From Reservoir Characteristics, Through Environmental Risk Assessments to Oil Spill Response
Lessons Learned from a Comprehensive Systematic Development by an Operator

Skeie, G. M.[1], Sørnes, T.[2], Engen, F.[2], Boye, A.[2], Heggø, A.L.[2], Rasmussen, S.[3] & C. S. Spikkerud[2]

[1])Akvaplan-niva, [2])Statoil, [3])Aker Solutions

INTRODUCTION

Operators on the Norwegian Continental Shelf (NCS) are required to adhere to a comprehensive set of HSE regulations (/1/) which are risk based and where environmental risk and emergency preparedness are focus areas.

Statoil is the largest operator on the NCS, is operating 42 assets and has an exploration activity in the order of 20-25 wells per year. In 2011, Statoil decided to undertake a full review of the basis for the oil spill response level for their activities, and establish a fully documented, transparent documentation of their approach. Lessons learned and results from this work is presented here.

MATERIALS AND METHODS

Operators are required to perform environmental risk (ERA) and oil spill emergency preparedness assessments (OSEPA) for all activities, as a basis for oil spill response plans. These assessments are of a complex and quantitative nature, and follow industry (/2, 3/) as well as Authority (/4/) guidelines.

It had for a while been realised that these guidelines needed detailing and specifications, or a more specific analytical method would need to be developed. In particular, a good link between well characteristics and the oil spill response level established was sorely needed.

Due to the extensive Norwegian coastline (> 82 000 km) and the complexity of bathymetric and oceanic conditions of the coastal waters, spill response would need to be targeted for the operational conditions and environmental protection strategies, e.g. as environmental strategic plans (/4/).

Information relevant for spill response plans had for a number of years systematically been collected by Norwegian operators, and these data were compiled for the purpose of this work.

The approach to the task was focused on three main issues:

- Develop company specific scaling criteria for oil spill response.
- Compile, verify and establish consensus on assumptions for capability and operability of spill response resources.
- Develop a transparent analytical method for OSEPA that can form the basis for verification of activity specific spill response levels.

Implementation of the work involved review of existing information, consultations with Norwegian Coastal Authority (NCA), Norwegian Environment Agency, Norwegian Clean Seas Association for Operating Companies (NOFO), other operators and equipment manufacturers.

As the work progressed, regular project workshops reviewed aspects and issues in the context of criticality with regards to end result.

OBJECTIVES

The key objective for this work was to Identify all needs and requirements to establish an oil spill response level that was transparent and could be verified in reference to internal scaling criteria.

Secondary objectives were to:

- Establish full documentation of underlying assumptions and data sets applied in the OSEPA, and transparency in how these were applied.
- Close any gaps identified.
- Communicate findings with authorities and other operators.
- Implement results for all fields in operation as well as exploration wells.

RESULTS

Scaling criteria

As the HSE regulations are risk based, but not prescriptive, each operator is required to establish individual acceptance criteria, based on company policy and values. This policy was adopted for developing company specific scaling criteria through a series of internal discussions. The results are a set of criteria applied by the company worldwide, as well as a more detailed set applied for activities on the NCS (Table 1). These scaling criteria are of a general nature, and activity specific criteria are derived for each individual activity based on the results of oil drift simulations and ERA.

Table 1. Statoil scaling criteria for oil spill response on the NCS.

Element	Applicable for	Requirement
Detection	Barrier 0	Within 3 hours
Dimensioning event	Input data	Loss of well control
Dimensioning rate	Input data	Weighted release rate
Mapping and detection	-	To be in place and operational (guideline in progress)
Response time of first unit	Barrier 1	As soon as possible based on standard location and within 5 h, unless ERA indicate stricter requirements
Extent of response	All barriers	Sufficient capacity in each barrier
Response time for entire barrier	Barrier 1 and 2	ASAP given normal locations, unless ERA indicates further requirements.
Response time nearshore	Barrier 3 and 4	95 percentile of outcome of simulations in terms of minimum drift time
Extent of response	Barrier 3 and 4	95 percentile of outcome of simulations in terms of amount of oil emulsion per day
Geographic distribution within affected area	Barrier 3 to 5	Basic response level for selected sensitive areas within area affected by oil drift simulations
Shoreline cleanup	-	Cleanup completed within 3 months
Mapping	All barriers	Effective mapping of pollution, irrespective of reduced visibility and light
Competence	All barriers	Specified and documented

Analytical method

The overall strategy for oil spill response on the NCS (/5/)may be visualized as a set of independent barriers:

- Barrier 1: Near the source of the oil spill
- Barrier 2: Along the drift trajectory towards the coast
- Barrier 3: In moderately exposed coastal waters
- Barrier 4: In sheltered waters near the shoreline
- Barrier 5: Shoreline cleanup

To allow analyses of requirements for these barriers, drawing on a diverse source of resources, an algorithm applicable for all resources was developed and implemented in an Excel spreadsheet:

T_b = Proportion of time where wave conditions allow operations (Value between 0 and 1)
T_s = Proportion of time here light and visibility allow operations (Value between 0 and 1)
E_o= Effectiveness in operational light within the operational window (Value between 0 and 1, or as a mathematical function)
E_m = Effectiveness in reduced visibility and darkness (Value between 0 and 1), in relation to effectiveness in operational light.
E_k = Reduction in effectiveness related to configuration and barriers (Value between 0 and 1)
K = Capacity during operation (m^3/h)
L = Onboard storage capacity of recovered emulsion (m^3) (included in D for the time being)
D = Total downtime per day (hours)
T_e = Proportion of time with sufficient availability of emulsion (Value between 0 and 1)

The upper limit of effectiveness of a system unit (E_s) may be calculated as:

$$E_s = (T_s * E_o)+((1-T_s)*E_m)$$

The effect of a system unit (Y_s) in m^3/day may be calculated as:

$$Y_s = (K * (24 - D)) * (Tb * Ts) * E_s$$

The upper limit of effect of a barrier is given by the upper limit of the effectiveness, modified for E_k of additional units exceeding standard requirements (effect sufficient for amount of emulsion) This implies that additional resources within a barrier will follow the principle of diminishing return, with decreasing effect or "catch per unit effort"

RESULTS

While mechanical recovery has been the traditional combat option on the NCS, regulations and guidelines call for an evaluation of alternatives that may provide the minimum overall environmental impact (NEBA/NEIA). For this element of the method, an existing approach was adopted (/6/), providing quantitative estimates (Figure 1).

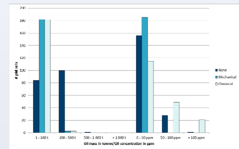

Figure 1. Effects of three alternative combat alternatives in terms of surface oil amounts (left side) and water column oil concentrations (left).

Based on oil drift simulations undertaken according to guidelines and standards, and subsequently analyzed according to a set of specified algorithms, activity specific requirements for spill response is derived.

From these, various alternative combat options for each barrier are analyzed through the Excel spreadsheet, and an activity specific oil spill response conforming to company criteria is identified.

This oil spill response is described in an activity specific oil spill response plan, which forms the basis for oil spill exercises and verification.

The method developed and interactions are presented in Figure 2.

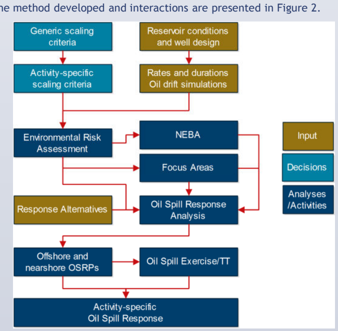

Figure 2. Elements and interactions of the method developed, providing a "red thread" from reservoir characteristics to oil spill response.

RESULTS

Assumptions and data sets

Underlying assumptions, data treatment and data sets were in a very early phase of the work identified as critical to the end result and were subjected to comprehensive discussions and consultations, documented in a series of reports, memos and data sets. These include:

- Operational and technical capabilities and limitations for all relevant units involved in spill response
- Effectiveness and applicability of chemical dispersants
- Crude oil properties
- Seasonal wave conditions in coastal waters
- Elements in response times calculation
- Improvements in organizational elements
- Criteria and GIS data sets for prioritization of environmental resources, navigation operability, access points, driftwood bays etc.

For near shore oil spill response planning, the project initiated generation of a set of thematic maps in A1 PDF format, forming the backbone of environmental strategic response plans (/7/) for a range of sensitive areas along the Norwegian coastline. These maps include priority sites for protection and operational water depth (Figure 3). These are all made public to serve all parties involved in oil spill response planning in Norway.

The resulting method (/8/) and related information have been made public and has been applied in a number of OSEPAs, also by other operators on the NCS.

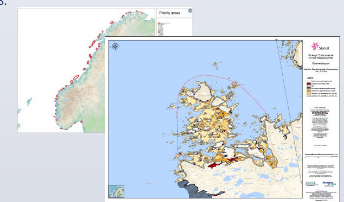

Figure 3. Sensitive areas where strategic plans are developed, marked in red on upper left illustration, and example of map showing operational depth for ship based operations (right).

Lessons learned

Throughout the work over a 2 year period, the importance of linkages from well characteristics to oil spill response planning was confirmed, and is an essential element in arriving at transparent and verifiable oil spill response. While the underlying assumptions and data sets were confirmed important, the criticality assessment workshops identified that variations in treatment of results from oil drift simulations to define risk related requirements had an even stronger effect on the results. The method developed now has very detailed specifications on these issues. As the initial approach clearly defined company specific scaling requirements as a policy issue, this avoided "muddling" the discussion of technical and scientific issues on assumptions, data sets and analytical method.

As a side effect of sensitivity assessments, it was possible to document the effect of spill response on environmental risk related to acceptance criteria (Figure 4).

RESULTS

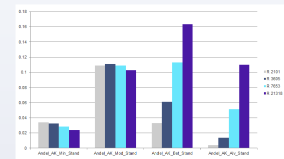

Figure 4. Effect of oil spill response in reduction of risk of moderate and serious environmental impact.

CONCLUSIONS

- It is possible to establish a transparent and verifiable approach to a risk based oil spill response assessment and establishing an activity specific oil spill response level.
- The approach requires systematic and documented linking from the well characteristics to activity specific oil spill response plans.
- Standardization and documentation of underlying assumptions and data sets is needed.
- Policy issues and decisions should be clearly separated from technical and scientific discussions in an early phase of a review process.
- Śharing of results between operator, authorities and parties involved in oil spill response planning is an effective means of dissemination and communication.

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Contact persons for further information:

- Tom Sørnes: tosorn@statoil.com
- Frode Engen: Froen@statoil.com
- Geir Morten Skeie: gms@akvaplan.niva.no