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An approach to Net Environmental Benefit Analysis (NEBA) for the Norwegian Continental Shelf

Odd Willy Brude[1], Kjell Are Moe[1], Geir Morten Skeie[1], Cecilie Østby & Frode Engen[2]

[1]Alpha Environmental Consultants, [2]Norwegian Clean Seas Association for Operating Companies (NOFO)

Abstract
Chemical dispersants have been used in oil spill combat in the marine environment for several decades. In January 2002 the Norwegian authorities introduced new regulations regarding the use of chemical dispersants in oil spill response at sea, allowing pre-approval for the use of dispersants when net environmental benefit is obtained. A methodology for NEBA has been developed and implemented within a geographical information system (GIS) for Norwegian offshore production facilities. The approach includes resource specific criteria for determination of pros and cons for each combat type (no combat measure, mechanical recovery or chemical dispersion). The main components of the methodology are the fate of the oil at sea as a prerequisite for exposure of environmental resources, and the distribution and vulnerability of these resources as a prerequisite for potential damage.

The results are presented as an interactive web atlas for each production facility indicating areas and times of year when chemical dispersant agents will have a net environmental benefit for the resources at risk. The maps identify the window-of-opportunity and will form a basis for the use of chemical dispersants in oil spill combat.

Background

Chemical dispersants have been used in oil spill combat in the marine environment for several decades. The strategy has in many cases proven itself valuable when it comes the changing the fate of the oil spill. However, many scientists and stakeholders have raised questions concerning the environmental benefit of the dispersion strategy. Uncritical use of chemical dispersants like in the *Torrey Canyon* incident (1967) has provoked further controversy as their use likely caused more environmental damage than the oil spill itself (Southward & Southward, 1978). On the other hand, well defined use like under the *Sea Empress* incident in 1996, showed that chemical dispersants contributed significantly in reducing the overall environmental damage caused (Lunel et al, 1997).

In 2002, the Norwegian government presented new guidelines towards the use of dispersants and beach cleaning agents in Norwegian waters (MD, 2001). The overall aim for the new regulations was to reduce the damage to the environment in the event of acute oil pollution, allowing the use of chemical dispersants as an alternative or supplement to mechanical oil spill combat when net environmental benefit can be obtained.

To comply with the new regulations and in the maintenance of regional oil spill contingency plans for the Norwegian Continental Shelf (NCS), the need of net environmental benefit analysis (NEBA) were identified and the work with designing such a framework were initiated from the Norwegian Clean Seas Association for Operating Companies (NOFO) during spring 2002.

Principles of NEBA

Net environmental benefit includes the common understanding that biological effects will occur only when the environmental resources is exposed to a contaminant, i.e. oil. This further implies that marine organisms will need to occur in the polluted area at the time of pollution and that the oil must be available in a substantial amount and in a form that will trigger a response from the organism. In this regard, pollution and environmental effect is a combination of two elements; on one hand the fate of the contaminant in the environment, and on the other hand the spatial and temporal exposure of biological components and their respective response to this exposure. The main factors in a NEBA are thereby:

- The fate and significance of oil i.e. oil drift and spreading
- The distribution and properties of marine organisms regarding possible exposure of and response to oil

As different response strategies will affect different environmental compartments, a NEBA will have to take into account the net effect while addressing the individual compartments.

Mechanical oil spill combat

Mechanical combat will lead to removal of oil from the sea surface and in this order influence the further oil drift and spreading. Mechanical oil spill operations will in many cases start at a time where the most volatile oil components have evaporated and the most Water Soluble Fractions (WSF) of the oil have been naturally dispersed into the water column. Therefore they can hardly play any role in selecting the most preferable response option. Mechanical oil spill combat will mainly reduce the potential of being exposed to oil both for environmental resources on the sea surface but also to some extent for resources in the water column. It will also reduce the possibility for subsequent stranding of oil and exposure of beach communities.

Chemical dispersion

Natural dispersion of an oil slick occurs when waves and other turbulence at the sea surface cause all or part of the slick to break up into droplets and enter into the water column. The addition of chemical dispersants is intended to accelerate this process.

When a dispersant is sprayed onto an oil slick, the interfacial tension between the oil and water is reduced, promoting the formation of finely dispersed oil droplets. These droplets will be of varying sizes and although the larger ones may rise back to the surface some will remain in suspension. If dispersion is successful, a characteristic plume will spread slowly down from the water surface a few minutes after treatment. However, the effective distribution of surfactant throughout the oil is crucial to the success of the process. To achieve the required distribution, most dispersants contain a suitable solvent which allows the dispersant to penetrate into the slick and acts as a carrier for the surfactant.

Many studies have examined what effect dispersion will have on the degradation of oil, but results are not plain. Meanwhile, most studies concludes that chemical dispersion will cause both increased rate and extent of the biodegradation as a result of increased oil surface and further on increased availability of micro-organisms.

Evaluation of environmental benefit

The following assumptions formed the basis for the evaluation of environmental benefit:

- No combat measures are seen as the least preferable alternative as the possibilities of exposure of environmental resources and triggering of their damage potential always will be higher than if oil spill combat is undertaken
- Mechanical oil spill combat will reduce the amount of oil on the sea surface and thereby also reduce natural dispersion into the water column.
- Chemical dispersants will remove oil from the sea surface and increase hydrocarbon concentrations in the water column to a higher degree than what is the case for mechanical combat.

As an approach to NEBA on the NCS, two levels of results were established. At the first level, a detailed analysis of the resources at risk were performed in order to outline in which areas and at which time of year application of chemical dispersants could have environmental benefit for the resources at risk. At the second level, the time-frame of dispersible oil types were recorded and used to establish the window of opportunity for using chemical dispersants as a tool in oil spill combat, either as an alternative for small spills or as a supplement for larger spills.

Level I: Data sources and availability

There was a common understanding that the NEBA should be based upon best available resource information and data sets. Data sets describing the spatial and temporal distribution of biological resources at risk were derived from professional institutions including material achieved through previous work with environmental risk analysis (ERA) and impact assessments. Data sets include:

- *Fish*; distribution of fish eggs and larvae established in connection with a Regional EIA for the Norwegian Sea (Brude *et al.* 2002), EIA for Snøhvit LNG (Moe & Brude, 2001), ERA for exploration drilling outside Møre (Moe et al, 2001) and co-coordinated exploration drilling in the Barents Sea 2001-2001 (NOBALES) (Brude et al, 2000). All source data from the Institute of Marine Research (IMR).
- *Seabirds*; Distribution of seabirds obtained through the work with explo*ration drilling on Nordland VI (*Hanssen et al, 1998*), Snøhvit LNG (*Systad et al, 1998) and NOBALES (Systad et al, 1999). All source data from Norwegian Institute for Nature Research (NINA) except for some additional material available though the United Kingdom Digital Marine Atlas (UKDMAP) (BODC, 1998).
- *Prioritized resources*; identified from the results of the Particular Environmental Sensitive Areas (SMO) (Moe et al, 1999) and proposed marine protected areas (Brattegaard & Holthe,1995; advisory committee 2001)

As a supplement to the data sources mentioned above, oceanographic information and ecological properties were derived from results of scientific papers and selected professional reports.

For use in contingency analysis, oil drift data were selected from the digital oil drift archives at NOFO, originally modeled by Det Norske Veritas (DNV, 2000) for each of NOFOs five contingency regions.

Analysis tools and data set criteria

All data were prepared in ArcView geographical information system (GIS). Data set specific criteria were implemented to select areas particular suited/recommended with regards to use of chemical dispersants. These include:

1. Areas with high concentrations of seabirds (+ 2 st.dev)
2. Areas with particular physical conditions for aggregations of high concentrations of seabirds in the open sea; i.e. frontal and upwelling areas
3. Important breeding areas for harbour seal and grey seal

Areas defined as unsuitable/not recommended for chemical dispersants include:

1. Shallow areas near shore including fjord areas
2. Areas with high concentrations of fish egg and larvae (+2 st.dev)
3. Protected areas with focus on marine values

Each data set were analyzed on 10x10 km grid cells and each cell were marked as either Neutral (no preference), Recommended or Not recommended for chemical dispersion. Areas or grid cells both recommended and not recommended were marked with Conflict. Examples of data sets are shown in Fig. 1 and 2.

Level II: Use of NEBA maps in contingency planning

In contingency plans for production installations on the NCS, NEBA maps were used together with the weathering properties for oil types produced at the installation. The results present dispersible oil types and the time frame in which dispersion can be carried out. Calculation of the area in which dispersion can take place for specific oil types are then given by identifying distances from the oil spill site under different weather conditions (wind speeds of 2, 5, 10 and 15 m/s).

Maps of the area where the oil type is dispersible where generated, including where:

- chemical dispersion are possible under different wind conditions and seasons
- areas with net environmental benefit, loss or conflict when chemical dispersants are used

In some cases, environmental resources outside the area where the oil is dispersible would influence the decision on whether to disperse or not. In the analysis this is indicated by including a buffer distance corresponding to one day drifting distance of the oil.

Results

NEBA maps

The result of the data set analyses were monthly NEBA maps indicating in which areas the use of chemical dispersants were recommended or not, or whether there were conflicting interests or no preference at all. An example is presented in Fig. 3.

For contingency planning; the maps are a combination of oil type, wind speed and season, and a large number of maps are available. This information is presented in a web with a database interface for easy access (NOFO, 2001; http://planverk.nofo.no/neba.htm). An example of such a map is presented in Fig. 4.

Conclusions

A simple and straight-forward approach to NEBA has been implemented for Norwegian offshore production facilities, and the window-of-opportunity for using chemical dispersants have been mapped for all produced oil types. The introduction of NEBA maps in the maintenance of contingency plans on the NCS has provided a valuable tool for establishing a framework for decision on where and when to use chemical dispersants in oil spill combat.

Acknowledgments

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Figures

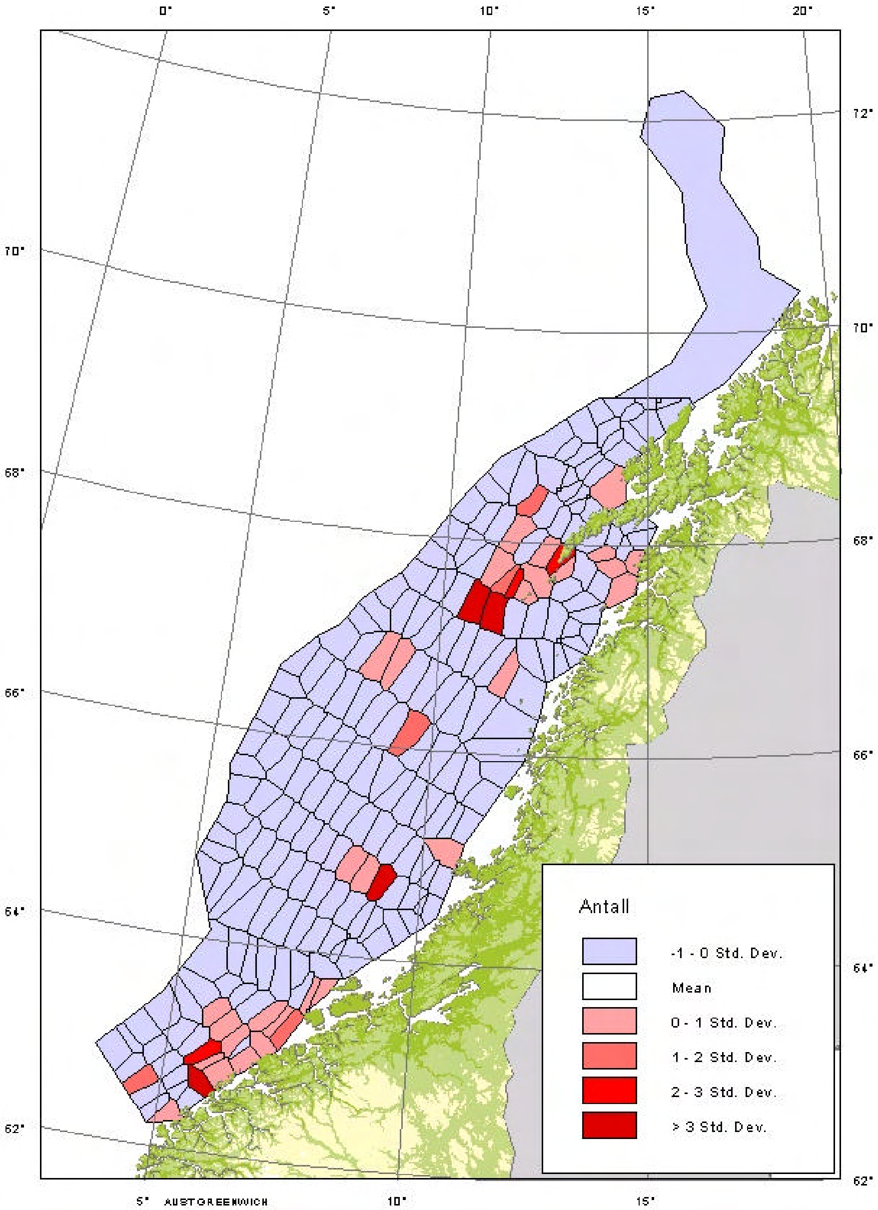

Figure 1. Example on data set showing statistical distribution of saithe (*Pollachius virens*) eggs and larvae in April.

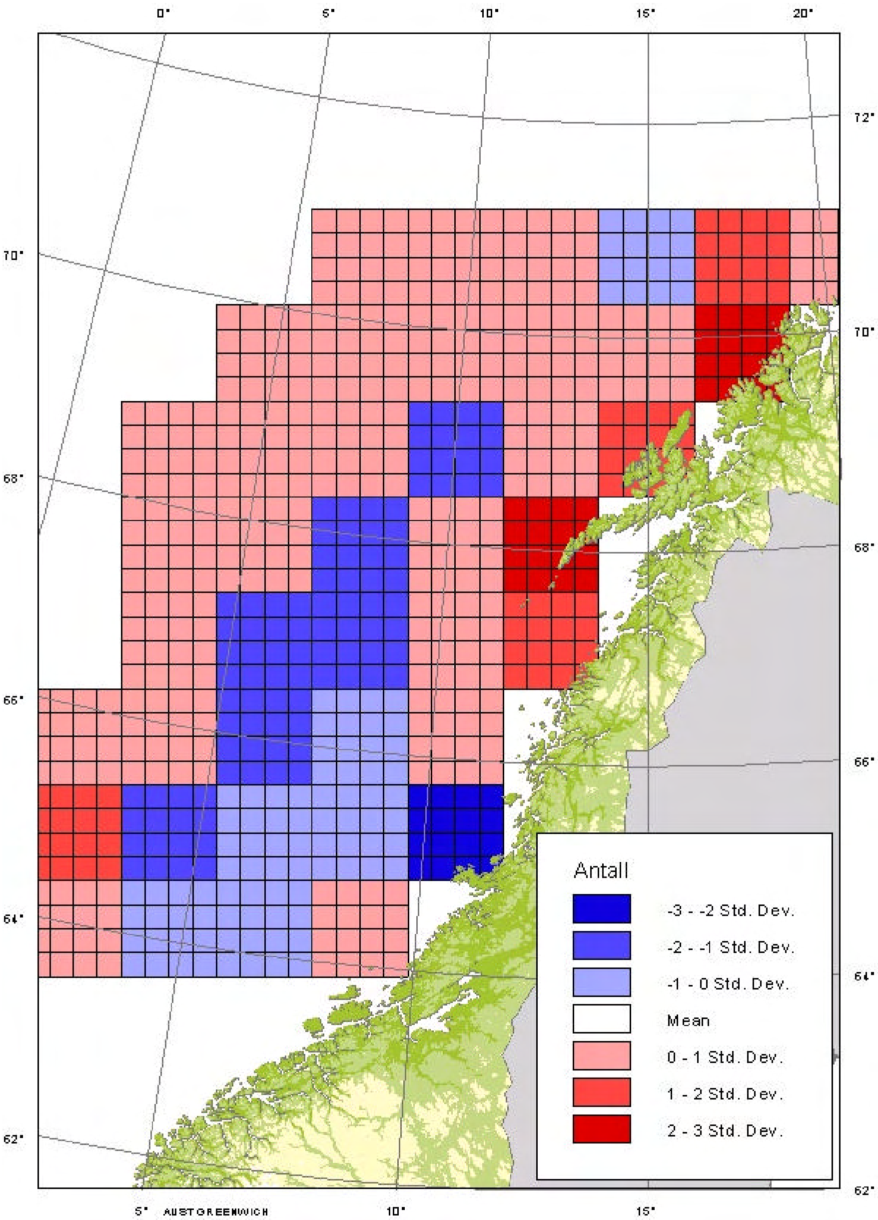

Figure 2. Example on data set showing statistical distribution of puffin (*Fratercula arctica*) at open sea in the summer season.

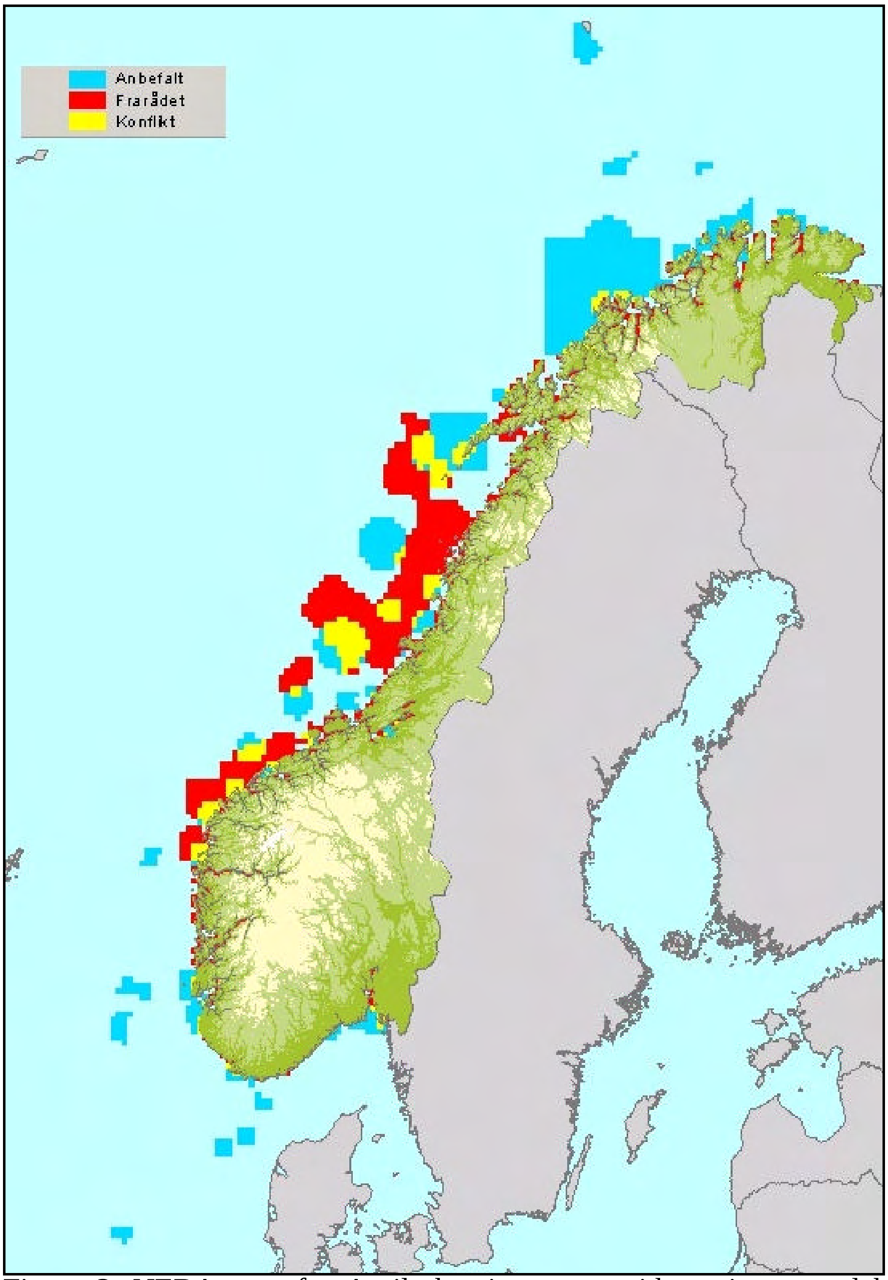

Figure 3. NEBA map for April showing areas with environmental benefit of chemical dispersion (dark blue), net loss (red) and conflicting areas (yellow).

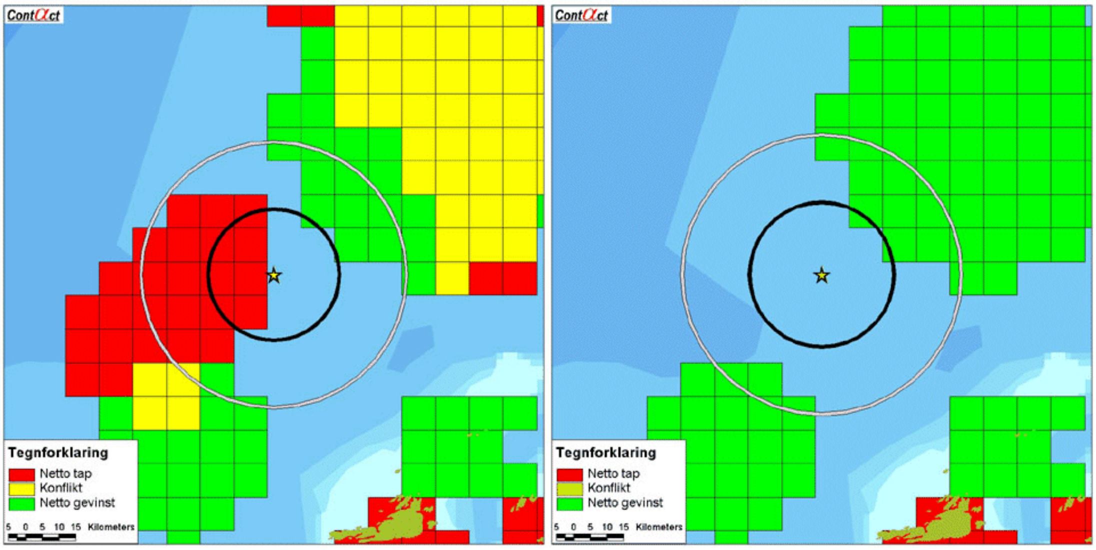

Figure 4. NEBA maps for the production facility at Draugen in April (left) and June (right) indicating areas with net environmental benefit from chemical dispersion (green), net loss (red) and conflict areas (yellow). Wind speed = 5 m/s.