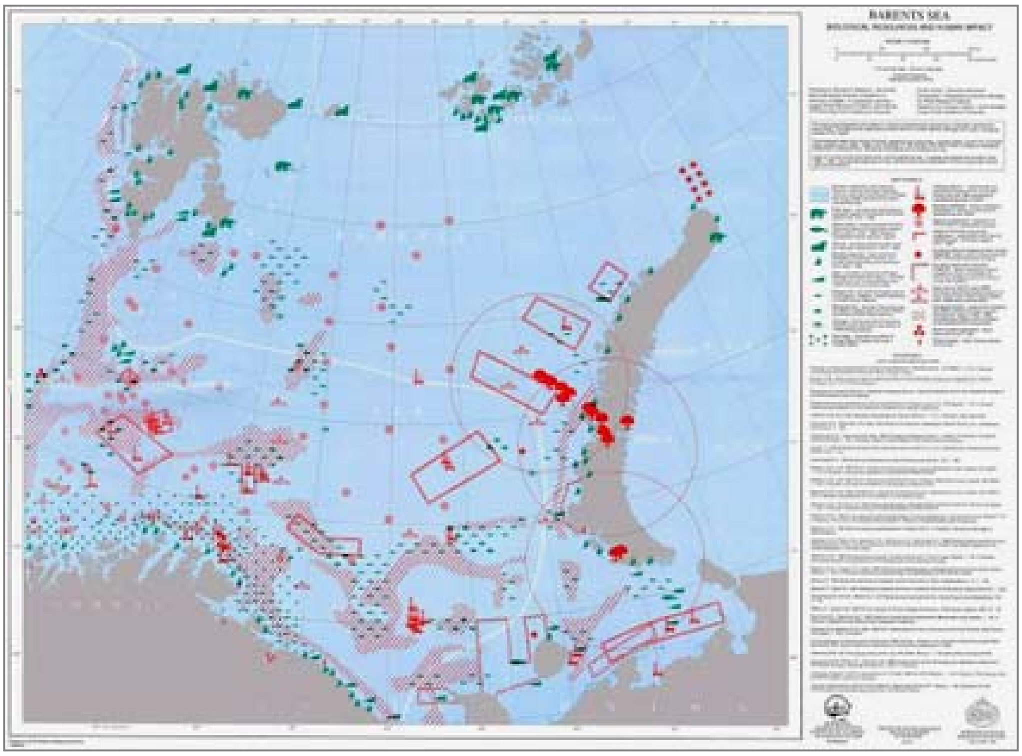
CRESTED SEAL HABITAT



1. Reproduction Areas 2. Moulting Areas 3. Supposed migration routs
4. Supposed migration routes, including ones of the off-springs (according to: Rasmussen, 1960)
5. Habitat's boundaries, including the probable ones
6. Possible present migration routes of crested seal to the West Kara Sea
7. Areas of entering the Russian waters (Chapskyi, 1976)

BARENTS SEA. BIOLOGICAL RESOURCES AND ANTROPOGENIC IMPACT MAP

Barents Sea Biological Resources and Human Impact. Map Scale: 1:3 000 000/ Matishov G., Weslawski S. MMBI, Institute Oceanology Polish Academy of Sciences, Norwegian Polar Inst. Oslo, 1991



COMPLEX ECOLOGICAL MONITORING FOR THE EXPERIMENTAL TRYING OUT OF THE ROADSTEAD OIL TRANSFER IN THE PECHORA SEA
In the framework of the project "Prichal-Varandey" ("Wharf-Varandey") 2000-2004


РОССИЙСКАЯ АКАДЕМИЯ НАУК
КОЛЬСКИЙ НАУЧНЫЙ ЦЕНТР
МУРМАНСКИЙ МОРСКОЙ БИОЛОГИЧЕСКИЙ ИНСТИТУТ

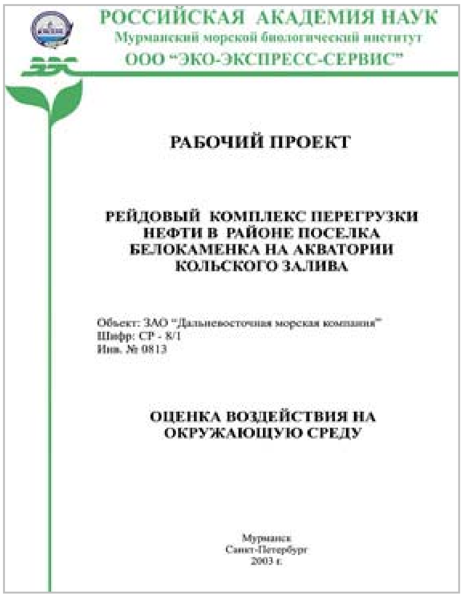
ОТЧЕТ

о проведении научных работ по х/д
2004 - 11/ 2003 от 01.08.2003 г.
"Мониторинг Печорского моря в период эксплуатации арктического подводного погрузочного терминала в п. Варандей"

Мурманск
2003

Customer:
Murmansk Shipping Company

DRAFT PROJECT ON THE ENVIRONMENTAL IMPACT ASSESSMENT
"Oil transfer terminal in the area of Belokamenka on the Kola Bay water area" 2003"


РОССИЙСКАЯ АКАДЕМИЯ НАУК
Мурманский морской биологический институт
ООО "ЭКО-ЭКСПРЕСС-СЕРВИС"

РАБОЧИЙ ПРОЕКТ

РЕЙДОВЫЙ КОМПЛЕКС ПЕРЕГРУЗКИ НЕФТИ В РАЙОНЕ ПОСЕЛКА БЕЛОКАМЕНКА НА АКВАТОРИИ КОЛЬСКОГО ЗАЛИВА

Объект: ЗАО "Дальневосточная морская компания"
Шифр: СР - 8/1
Инв. № 0813

ОЦЕНКА ВОЗДЕЙСТВИЯ НА ОКРУЖАЮЩУЮ СРЕДУ

Мурманск
Санкт-Петербург
2003 г.

WAYS OF TRANSPORTING OIL FROM THE ARCTIC REGIONS

CONCEPTION

Development of the system of production environmental monitoring of the Shtokman project 2003

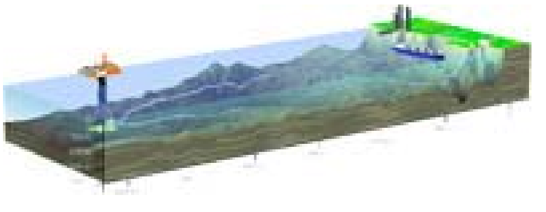
НТЦ «ОРГЭКОГАЗ» ДОАО «ОРГЭНЕРГОГАЗ» ОАО «ГАЗПРОМ»
МУРМАНСКИЙ МОРСКОЙ БИОЛОГИЧЕСКИЙ ИНСТИТУТ КНЦ РАН

КОНЦЕПЦИЯ

СОЗДАНИЯ СИСТЕМЫ ПРОИЗВОДСТВЕННОГО ЭКОЛОГИЧЕСКОГО МОНИТОРИНГА (ПЭМ) ШТОКМАНОВСКОГО ПРОЕКТА

Книга 1. «Производственный экологический мониторинг (ПЭМ) морского добычного комплекса и морского газопровода Штокмановского проекта»

2003



Customer: “Orgekogaz”

INTERNATIONAL CONFERENCE “OIL AND GAS OF THE ARCTIC SHELF-2004”
Murmansk 17-19 November 2004

- 25 organizations and institutions participated in the meeting
- 38 reports were presented and discussed

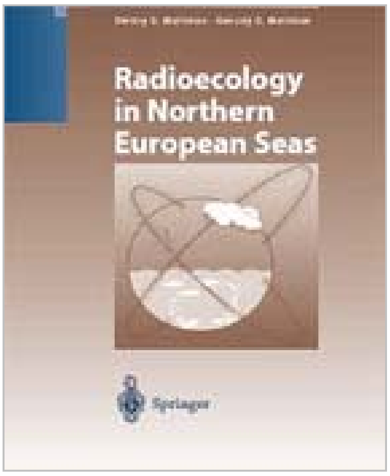
Subject-matter of the reports made at the section:

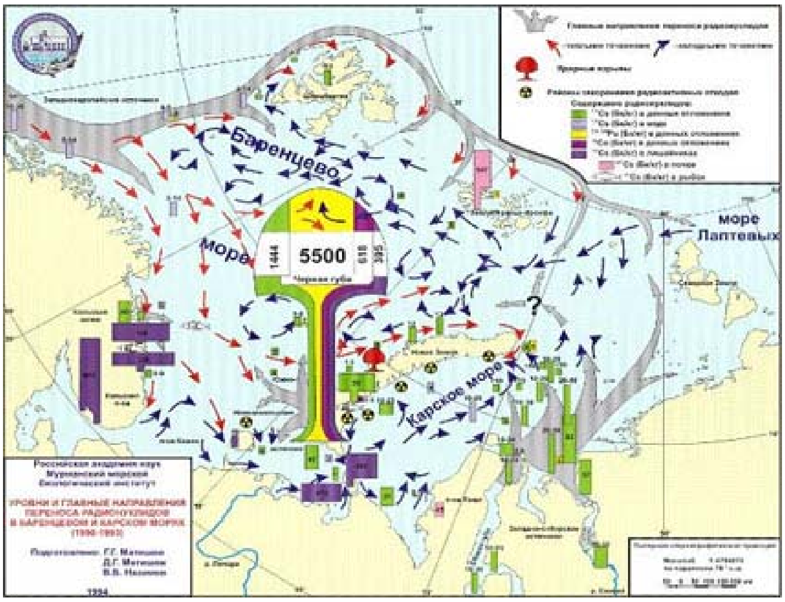
- Monitoring of the ecosystem status of arctic seas in relation to the development of the shelf, different aspects of the Environmental Impact Assessment and engineering and ecological investigations;
- Equipment for the treatment and clean-up of oil spills;
- Remote monitoring methods (air-plane laboratory, satellite);
- databases;
- GIS-technologies;
- Impacts of oil production on different components of the Barents Sea ecosystem (benthos, birds, macrophytes, etc.).

LEVELS AND MAIN DIRECTIONS OF RADIONUCLIDE TRANSFER IN BARENTS AND KARA SEAS

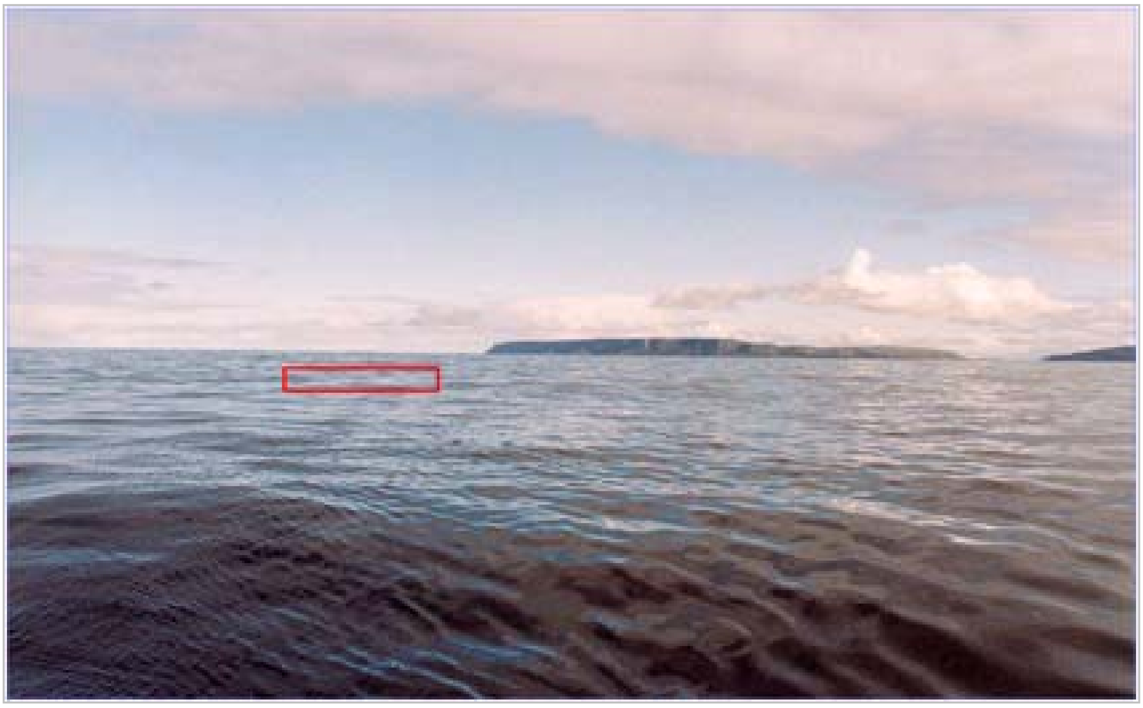
Levels and main directions of radionuclide transfer in Barents and Kara Seas.

Scale 1:4 704 075/ Edit. Matishov G. G., Matishov D. G., Nazimov V. V. , Rovaniemi, Finland, 1994.

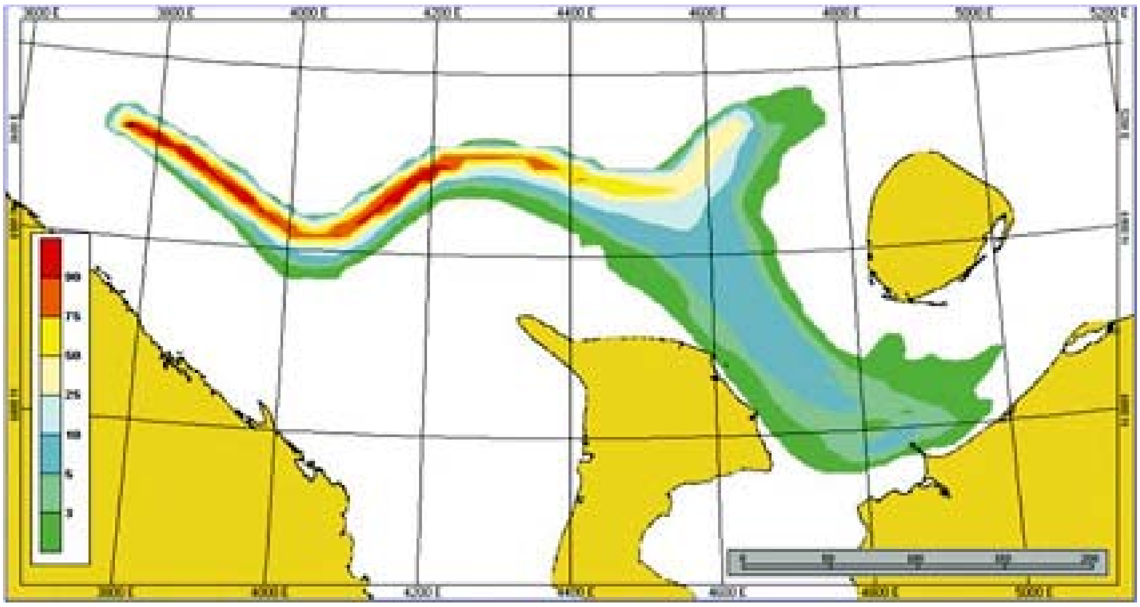




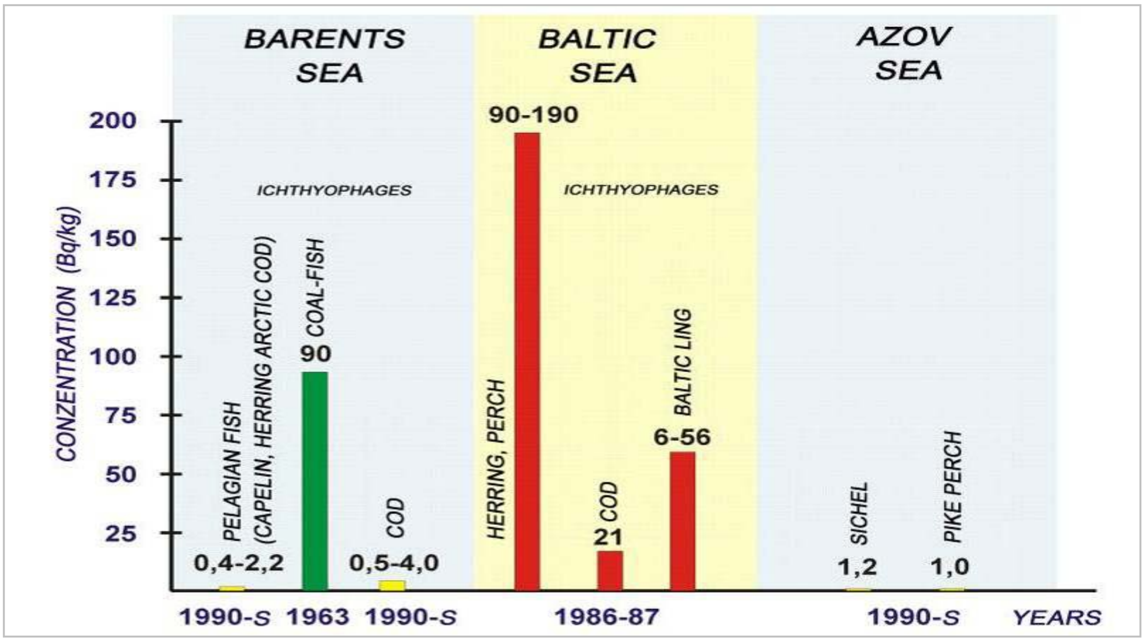
AREA OF AS «K – 159» WRECK NEAR KILDIN ISLAND IN BARENTS SEA



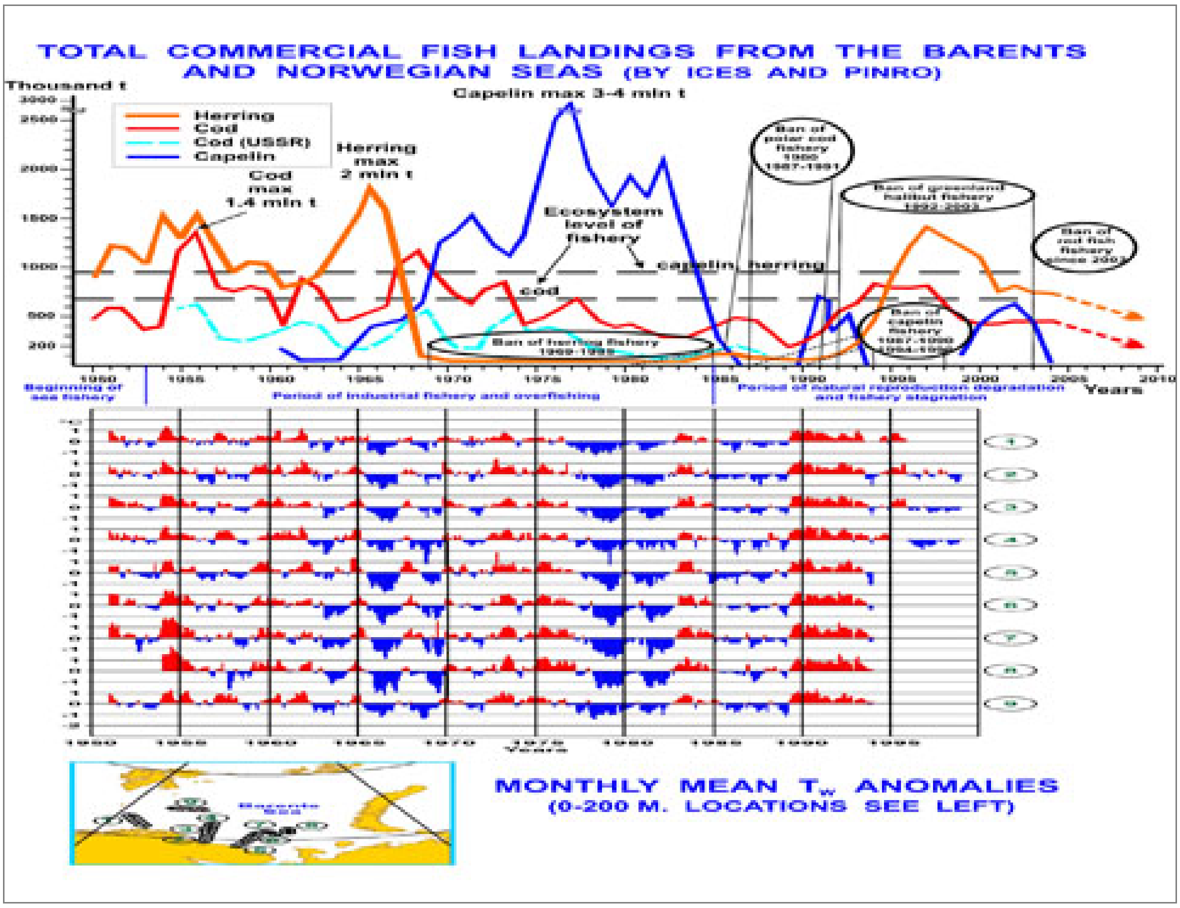
PROBABILITY (%) OF POLLUTION OF BOTTOM LEVEL UNDER
A ONE-TIME SHOT OF 50 M3 RADIOACTIVE SUBSTANCES
IN THE AREA OF DESTRUCTION OF NS “KURSK”



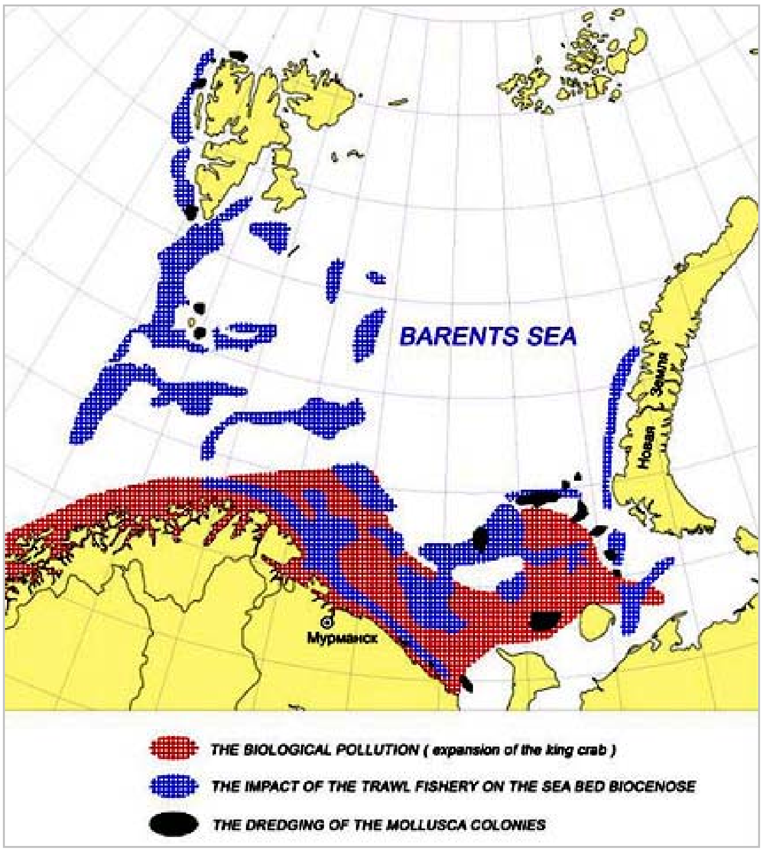
137Cs CONCENTRATION IN FOOD FISH IN 1960 – 1990



OVER-FISHING AND ILLEGAL USE OF BIOLOGICAL RESOURCES

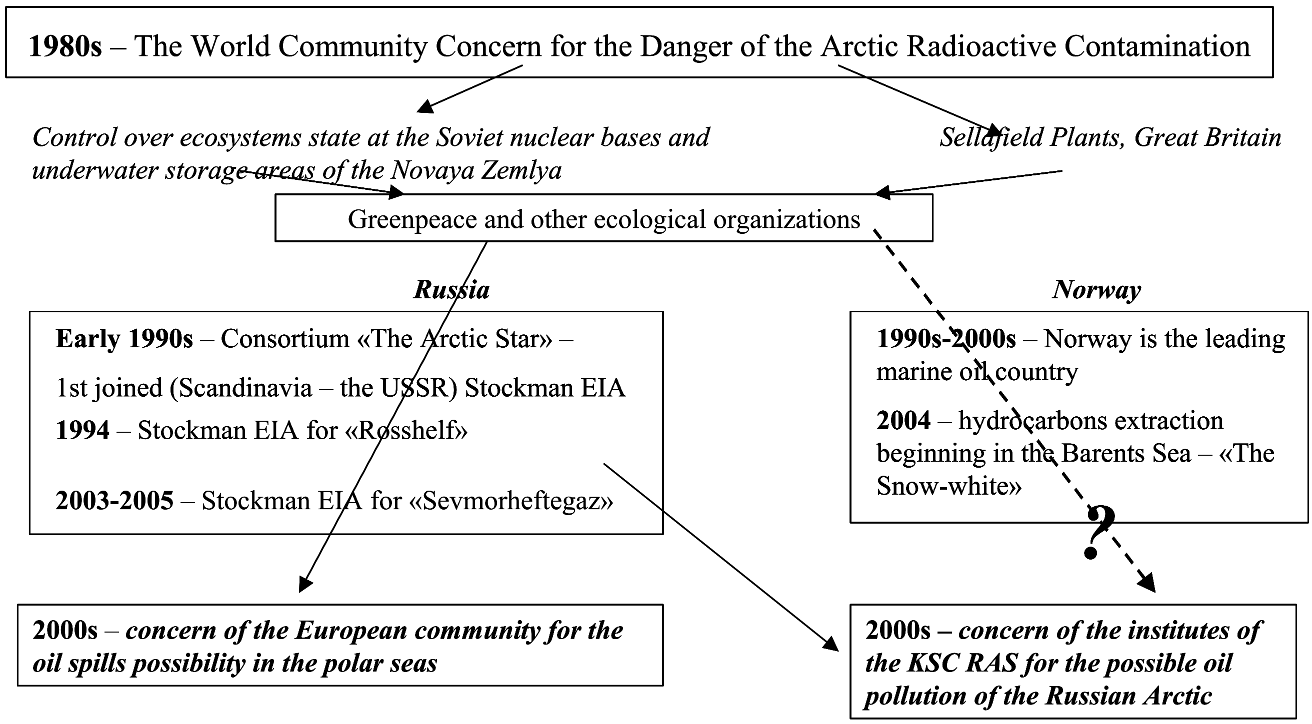


REGIONS, EXPOSED TO FISHERY IMPACT ON BARENTS SEA ECOSYSTEM



APPENDIX 8

GEOPOLITICS IN THE BARENTS REGION: CLASH OF INTERESTS



TRAINING FOR ARCTIC NAVIGATION

Recommendations for training of arctic navigation

Anniek Platzer, Wagenborg Shipping; Sergey Rodionov, CNIIMF;
Leif Baarman, Meriturva; Ger Scheepstra, MIWB
presented by Bob Derks, Wagenborg Shipping

CONTENT OF PRESENTATION

- Purpose of this Study
- Purpose of Training
- Rules and Regulations
- Human Factor
- Aspects of navigation of NSR
- Levels of Training
- Recommended Framework
- Duration and Cost
- Expected Number of Trainees
- Certification
- Points of Discussion

PURPOSE OF THIS STUDY

- Current practice
- Available training and facilities
- Recommendations for the training system for Arctic transportation system

PURPOSE OF TRAINING

- Reduce the risk of damage when sailing with a total inexperienced crew
- High percentage of new crew or crew rotation
- New regulations like the IMO Guidelines
- More intensive use of high risk routes like Northern Sea Route

RULES AND REGULATIONS

- STCW-95
- IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters
- Rules of navigation on the seaways of the Northern Sea Route

HUMAN FACTOR

- Virtually no information available
- Most of the accidents while sailing in convoy
- Institutes to set up a data base

ASPECTS OF NAVIGATION OF NSR

- Ice Formation & Ice Forecasts (WP1)
- Vessel Design & Transportation System (WP3.2/WP3.3/WP3.4)
- Intensity of Traffic
    - 93 transport ships of ice class
    - 15 icebreakers

LEVELS OF TRAINING

- Training Crews
    - Navigators & engineers of Icebreaking vessels
    - Navigators & engineers of Ice strengthened vessels
- Training Pilots
- Training Management
- Entry Level

RECOMMENDED FRAMEWORK

- STCW code is the standard
- Basic training in accordance with IMO Guidelines
- Additional modules for Northern Sea Route
- Theoretical Training
    - IMO Guidelines chapter 14 prescribes Ice Navigator qualifications and training
- Practical Training
    - IMO Guidelines chapter 13.3.3 prescribes training manual

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	Navigators	Engineers	Management	Navigators	Engineers	Management
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
ARCOP 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
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

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**Navigators**	**Engineers**	**Management**	**Navigators**	**Engineers**	**Management**
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 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
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

		Icebreaking Vessels			Ice Strengthened Vessels		
	Pilots	**Navigators**	**Engineers**	**Management**	**Navigators**	**Engineers**	**Management**
<u>Hull stress caused by ice</u>							
Describes the different ice classes	yes	yes	no	optional	yes	no	optional
Describes where to find ic 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
Escorted operation							
<u>Ice breaking operations</u>							
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

RECOMMENDED FRAMEWORKS

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

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

DURATION & COST

- Basic Ice Navigation Training
  - Theoretical training 3 days at 150-200 eur/day/trainee
  - Simulator training 3000 eur/day depending on the number of simulators used.
- Management Training
  - Theoretical training 1 day 150-200 eur/day/trainee
- Engineers Training
  - Theoretical training 1 day 150-200 eur/day/trainee

EXPECTED NUMBER OF TRAINEES

- Based on CNIIMF indication on number of vessels in NSR – some 3390 crewmembers
- Based on Newspaper Article about Stena and Sovcomflot cooperation in Baltic – some 2400 crewmembers

CERTIFICATION

- IMO Guidelines chapter 14.2
  - "The Ice Navigator should have documentary evidence of having satisfactorily completed an approved training program in ice navigation"
- Approval by
  - the authorities of the country in which the Training Institute is situated a classification society

POINTS OF 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

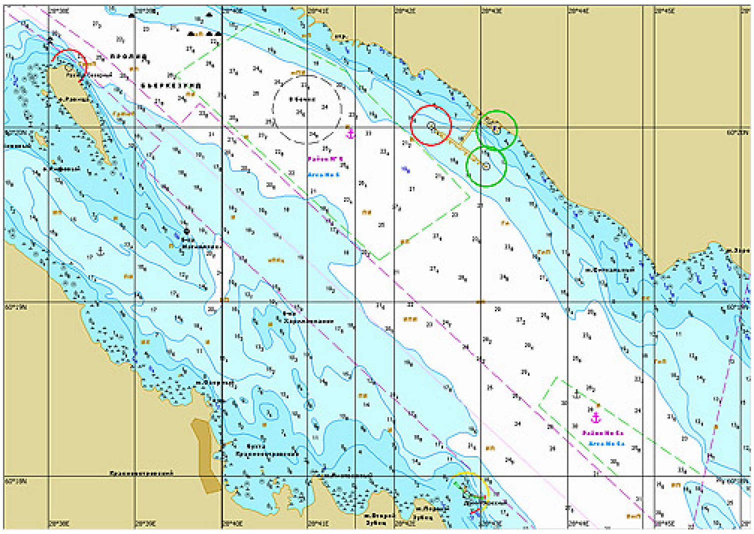
MASTERS AND DECK OFFICERS SIMULATOR TRAINING ON ICE NAVIGATION

by Vladimir E. Kuzmin, Admiral Makarov State Maritime Academy

FACILITIES

- Since 1996 shipping companies train their Masters and Deck Officers using full mission bridge simulator “Navi-Trainer Pro 4000” which is integrated with GMDSS simulator and VTMIS training complex.

- Visualization system uses 57 ship models and 65 sailing areas including approaches and ports of Primorsk, Vysotsk, Saint-Petersburg, Vladivostok and many others.



TRAINING

- At the end of March 2003 Ice navigation module was installed
  - new training program was started
  - ice passage to the port of Primorsk

This module was thoroughly tested and approved by the Representatives of Russian Maritime Administration on 17th of April, 2003

PROGRAM

- Makarov Training Centre developed training program for Ice Navigation in cooperation with Saint-Petersburg Pilots, Primorsk Pilots, Ice Masters from Harbour fleet of Saint-Petersburg and Murmansk Shipping Company.
- Instructors of Makarov Training Centre have good experience in ice navigation.

MAKAROV ICE TRAINING EXPERIENCE

Start 2003

Main Sailing Areas:

- St. Petersburg
- Primorsk
- Vysotsk

Number of trainees: 92

Main clients:

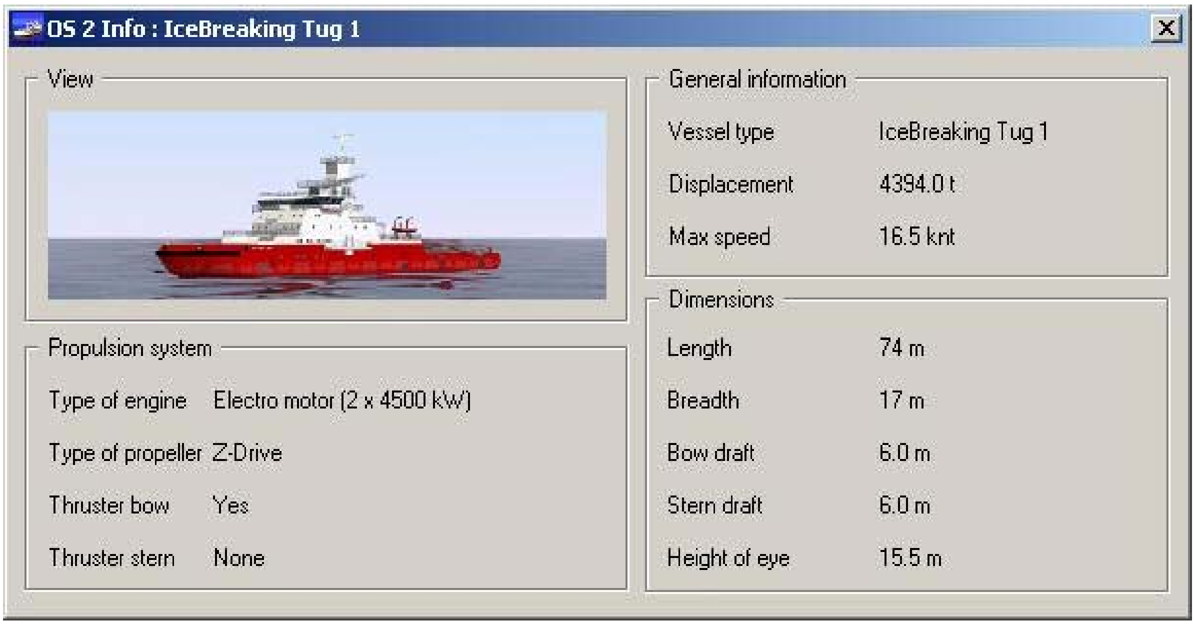
- Unicom (Cyprus)
- Interorient (Cyprus)
- Tsakos (Greece)
- RosMorPort (Russia)

MAKAROV ICE TRAINING FACILITIES

1. Full-mission Ship Handling Simulator
2. Sailing Areas Library
3. Model Wizard Constructor
4. Knowledge & Skills Assessment Instruments
5. "Ship Handling in Broken Ice" Mathematical Model

SHIP MODELS

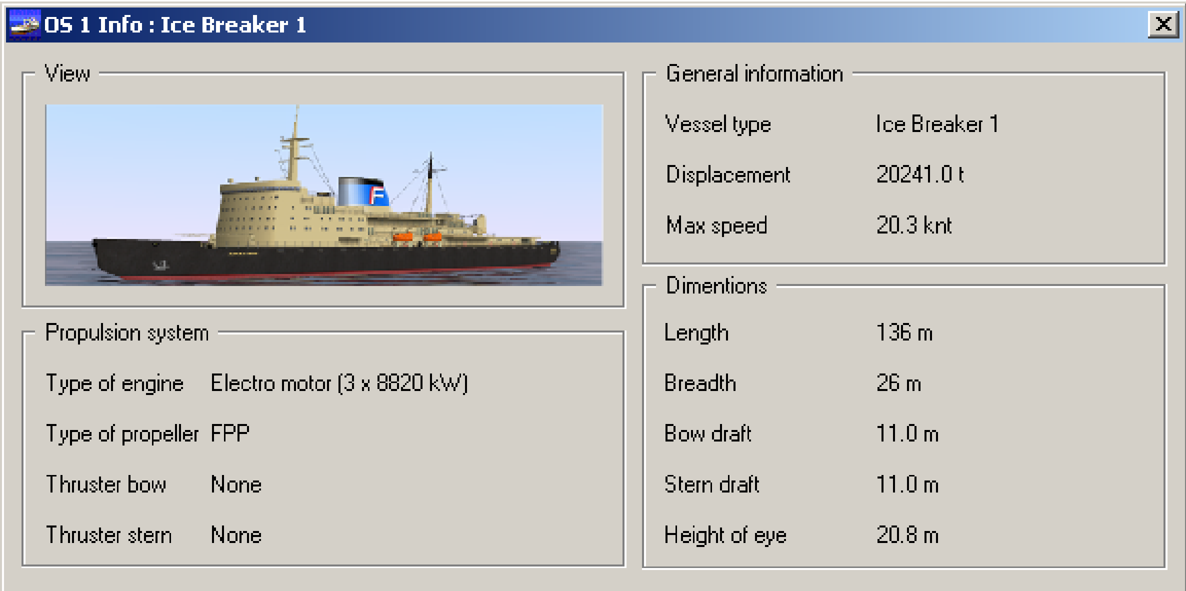
Ice Breaking Tug



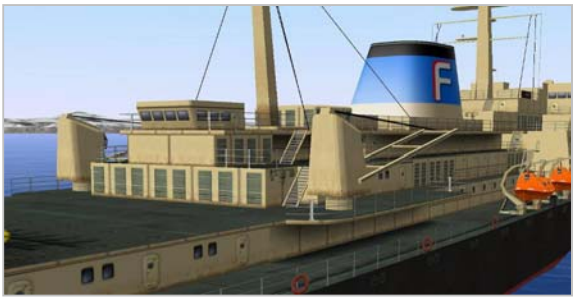
Ship general information


Illustrative screenshots

Diesel-electrical Ice Breaker



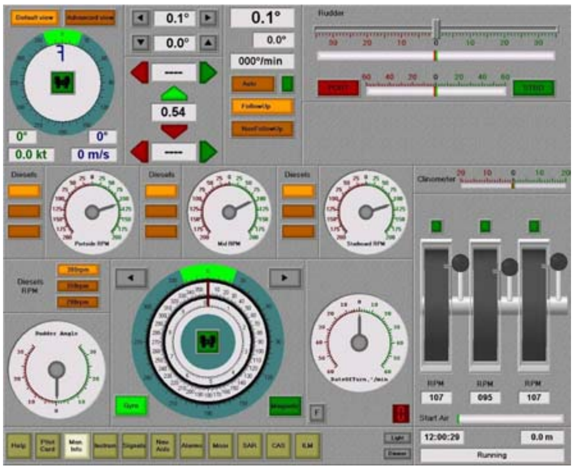
Ship general information

Illustrative screenshots

Simulator conning display:

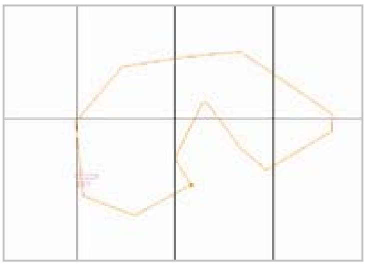
- Diesel RPM controls
- Diesel-generator start/stop controls
- 3 engine telegraph controls

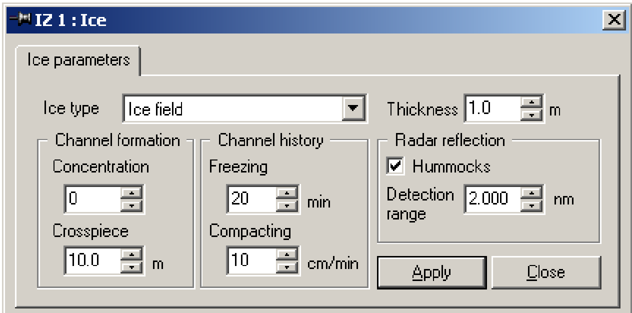


ICE FIELD MODELING

<u>General</u>

- Ice Field is entered from the Instructor Station as a polygonal zone with properties. Maximum quantity of these zones is technically not limited and depends on hardware capabilities.
- The zone properties could be adjusted both before and during scenario run. Changing the zone properties during the scenario run allows to simulate changing of the weather conditions affecting ice navigation conditions.
- Ice Fields could overlap. Ship model will be affected by both fields when sailing within zones of overlap.

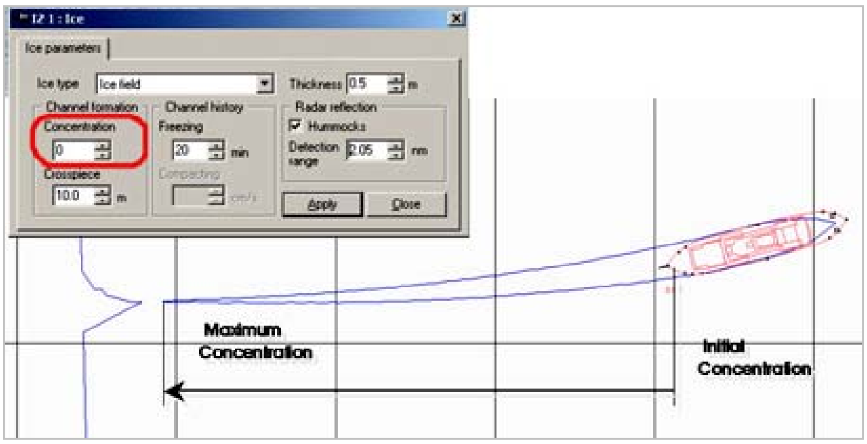




Ice field object properties

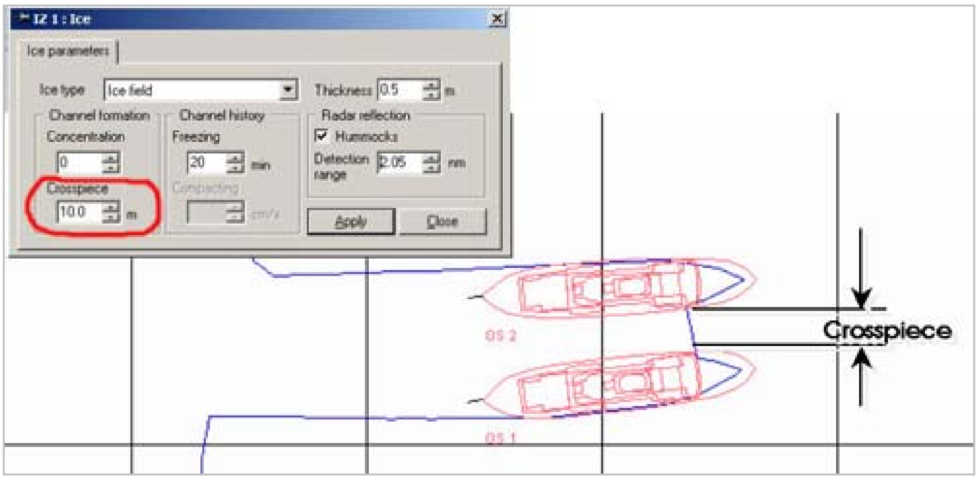
<u>Channel formation</u>

- Concentration of the broken ice in the channel increases linearly from an initial value (specified in the properties) to the maximum (100%).
- Thickness of the broken ice in the channel is equal to the thickness of an initial ice field.



- Concentration of the broken ice in the channel is visually represented by means of dynamic texture changing.

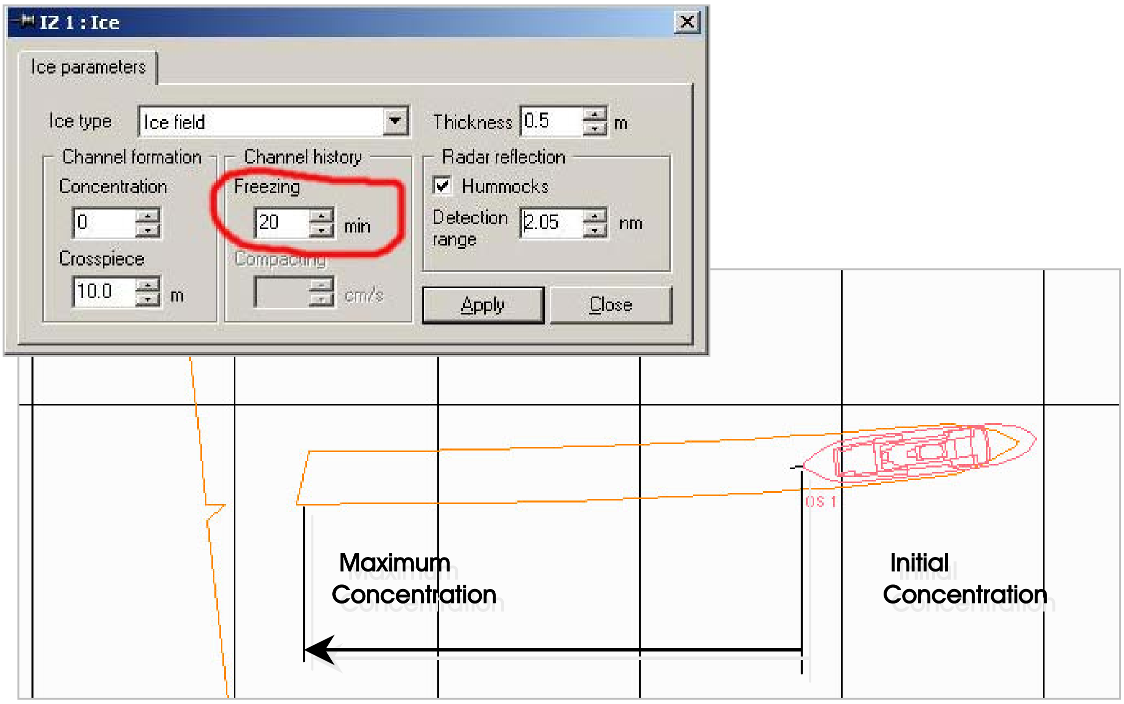
- “Crosspiece” parameter specifies the widest ice field that would be broken between two moving icebreakers.
- Thickness of the broken ice in the channel is equal to the thickness of an initial ice field.



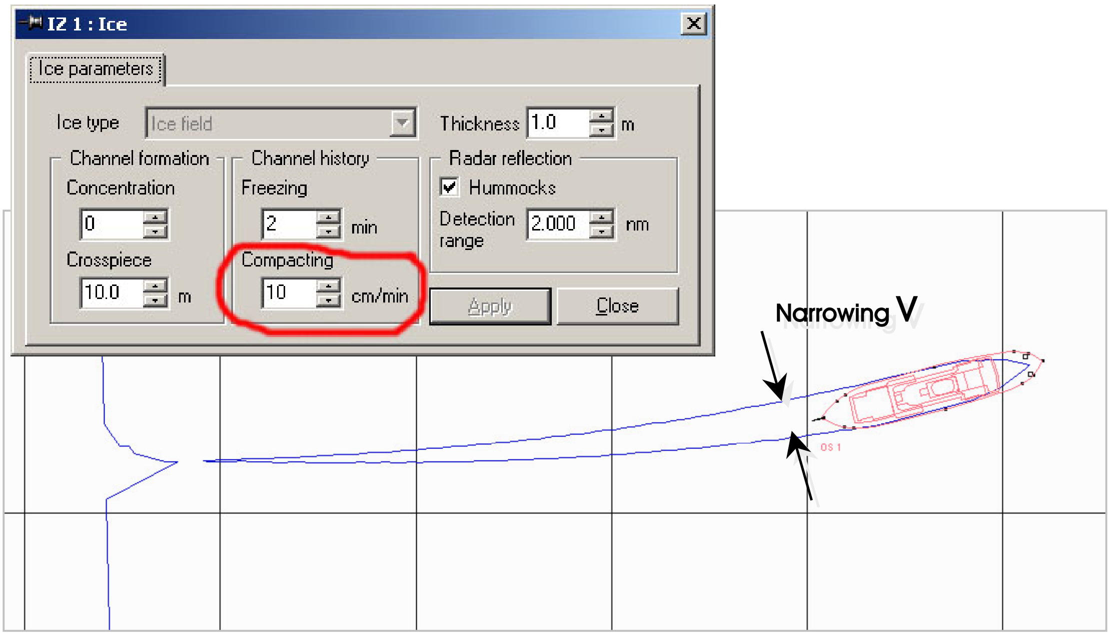
- “Crosspiece” is visually represented by a polygon with a specific photorealistic texture.

Channel history

- “Freezing” parameter specifies the time (in minutes) that takes broken ice to get maximum concentration (become solid) in the channel.

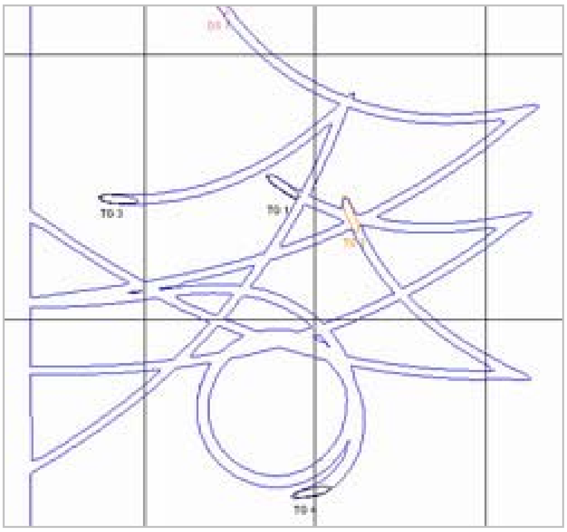


- “Compacting” parameter specifies the speed (cm/sec.) of the ice channel closing from its edges.



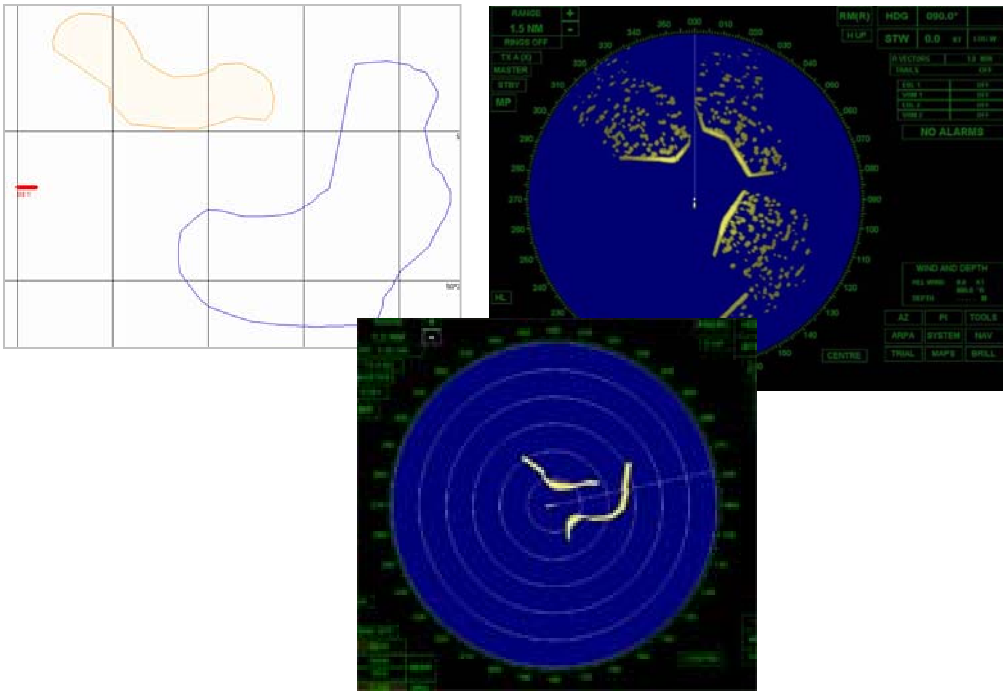
Complexity of the modeling approach

- Ice channels could be made by multiple ice breaking models.
- Ice channels can have any configurations including interactions with each other and self interactions.
- Compacting and freezing of the ice channels are calculated correctly regardless complexity of the channels' configuration.



Radar reflection

- "Detection Range" parameter specifies maximum distance of the ice field edge detection by the navigational radar
- "Hummocks" sets generic noise that could be produced by hummocks reflecting on the actual ice field.



SHIP – ICE INTERACTION

Modeling

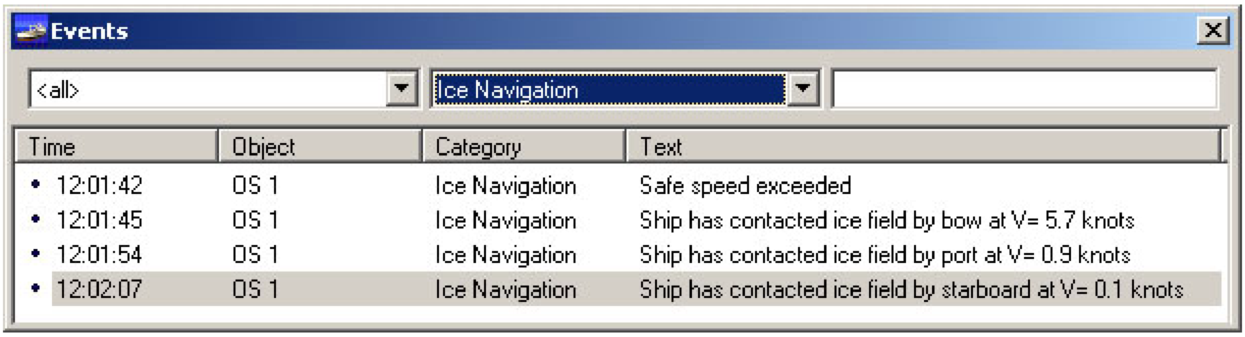
- The system uses general mathematical equations of interaction between vessel hull and ice field which were produced by the state Arctic and Antarctic Research Institute (AARI), Russia.
- Calculations of admissible speed and icebreaker escorting parameters for the navigation in broken ice of the Crude Oil Tanker 120750t are done in accordance to

the Ice Passport provided by the Central Marine Research And Design Institute (CNIIMF), Russia.

- Safety of navigation in solid and broken ice provided by hull strength and propulsion/steering unit for the other models is regulated by assigning of appropriate ice category (ice class) from the exercise editor.

Event Logging

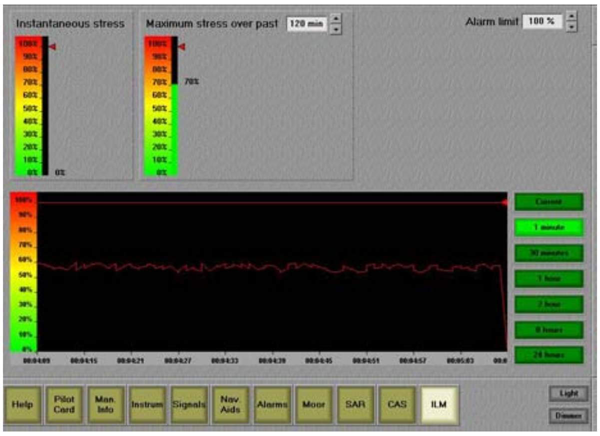
- All controlled events of ship and ice interaction are separated into a special category “Ice Navigation”.
- The following events are monitored and logged by the simulator:
  - ➢ Exceed of the safe speed (according to the ice passport and ice class of the ship);
  - ➢ Event of the ship’s hull contact with the solid ice edge:
    - Time of contact;
    - Contacted hull segment (bow \ stern \ port \ starboard);
    - Actual speed of contact;
- Event of ship maneuvering astern under a shifted rudder;
- Event of the propeller impact into a dangerous zone of a target vessel.



Time	Object	Category	Text
12:01:42	OS 1	Ice Navigation	Safe speed exceeded
12:01:45	OS 1	Ice Navigation	Ship has contacted ice field by bow at V= 5.7 knots
12:01:54	OS 1	Ice Navigation	Ship has contacted ice field by port at V= 0.9 knots
12:02:07	OS 1	Ice Navigation	Ship has contacted ice field by starboard at V= 0.1 knots

Crude Oil Tanker

- Current ice pressure on the vessel hull and the history of its change are indicated on the Ice Load Monitor which is available within the simulator conning task.
- The monitor allows to define a critical pressure value and provides an alarm when exceeding it.



Ice Load Monitor

SHIP – BROKEN ICE INTERACTION
Crude Oil Tanker
Precision of Modeling

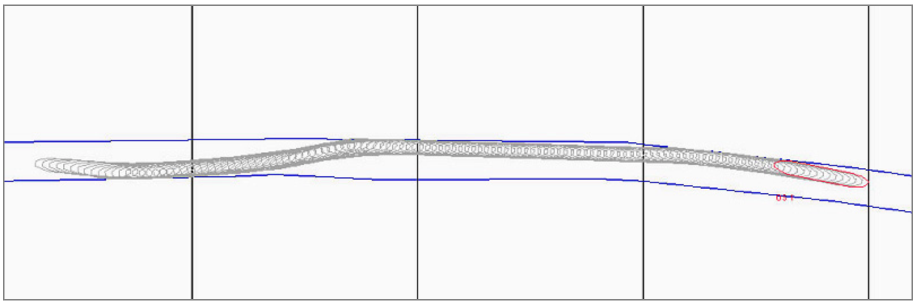
- The following table shows comparison between data from the Ice Passport and the simulator model parameters.

Ice thickness m	Ice compactness %	Attainable speed, knt		Error %
		Ice passport	Simulator model	
0.3	50	14,2	14,4	1,41
0.5	50	12,3	12,5	1,63
0.7	50	9,8	9,9	1,02
1.0	50	4,7	4,7	0,00
0.3	70	13,7	13,6	-0,73
0.5	70	11,2	11,2	0,00
0.7	70	7,8	7,9	1,28
1.0	70	0,8	0,8	0,00
0.3	90	13,2	13,4	1,52
0.5	90	10,1	10,3	1,98
0.7	90	5,7	5,8	1,75
1.0	90	0,0	0,2	

SHIP – SOLID ICE INTERACTION
“Channel effect”

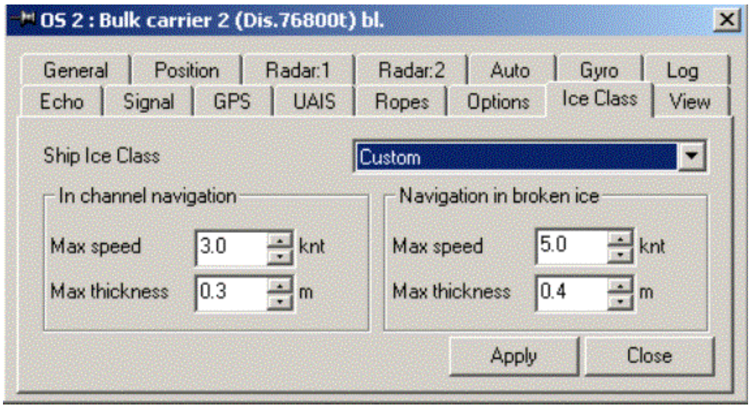
- Interaction between a ship and a solid ice edge (channel effect) has been adjusted in accordance to the recommendations of the experienced ice navigating seafarers.

SHIP – ICE INTERACTION



Ice Class properties

- Safety of ice navigation provided by hull strength and propulsion/steering unit for the other models is regulated by assigning of appropriate ice category (ice class) from the exercise editor.



ILLUSTRATIONS

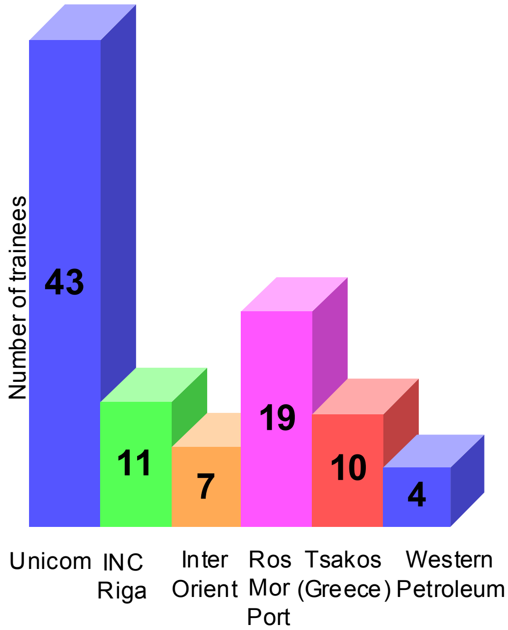

Making channel *Convoy*

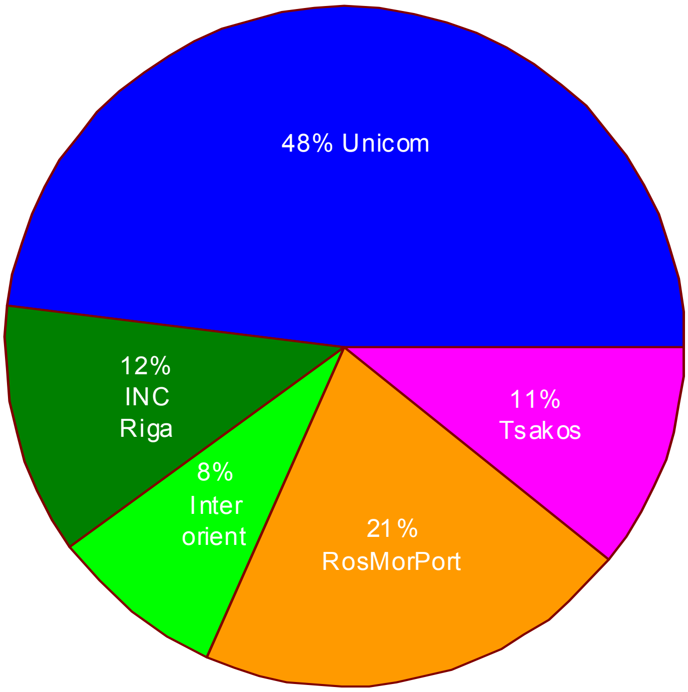
ICE PROJECT BACKGROUND


- Initially this course was started as a short goal-based course - Ice Navigation to the port of Primorsk - according to Unicom/Sovcomflot request.
- Later on, some other companies requested extended course, and now one week course of Ice Navigation, including both Primorsk and Vysotsk areas is available.
- The training is offered both in the English and Russian languages.
- The course consists of theory classes combined with practical exercises using the simulator.
- Exercises include bridge watch keeping during unassisted passage of tanker in ice, entering an ice area, passage with

ice breaker assistance. Convoy passage and ice passage in broken ice, maneuvering in ice channel, rudder and engine operations, safe port operations procedures in low temperatures, mooring/unmooring, working with tugs in ice conditions. Both daytime and night time navigation.

- To make course more realistic, senior pilots from Primorsk, Vysotsk and St Petersburg are involved in the training program.
- To make training company even ship specific new ship models are offered - exactly the same as the ships in your fleet
- On May, 2003 3 groups of Unicom/Sovcomflot Deck Officers were scheduled for simulator training on ice passage to the port of Primorsk
- Since then, 92 deck officers had been trained for different companies.





PERSPECTIVES

- Only for last 9 months 57 deck officers and masters were trained at Admiral Makarov State Maritime Academy. Several more courses are already scheduled. And we are ready to provide company specific training courses upon request.

FURTHER DEVELOPMENT

- In late February simulator software is to be upgraded.
- Agreement with Memorial University of Newfoundland, Canada to exchange experience in ice training
- Agreement between AMSMA, Sovcomflot and Stena Bulk regarding ice training for their specialists

ENVIRONMENTAL RISK ASSESSMENT FOR ARCTIC SHIPPING
by Odd Willy Brude, Det Norske Veritas

ENVIRONMENTAL RISK ASSESSMENT -ERA

- Environmental Impact Assessment: Indicate possible consequences and impacts
- Environmental Risk Assessment: Integrate probability & consequences
  Probability of an Event (P) * Consequences of the Event (C)

- Event
  - *Ship transportation of oil products, serious oil spills*
- Probability
  - *Accidental frequencies & oil spill modelling*
- Consequences
  - *Resources at risk*
  - *Their sensitivity / vulnerability to oil*
- Risk calculation

ACCIDENTAL EVENTS

- D.4.1.2.2: "Seaborne transportation characteristics" (SafeTec Nordic & DNV)
- Appendix A: Modelling of ship accidents
- Frequency calculations for accidental events (oil pollution)
  - *Collision*
  - *Grounding*
  - *Structural failure*
  - *Fire/Explosions*

- Assumptions / limitations
  - *Only serious accidents causing crude oil spill from cargo tanks of loaded tankers are included in the analysis*
  - *Accidental events reported in a similar manner within the area of interest*

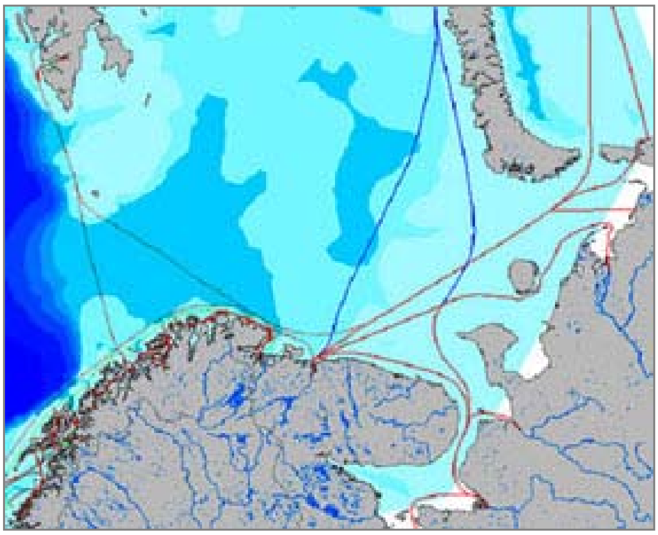
Existing terminals

Location	Type of terminal	Geographical description
Dikson	Oil loading terminal	Town located east of where the river Yenisei is running into Kara Sea
Ob Bay	Reloading	Kara Sea
Varandey	Oil terminal and Underwater oil reloading terminal	Pechora Sea
Kolguev Island	Oil terminal	Eastern shore of Pechora Sea
Talagi, Archangelsk	Oil storage depot	Archangelsk, White Sea
Vitino	Oil terminal	Kandalaksha Bay east in the White Sea
Murmansk (5 of)	Oil terminal/reloading	2 oil terminals and 3 offshore reloading terminals in the Kola Bay, Barents Sea

Planned terminals

Location	Type of terminal	Geographical description
Dikson	Oil loading terminal by 2008	Kara Sea
Prirazlomnoye	Offshore platform	Pechora Sea
Onega Bay	New activity are planned	White Sea
Severodvinsk	New oil terminal	Archangelsk, White Sea
Murmansk	Oil terminal	One in Severomorsk District and one one near Kolunga, Kola Bay, Barents Sea
Bøkfjord, Kirkenes	Reloading terminal	Coast of Norway outside Kirkenes, Barents Sea
Snøhvit	Facility for liquefied natural gas (LNG)	Melkøya just outside Hammerfest at the coast of Northern Norway, Barents Sea

Carrying capacity of crude oil tanker	Number of round trips per year		
	Year 2003	Year 2012	Year 2020
30 kT	190	-	-
120 kT	60	53	108
300 kT	-	66	86



Year 2003 – Frequencies and return periods for serious oil spills

Zone	1	2	3	4	5	Total (All zones)
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

Year 2020 – Frequencies and return periods for serious oil spills

Zone	1	2	3	4	5	Total (All zones)
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

- Navigational hotspots
  - Crossing collisions between loaded tanker and Svalbard traffic
  - Crossing collisions between loaded Varanday tankers, cargo ships and westbound oil tankers at the entrance of the Murmansk Fjord
  - Meeting collisions between loaded Varanday tankers, cargo ships and westbound oil tankers inside the Murmansk Fjord

F(Meeting collisions) per year for the Murmansk Fjord

Group	Release (tons)	Year		
		2003	2012	2020
1	7.600-20.000	1.22E-5	1.45E-5	1.83E-5
2	20.001-40.000	8.2E-8	1.23E-7	2.7E-6
3	40.001-120.000	-	1.58E-6	3.75E-6
Sum		1.23E-5	1.57E-5	2.48E-5
T (years)		82000	64000	40000

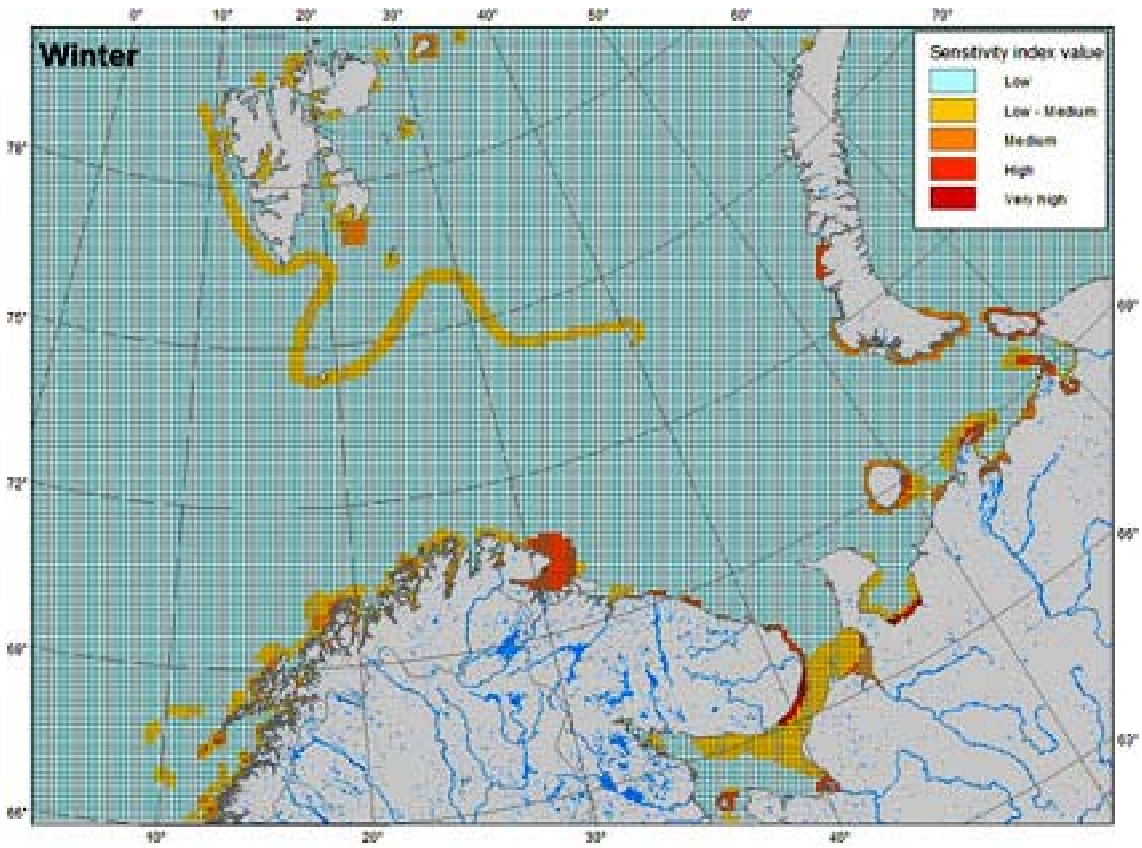
ENVIRONMENTAL CONSEQUENSES

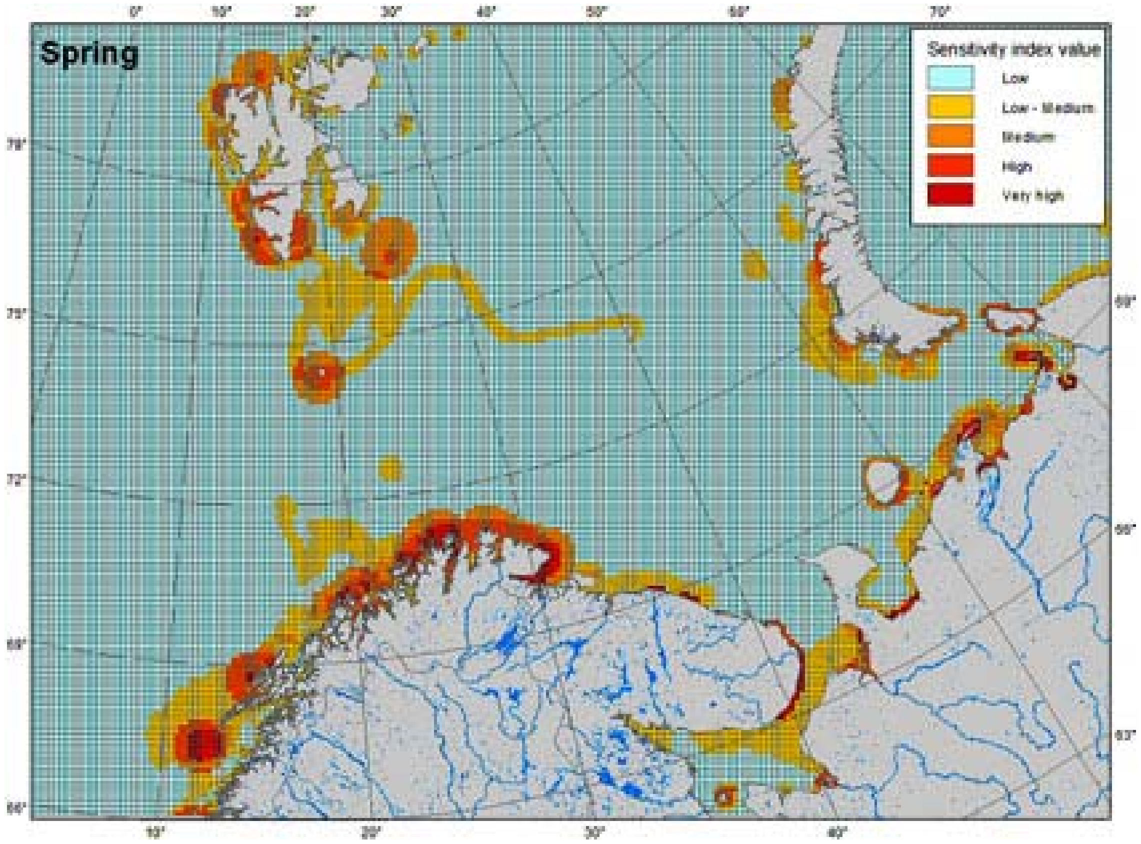
- Two overall criterias considered for data compilation
  - Vulnerability; i.e. focus should be placed on those resources considered most vulnerable to the sea-borne transportation activity. In this regard, accidental oil pollution is considered a dimensional impact factor, and resources like e.g. shallow water benthos, shoreline substrate and communities, fish eggs and larvae (spawning grounds), seabirds, seals and walruses may be significantly affected.
  - Ecological significance; this means that effort has been placed on the most important resources, e.g. large populations of fish, seabirds, seals etc. Resources of minor ecological importance are not compiled
- Source data documented in the Environmental Atlas (D.4.1.3.1)

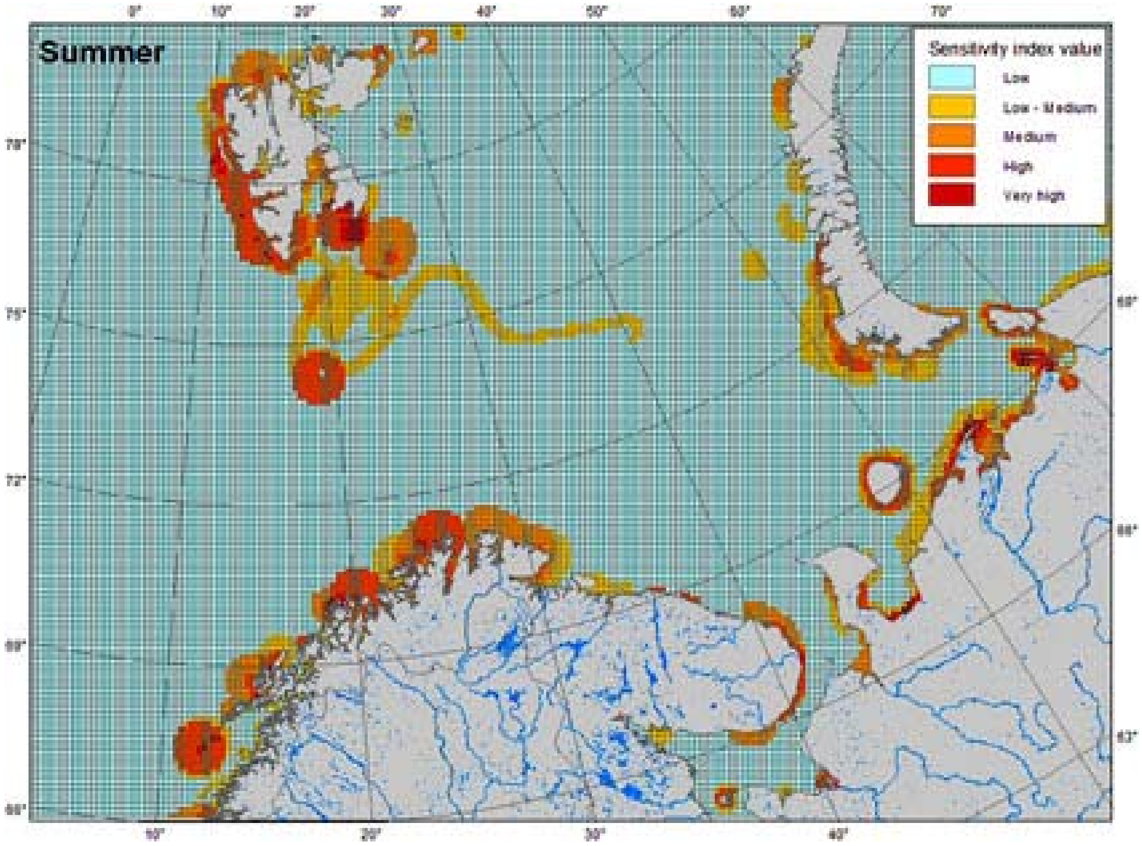
- Vulnerability assessment
  - Specific vulnerability to oil pollution (Factor value 1-3)
  - Significance of areas related to species / stocks (Factor value 1-3)

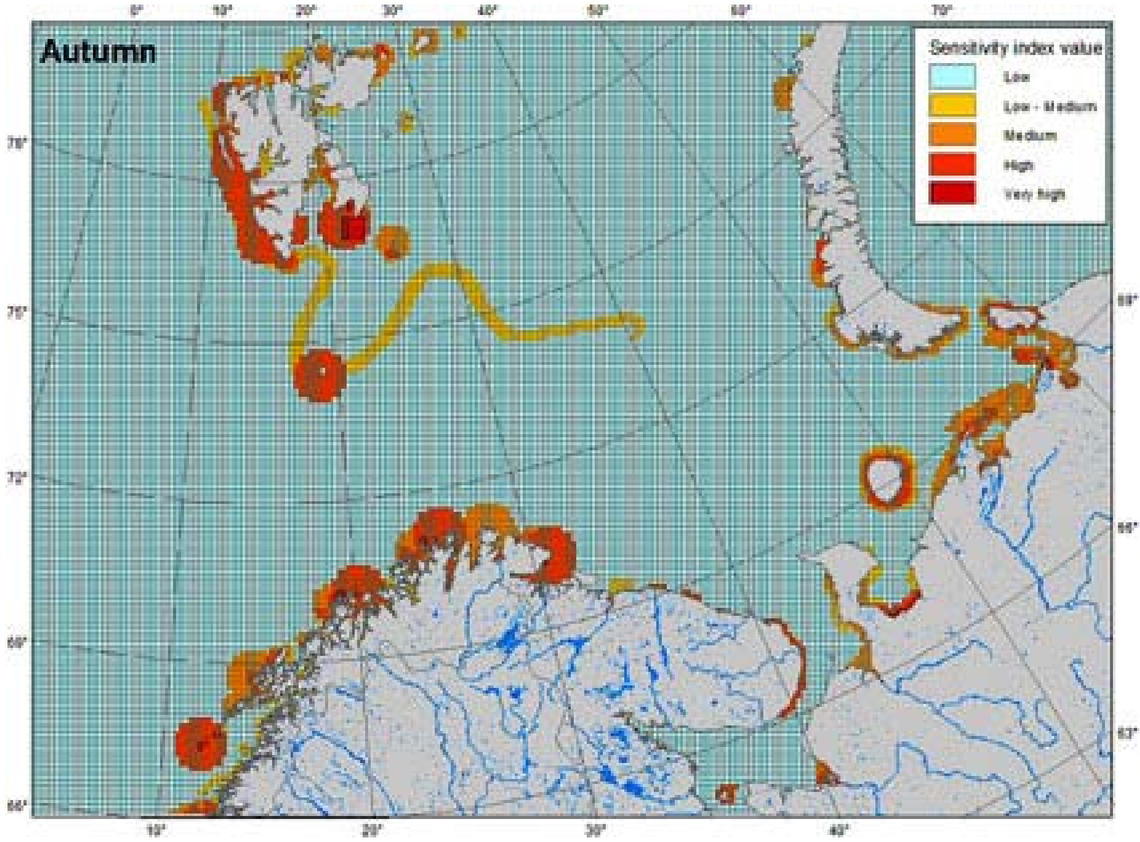
  - Divided by resource groups
    - Seabirds
    - Marine mammals
    - Fish eggs/larvae
    - Benthos/shoreline

Each group will have a seasonal score of 0-9 giving a max seasonal score of 4*9 = 36.

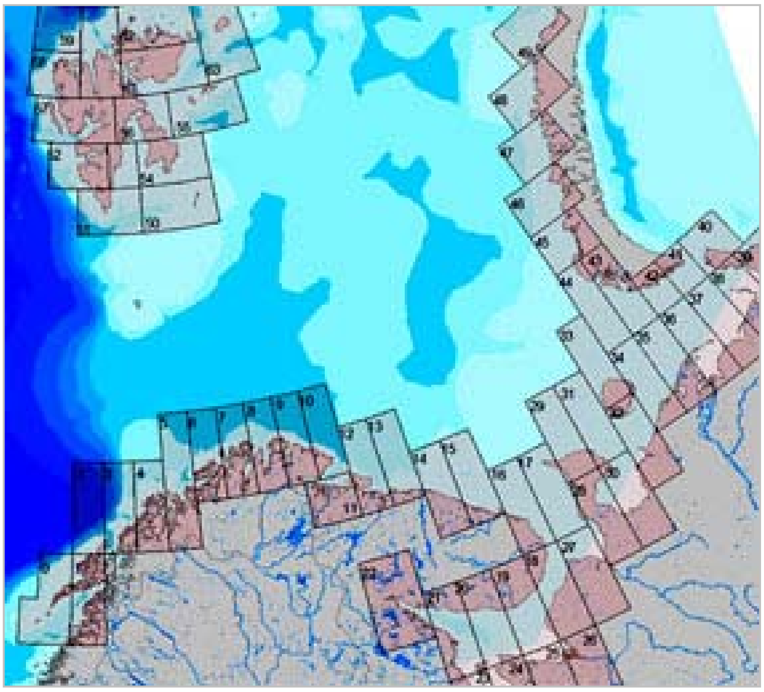


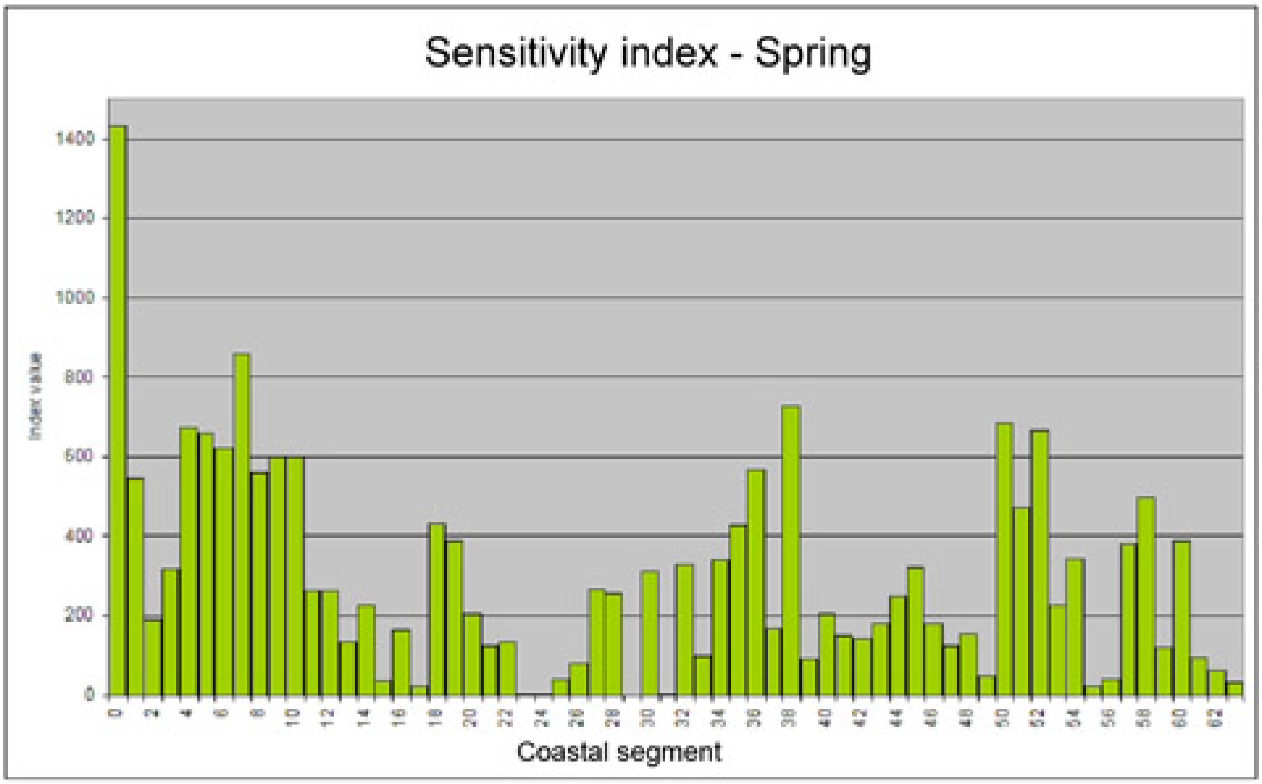

Spring
Sensitivity index value
Low
Low - Medium
Medium
High
Very high

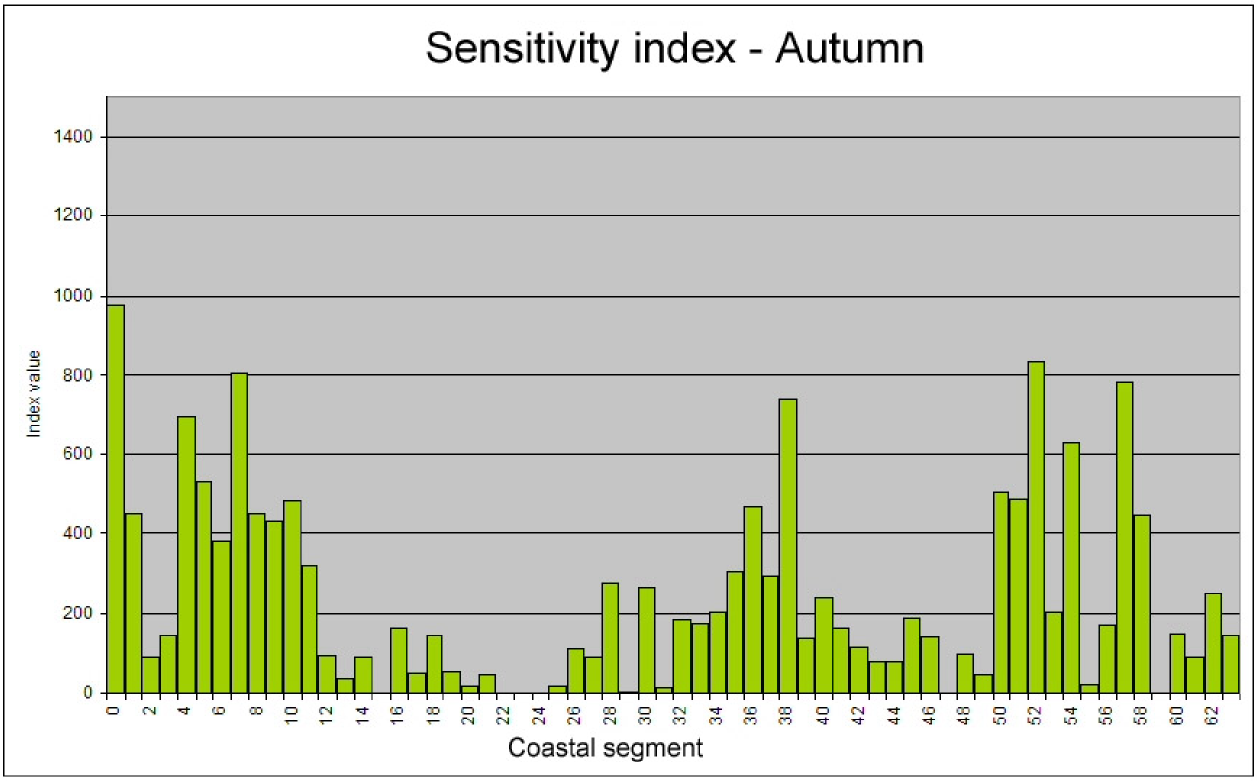

Summer
Sensitivity index value
Low
Low - Medium
Medium
High
Very high



Summarized to coastal segments




Sensitivity index - Spring
Index value
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
Coastal segment

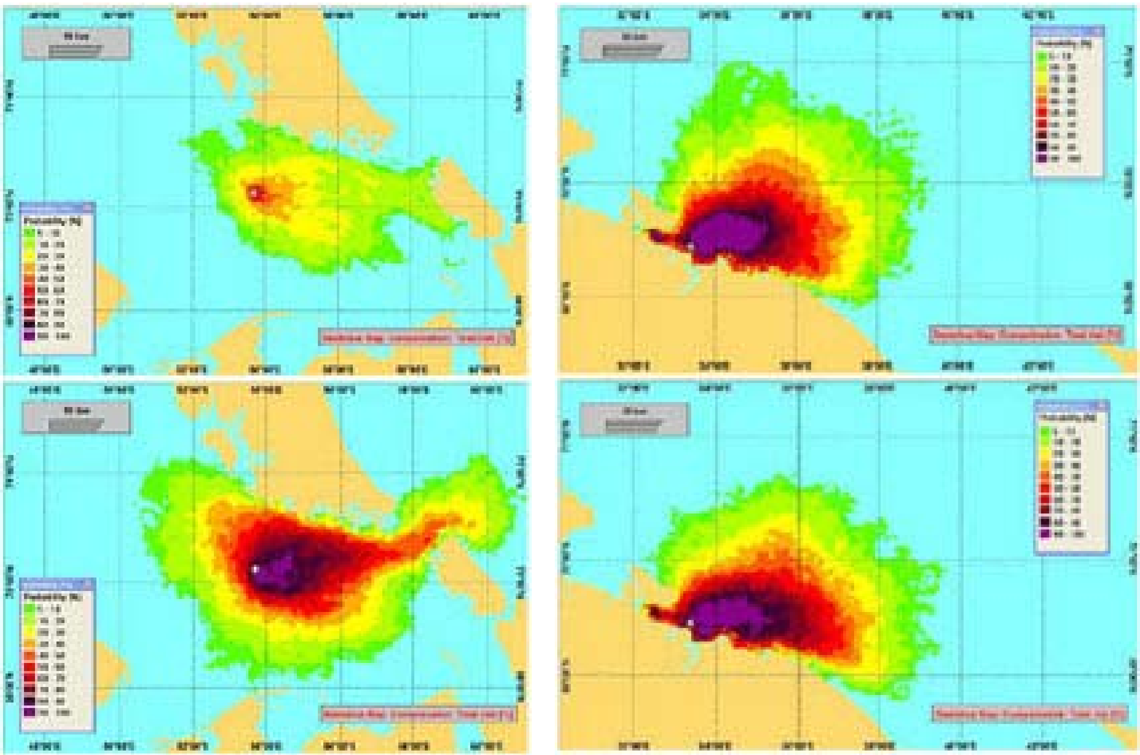

Sensitivity index - Autumn
Index value
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
Coastal segment

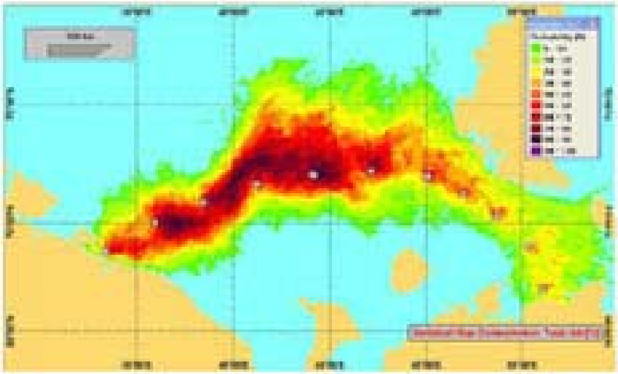
ENVIRONMENTAL RISK

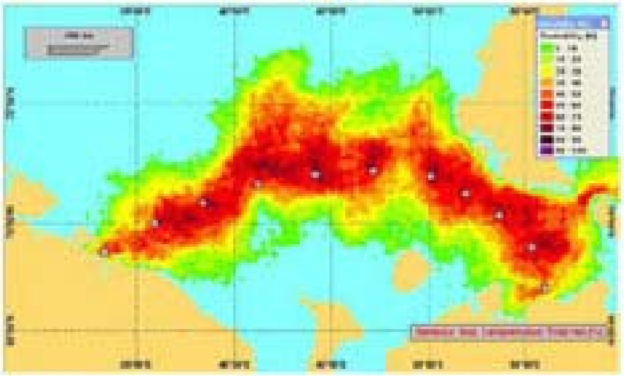
- Risk assessment
  - Combining the accidental frequency with the sensitivity index
  - Take into account the spread of an oil spill

  - D.4.2.2.2. Simulation of Drift and Spreading of the Oil in open and iceinfested water (SINTEF)
    - Western spill site: Murmansk Fjord; E 33º 24' 00", N 69 º 27' 00"
    - Eastern spill site: Pechora sea; E 53 º 41' 30", N 70 º 07' 30"
    - Possible tanker route (11 spill sites)
    - 10 000 m3 crude oil (Troll oil), released over a 10 hour period
    - two seasons; spring (March, April and May) and autumn (August, September and October)
    - Each statistical simulation includes three oil drift scenarios per year in the period covered by the hindcast wind data set (23 years), i.e. a total of 69 oil drift scenarios (3 per year in 23 years)

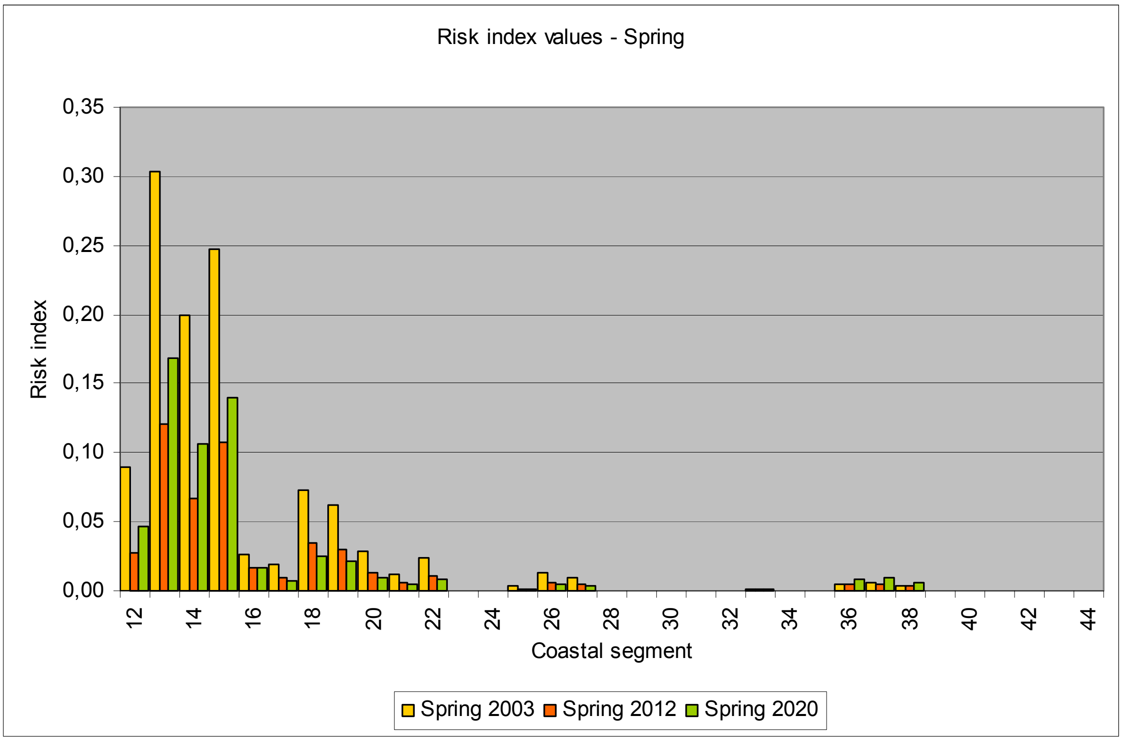
<u>Oil spill scenarios</u>

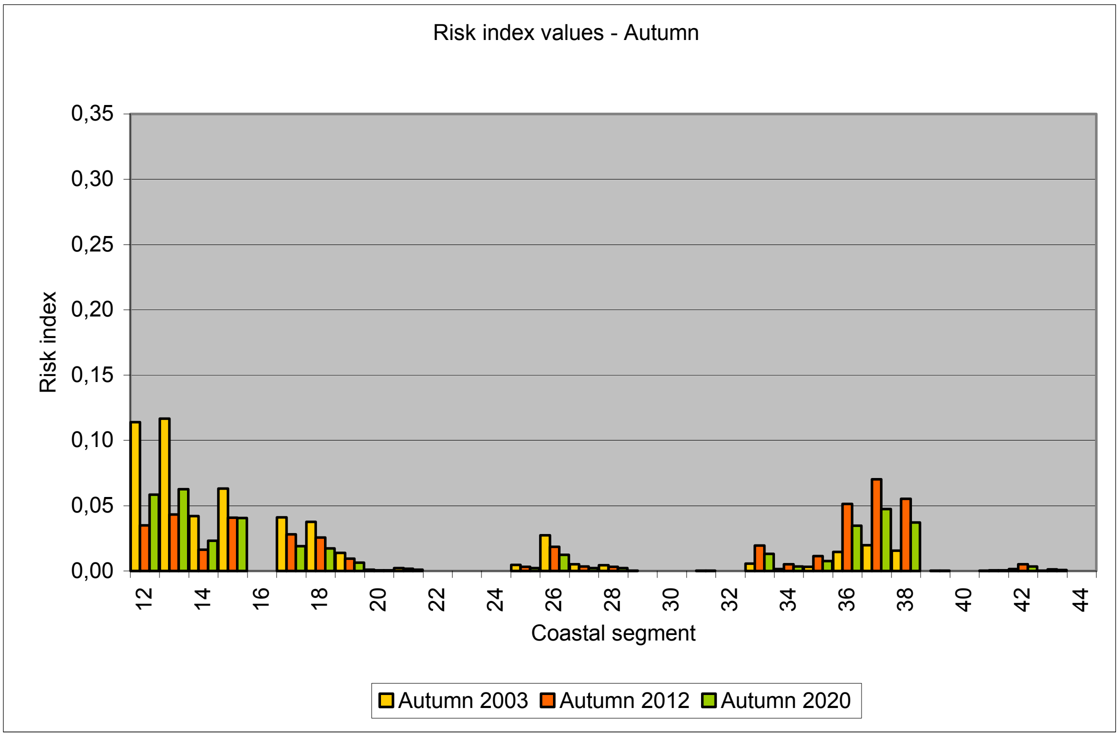


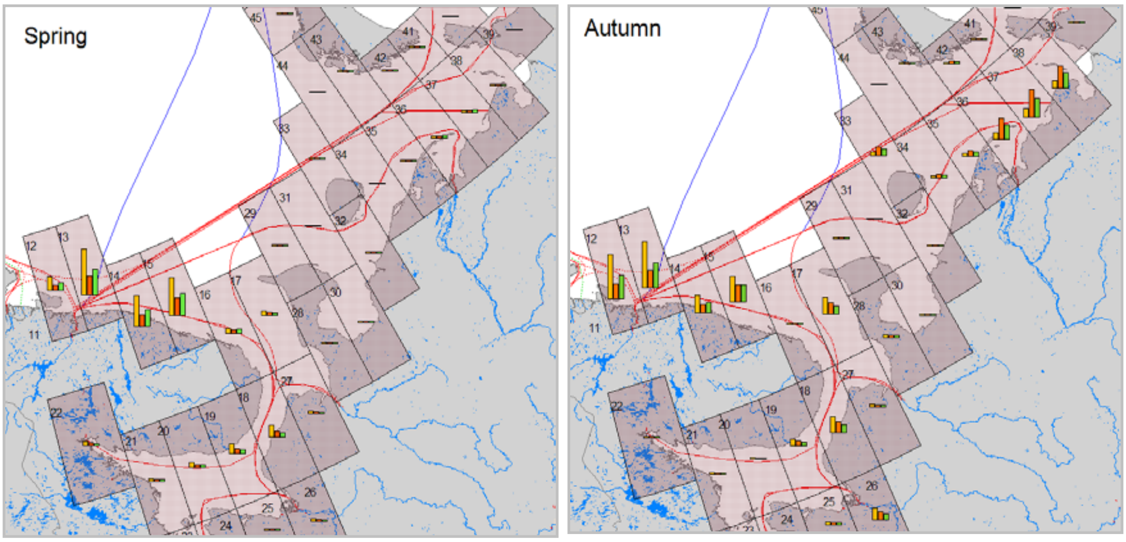




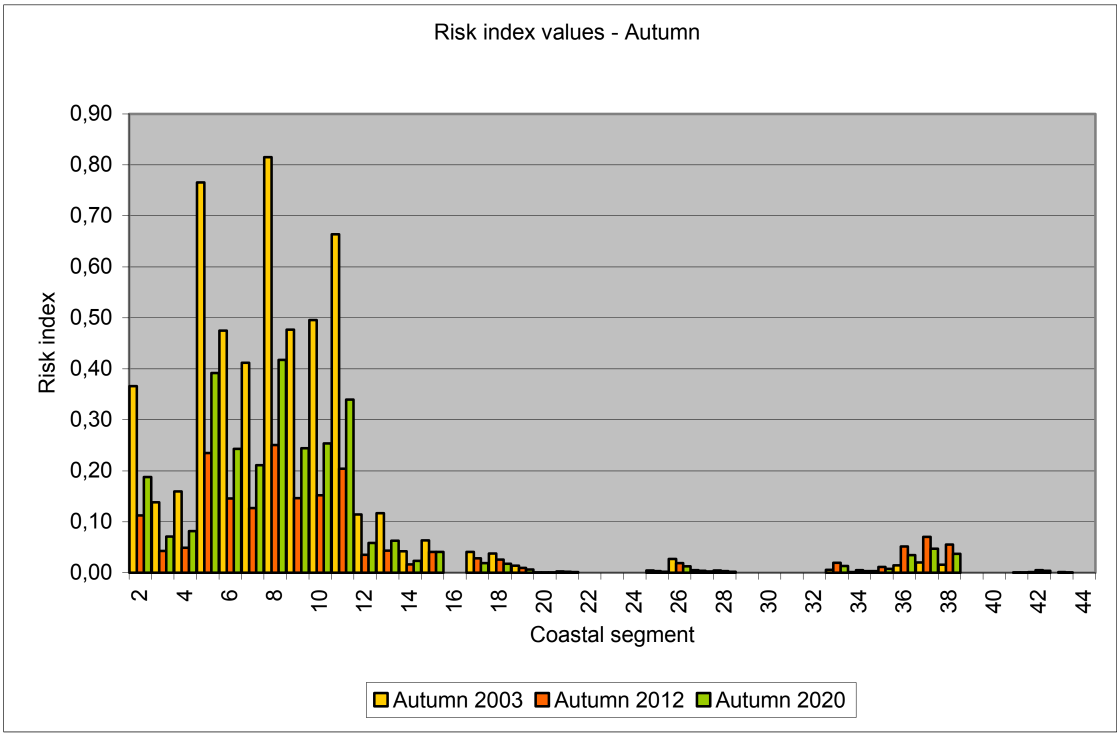
Risk index = Accidental frequency * sensitivity index * contamination probability (oil drift)







The risk in the Pechora and eastern Barents sea are an order of magnitude below the risk levels on the Norwegian coast (segment <10)



ENVIRONMENTAL CONCERN

- Low risk index values due to
  - Limited traffic
  - Limited exposure during periods of ice cover
  - Apparently lower resource index values ?
  - Regime with icebreaker assistance

- Main concerns regarding environment
  - Personell / operation
  - Tankers without icebreaker assistance
  - Regularity vs. Security
  - Speed vs. Ice conditions
  - Economical demands

- Risk reducing measures
  - Ship specific (icebreaking abilities, double acting tankers, ”winterization”)
  - Personell training and experience
  - Oil spill response & contingency
  - Ice monitoring and forecast

BIOLOGICAL DEGRADATION OF CRUDE OIL IN ARCTIC SEA ICE

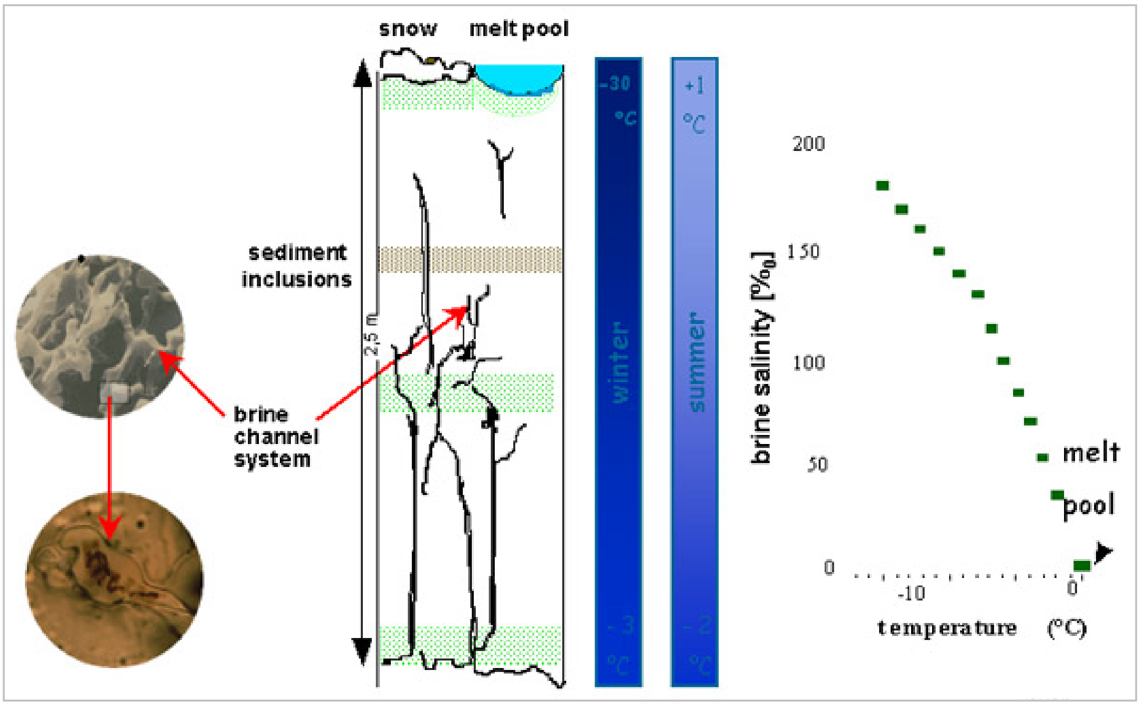
by Birte Gerdes and Gerhard Dieckmann, Alfred Wegener Institute

Aim: To investigate changes in the bacterial communities after oil contamination and to determine the effectiveness of crude oil bioremediation in sea ice

KNOWLEDGE OF OIL DEGRADATION

- Most literature deals with oil degradation in soil, sediment, sea water or ground water
- Only a few investigations deal with cold environments and only some of them have been carried out with sea ice
- Hydrocarbon degrading bacteria are ubiquitously distributed in the marine environment
  - Generally < 1% of the total bacterial population
  - After oil contamination the proportion rapidly exceeds 10%

SEA ICE ECOSYSTEM - A UNIQUE AND EXTREME ENVIRONMENT



BIOREMEDIATION

<u>Definition</u>

Bioremediation is the acceleration of the natural degradation process through the addition of exogenous microbes (bioaugmentation) or through the addition of nutrients and/or oxygen.

- Not a new concept, studied since 1940's
- Applied and considered technology since 1989

LIMITING FACTORS FOR DEGRADATION

- Nutrients
- Availability of oxygen
- Temperature
- Sometimes trace elements like iron
- Salinity and pH
- Solubility, droplet size

FIELD EXPERIMENTS ON SVALBARD

CHANGES IN MICROBIAL COMMUNITY

- Duration ~ 2 months (63 days) mid Feb – mid April 2004
- Temperatures on ice surface from -2°C to -20°C (Ø -13°C)
- Changes in microbial diversity through different treatments

Fertilized samples showed high number of active cold-adapted sea-ice bacteria
But no significant oil degradation in winter

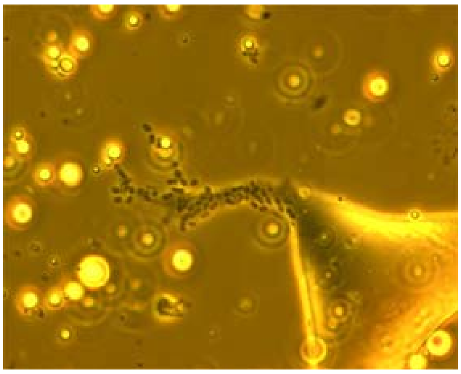
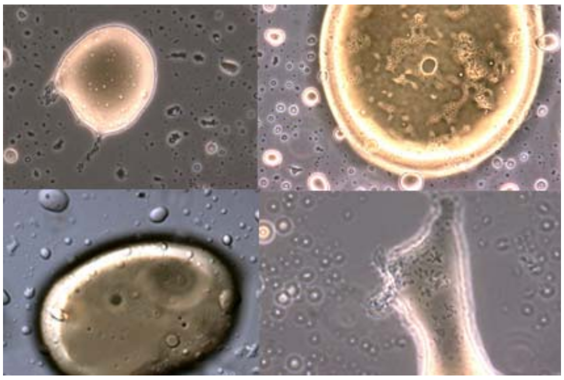
⟹ due to the very cold temperature oil-hydrocarbons are not bioavailable

OIL-DEGRADING COLD-ADAPTED BACTERIA FROM ARCTIC SEA-ICE

- More than 500 bacterial strains of 15 different genera were isolated from oil bioremediation experiments with sea-ice
- All cold-adapted (psychrotolerant or psychrophilic)

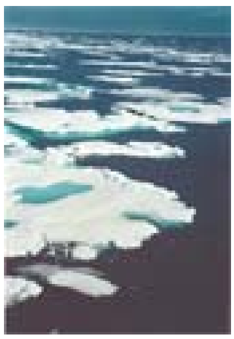
Dominant groups: γ-proteobacteria
gram-positive bacteria
CFB *(Cytophaga-Flavobacterium-Bacteroides group)*

Shewanella spp., *Pseudomonas* spp., *Pseudoaleromonas* spp. and *Marinobacter* spp. were the predominant phylotypes of the - γ proteobacteria and *Dietzia* spp. and *Rhodococcus* spp. of the gram-positive bacteria in the oil-treated experiments

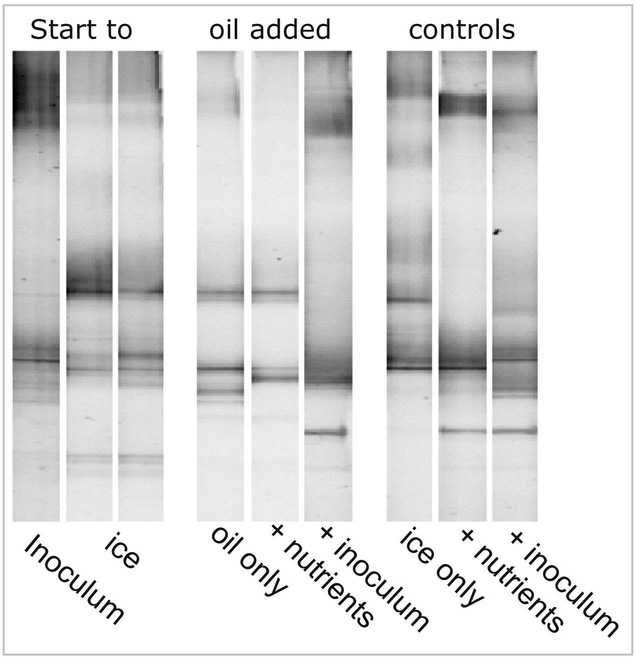



BIOREMEDIATION EXPERIMENTS DURING SUMMER (ANTARCTICA)

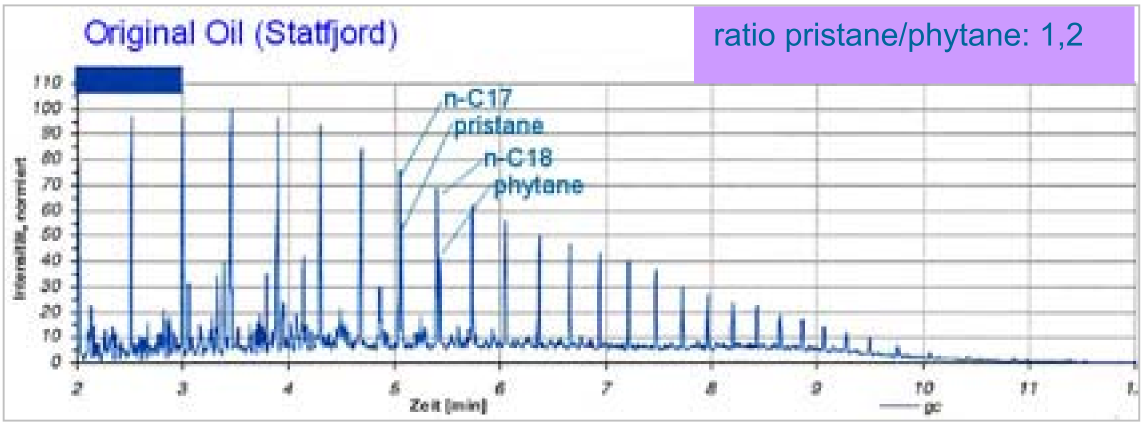
- Duration 6 months (Dec 2004 – June 2005)
- sea-ice at -3°C
- melt water pools at 0°C
- Fertilization with inorganic nutrients
- Inoculation with hydrocarbon-degrading bacteria

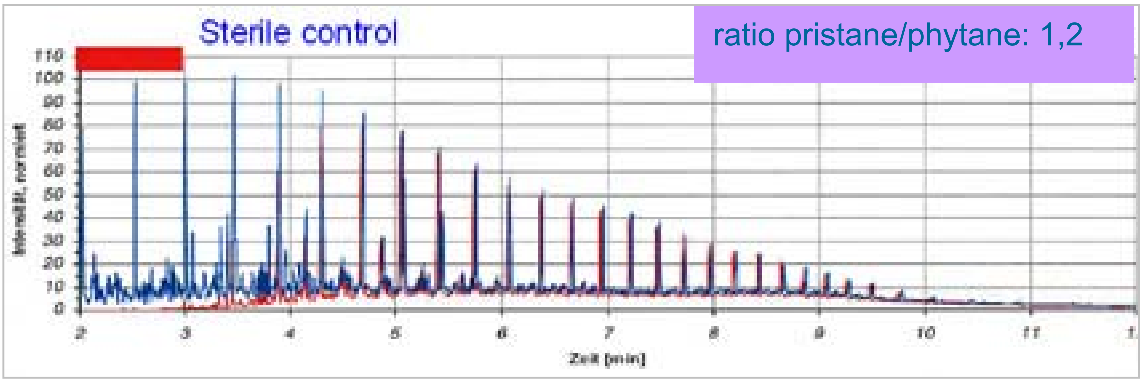


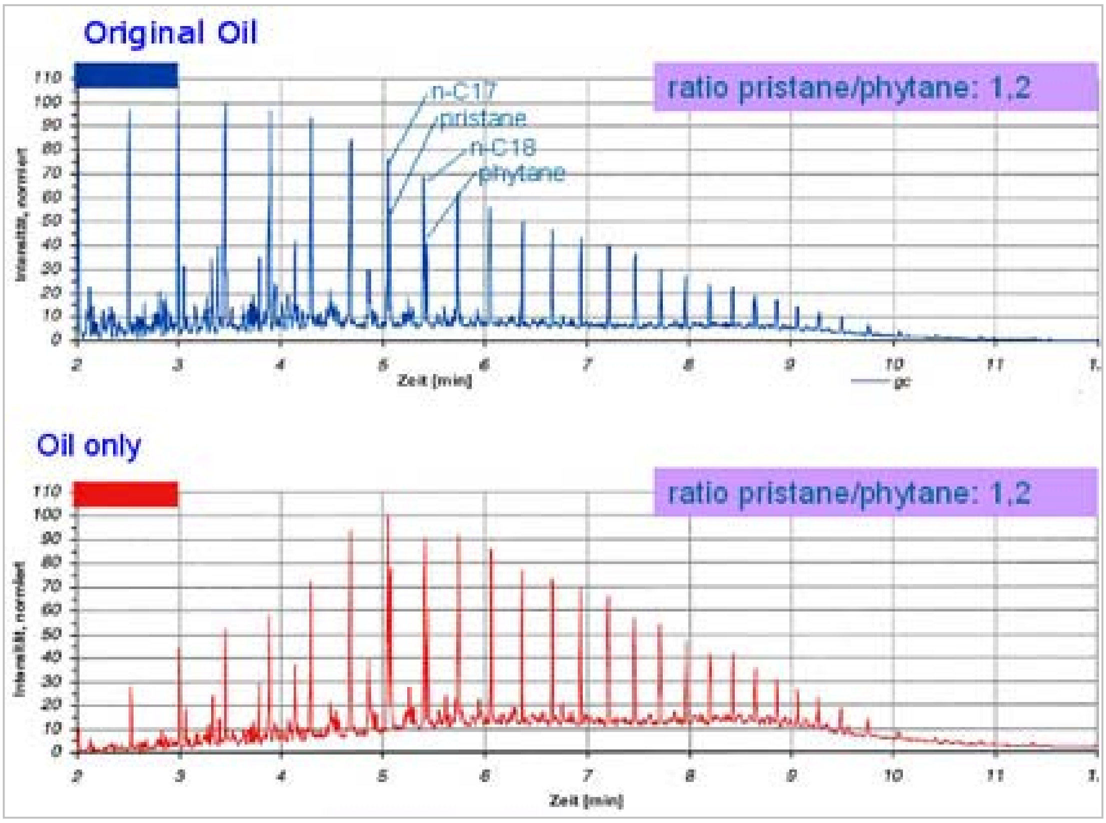
RESULTS: CHANGES IN BACTERIAL COMMUNITIES

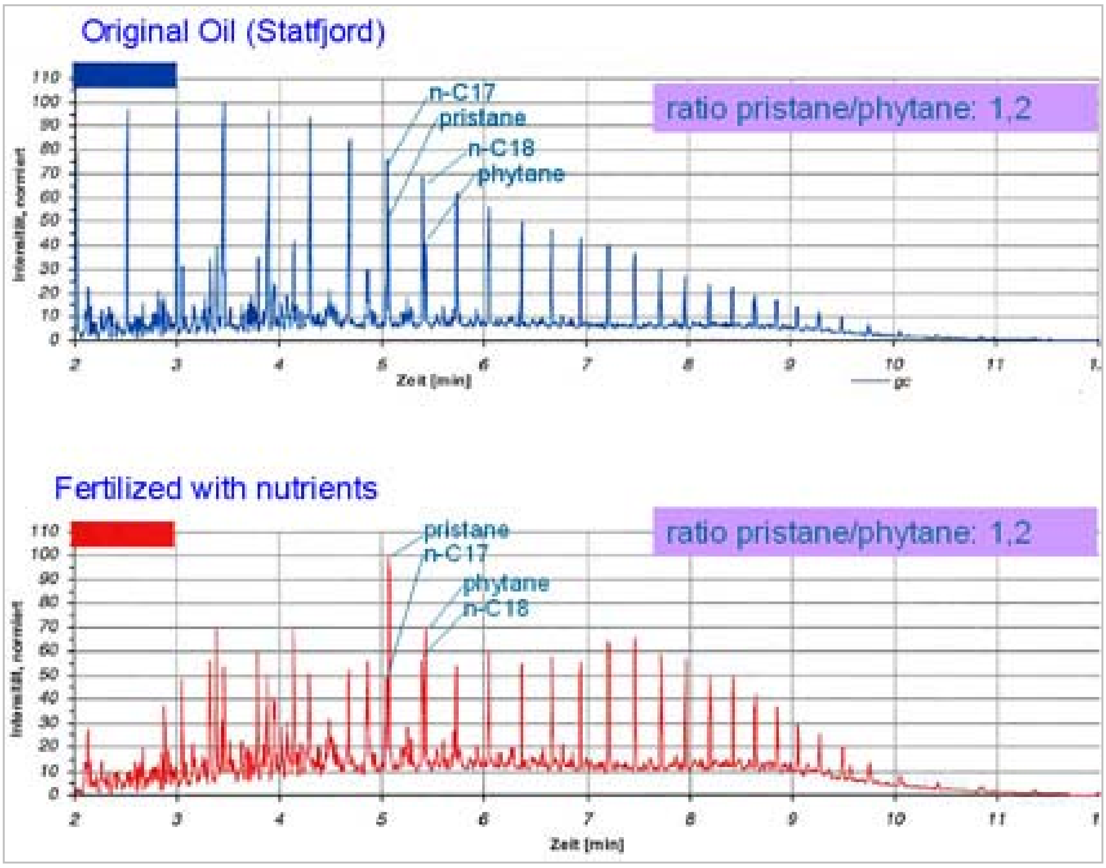


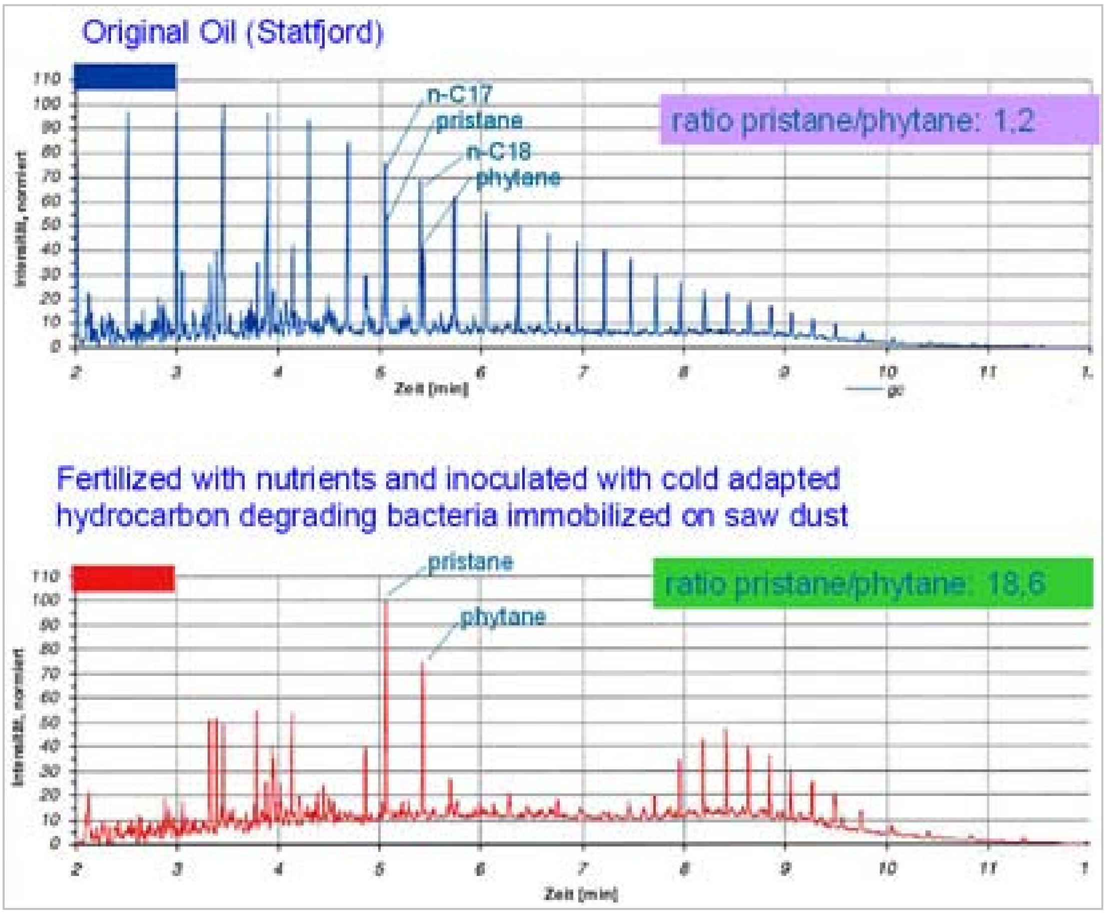
OIL ANALYSIS BY GC/MS






Original Oil
ratio pristane/phytane: 1,2
n-C17
pristane
n-C18
phytane
Zeit [min]
gc
Oil only
ratio pristane/phytane: 1,2
Zeit [min]


Original Oil (Statfjord)
ratio pristane/phytane: 1,2
n-C17
pristane
n-C18
phytane
Zeit [min]
gc
Fertilized with nutrients
ratio pristane/phytane: 1,2
pristane
n-C17
phytane
n-C18
Zeit [min]



SUMMARY OF OIL ANALYSIS

- At - 3°C no significant degradation of oil hydrocarbons occurred in sea ice with fertilization of nutrients as well as inoculation
- At 0°C melt pool samples fertilized with inorganic nutrients showed a significant biodegradation of n-alkanes.
- In fertilized and inoculated samples, n-alkanes up to n-C27 were completely degraded. Also branched alkanes where biodegraded.

CONCLUSIONS

- It appears that biodegradation of oil hydrocarbons comes to a halt at temperatures below freezing.
- However, when temperatures rise above 0°C and melt water pools begin to develop bioremediation could be applied as a sensitive alternative oil spill response method.
- Future bioprospection and the culturing of more specific PAH-degrading cold-adapted bacteria should improve the prospects of oil remediation in sea ice.

PUBLICATIONS

- Influence o f crude oil on changes of bacterial communities in Arctic sea-ice
  Birte Gerdes, Robin Brinkmeyer, Gerhard Dieckmann,
  Elisabeth Helmke
  FEMS Microbiology Ecology 53 (2005) pp:129-139

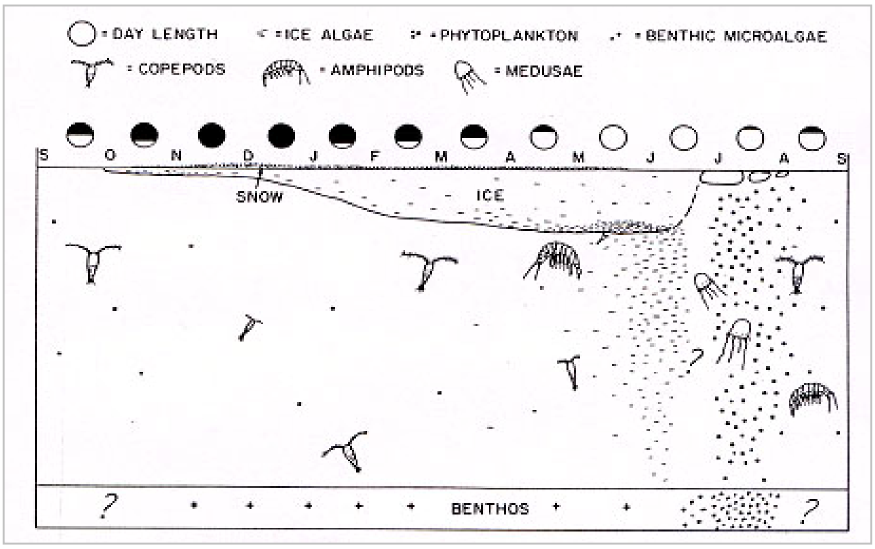
- Documentation of marine biological experiments
  Birte Gerdes and Gerhard Dieckmann
  Report for the EU project Arctic Operational Platform (ARCOP)
  available to public in Dec 2005

EFFECTS OF CRUDE OIL, INIPOL AND FISH MEAL ON ARCTIC SEA ICE BIOTA

by Johanna Ikävalko, Finnish Institute of Marine Research,
Gerhard Dieckmann & Birte Gerdes, Alfred Wegener Institute

BACKGROUND

Sea ice associated food webs in the Arctic
= sea ice is the beginning



(and the end?)

"Oh hey.. I just love these things. Crunchy on the outside and chewy center".

of pelagic food webs in the Arctic

- oil transportation in the Arctic, particularly the Barents Sea is in rapid growth (e.g. USEP 2004)

→ elevated risk of an oil spill/accident

- the presence of ice cover adds to the risk
- effects of oil on ice biota very sparsely studied (Cross et al. 1987 (BIOS project))

EXPERIMENTAL DESIGN

- The experiment of effects of oil, Inipol and fish meal on bacteria (bioremediation: Dieckmann & Gerdes) and protist communities (=biota: Ikävalko) was made in Van Mijenfjorden, Spittsbergen during 2-4/2004 (63 days)
- Statjord oil, inipol (commercial product incl. nutrients N+P, with urea as nitrogen source) and *fish meal* (nutrients) were added onto ice

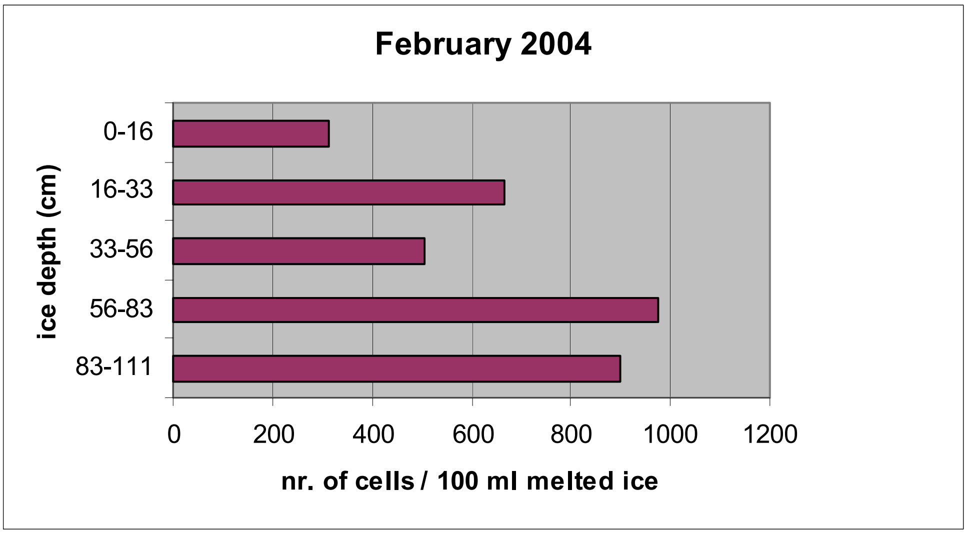
EXPERIMENT SET-UP

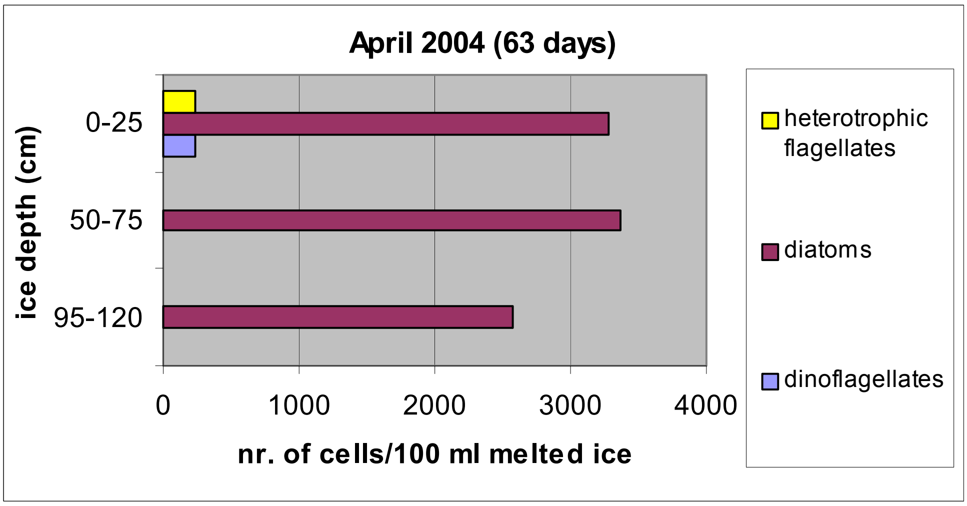
oil only 150 ml	oil 150 ml + Inipol 15 ml	oil 150 ml + fish meal 15 g
control	Inipol only 15 ml	Fish meal only 15 g
oil only 150 ml	oil 150 ml + Inipol 15 ml	oil 150 ml + fish meal 15 g

area:
10 x 10 metres

RESULTS:

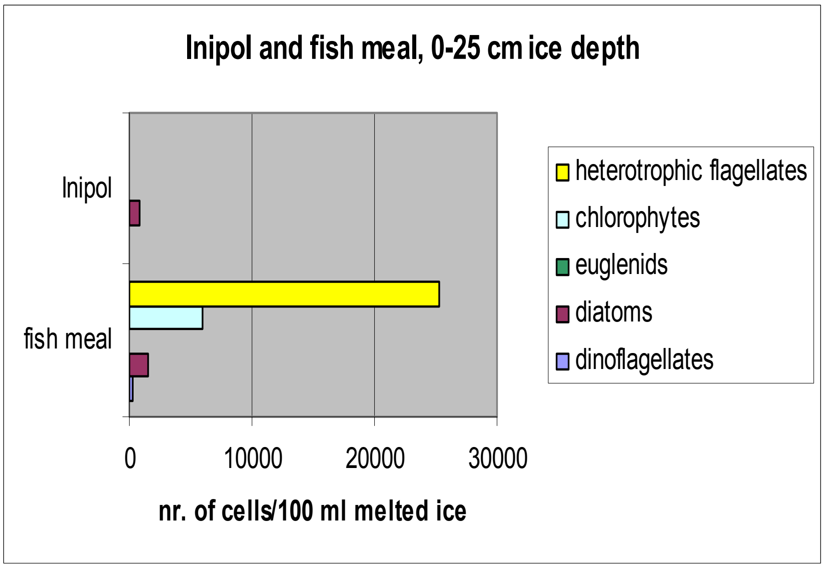
Controls



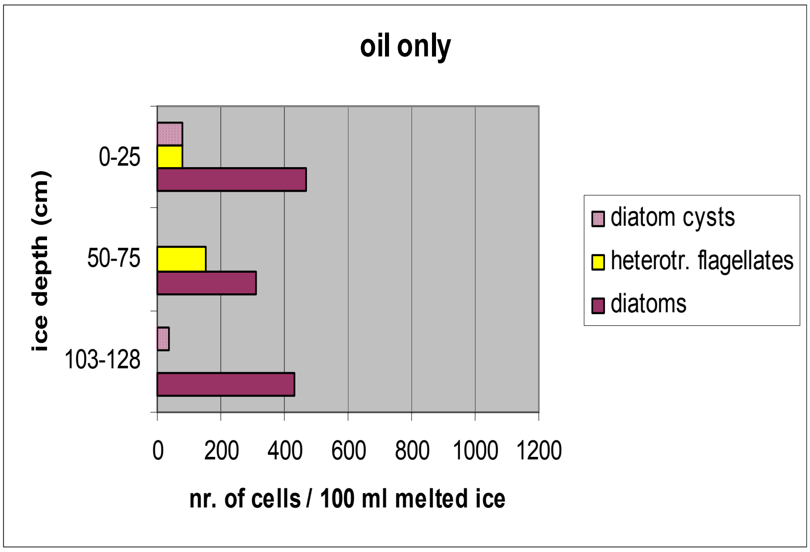


- diatoms increased ~3x from February to April
- heterotrophic flagellates and dinoflagellates appeared in ice surface

Iinipol, fish meal and oil only

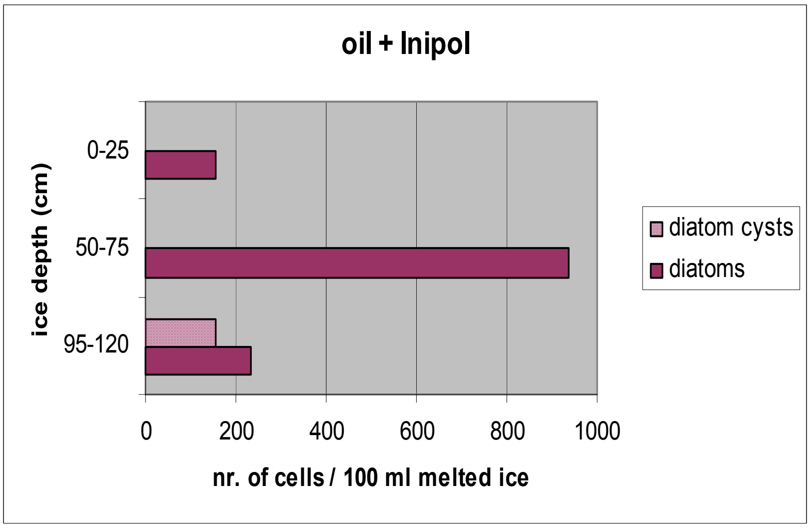


- inipol only: diatoms decreased strongly, others disappeared
- fish meal only: dramatic increase of heterotrophic flagellates, notable increase of chlorophytes (mixotrophic?)

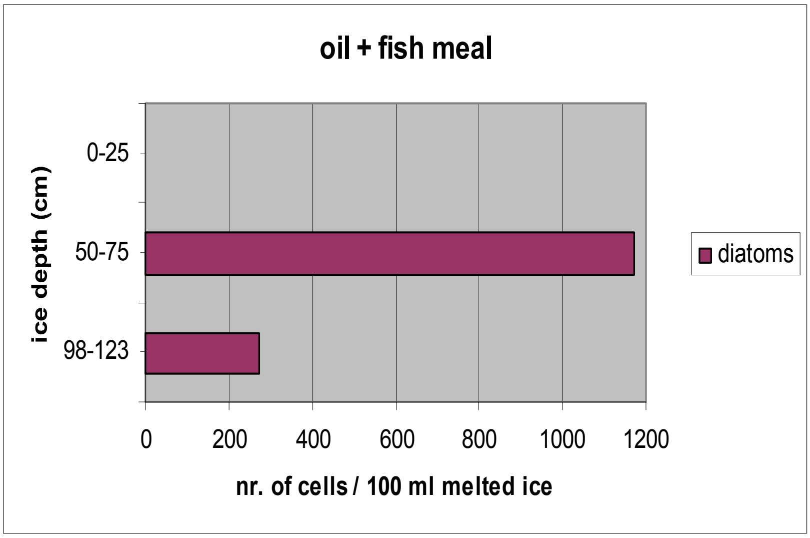


- oil only, entire ice cover: diatoms decreased to about 1/6 (from ~3000 to 500 cells/100 ml melted ice), development of diatom resting stages (cysts)

Oil+inipol & oil+fish meal



- oil + inipol, ice surface: diatoms decreased strongly
- oil + inipol, ice interior and bottom layers: formation of diatom cysts



- oil + fishmeal, ice surface: all cells died
- oil + fishmeal, ice interior and bottom layers:
  decrease of diatoms to about 1/3 (interior) - 1/10 (bottom)

CONCLUSIONS

- oil only: *destroyed* most of the protists through the entire ice cover, heterotrophic flagellates avoided contamination by *migrating downward*
- oil + inipol & oil + fish meal: very strong effects in the ice surface, less pronounced decline of organisms in the ice interior
- the use of inipol and fish meal helped to maintain higher diversity and biomass of protists in ice: no notable difference between the use of inipol and fish meal
- diatoms form resistant resting stages during contamination (oil, inipol, fish meal)
- Thinking *cap*: ice break up + increasing temperatures
  - increasing oil migration and weathering
  - increasing effects of oil on protists
  - processes in spring!

PUBLICATIONS

Ikävalko, J. 2004: Checklist of unicellular and invertebrate organisms within and closely associated with sea ice in the Arctic regions. - Meri, Report Series of the Finnish Institute of marine Research 52: 1-41.

Ikävalko, J. 2005: Effects of oil spills on Arctic marine ecosystems. - Report for the EU project Arctic Operational Platform (ARCOP), www.arcop.fi. & Meri, Report Series of the Finnish Institute of Marine Research (in print).

Ikävalko, J., Dieckmann, G. & Gerdes, B. 2005: An experimental study of the effects of Stafjord crude oil, and application of Inipol and fish meal on the sea ice biota in Svalbard in February-April 2004. – Arctic and Marine Oil Spill Program 28: 993-1003.

CURRENT PROJECTS

- the study of oil effects on Baltic Sea plankton and benthic invertebrates in the Gulf of Finland (Ikävalko et al., funded by the Univ. of Helsinki)

- the study of the use of cotton grass fibre as oil absorber in brackish water (Romantschuk et al., funded by the Academy of Finland

ACKOWLEDGEMENTS

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- Disclaimer: Research leading to this presentation was conducted under the ARCOP project (Arctic Operational Platform), co-funded by DG TREN of the European Commission under the 5th R&D Framework Programme. The authors are solely responsible for the provided information that does not represent the opinion of the Community, and the Community is not responsible for any use that might be made of data appearing therein.

WEATHERING OF OILS IN OPEN SEA AND ICE- INFESTED WATERS
by Ivar Singsaas, SINTEF Materials and Chemistry, Marine Environmental Technology

ACCIDENTS HAPPEN!



We need to be prepared. Important basis is a good knowledge about the oil types we have to deal with.

BEHAVIOR / PROPERTIES OF DIFFERENT NORTH SEA CRUDES
(after 3 days weathering in SINTEF's Meso-scale Flume Basin)

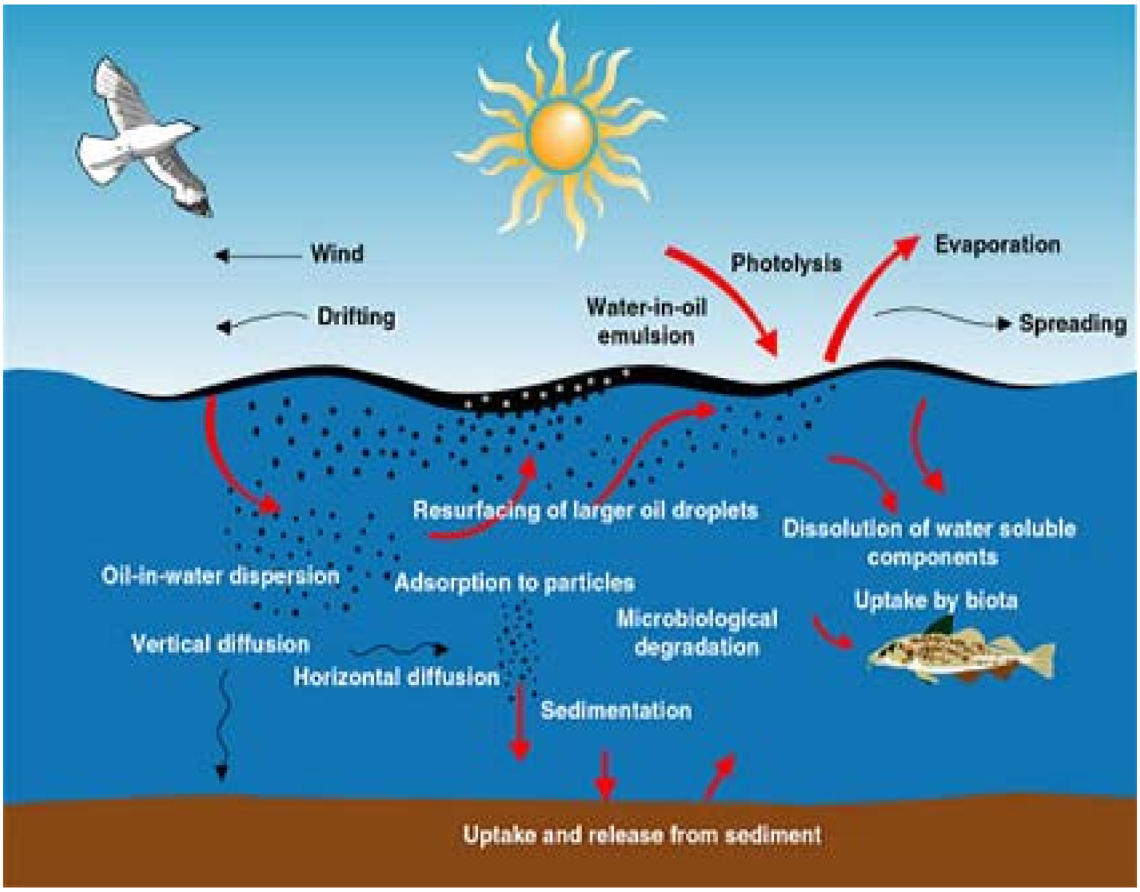


Norne - waxy crude, form solidified oil lumps (35 % water)

Grane - asphalthenic crude form viscous lumps, (70% water)

Jotun - paraffinic crude form yellow / light brown emulsions (58% water)

WEATHERING PROCESSES OF OILS SPILLED IN OPEN SEA



SINTEF METHODOLOGY FOR CHARACTERIZATION
AND PREDICTION OF OIL WEATHERING PROPERTIES AT SEA:

- Bench-scale weathering / characterization
- Meso-scale flume basin studies

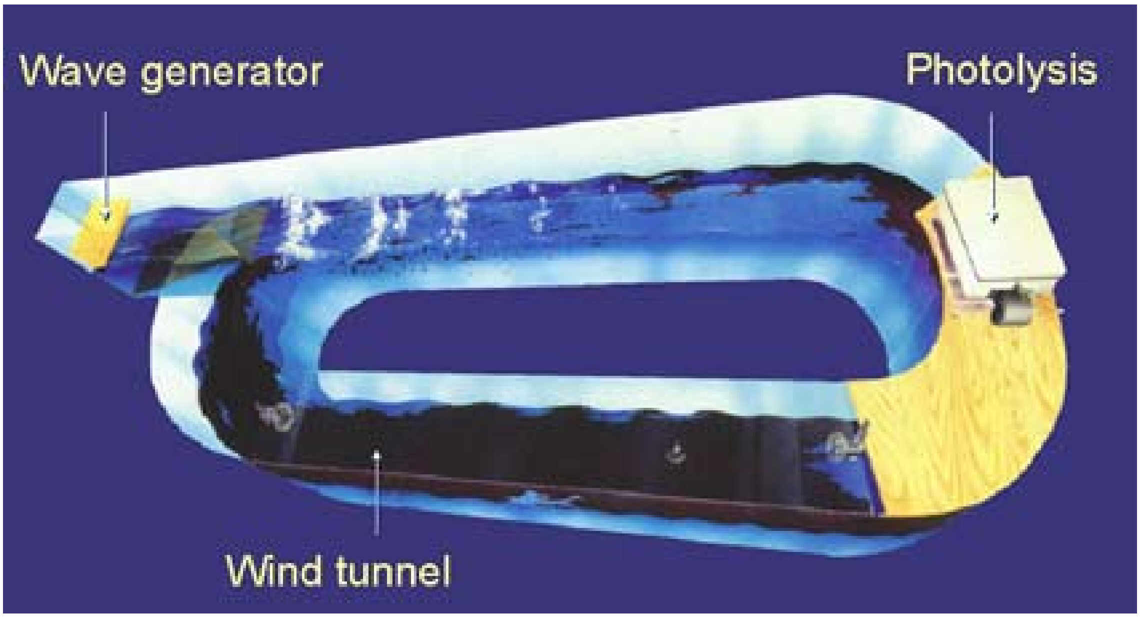
⬇

- Oil weathering model predictions

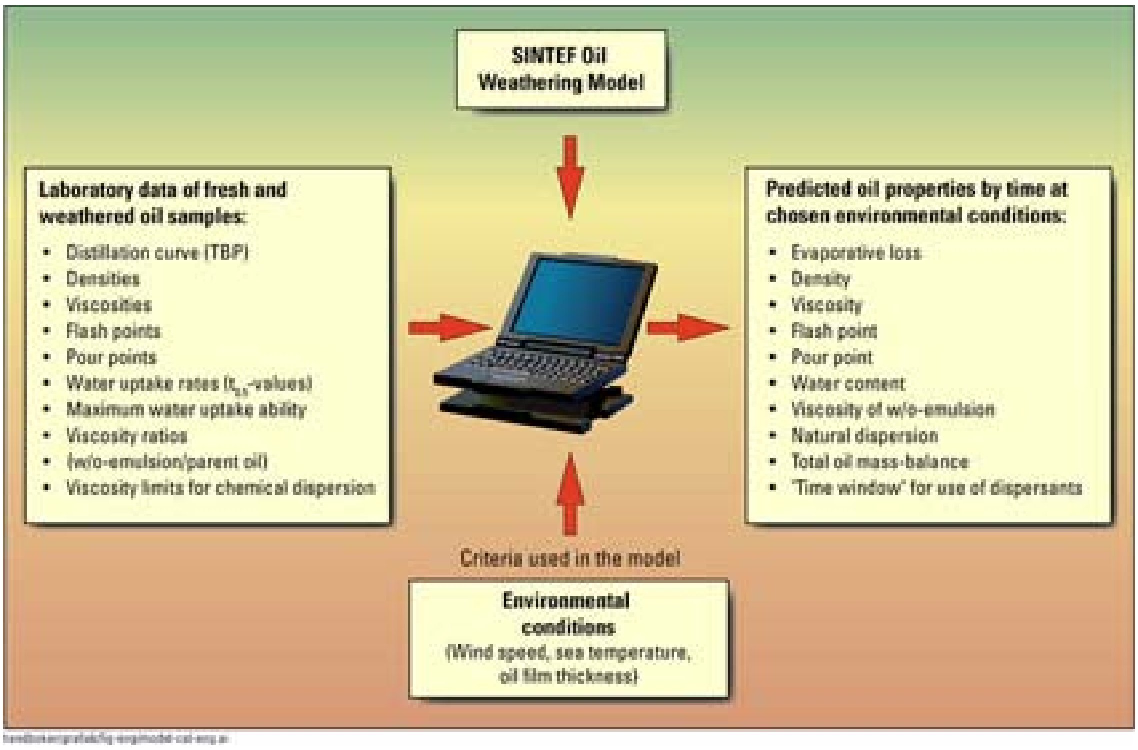
⬆

- Verification by field trials

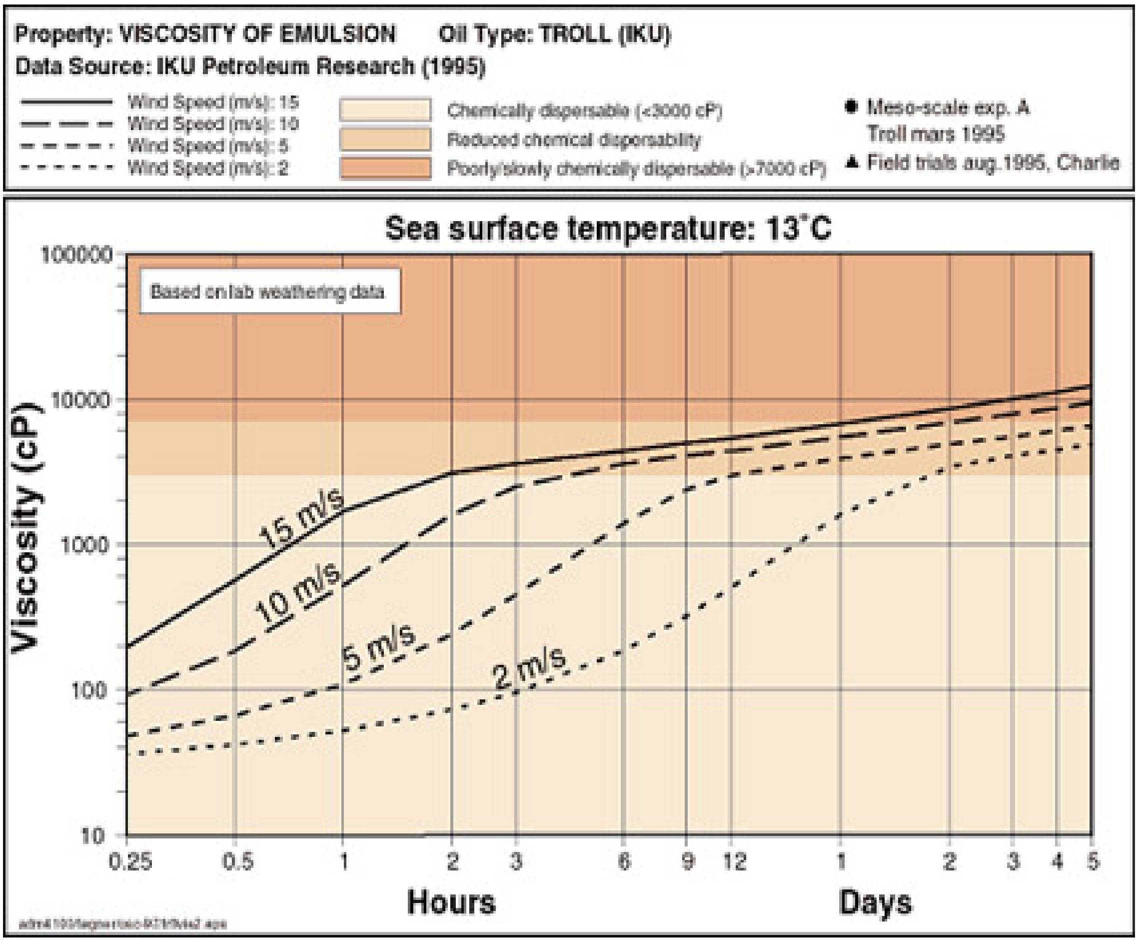
SINTEF MESO-SCALE OIL WEATHERING FLUME BASIN



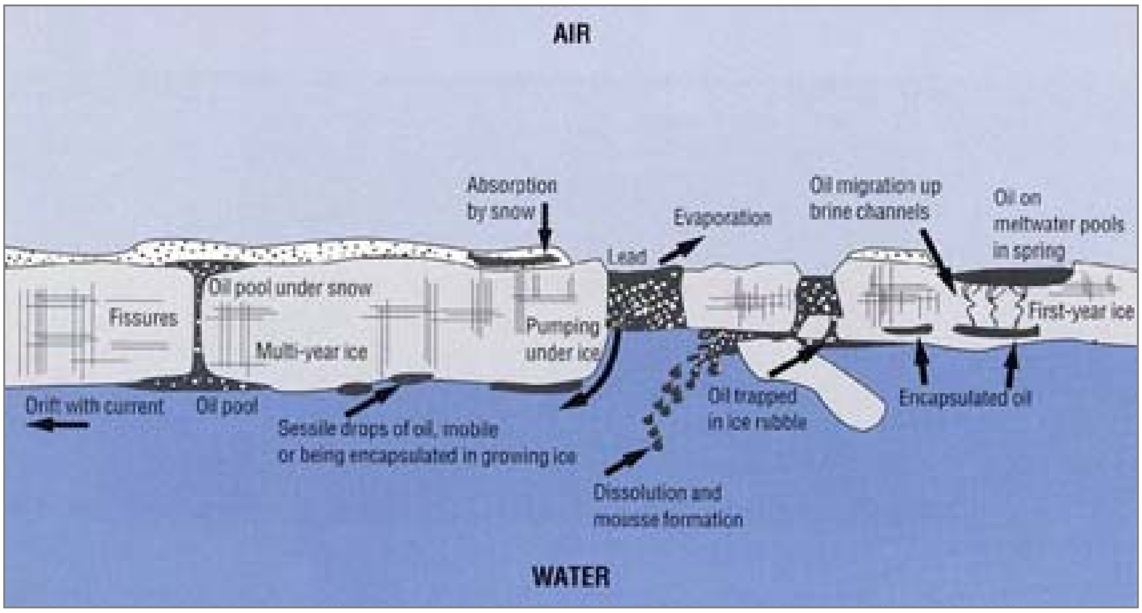
SINTEF OIL WEATHERING MODE

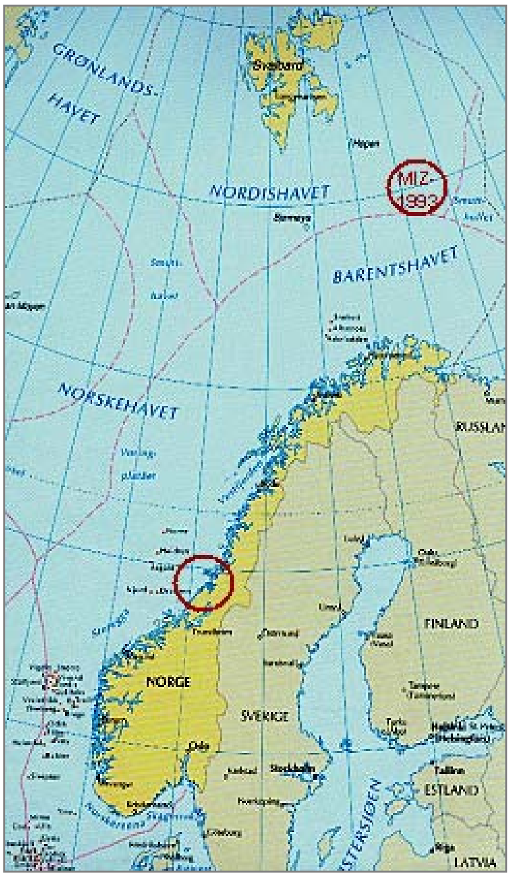


PREDICTED EMULSION VISCOSITY AT SEA



FATE AND BEHAVIOUR OF OIL IN ICE
Much more complicated than in open waters





BEHAVIOUR OF OIL SPILL IN ARCTIC VERSUS NORTH SEA CONDITIONS:

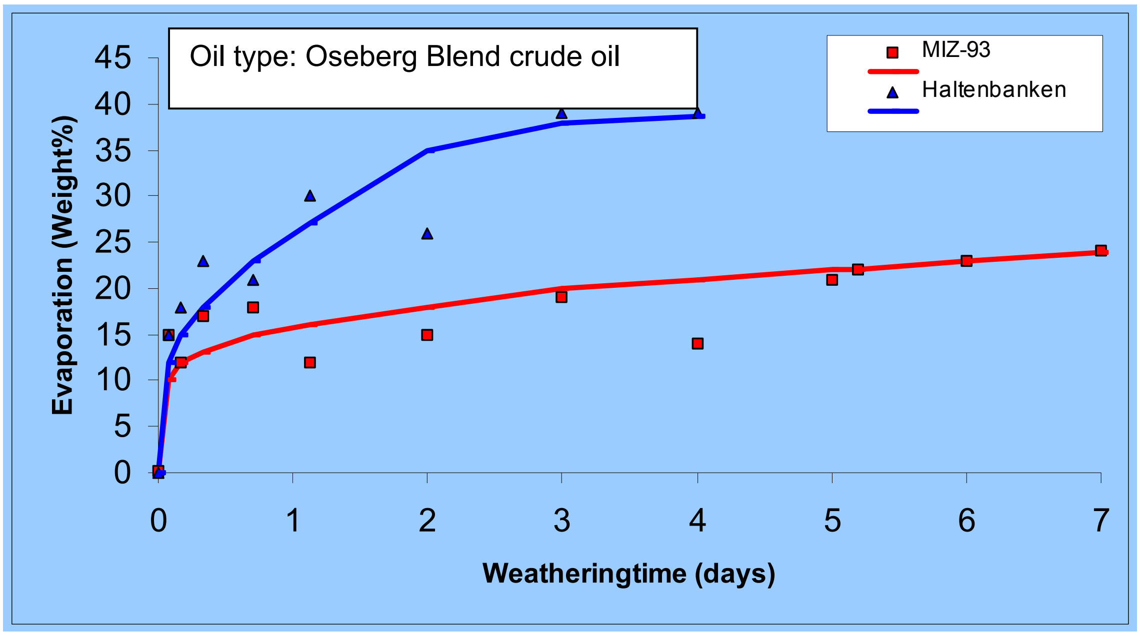
- Experimental oil spill in the North Sea, 1990
- Experimental oil spill in the Marginal Ice Zone (MIZ) in the Barents Sea, 1993

- Norwegian crude oil
- 25 m3 released

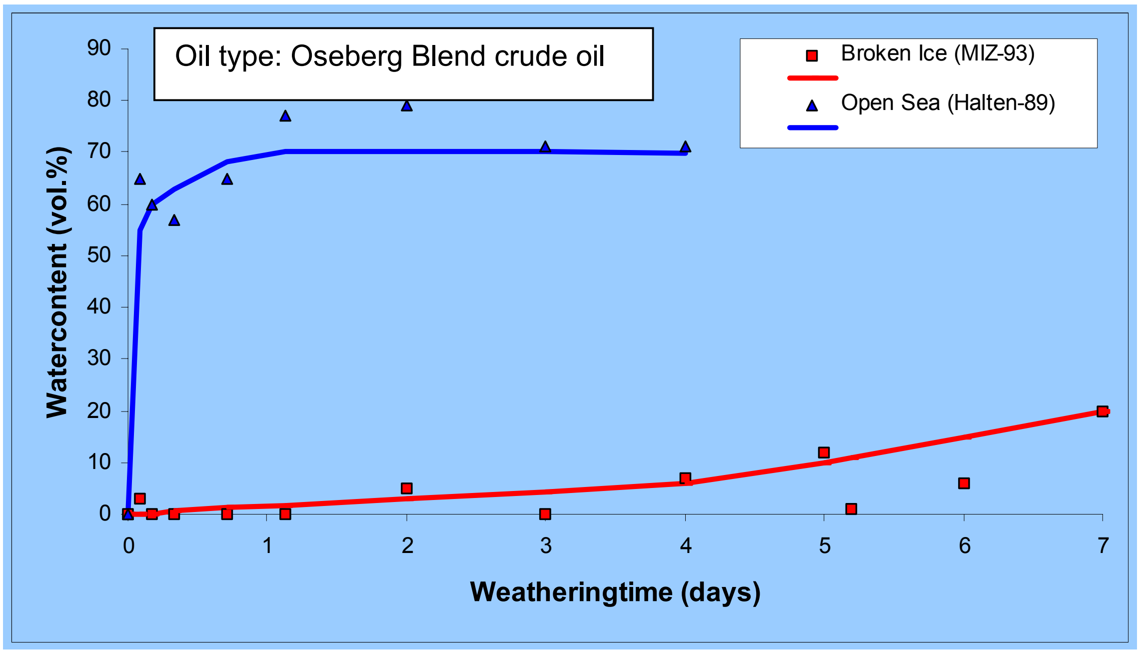
OIL RELEASE IN THE MARGINAL ICE ZONE (MIZ-93)
Release of 27 m^3 crude oil in MIZ, May 1993, Followed for 2 weeks

ARCTIC VS. NORTH SEA CONDITIONS

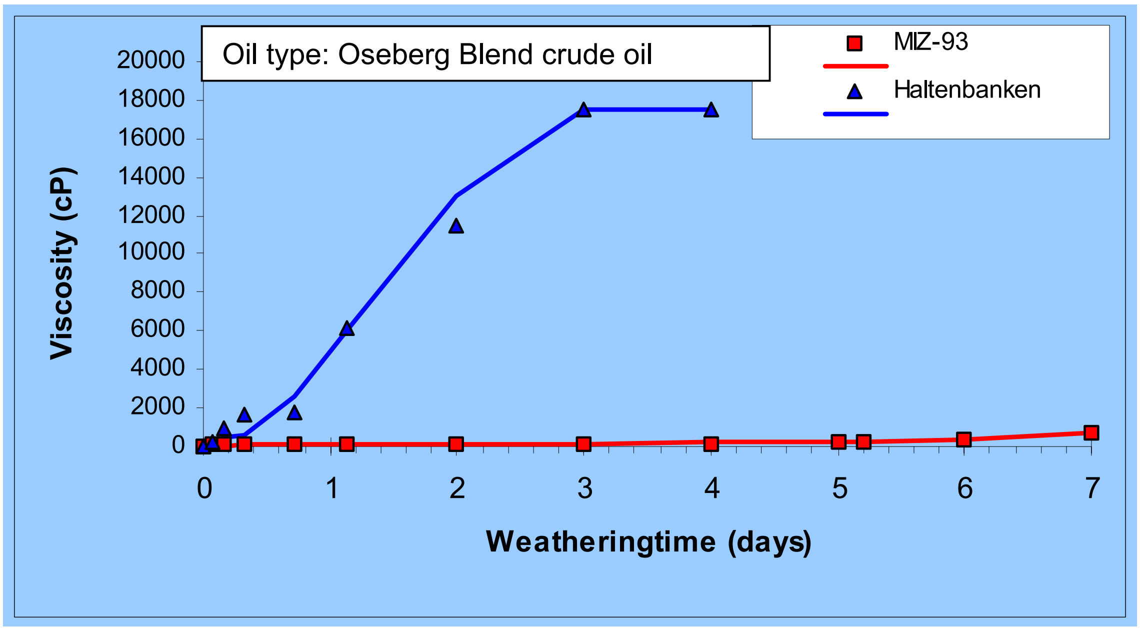
Evaporation



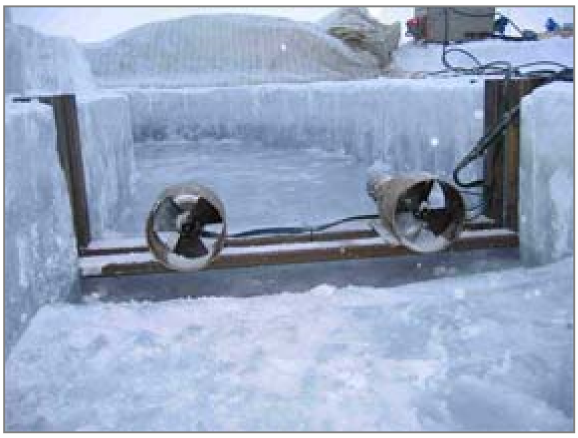
Water uptake



Viscosity



FATE AND BEHAVIOUR OF OIL IN ICE
Meso-scale oil weathering experiments on Svalbard March 2005



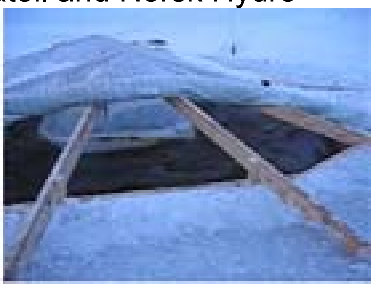
Propellers to induce current

Wave generator

Arctic fieldwork is very weather ependant

PROOF project (NFR) with additional funding from Statoil and Norsk Hydro



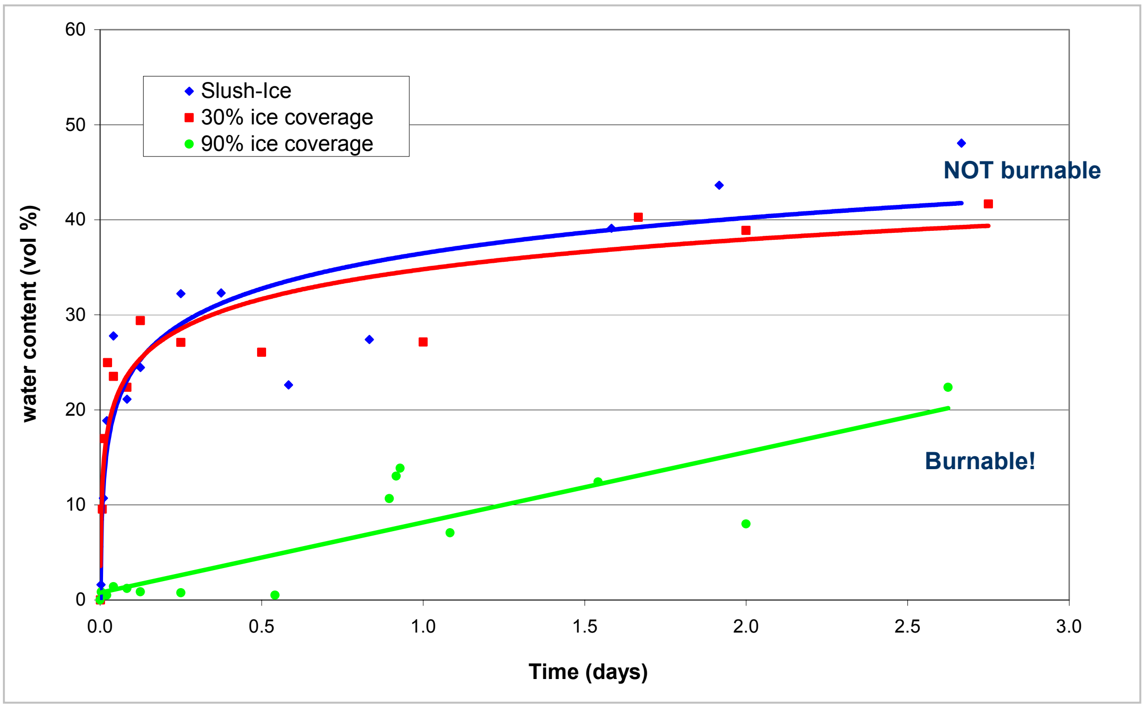


Open water, no ice

90% ice coverage

30% ice coverage

WATER UPTAKE AS A FUNCTION OF ICE COVERAGE



NORTHWEST RUSSIA TRANSPORT ROUTES AND EXPORT TERMINALS

Refineries
Existing terminals
Planned terminals
Railways
Pipelines in operation
Planned pipelines

INCREASE IN TRANSPORT OF RUSSIAN OILS

- Scenario without new pipeline from Siberia:
- In 2005 – one 30 000 t oil tanker a day
- In 2015 – one 100 000 t oil tanker a day

- Scenario with new pipeline from Siberia:
- In 2005 – one 30 000 t oil tanker a day
- In 2015 – three 100 000 t oil tankers a day

- With a three days sailing along the Norwegian coast, 9 fully loaded oil tankers southbound and 9 tankers in ballast northbound will be transiting Norwegian area of responsibility

Source: Norwegian Coastal Adm.

PROJECT INITIATED BY NCA: "WEATHERING STUDY OF RUSSIAN CRUDE OILS AND OIL PRODUCTS"

Establish cooperation with Russian institutes to:

- Provide knowledge about Russian oil transportation

- Perform weathering studies on a broad range of selected Russian oils

- Establish long term cooperation with Russian institutes within chemical and biological oil analyses, weathering studies and oil weathering modelling

SINTEF has cooperation with Murmansk Marine Biological Institute (MMBI).

PROPERTIES AND WEATHERING DATA ON RUSSIAN OILS

Oil	Density 20°C, g/cm.cub.	Viscosity 20°C, mm.cm./c	Temperature, °C		Wax Content, %	Asphaltene Content, %	Distillation loss, %	
			Pour Point	Flash Point			up to 200°C	up to 300°C
Oils with only physical-chemical data:								
Ural og Volga region								
Arlansk	0,8918	39,7	-34	-13	3,4	5,8	18,7	42,8
Bavlinsk	0,8830	25,8	-48	40	4,1	6,1	19,2	42,4
Zgirnovk	0,8567	17,7	-6	-22	1,7-5,1	0,2	8,6	50,8
Kamenolozgsk	0,8110	4,7	-47	<-35	4,05	0	33,9	61,9
Kuleshovsk	0,8240	4,0	-14	-44	4,0	0,7	35,0	63,6
Mukhanovsk	0,8462	13,3	-27	<-35	6,9	2,2	26,0	54,0
Romashinsk	0,8620	14,2	-42	-38	5,1	4,0	24,0	49,0
Sernovodsk	0,9160	-	-35	-36	3,4	5,7	15,8	26,5
Tuimazinsk	0,8560	19	-29	-20	4,1	3,4	26,4	53,4
Shkapovsk	0,8624	13,8	-24	<-17	4,1	3,3	25,7	52,3
Komi republic								
West-Tebuksk	0,8490	13,8	-14	<-35	3,7	1,5	26,0	50,0
Usinsk	0,8369	-	3	<-35	10,8	0,68	25,4	52,2
Yagersk	0,9449	86,3	-10	108	1,4	3,7	0,4	18,8
Westsiberia								
Megionsk	0,8560	7,1	-35	-22	2,28	1,13	27,2	59,2
Samatlor	0,8426	6,1	<-33	<-34	2,3	1,94	30,6	58,2
Ust'-Balyk	0,8704	25,1	-20	-30	2,3	2,3	19,3	42,8
Shaimsk	0,8269	6,8	-2	-35	2,9	0,8	32,0	58,0
Sakhalin								
Ekhabinsk	0,8695	7,7	<-30	-35	3,1	0,9	27,2	60,4
North Kavkaz								
Malgobek	0,8463	7,7	3	-22	7,0	1,35	30,9	59,5
Novo-Dmitrievsk	0,8271	5,2	3	<-30	4,4	1,13	34,2	63,1
Ozeksuatsk	0,8230	6,3	20	0	17,5	0,38	24,2	58,1
Troetcko-Anastas'evsk	0,9067	37,8	-54	28	1,0	0,81	8,2	48,3
Oils with physical-chemical and weathering data:								
Turyshevskoe	0,8443	7,6	-18	-35	0,87	2,76	31	51
Bolshepurgovskaya	0,8823	71,7	-19	-10	0,26	8,5	20	38
Kyrtael	0,8157	-	8	-14	11,4	1,4	31	49

CONCLUSIONS

- ARCOP has produced reports on:
  - State-of-the-art on weathering of oils and oil spill response technology in open and ice-infested waters
  - Ideas and suggestions to further development of oil spill response for ice-infested waters
  - Oil spill response analysis for shipment of oil from Varandey to Murmansk
  - Recommendations for input to oil spill contingency plan

- We do not have a sufficient oil spill contingency for ice-infested waters today
- There is a need for further development and improvement

RECOMMENDATIONS

- Improve the knowledge about weathering of Russian oils being shipped and/or produced in Arctic areas
    - Based on a joint project between the Norwegian Ministry for Fisheries and the Ministry of Transport in Russia
    - Continue the good cooperation with Murmansk Marine Biological Institute (MMBI)
    - Potential financing from the oil industry
    - Continued cooperation with the authorities

- Joint Industry project to develop tools and technology for environmental beneficial oil spill response strategies in arctic and ice-infested waters
    - Fate and behaviour of oils in ice-infested waters
    - Ecological Impacts / Biological studies
    - Oil spill response technologies in ice-infested waters
    - Mechanical recovery
    - In-situ burning
    - Oil Spill Dispersants
    - Development of operational tools (NEBA / contingency planning / decision-making)
    - Full-scale field validation testing

Participation from Russian institutes are welcomed

OIL SPILL COUNTERMEASURES

by Karl-Ulrich Evers, Hamburgische Schiffbau-Versuchsanstalt GmbH

AREA OF INTEREST IN THE ARCOP TRANSPORTATION SCENARIO

Source:UNEP/GRID Arendal

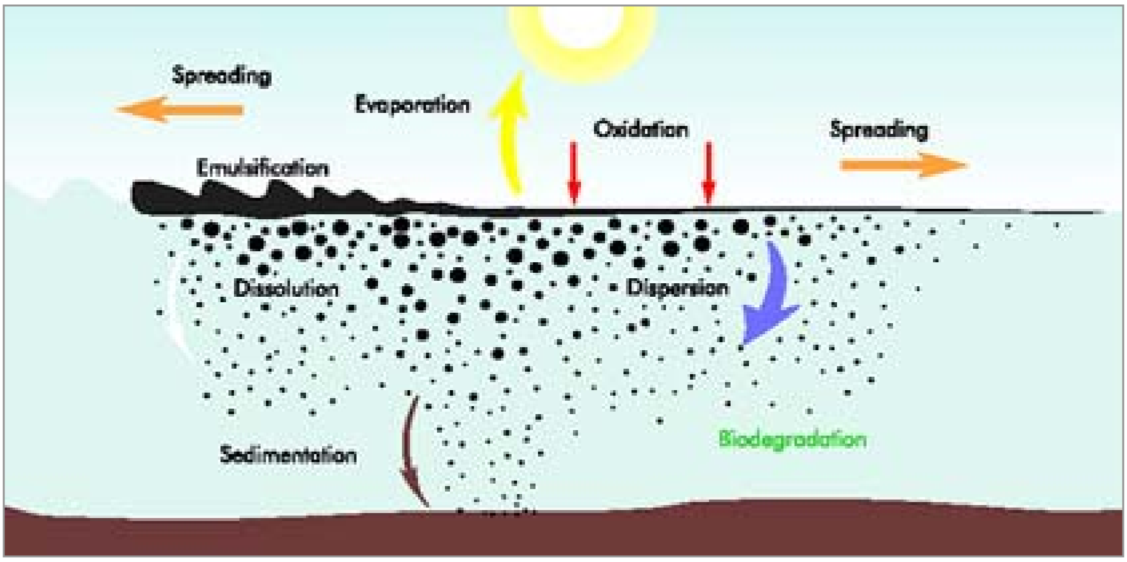
INTRODUCTION

- Oil spilled into the sea undergoes physical and chemical processes
- Oil can partly removed from the sea surface - other parts may persist
- Although spilled oil is eventually assimilated by the marine environment the time involved depends on various factors:
    - amount of spilled oil
    - initial physical / chemical characteristics
    - prevailing meteorological and sea conditions
    - and whether the oil remains at sea or is washed ashore

- The understanding of processes involved and how they interact to alter the composition and behaviour of oil with time is fundamental to all aspects of oil spill response
- When oil response is required,
    - the type of oil
    - behaviour and fate of oil

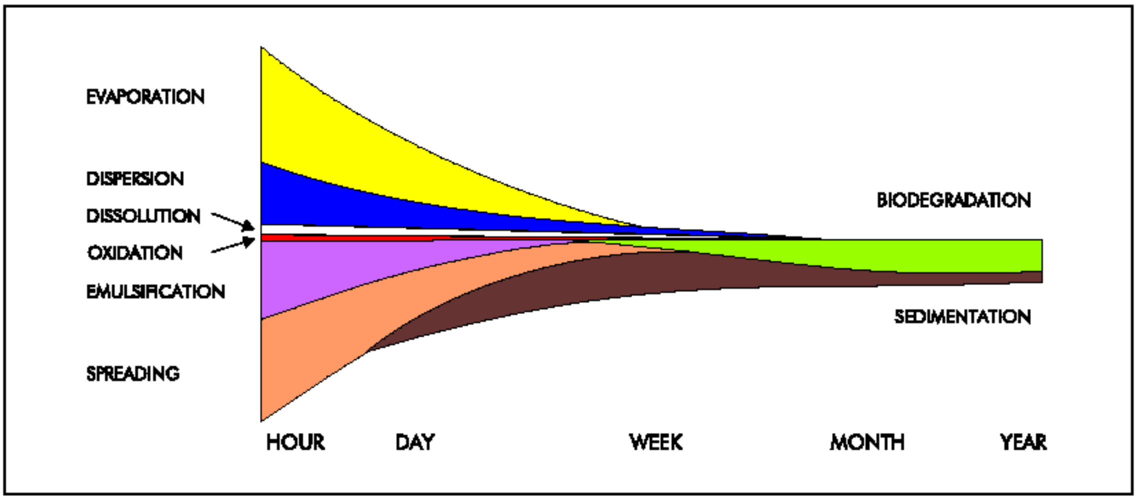
will determine which oil spill response methods and devices are likely to be most effective and should therefore be applied.

PROCESS ACTING ON SPILLED OIL IN OPEN WATER



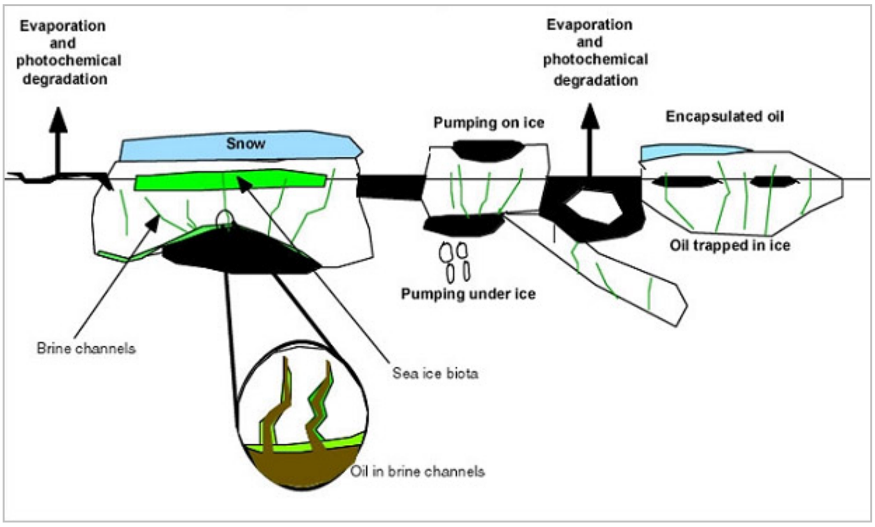
Source: International Tanker Owners Pollution Federation (ITOPF)

FATE OF A CRUDE OIL SPILL – CHANGES OF RELATIVE IMPORTANCE OF WEATHERING PROCESSES WITH TIME

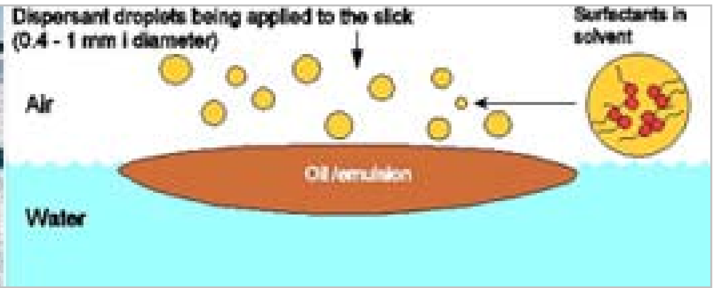


Source: International Tanker Owners Pollution Federation (ITOPF)

BEHAVIOUR OF SPILLED OIL IN SEA ICE

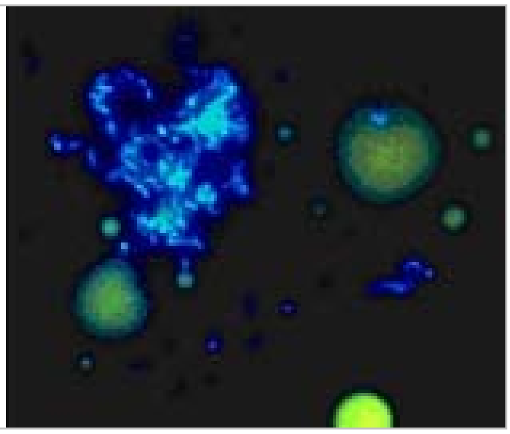


OIL SPILL RESPONSE METHODS



Mechanical Oil Recovery

Application of Dispersants



In-Situ Burning

Bio-Remediation

MECHANICAL OIL RECOVERY IN ICE

For <u>large</u> oil spills in broken ice there are in general limitations, i.e. recovery values are highly variable depending on the variety of environmental conditions and logistics constraints:

- Ice conditions (light / medium / severe)
- Access to the spill site (duration; time consuming)
- Long distances for transport of equipment to and recovered oil from the spill site
- Limited storage capacity of recovered oil at spill site
- Functionality of devices due to low temperatures (e.g. freezing, accretion, etc.)
- Efficiency of mechanical recovery units (recovery rate)

⇨ Mechanical oil recovery including treatment, transfer and disposal of recovered products is very complex

VARIOUS VESSEL TYPES FOR OIL SPILL RECOVERY IN OPEN WATER

Source: Central Command of Maritime Emergency Germany / D. Reichenbach

OIL SPILL COMBATTING EXERCISE

Oil Pollution Combat Vessel “BOTTSAND

Source: Central Command of Maritime Emergency Germany". D. Reichenbach

VARIOUS SYSTEMS FOR RECOVERY OF SPILLED OIL IN OPEN WATER AND ON SHORELINE

Source: Central Command of Maritime Emergency Germany / D. Reichenbach

SURVEILLANCE AIRCRAFT DORNIER DO 228-212 LM USED FOR MARINE POLLUTION MONITORING

Source: Central Command of Maritime Emergency Germany".

Long distance sensors	**Short distance sensors**
Line Scanner: ± 30 km Side Looking Airborne Radar (SLAR)	Line Scanner: ± 250 m Infrared / Ultraviolet Scanner (IR / UV) Microwave-Radiometer (MWR) Laser-Fluoro Sensor (LFS) Forward Looking Infrared Camera (FLIR) Satellite Communication

MARINE POLLUTION CONTROL VESSEL “SCHARHÖRN

<u>Main Dimensions</u>

Length:	56.1 m
Width:	14.2 m
Draft:	4.2 m
Speed:	14 knots
Engine Power:	2575 kW
Operational Area:	Baltic Sea

MARINE POLLUTION CONTROL VESSEL “NEUWERK”

Main dimensions

Length:	78.91 m
Width:	18.63 m
Draft:	5.79 m
Speed:	14 kn
Engine Power:	8400 kW
Recovery rate:	640 m3/h
Storage Volume:	1000 m3
Operational Area:	Baltic Sea

MARINE POLLUTION CONTROL VESSEL “ARKONA”

Main Dimensions

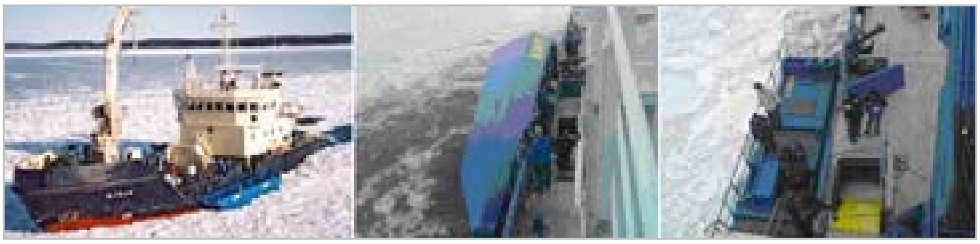
Length:	78.9 m
Width:	18 m
Draft:	5 m
Speed:	10 kn
Engine Power:	2 x 2900 kW
Operational Area:	Baltic Sea

MARINE POLLUTION CONTROL VESSEL “NEUWERK”

Source: Central Command of Maritime Emergency Germany / D. Reichenbach

EXAMPLES

Lamor Oil Ice Separator (LOIS)

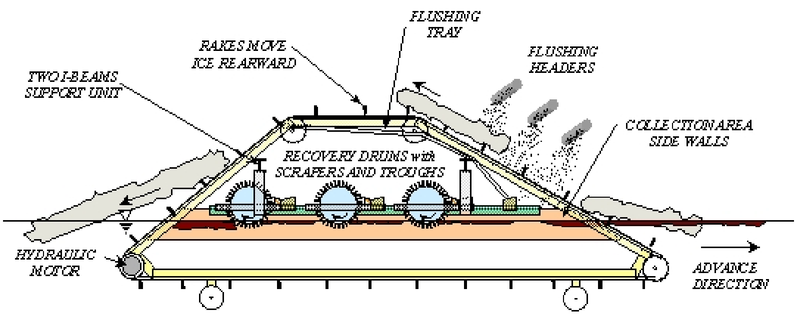


- LOIS device is lowered to the water along the ship hull by hinges and hydraulic rams
- Oil that has been under the hull of the vessel is forced aside and passes into the oscillating grids of the LOIS for processing (oscillating: stroke 200mm;f = 0.7Hz)
- Vessel moves through water at a speed of 1-3 knots

Arctic Skimmer (Lamor)

- Crane-deployed system for recovery of oil in broken ice and debris conditions
- Efficient rotating brushes for oil separation
- Screw conveyors
- Offloading pump
- Archimedes screw pump to transfer the recovered material away from the skimmer

Morice System (LGB)

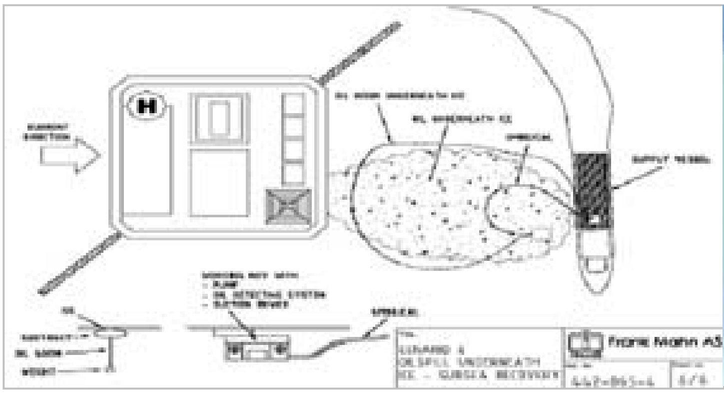


Tests in HSVA's Ice Tank

- Ice processing and recovery harbor size unit sheltered from exposure to wind
- Temperatures can be kept around +30°C with an air heater even at outdoor temperatures around –20°C.
- This solves the problems with respect to icing and freezing.

Field testing in Point Barrow, Alaska

Subsea Oil Recovery with ROV (FRAMO)



Sub-sea recovery of an oil spill from a platform that drifts *underneath the ice*.
The oil recovery vessel with a moon pool deploys a special designed "underneath ice oil boom" that traps the oil by use of an ROV.

USE OF DISPERSANTS

There is a potential for the use of dispersants in cold water and ice. In order to perform an effective dispersant operation in Arctic areas, it is important to evaluate the following *critical parameters*:

- Acess (contact) of the dispersant to the oil
- Prvision of sufficient mixing energy for the dispersion process (preferably by vessels with azimuth drives)
- Viscosity and pour point of oil at low temperatures (weathering degree)
- Performance and properties of dispersant under the relevant conditions (e.g. salinity, temperature, oil type)

IN-SITU BURNING

In-situ burning has a considerable potential for use in ice
Conditions and may often be the only practical option for removal
of surface oil in such situations, in particular for *larger* spills.

- In-situ burning of thick, fresh oil slicks can often be initiated very quickly by igniting the oil with simple devices such as an oil-soaked sorbent pad.
- Oil from the water surface can be removed by in-situ burning efficiently and at high rates
- Oil removal rates of 2000 m3/hour can be achieved within a fire area of about 10 000 m2.

IN-SITU BURNING: LIMITATIONS & RISKS

Limitations for the application of the in-situ burning technique:

- most slicks are not ignitable when oil slicks emulsify and the water content of stable emulsions exceeds about 25%.
- maximum wind speed for successful ignition of large burns is about 10 to 12 m/s

Secondary fires that threaten human life, property and natural resources

- Potential environmental and human-health effects of the by-products of burning (e.g. smoke, etc.)
- Chemical toxicity of burn residues (e.g. sea biota, food chain)

BIO REMEDIATION

"Bioremediation is the acceleration of the natural degradation process through the addition of exogenous microbes"

- Oil degradation in soil, sediment, sea water or ground water is well-known
- Only few investigations deal with cold environments and with sea ice
- Hydrocarbon degrading bacteria are everywhere distributed in the marine environment
  - generally < 1% of the total bacterial population
  - after contamination with oil the proportion rapidly exceeds 10%

- From oil bacteria experiments carried out at the Alfred-Wegener-Institute for Polar and Marine Research (AWI), Germany HC-degradation was achieved at a temperature of -2°C
- Biosurfactants produced by some bacteria have the ability to emulsify oil and enhance the degradation processes
- Bioremediation is proven to be a useful technique for an oil spill clean up even in cold environments (e.g.Exxon Valdez)

FUTURE NEEDS

Dispersants

- Systematic laboratory and tank studies and their validation in field experiments are needed to make dispersants useful as a practical countermeasure in ice covered waters
- New ecological harmless dispersant products should be developed
- Aerial application, vessel application and the injection of dispersants from the seabed should be further explored

- Due to the wave damping effect by the presence of ice, means and techniques of creating "artificial turbulence" have to be further investigated

Mechanical recovery

- Due to the low temperatures in Arctic regions, most of the *existing response equipment* needs to be modified to operate under harsh conditions (winterization) regarding:
  - improved ice processing
  - reduction of icing / freezing (additional heat supply)
  - transfer of recovered products (including ice)
  - separation of oil from ice
- Laboratory tests of equipment are required to optimize various significant parameters with respect to oil recovery efficiency
- Performance of field tests and exercises under realistic conditions

CONCLUSION

- Oil spill response in ice covered regions is much more complex than in open water, consequently there is a challenge for the improvement of existing device and development of new systems
- It is proposed to make efforts on new design and further development of existing open water recovery systems to make them usable also for conditions in cold environment
- More laboratory and field tests of oil spill response equipment under real conditions are required to optimize the functionality and efficiency
- Training programmes and exercises under realistic conditions should be performed in order to keep the tanker crew and contingency personnel skilled
- Icebreaking multi-purpose vessels with oil combat capabilities should be provided at oil loading terminals, in harbours and along the main shipping routes in order to be at the spill site in short time
- The balance of economy and ecology must be carefully considered when doing any environmental control and protection measures
- Oil spill prevention and preparedness is the best defence !

FORECASTING THE PROPERTIES AND BEHAVIOUR OF OIL IN ARCTIC WATERS

by Mikhail N. Grigoriev, Gecon Geosciences Consulting Center

PAPER OUT OF THE ARCOP LIST
ARCOP: SNOWBALL EFFECT
PRELIMINARY STUDY - THE PROJECT OF A THEME

TARGET

The forecast of physical and chemical characteristics of the oils flows, transported and planned to transportation by water areas of White, Kara, Pechora and Barents seas on the basis of projects of field development and its oil parameters.

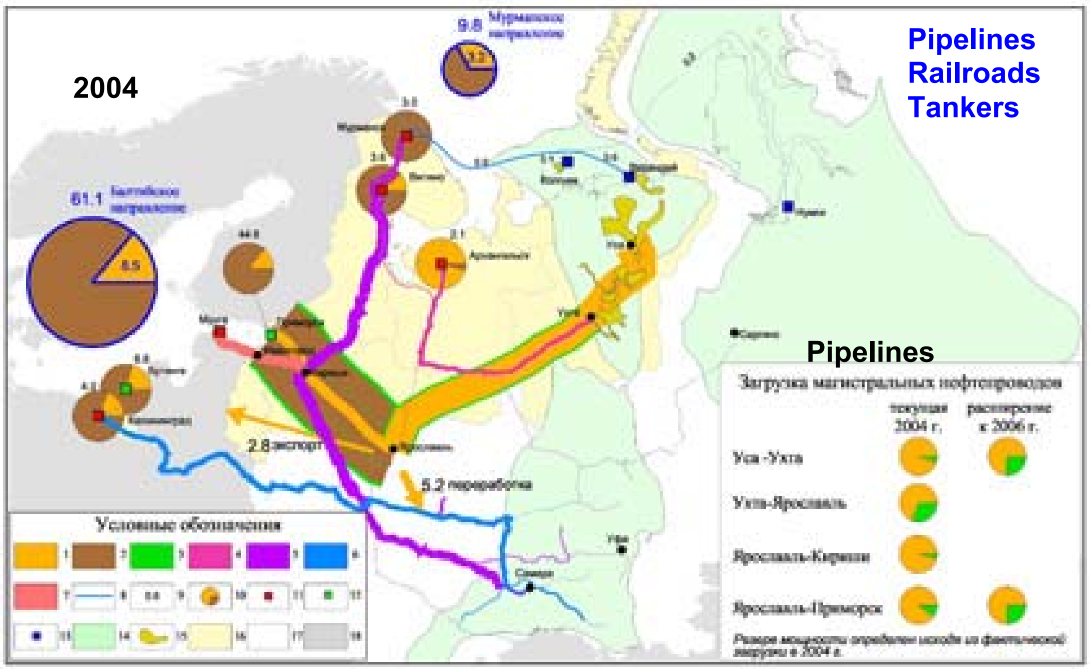
The knowledge of properties of the transported oil is necessary for development of mathematical model of behaviour of oil in water, a choice of forces and means for struggle against floods and their consequences.

Data can be used by ecological institutes and other organizations.

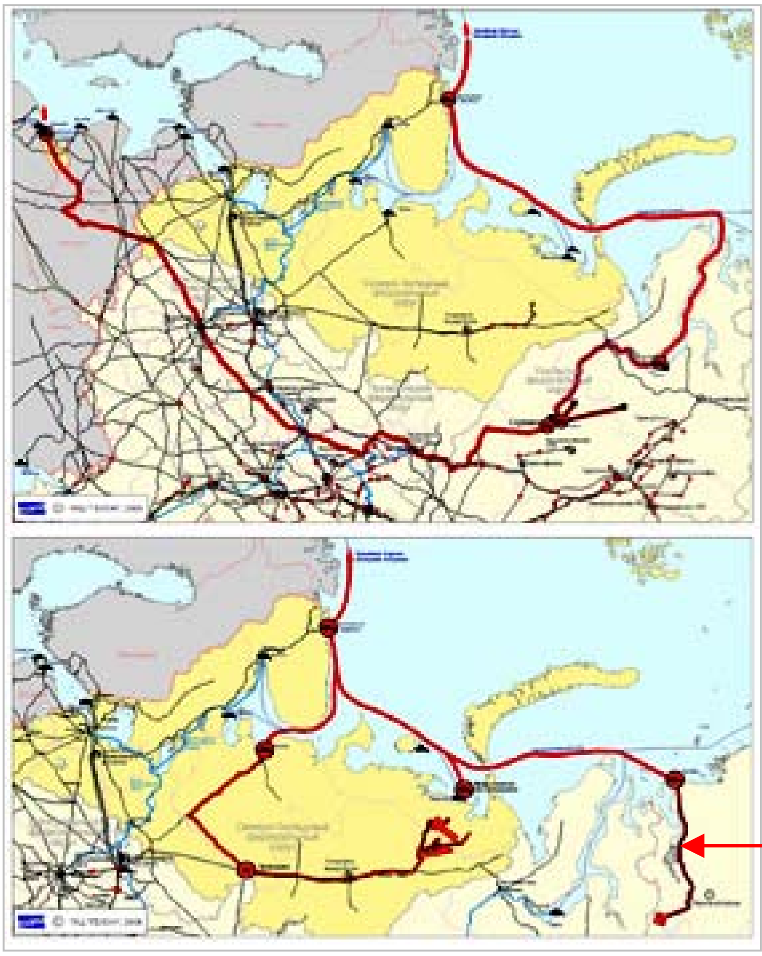
TOPICS

- Crude oil NW transport routes
- How to evaluate transported crude oil properties?

CURRENT CRUDE OIL NW TRAFFIC



PARTICULAR TRANSPORT SCHEMES



RITEK (LUKoil)

ROSNEFT

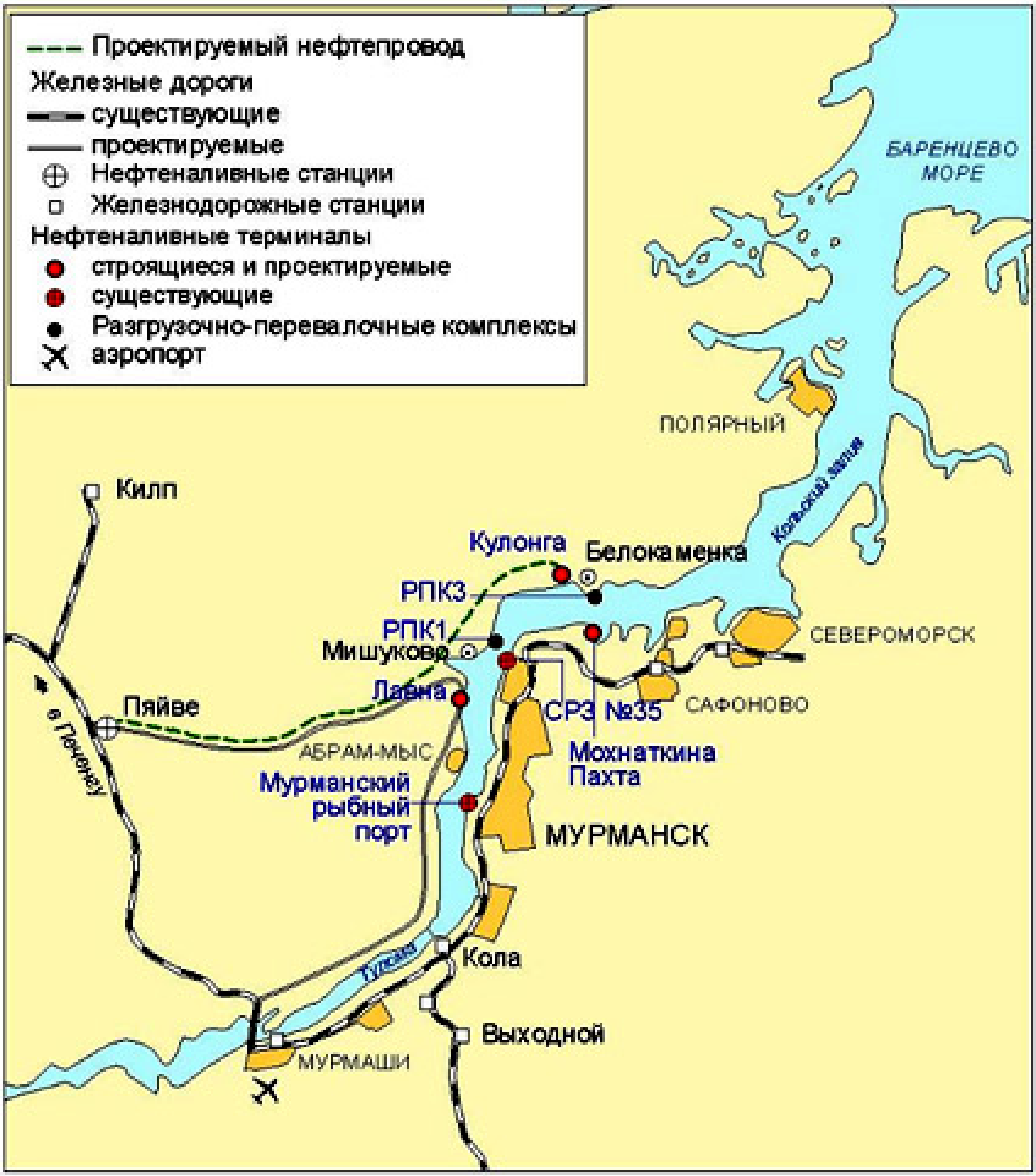
Vankor?

CRUDE OIL STREAMS THROUGH MURMANSK HUB

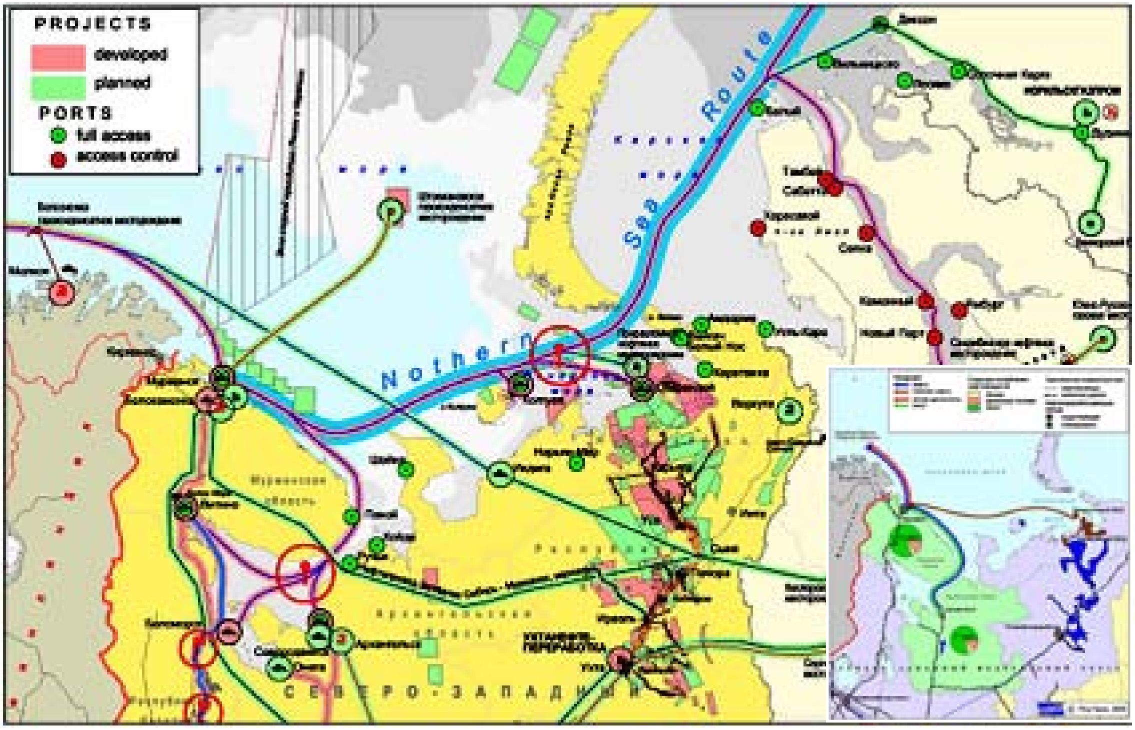
- Current transportation:
  - from Volga region by railway road directly to Kola and Murmansk
  - mainly from Volga region by railway road to station Beloe More with reloading in Vitino for the shuttle tankers for Murmansk BOB terminal
  - mainly from Timan-Pechora by railway road to Archangelsk with reloading for the shuttle tankers for Murmansk BOB terminal or exported directly
  - from Varandey and Kolguyev sea terminals
  - from Numgi (West Siberia) river-sea terminal

- Future transportation: current streams strengthening and new routes (Prirazlomnoe, Vankor etc.)

MURMANSK – TOO CROWDED



PLANNED SCHEMES



TRANSPORT FLOWS MODELLING: KEY PROBLEMS AND SOLUTION

- Uncertainties
  1. Developed fields production
  2. Planned production projects – changes of the on-stream date and transport scheme
  3. New areas licensing
  4. Terminal capacities
  5. Railroad tariffs
  6. Icebreaker fleet
  7. Markets

- Solution – permanent parameters monitoring

TOPICS

- Crude oil NW transport routes
- How to evaluate transported crude oil properties?

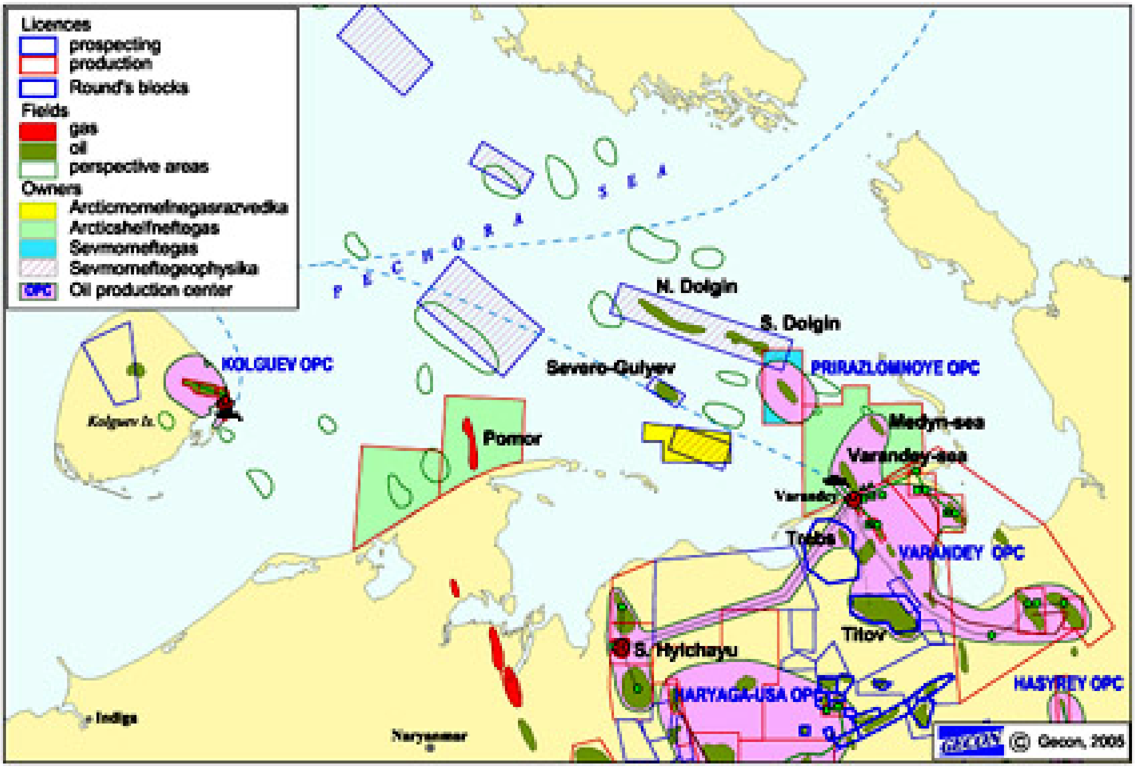
CRUDE OIL STREAMS

1. Transported directly from the fields
2. Transported with mixing from the regions with the known regional crude oil type parameters
3. Transported with mixing from the regions with the high variety of the crude oil types

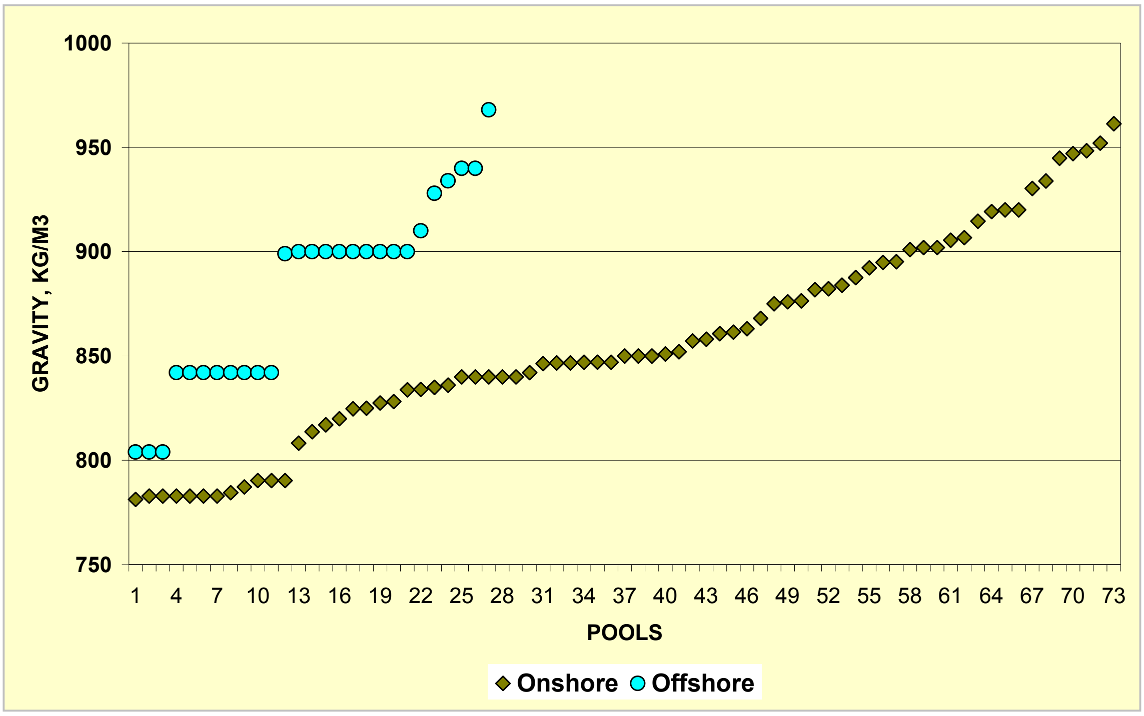
WHAT CAN WE EVALUATE?

STREAM	TERMINAL	Sea			
		Kara	Pechora	Barents	White
1	West&East Siberia (Numgi, Vankor?)	x	x	x	
	Varandey OPC		x	x	
	Kolguyev OPC		x	x	
	Prirazlomnoe OPC		x	x	
2	Archangelsk			x	x
3				x	x
	Vitino			x	x
	Murmansk			x	x

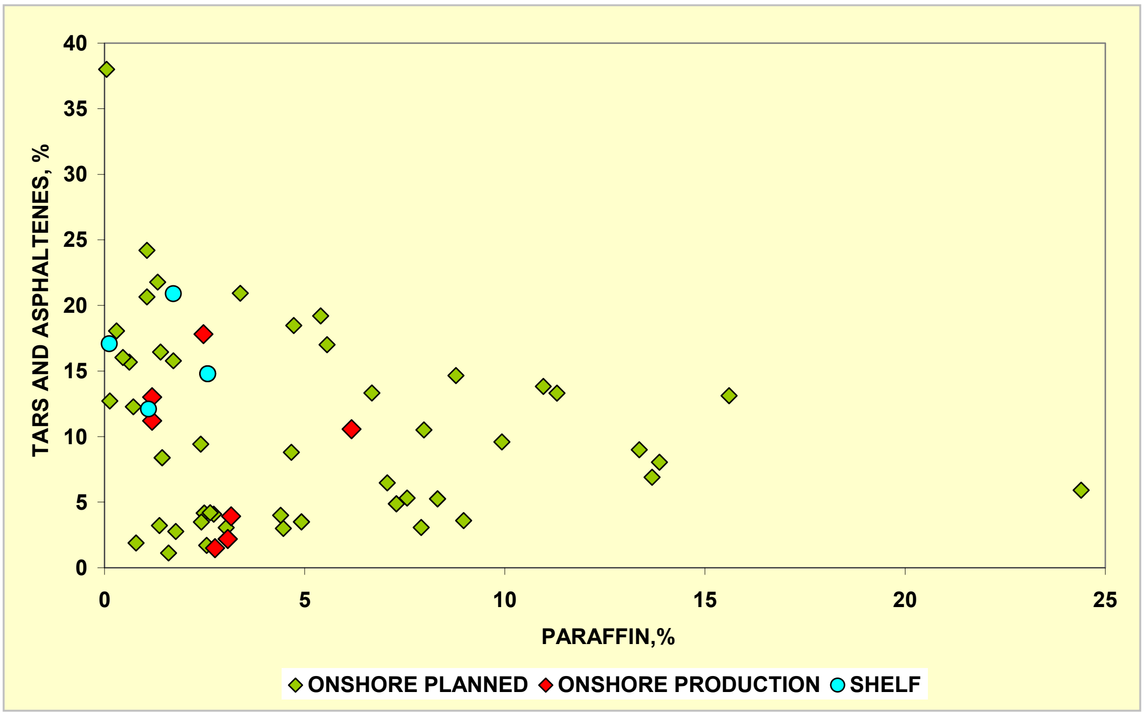
LOCALS



GRAVITY



TARS & ASPHALTENES VS PARAFFIN



PLANNED HEAVY JOB: DATA

- Available Oil characteristics:
  - Tars
  - Asphaltenes
  - Paraffins
  - Sulfur
  - Viscosity
  - Density
  - Freezing point
- Available Data quality:
  - Accuracy
  - Completeness
- OPC: oil characteristics monitoring
- Crude oil samples for the detailed study – oil companies courtesy

Interaction of parameters and new discoveries parameters prediction

Some data to be collected and revised

OIL SPILL RESPONSE ANALYSIS FOR THE VARANDEY – MURMANSK TANKER ROUTE

by Øistein Johansen, SINTEF Environmental Technology

BACKGROUND

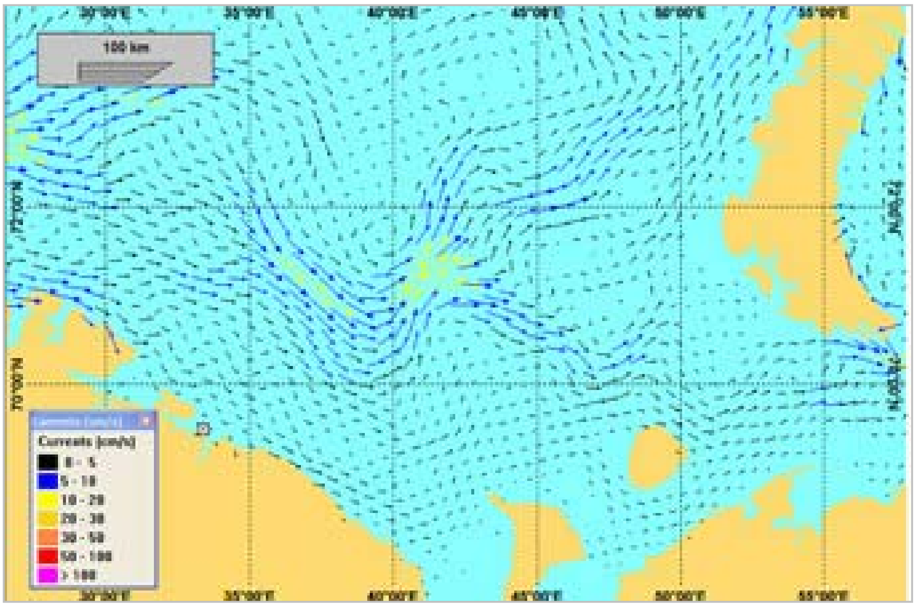
- ARCOP activity:
  - Work Package 4 – Environmental Protection and Management System for the Arctic
  - Activities 4.222/ 4.2.2.3: Simulation of drift and spreading of oil in open and ice-infested water/ Oil spill response analysis
- Scope of work:
  - Simulations of oil drift and oil spill response for possible spills from oil tanker transport from the Pechora Sea to the Murmansk region.
- Objectives:
  - To provide information on the possible area of influence of such spills for environmental risk assessments
  - Provide input to a framework and guidelines for an oil spill plan for the area
- Work performed by: SINTEF and HSVA

OIL DRIFT MODEL

- OSCAR is a 3D Oil Spill Contingency And Response model developed at SINTEF
- One of several models in SINTEF's Marine Environmental Modelling Worksbench (MEMW)
- Capable of running single scenarios and statistical simulations
- Performs simulations of oil drift and fate, and simulations of oil spill response (mechanical recovery, chemical dispersion).
- Handles open water and ice infested waters, the latter based on information of ice coverage

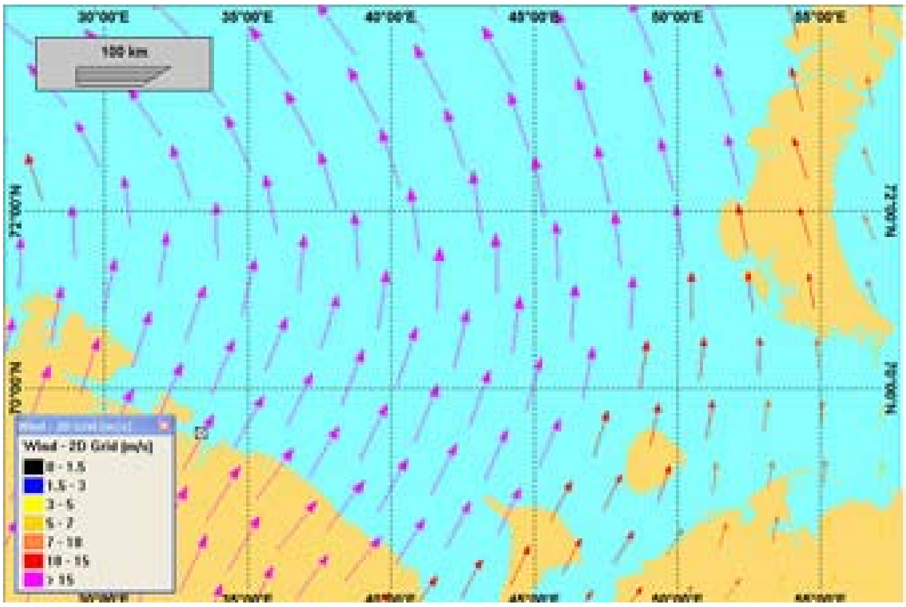
GEOPHYSICAL INPUT

Climatological currents provided by met.no



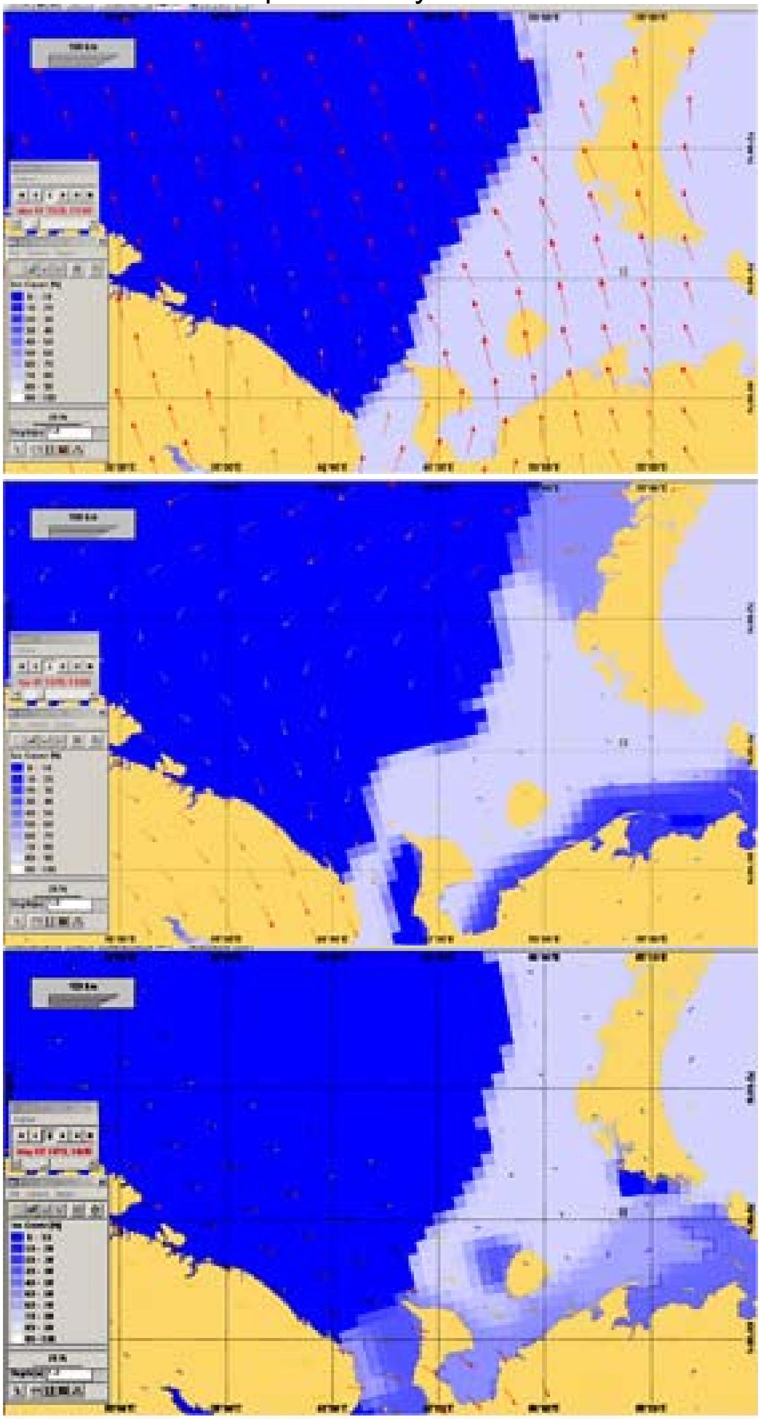
Monthly values in 20 x 20 km resolution

Historical wind data (hindcast wind) provided by met.no



Values at 6 hour intervals in 75 x 75 km resolution

Historical ice data provided by met.no



Values at 24 hour intervals in 20 x 20 km resolution

OIL-ICE INTERACTIONS IN OSCAR

Major factors considered

- Reduced surface spreading of oil (thicker oil)
- Reduced rate of weathering
  - Evaporation
  - Emulgation (formation of water-in-oil emulsion)
  - Natural dispersion
- Drift of oil governed by ice drift
- All effects are scaled with ice coverage
- Scaling parameters calibrated from lab and field experiments

OSCAR OIL DRIFT SCENARIOS

- Spill location
  - Entrance to Murmansk Fjord (open water)
  - Between Varanday loading terminal and Kolguyev Island (seasonal ice)
- Type of spill
  - Grounding or collision
- Amounts and duration
  - 10 000 m^3 in 10 hour
- Oil type
  - Oil type (Troll crude) chosen on the basis of similarity with crude assay data for the Prirazlomnoye crude oil
- Season
  - Spring (March, April, May)
  - Autumn (August, September, October)

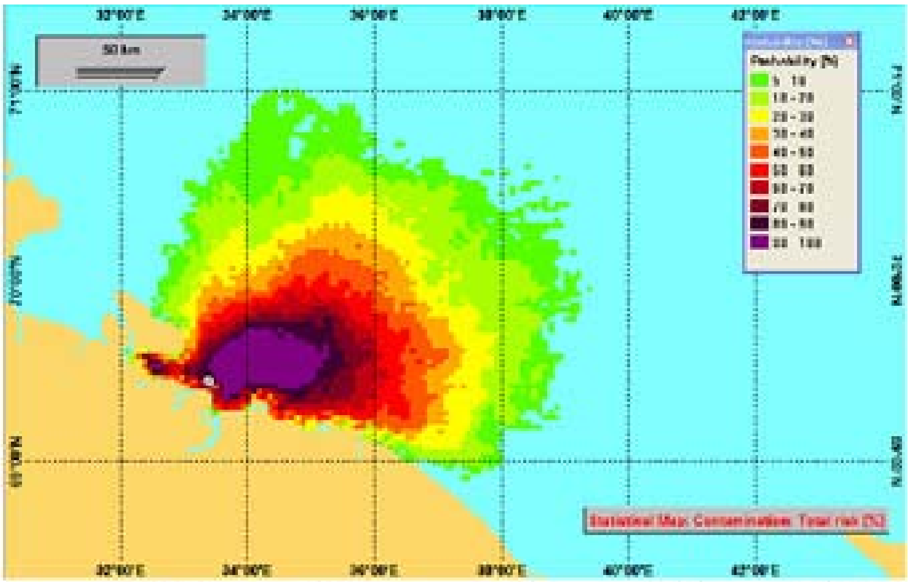
SIMULATION STRATEGY

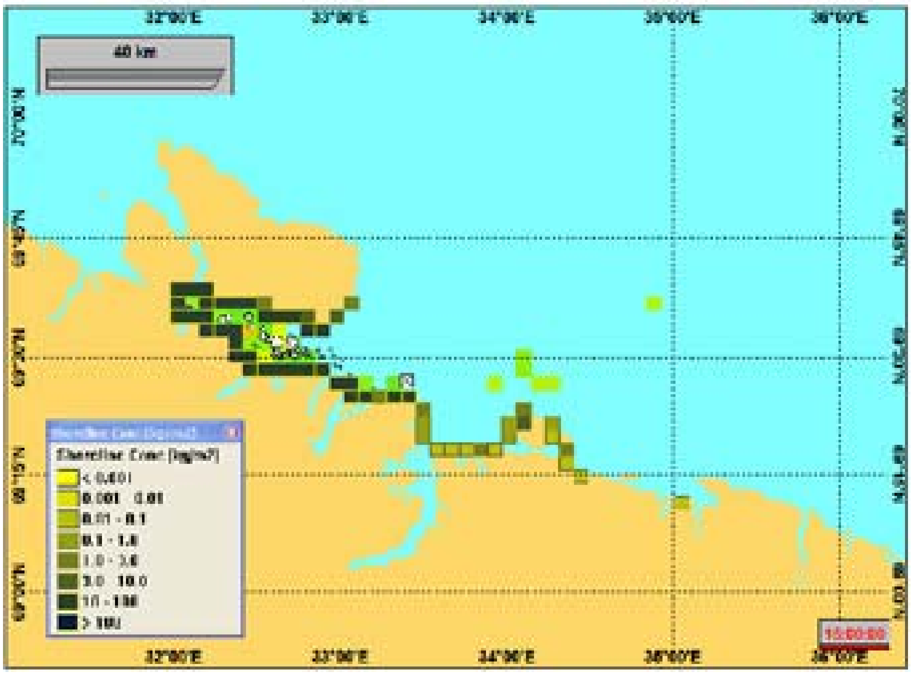
Statistical simulations

- Simulations based on 23 years of historical wind and ice coverage data, combined with climatologic current fields for the region of concern.
- Statistics obtained by running a number of oil spill scenarios starting in the prescribed season within the years with available data.
- Simulations made with no oil spill response and with various levels of oil spill combat measures

Single scenario runs

- Made for the scenarios with maximum stranded oil.
- Used to evaluate the benefits of additional oil spill response units

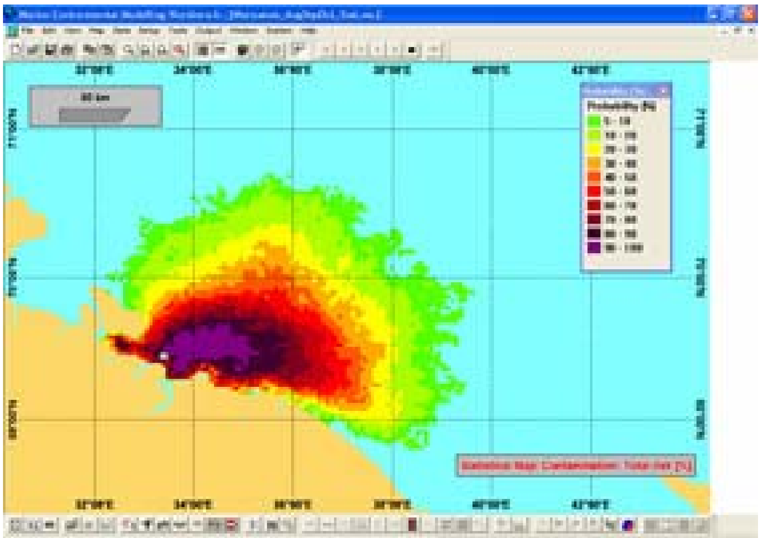


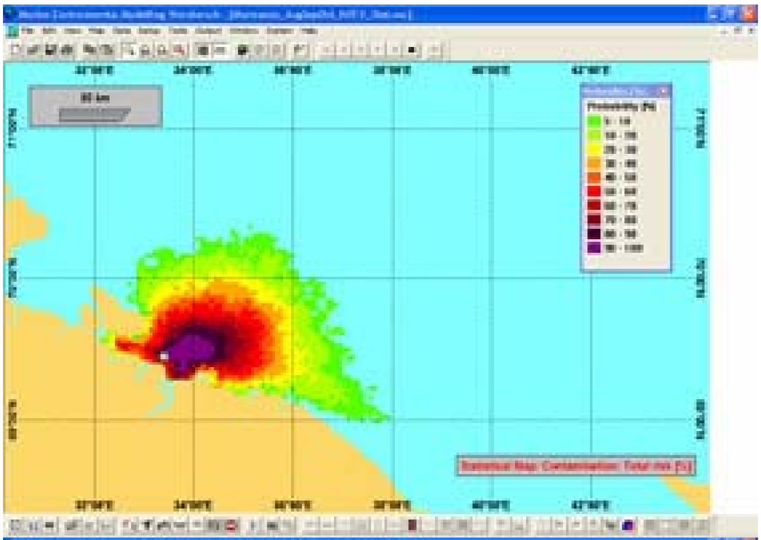


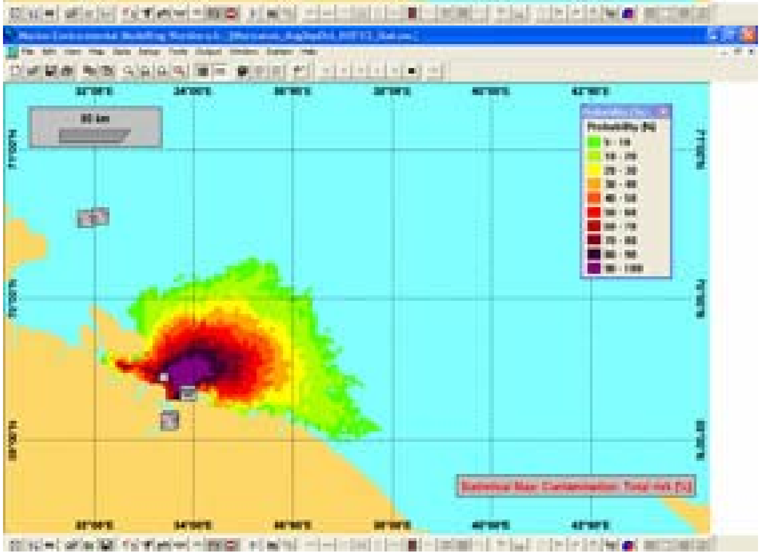
OIL SPILL RESPONSE OPTIONS

	Murmansk Fjord	**Pechora Sea**
1. Base case	- One system mobilized from an oil response base in Murmansk Fjord with 6 hours response time. - One system from Norway with 18 hours response time	Two systems mobilized from an oil response base near the Varandey oil terminal with 6 and 12 hour response times
2. Strengthened response	Base case + one additional system from Murmansk with 12 hours response time	Base case + one system from Murmansk with 40 hours response time
3. Maximum response	Strengthened response + one additional system from Norway with 30 hours response time	Strengthened response + one additional system from Murmansk with 46 hours response time

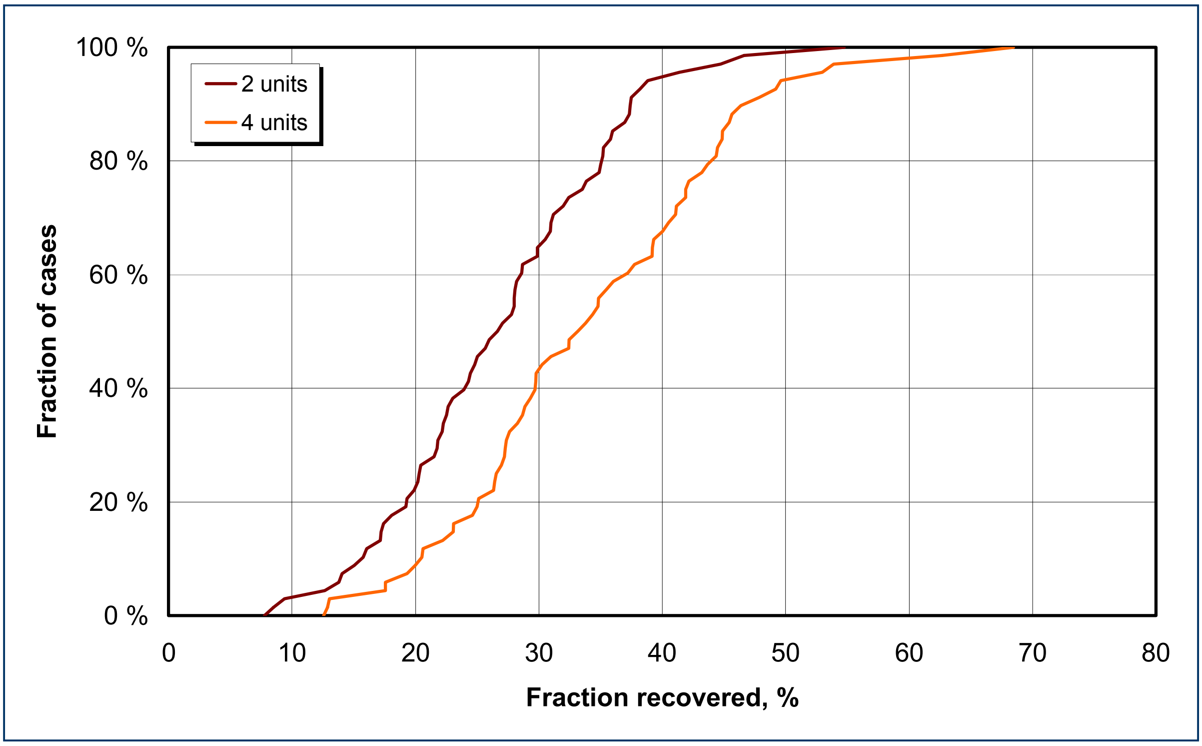
“MURMANSK” OIL DRIFT STATISTICS FOR AUTUMN

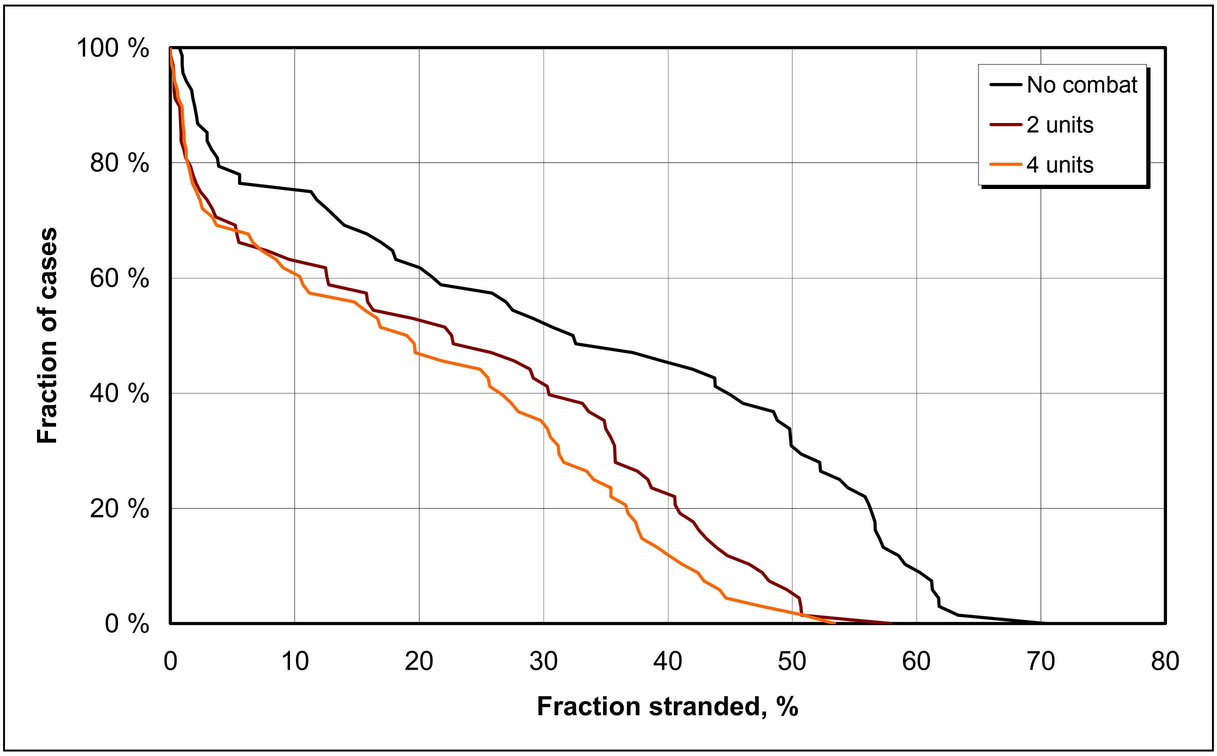




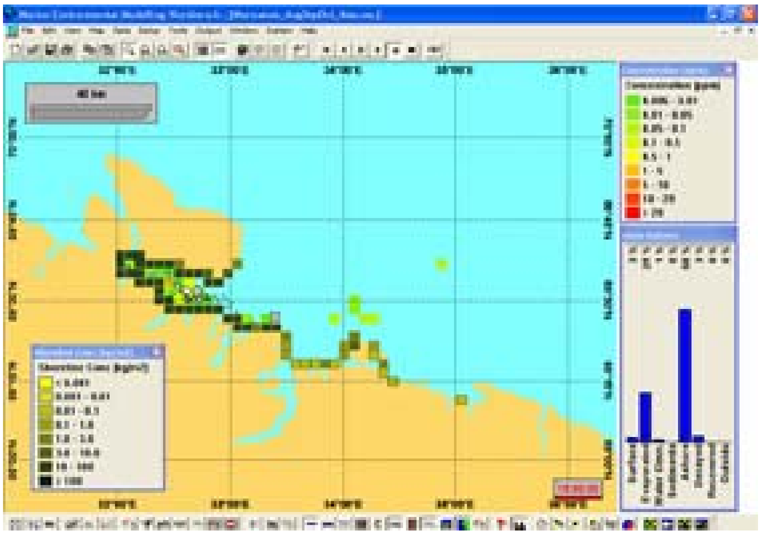


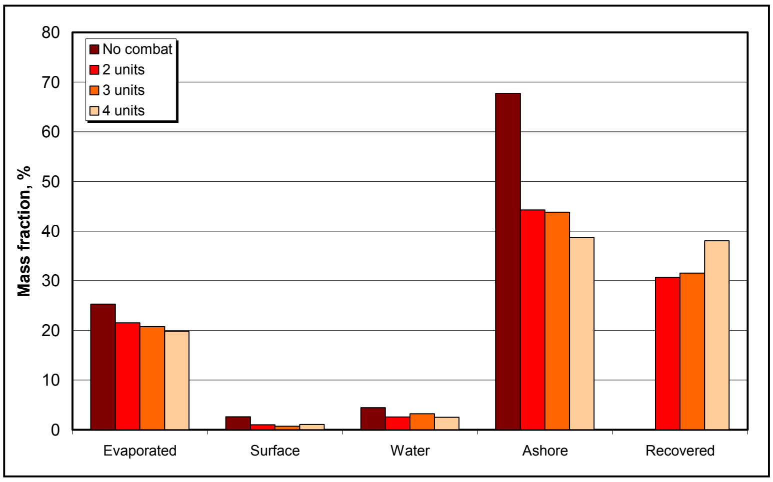
“MURMANSK” SCENARIO: STATISTICAL DISTRIBUTIONS OF RECOVERED AND STRANDED OIL



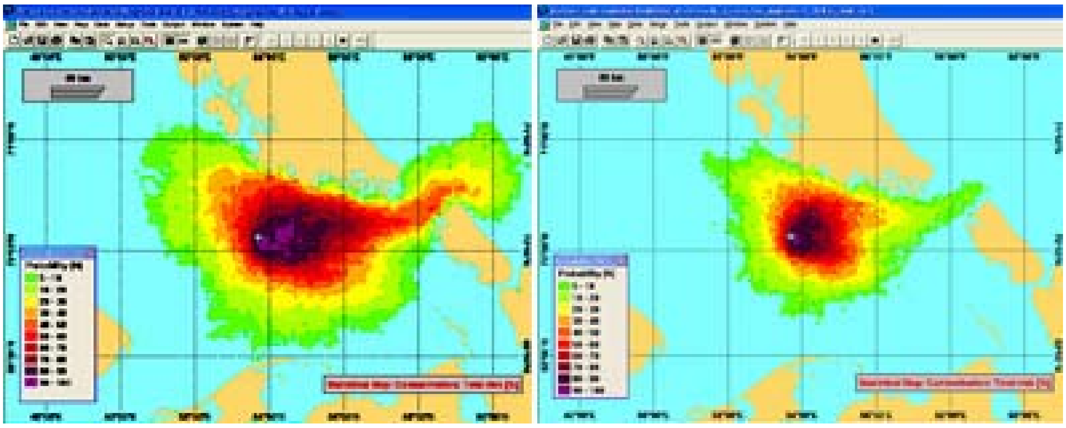


MURMANSK OIL SPILL RESPONSE – WORSE CASE SCENARIO

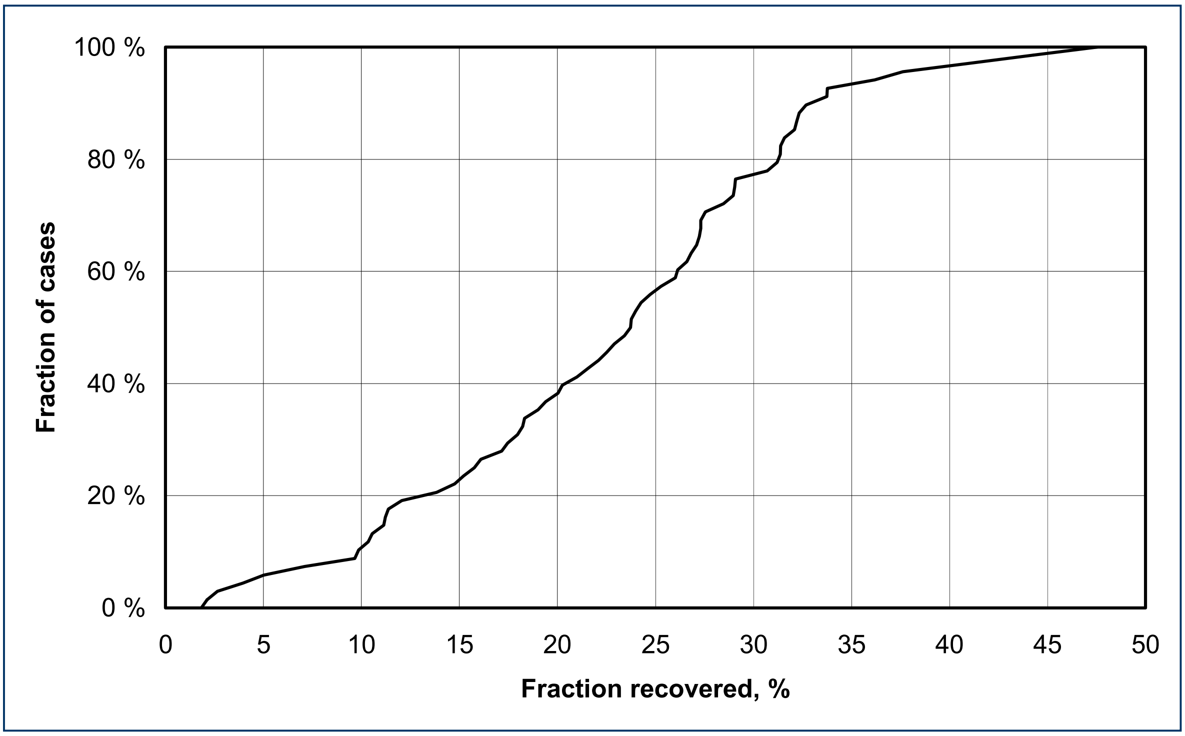


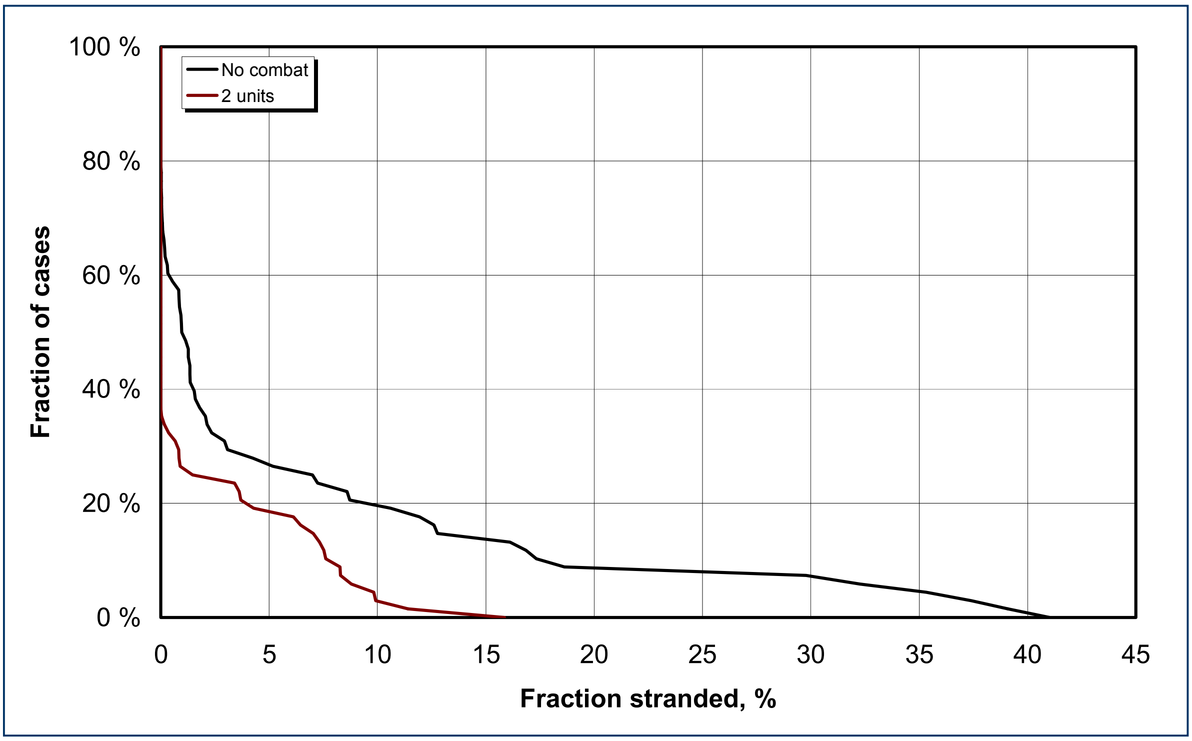


"VARANDAY" OIL DRIFT STATISTICS FOR AUTUMN

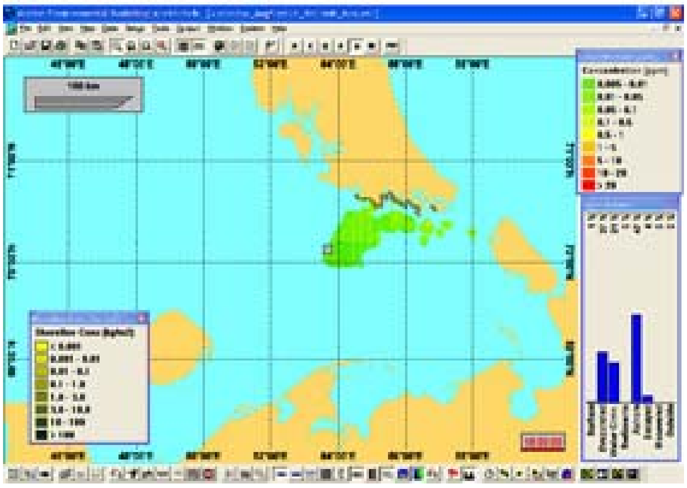


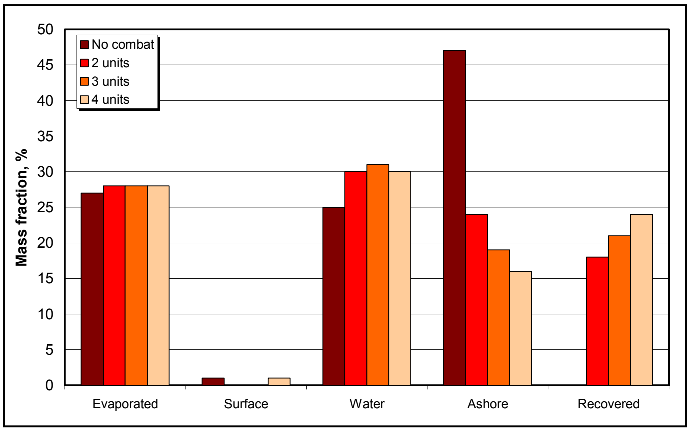
“VARANDAY” SCENARIO: STATISTICAL DISTRIBUTIONS OF RECOVERED AND STRANDED OIL





“VARANDAY” OIL SPILL RESPONSE – WORST CASE SCENARIO





CONCLUSIONS

- Cases studied
  - Oil tanker groundings or collisions on the Varanday – Murmansk ship route
  - Short term release (10 hours) of large amounts of oil (10 000 m3)
  - Simulations were made with no response and various levels of response efforts.
- The results differed for the two locations, depending of drift time to shore:
  - Marginal gain in terms of reduced amounts of stranded oil for the near shore location (“Murmansk”)
  - Significant gain for the offshore location (“Varanday”)
  - Short response time may be more important than high recovery capacity for near shore spills