Oil Spill Response in Ice-infested and Arctic Waters – Need for Future Developments

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Status on Arctic oil spill-related R&D

Testing and development of oil spill response technology related to Arctic and ice-infested waters have been important activities in many circumpolar countries. These activities have been motivated by vessel traffic through ice, oil exploration in Arctic areas and oil spill incidents. A recent state-of-the-art study (Brandvik *et al.*, 2006) indicates that large R&D activities were performed in the late 1980s and early 1990s. Focus has been on the following main subjects:

- Weathering processes of oil in ice,
- Mechanical recovery,
- *In-situ* burning, and
- Modelling of oil in ice processes.

The leading countries in this R&D work have been Canada, Norway, USA and Finland, but also with activities in Russia and Japan. From approximately 1995 until recently the activity level has been relatively low, however, with some oil skimmer developments in Finland and Norway. Recently some projects have been initiated with focus on dispersant effectiveness, use of chemical herders to enhance *in-situ* burning and study of fundamental weathering processes for oil in ice.

During the late eighties and early nineties SINTEF performed major laboratory and field studies on fate, behaviour, and weathering of oil under arctic conditions. These studies are summarized in Løset *et al*. (1994) and Singsaas *et al*. (1994). During a large experimental oil release in the Barents Sea Marginal Ice Zone (MIZ) in 1993, weathering processes were studied over a period of one week and compared to similar data for open waters (Figure 1). This study and other laboratory studies indicate that weathering processes such as water uptake, emulsion stability and viscosity, that are operationally important for oil spill operations, vary with oil type and ice conditions. These processes tend to progress relatively rapidly in open water, but are significantly retarded in the presence of ice (Figure 1). The extreme reductions in these process rates are probably attributable to temperature, ice type, ice coverage and energy conditions in the ice. However, there is not enough data available today to elucidate the functional relationships underlying these observations, with data being available for only a limited number of oil types and ice regimes through laboratory, meso-scale and field experiments performed in the US and Norway.

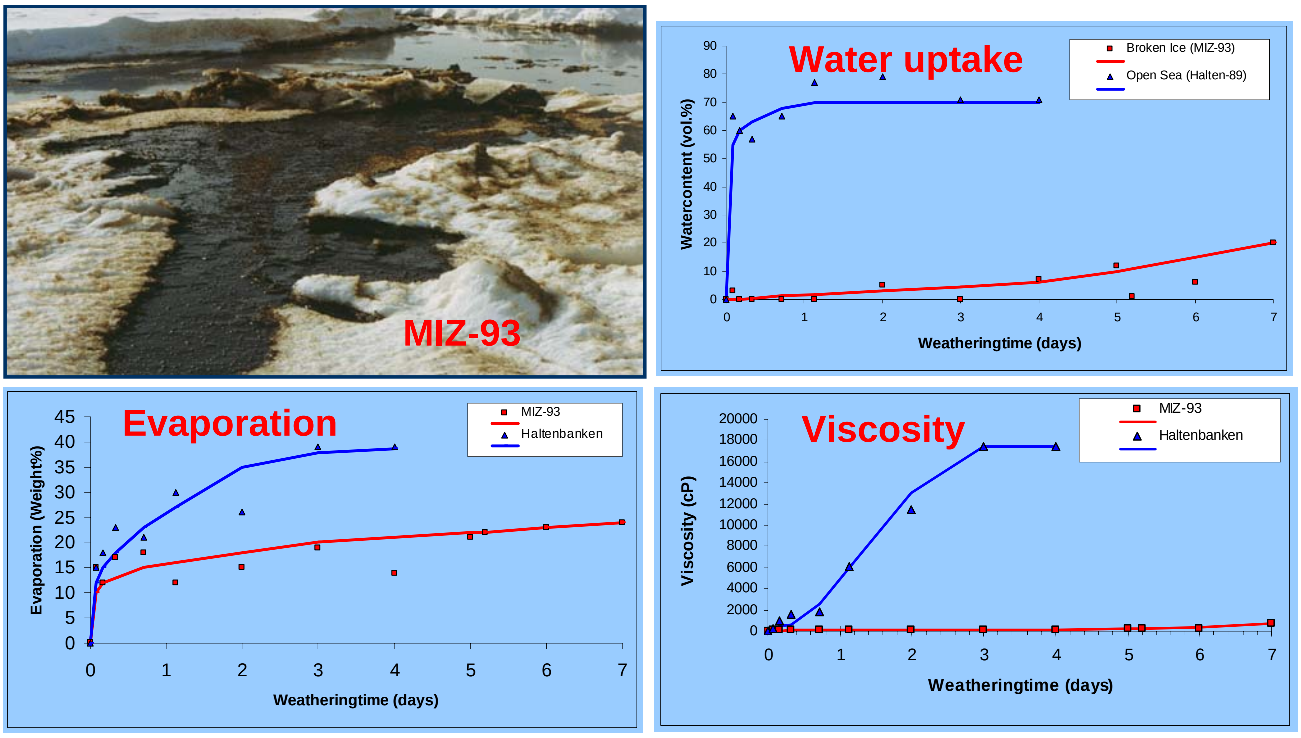

Figure 1 *Comparison of weathering parameters from the Barents Sea Marginal Ice Zone (MIZ) experiment in 1993 with similar data from open water field experiments.*

Need for future developments

Generally, oil spills in ice are far more complicated to combat compared to oil spills in open waters. Spill response will probably never reach the same level of effectiveness as for open waters due to physical interference by the presence of ice, low temperatures, darkness in the winter months, remoteness and generally poor infrastructure. The oil is less accessible in ice-covered waters and can be spilled on ice/snow, in open pools between ice floes, in open channels behind vessels or even under the ice.

Traditional use of booms and skimmers can be difficult in these conditions. However, there are also some advantages with oil spills in ice compared to open waters. The weathering rate is normally much slower for an oil spill in ice. This means that emulsification rate and hence viscosity increase may be slowed down resulting in an increased “window of opportunity” for use of most response techniques. The spreading of oil will normally also be much slower resulting in increased oil film thickness that may be favourable for oil spill response.

The ice concentration can become a governing factor in making decisions about equipment selection. One advantage of an oil spill in ice is that the ice can act as a natural containment in a variety of ice features such as floes, snow and ridges. If the oil is located on the ice, among ice floes or under the ice, different approaches to the problem may be required.

Table 1 gives an indication of expected effectiveness of different response methods as a function of ice coverage. Few of these methods have actually been tested in ice-infested waters, so there are large uncertainties associated with the listed technologies. It should also be mentioned that there are major differences in capacity (i.e. amount of oil removed per time unit) among the different methods.

Table 1 Indication of expected effectiveness of different response methods as a function of ice coverage (Evers et al, 2005).

		Ice coverage									
Response method	Open water	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Mechanical recovery:											
- Traditional configuration (boom and skimmer)											
- Use of skimmer from icebreaker											
- Newly developed concepts (Vibrating unit; MORICE)											
In-situ burning:											
- Use of fireproof booms											
- In-situ burning in dense ice											
Dispersants:											
- Fixed-wing aircraft											
- Helicopter											
- Boat spraying arms											
- Boat "spraying gun"											

Mechanical methods to deal with spills in moving broken ice in general have serious limitations, especially for large oil spills, and recovery values will be highly variable depending on a variety of natural conditions and logistics constraints. Most mechanical methods at hand are technology developed for open water conditions. The largest potential for improving mechanical oil recovery in Arctic and ice-infested waters may be to further improve and adapt existing concepts.

A small number of laboratory and field trials have been carried out to evaluate the efficacy of dispersant use in an oil-in-ice scenario, but the results are inconclusive. A key factor is the presence of sufficient energy to initiate the chemical dispersion process, either immediately or at a subsequent time. Laboratory testing at low temperatures has shown that only dispersants of type 3 (concentrates) are actual for use under arctic conditions. Strict requirements concerning physical properties have to be applied in order to avoid problems with high viscosity or precipitation at low air temperatures. Many dispersants show quite low effectiveness at low temperatures and salinity compared to North Sea conditions, and only products tested and approved for "arctic" conditions should be used. To our knowledge use of dispersants is not an operational response method for ice-infested waters in any areas today.

The technology to perform in-situ burning has developed during the last decade. New types of fire resistant booms (actively cooled) have been developed and tested in the past few years, but none have been tested in actual arctic conditions. Most burning projects have been conducted in small-medium test tanks. At the same time there are certain tactics and techniques that can only be accomplished through an in-the-field exercise. Testing both inside and outside the ice edge could be included. Information from such experiments will be used to make justifiable, science-based decisions on the suitability of *in situ* burn packages for the intended operating environment. *In-situ* burning is not an operational response method for any ice-infested waters today, even if it in principle can be used e.g. at Svalbard where a Helitorch igniter system is stored.

While satellite and airborne radars can be used to detect/discover an oil spill in open waters, this system is not applicable for most oil-in-ice scenarios. However, satellites can be used to communicate with drifting buoys. There is a need for further development of monitoring and remote sensing systems for oil in ice to,

- Detect and follow oil in ice floes and on ice.
- Detect oil under ice, and
- Follow oil covered with snow or frozen in the ice over long time until the melting period.

Risk assessment, oil spill response analysis and NEBA (net environmental benefit analysis) are normally required as a basis for an application for "licence to operate". In general, modeling tools developed to give the necessary input to these analyses for ice-infested waters are not available. Modeling of oil weathering in the presence of sea ice remains at an *ad hoc* level. Strengthening the basis for such modeling will make available a stronger basis from which to choose among alternate response strategies. Significant advances in oil-ice interaction modeling will require that the oil behavior and fates, ice formation and drift, and hydrodynamic models be coordinated to take advantage of new knowledge in both ice cover and oil-ice interaction modeling.

Oil-related activities such as shipment of oil and oil products, oil exploration and production are expected to increase in the years to come. Therefore there is a need for further development of tools and technologies to identify environmentally beneficial oil spill response strategies in ice-infested waters. Activities should be planned and executed under international collaboration to avoid redundancy, and should include a combination of laboratory studies, meso-scale testing and field experiments to achieve research goals in an efficient manner.

References

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