Development of oil spill response strategies for the Marginal Ice Zone

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1. ABSTRACT

Petroleum activity within the Norwegian sector of the Barents Sea has in later years moved northward with current exploration drilling taking place around 74° north. The physical and ecological environment at these latitudes undergoes large variations through the year, which affect the operating conditions for oil spill response significantly. Multiple response strategies must consequently be implemented. DNV GL has through recent projects developed a holistic approach for managing the different elements of oil spill preparedness and response planning. This includes collection of data on the distribution of biological resources and their vulnerability towards oil spills, documentation of statistical sea ice extension, and planning tools for assessment of operational possibilities and limitations of available response technologies.

The marginal ice zone (MIZ) necessitates special considerations both for evaluating environmental risks and for oil spill response in comparison with ice free water. It is a highly dynamic system both with regards to the presence of species and ice concentrations affecting oil exposure scenarios. Updated datasets on species distribution, expert based vulnerability assessments and high resolution ice data, presented with monthly resolution in a GIS-based interactive map, enables identification of vulnerable areas throughout the seasons.

For assessment of oil spill response strategies, applicability of relevant response options for various ice concentrations is calculated and displayed. This information combined with vulnerability data represents a powerful tool for assessing and comparing different response strategies in the MIZ.

2. INTRODUCTION

Petroleum activity on the Norwegian Continental Shelf started in the North Sea for more than fifty years ago, and has later moved northwards. Currently the northernmost exploration drilling is located around 74° north in the Barents Sea. Due to the relatively warm water of the Gulf Stream Current the ocean is generally ice free all year round even at these latitudes. Hence the Norwegian environmental risk management regime, including oil spill response, has not had high focus on ice-related issues and challenges. In 2011 the border line agreement between Russia and Norway was ratified and opened up for nomination of new exploration areas in the south eastern part of the Barents Sea along the border line. In January 2015 the Norwegian government announced 54 new blocks in the Barents Sea where 34 of these are in the north and south- eastern part. Although the ice extension in general have decreased in later years, some of these blocks overlap maximum sea ice extension in the period 1984 – 2013, as shown in figure 1.

This development has led to an increasing debate about environmental risk related to potential oil spills in areas with seasonal sea ice, hence prompting a need for knowledge and factual based assessment- and planning tools. The physical and ecological environment at these latitudes undergoes large variations through the year, which affect both the environmental vulnerability as well as the operating conditions for oil spill response. Data, methodology and planning tools thus need to be updated in order to address the highly dynamic environment in the MIZ.

Through recent projects DNV GL have started the development of such methodologies and tools that are necessary to address these issues in a holistic and transparent manner. These include:

- Methodology for environmental risk analysis in the MIZ
- High resolution response gap analysis, including the MIZ
- Oil drift modelling taking into account dynamic ice data.

3. METHODOLOGY, MAIN STEPS AND TOOLS

3.1 Biological resources and environmental risk in the MIZ

A standardized approach for calculating environmental risk for the MIZ has been identified. Because the presence of ice has not been a relevant issue previously, the MIZ is not included in the standard MIRA methodology (OLF, 2007).

3.1.1 Environmental risk analysis, MIRA approach

The MIRA methodology is the industry standard for environmental risk analysis on the Norwegian Continental shelf. The methodology is quantitative and is based on resource distribution data combined with oil drift simulations. Both resource data and oil drift simulations are distributed on 10 x 10 km grid cells. The resource data and the oil drift simulation are matched with a species-specific effect key, showing the individual mortality for a resource. The result of this is the total population loss of the resource per oil drift simulation. A damage key gives a measure of the population vulnerability shown as the probability for environmental damage distributed on impact categories presented as restitution time. The frequency for a potential discharge will along with the probability for environmental damage give a measure of the environmental risk. This will in turn be compared to the operators own acceptance criteria (OLF, 2007).

3.1.2 Adjustments to the MIZ

There are several definitions of the MIZ, but a currently used definition is the area with ice concentrations between 10 % and 30 %, (DNV GL, 2014a). The selected ice concentration dataset is provided by the Norwegian Meteorological Institute (NMI) and covers the period from 1990 to 2009. Because of a wide annual variation in ice coverage, the distribution of the species will vary on a monthly, seasonal and annual basis as distribution of species associated with the MIZ are highly influenced by the ice coverage.

In an ongoing project for OMV Norge AS three different datasets of environmental resources have been evaluated to assess the species' distribution in the MIRA-MIZ method: Seapop, Havmiljø and AMSA IIc. Each of the datasets has certain advantages. In general, SEAPOP is the most detailed with regards to species distribution. However, it has a limited coverage above 75° north. Havmiljø and AMSA IIc have good coverage in the MIZ area, but are less detailed with regard to distribution of the different species.

Currently, possibilities for modelling oil/ice interactions have been investigated. Studies have also been performed to identify environmentally sensitive and vulnerable species associated with the MIZ. Adapted species distribution datasets for implementation in environmental risk analysis either quantitatively or qualitatively have been prepared (DNV GL, 2014a). MIZ-specific effect and damage keys have been prepared. However, this method does not take into consideration the actual presence of the MIZ and is depending on coverage by the SEAPOP datasets to perform properly. In the OMV-project mentioned above, DNV GL has used Havmiljø-datasets where the resource data have been distributed evenly into 10 x 10 km grid cells covering the area defined as MIZ.

3.2 Ice distribution

3.2.1 The monthly maximum extent of the ice edge for the period 1984-2013

The data displayed in the map (figure 1) are produced by the Norwegian Polar Institute (NPI, 2014). Daily data on ice concentration obtained from the National Snow and Ice Data Center (NSIDC) were recalculated to the sea ice frequency for 1984-2013.

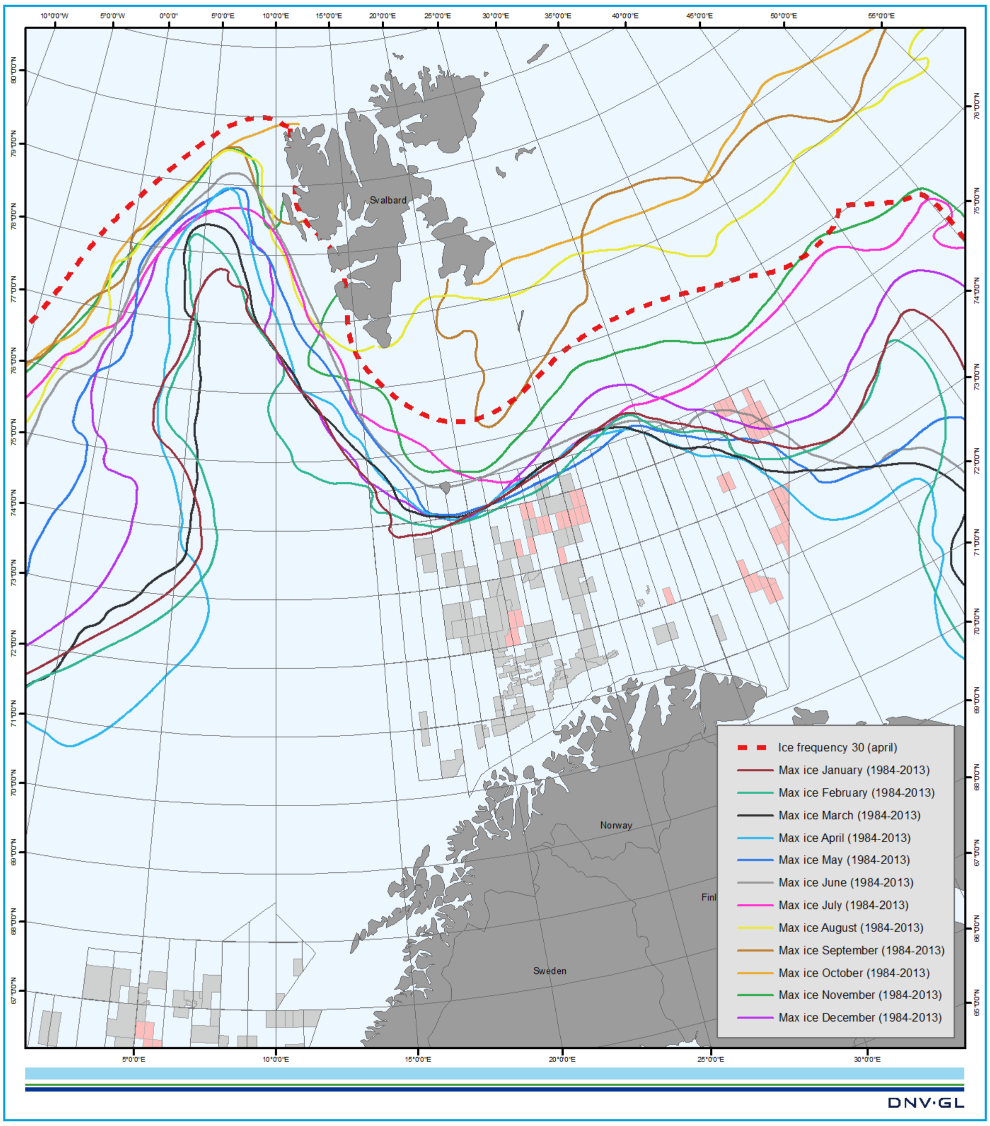

Figure 1. Overview announced blocks in 23rd licensing round, the monthly maximum sea-ice extent and the defined ice edge according to the Norwegian government.

3.2.2 The ice edge

The ice edge is defined as the boundary where the frequency (ice persistence) of ice concentration in April is 30 percent. The red dotted line on the map shows where 30 % of the days have more than 15 % ice concentration. The period of statistics is (daily ice concentration data) from 1984 to 2013.

3.3 Tools for Oil Spill Response assessments

A survey of best practices for oil spill response in arctic conditions has been executed, based on input from the international oil spill community, existing guidelines etc. (DNV GL 2014b). The general recommendation is that response strategies for the marginal ice zone should comprise of multiple techniques in order to cover a wide range of potential response conditions. Although this approach is probably valid as a general principle, it is not sufficient as a practical planning tool.

3.3.1 Response gap analysis

A Response Gap Analysis methodology has therefor been developed, quantifying the monthly expected response regularity for mechanical recovery, dispersant application and in situ burning techniques, caused by environmental factors such as wind, sea state, ice, temperature and visibility. A map based approach has been chosen, covering the Barents Sea and adjacent areas. High resolution historical data at a large spatial scale - grids of 10 x 10 km have been used. Based on best available technology, factual knowledge and expert judgment, a set of criteria known to limit oil spill response has been established for the environmental factors. The results enable visualization of the percentage of time when the response conditions are favorable, impaired or ineffective on a monthly basis for each response technique, or for a set of multiple techniques.

The response gap analysis is a quantitative assessment of the feasibility of the defined response techniques through the year at the chosen location or region. This makes it suitable for planning purposes as it reveals and ranks the optimal response techniques for the location at a given time, and also identifies the limiting factors. The analysis addresses the techniques for open water response and techniques adapted to ice conditions separately. The results indicate that effective adaptations can reduce the response gap in sea ice-infected waters by approximately 20 %.

3.3.2 Oil drift modelling in ice

In order to be more specific in oil spill risk calculations in the MIZ, ice concentrations need to be included in the oil drift modelling. The present version of SINTEFs OSCAR model (v 6.6.1) can use the ice-coverage as an adjusting parameter into the calculations. The fractional ice cover/ice concentration can be provided as grids similar to current, wind or habitat data. The ice cover affects weathering, spreading, evaporation of surface oil, as well as oil drift with ice. As the MIZ is very dynamic and changes in location occur over days, daily ice coverage values has been included in the modelling based on data of daily sea ice concentrations. Several other ice-related parameters are publicly available from the Nordic Seas 4 km numerical ocean hind cast archive (SVIM).

There is still limited implementation of oil in ice interactions in OSCAR and other models, so caution should be taken when trying to model longer periods (weeks) of oil drift within ice concentrations above 30 %. Currently the model does not support modeling of effects of oil spill contingency in ice, but an idea yet to be tested is to prepare the ice data to enable this when ice concentrations is less than 30 %.

4. CONCLUSIONS

As the oil industry moves northward in the Barents Sea, understanding, communicating and managing risks will be essential both to earning social license to operate and minimizing the environmental impacts of their activities. DNV GL is following the oil industry and wants to base our services and advice on updated knowledge and best practices for arctic conditions.

The projects outlined in this paper are examples of important contributions in the development of a holistic approach to oil spill response strategies in the marginal ice zone. There is still need for further development with regards to data and methodology, and it is also imperative to increase practical experience and competence with oil spill response in the MIZ in order to verify performance data from relevant oil spill strategies in realistic conditions.

5. REFERENCES

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