



BG NORGE

Document responsible: Steven Viddal

File location: Documentum – PL292 – Drilling – HSSE - Environmental

02	21.09.2007	Final Version	E.Hoell	S.Viddal	F.Hardinges		
01		IDC	Espen Hoell M I Aaserød K A Jødestøl				
Revision:	Date:	Reason for issue:	Prepared:	Checked:	Accepted:		
Title: Environmental Risk Assessment and Oil spill Contingency Analyses – Well N15/12 – Pi North				Responsible party: BGNO			
				No. of sheets: 54			
Doc type code: RA	Area code: N/A	Document number:				Revision Code: 02	Status Code: 03
		Project Code	Originator Code	Discipline Code	Sequence No		
Contract No.: N/A	System Code: N/A	PI1	BGNO	S	0003		
15/12-P-BGNO-S-0003							

0 Summary

BG plans to drill the exploration well N15/12 – Pi North using the jack-up rig Maersk Guardian, starting in January 2008. The drilling will be conducted using water based mud (WBM) in the upper sections and oil based mud (OBM) in the lowest section. Only chemicals from the upper sections will be discharged.

The drilling operations of Pi are planned to start in January 2008. Pi is located south of Varg, approximately 225 km off the Norwegian coast. This is an area with lots of both exploration and production wells as well as several installations.

As basis for planning and management of the drilling operation, identifying and implementing risk reducing measures, including oil spill contingency systems, an environmental risk analysis has been carried out. Based on the results from the risk analysis, different types of risk reducing measures has been described that will be further considered and implemented during the detailed planning phase and during the HSE management of the operation. The risk assessment has been used as basis for planning and identifying risk reduction measures for the drilling operation as basis for the oil spill contingency analyses.

No black chemicals will be used but the operation plan for use of two red chemicals, both are included in the rig chemicals (Statoil Multidope and Bestolife products) and will partly be discharged. Total discharge of red chemicals is estimated to be approx. 1,3 ton, mostly related to the jacking grease.

The most likely hydrocarbon in the reservoir is condensate. A probability distribution of 90% vs 10% is defined for condensate and oil. The dimensioning blowout rates are 1870 and 3640 m³/day respectively. If a blowout should occur, the probability for stranding is estimated to be in the order 10 - 30 %.

Based on the Environmental Risk Assessment, the highest risk from the drilling operation is related to an oil blowout. The risk levels are well below the BG's acceptance criteria for environmental risk, with values > 30% of the acceptance criteria. Among the operational (planned) discharges, the use and discharge of jacking grease is considered to represent a moderate environmental risk. Substitution of this product should be investigated.

In general the operation is considered to represent an environmental risk similar to other comparable drilling operations in the North Sea. The overall risk level related to the drilling is considered to be low.

The oil spill contingency analyses indicate a need for 3 NOFO systems in barrier 1, with a barrier response time of 24 hours and 1 additional NOFO system in barrier 2 with a barrier response time of 48 hours. BG's performance requirements are met with this contingency.

Contents

0	Summary.....	2
1	Introduction	5
1.1	Basic Information.....	5
1.2	Rules and regulation	6
1.3	Policy and requirements	6
1.4	Acceptance criteria for environmental risk.....	7
1.5	Activity and well description	7
1.6	Defined situations of hazard and accident (DSHA)	9
1.6.1	Blowout statistics	10
1.6.2	Blowout scenarios.....	11
1.6.3	Minor spills of oil and chemicals	15
1.6.4	Operational discharges	16
1.6.5	Summary of acute spill calculation and operational discharges.....	17
1.7	Fluid characteristics and weathering properties	18
1.8	Oil Drift simulations	18
1.9	Area of influence	20
2	Environmental description.....	21
2.1	Water masses	21
2.2	Weather statistics	21
2.3	Salinity and water Quality	23
2.4	Sediments	23
2.5	Cold water corals.....	24
2.6	Seabirds	24
2.7	Sea mammals	27
2.8	Fish resources.....	27
2.9	Fishing activity.....	29
2.10	Aquaculture	30
2.11	Important coastal areas.....	30
2.12	Recreational areas	31
2.13	Background pollution	32
3	Environmental risk assessment.....	34
3.1	Impact assessment	34
3.2	Activity specific environmental risk.....	38
3.3	Regional environmental risk	40
3.4	Risk reducing measures	40
4	Oil spill contingency analysis.....	42

4.1	Introduction	42
4.2	Combating strategies	42
4.3	Equipment, capabilities and effectiveness.....	43
4.4	Barrier 0 – monitoring and detection	45
4.5	Barrier 1 and 2 – combat actions in open waters	46
4.6	Barrier 3 – combat actions in coastal areas	48
4.7	Barrier 4 – combat actions at environmental priority areas	49
4.8	Barrier 5 – combat actions on the beach.....	49
4.9	Systems for remote monitoring during an oil spill	49
4.10	Post-spill investigations	50
4.11	Performance requirements.....	51
5	Summary and conclusions	52
6	References	53

1 Introduction

Exploration drilling implies both planned operational discharges and a possibilities for spills to sea. As basis for planning and management of the drilling and production operations, identifying and implementing risk reducing measures, including oil spill contingency systems, a simplified semi quantitative environmental risk assessment (ERA) has been carried out. The industry standard MIRA for assessment of environmental risk for petroleum activities (OLF 2005) is considered more suitable for use in environmental sensitive areas and for long term production operations facilities.

The method used here imply a relative ranging of discharges to sea which is emphasized to get a better basis for planning and follow-up of the operation. The basis for using this methodology for the environmental risk assessment for this specific exploration well is:

- the operation is planned in a well-established area with several installations
- a large number of exploration drillings has been conducted in the area
- the distance to shore is large - about 225 km
- the well is not considered to be located in, or close to, particular vulnerable areas
- several ERA's and MIRA's have been carried out in the area.

1.1 Basic Information

The exploration well 15/12 - Pi North (hereafter kalled Pi) is planned to be drilled in block 15/12 in production licence 292 south of the Varg field. BG Norge AS plan to drill the well by the jackup rig Maersk Guardian operated by Maersk Contractors Norge AS (MCN). Planned startup at Pi is january 2008 with a duration of 62 days. The location of the well is presented in Figure 1.

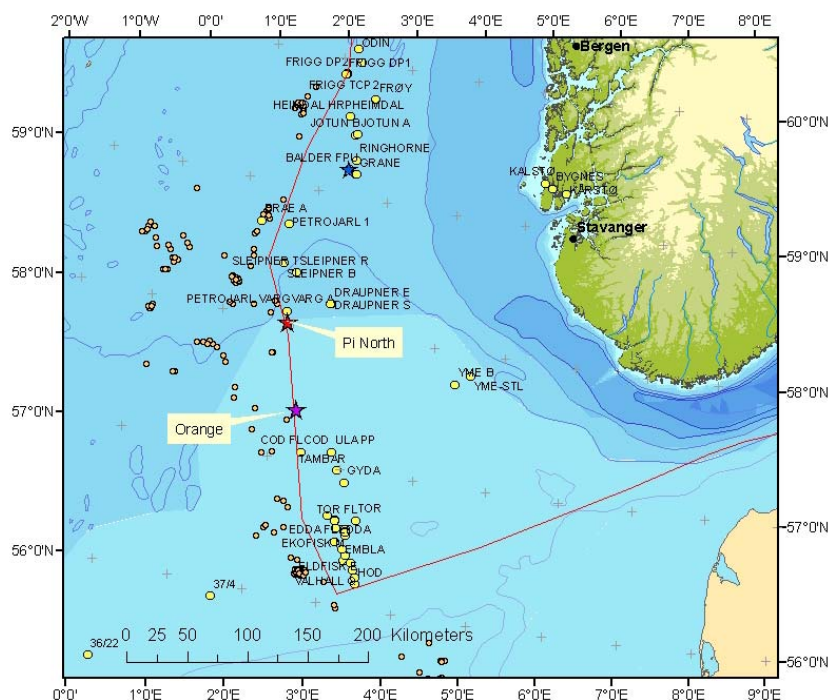


Figure 1. Location of Pi. The well Orange, also operated by BG is included.

Please note; As the reservoir also stretches into block N6/3 the well has previously been named N6/3-1 Pi north. Mark that both well names are used in the assessment as the previous names were used in the underlying reports (WFD 2007 and DNV 2007).

In recent dialogs between Statens ForurensningsTilsyn (SFT) and the operators in region 3 and 4, an agreement was established to use the 90 percentile of blowout rates for production wells, or weighted blowout rates for production drilling. For exploration drilling the operators has concluded to use weighted blowout rates as basis for the environmental risk assessment and as dimensioning rate for the oil spill contingency assessment. The reason for this decision is the relatively short duration of the drilling activity (i.e. drilling in the reservoir zone), and the low probability for blowout incidents. Thus the weighted rate has been used as the dimensioning rate in this assessment.

Table 1. Key information for the well.

Item	PL 292 Well 15/12-Pi North
Operator	BG Norge AS 60%
Partners	Lundin AS 40%
NOCS Block	15/12
Position – Geographical (ED50 GB) and Grid (UTM Zone 31, CM 3°E)	1°55'16.30" N, 58°00'13.83" E 6,429,793mN, 436,238mE
Drilling period	January – March 08
Water depth	85 meter
Weighted oil blowout rate	3640 Sm ³ /d
Weighted condensate blowout rate	1870 Sm ³ /d

1.2 Rules and regulation

Norwegian regulations require the operators to operate in a safe and prudent manner (the Framework regulations (FR) §8), and to reduce the risk in their activities (FR-§9). The operator must define acceptance criteria for environmental risk (the Management regulations (MR) §6), and analyse the environmental risk to assess compliance with the acceptance criteria (MR-§16). Based on the results from the environmental risk assessments, a contingency analysis for relevant spill scenarios shall be carried out (MR-§16) as basis for establishing an (oil spill) contingency organisation (the Activity regulations (AR) §66) and contingency plan (AR-§67) for the activity. The operators are also required to co-operate in establishing contingency facilities (FR-§29-30, AR-§65) and to consider regional contingency systems (AR-§69).

1.3 Policy and requirements

BG has established environmental objectives and requirements for the drilling operations, described in “HSSE programme 15/12-P-BGNO-S-0003. These describe acceptance criteria for environmental risk and requirements for assessment of chemical usage and discharges with focus on reduction, reuse, recycling and substitution, combined with effective waste management.

1.4 Acceptance criteria for environmental risk

The BG Norway acceptance criteria for environmental risk are based on the described in Appendix C, NORSOK Z-013, rev 1 (March 1998), and are comparable to the criteria used by most operators in the Norwegian oil and gas industry (Table 2). The operation specific acceptance criteria apply for risk assessments of exploration drilling.

Table 2. Environmental risk acceptance criteria applied for operations.

Environmental damage	Operation specific acceptance criteria (per operation)
Minor (< 1 year recovery time)	$< 1,0 \times 10^{-3}$
Moderate (1-3 years recovery time)	$< 2,5 \times 10^{-4}$
Considerable (3-10 years recovery time)	$< 1,0 \times 10^{-4}$
Serious (>10 years recovery time)	$< 2,5 \times 10^{-5}$

These acceptance criteria are used for comparison with the estimated risk for impacts that result in a restitution time for the resource affected.

1.5 Activity and well description

The drilling operation is planned using the jackup rig Mærsk Guardian (Figure 2). The rig will position itself by jacking down the three legs into the seabed substratum. The lengths of the legs are 157 m, and enabling the rig to drill at a maximum depth of 107 m. The water depth at Pi is 85 m. Planned startup at Pi is January 2008, and the operations will take approx. 62 days. The drilling period is longer than normal due to core sampling. Accordingly the risk assessment must cover the period January through March.



Figure 2. Mærsk Guardian.

The location of the Pi reservoir is presented in Figure 3.

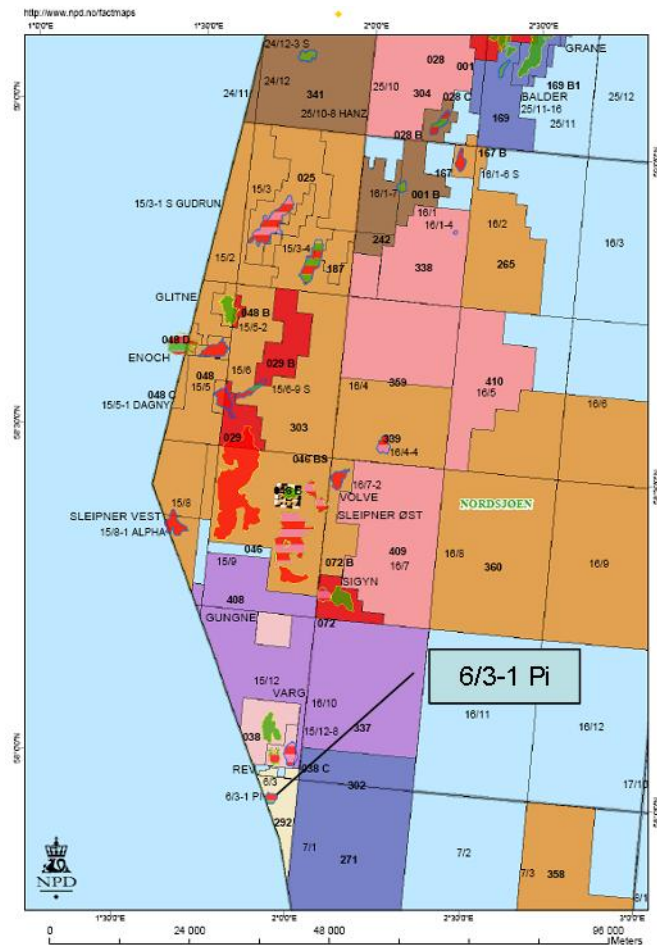


Figure 3. Location of the reservoirs at Pi. Figure by NPD maps.

The well is planned vertically to a depth of 3164 m TVDSS. Water based drilling mud will be used in the sections, except from the 12 ¼ and 8 ½ “ sections where oil based drilling mud will be used for technical reasons. If hydrocarbons are found, a well test is planned. This will add 14 days to the drilling period. The well configuration is presented in Figure 4.

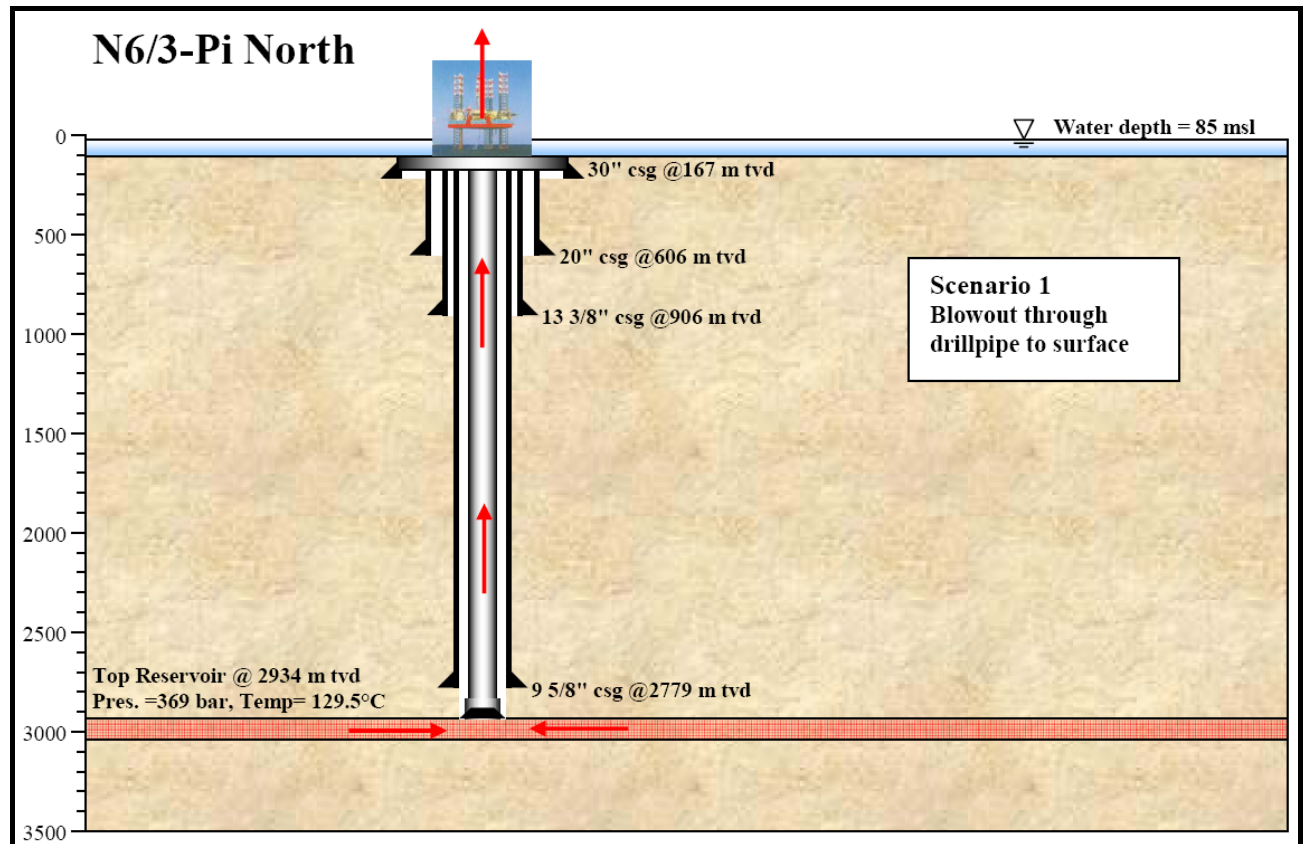


Figure 4. Pi well design, with illustration of a blow out through the drill pipe (figure: Well Flow Dynamics).

1.6 Defined situations of hazard and accident (DSHA)

Exploration drilling in offshore areas implies a risk for acute spills to sea. Major incidents are blowouts during drilling into the reservoir zone. Minor incidents include small spills of crude oil (well releases), diesel (from the rig or from supply vessels), oil based or water based drilling mud (from the rig or during transfer from supply vessel) or hydraulic oil (from the rig).

With respect to environmental risk and acceptance criteria, and oil spill contingency, the dimensioning incident is a blowout. Minor incidents and planned operational discharges are included in the assessment in order to provide a comprehensive picture of the drilling operation, and to form a basis for identifying technical and/or operational measures and best practices to reduce the overall environmental impact and risk.

The most likely fluid that may be discovered at Pi is condensate. However the possibility to find oil cannot be excluded, thus the risk assessment include both condensate and oil blowouts.

In the study carried out by Well Flow Dynamics (WFD 2007) the possible oil is assumed to have properties similar to the Varg oil. Blowout rates have been calculated and simulations have been performed for a dynamic kill operation by using a relief well with direct intersection into the blowing well. In the condensate case the dimensioning rate is 1870 Sm³/d, and for the oil case the dimensioning rate is 3640 m³/d.

1.6.1 Blowout statistics

Potential blowout scenarios for a drilling operation include both topside and sub-sea blowout, from either open hole or from a hole with restrictions (eg. drill string in the hole), and with different flow pathways such as directly through the drill hole, outside the casing or through annulus.

Generic blowout frequencies for exploration drilling (normal wells) in Norwegian areas has been calculated by Scandpower (2007) to $2,9 \times 10^{-4}$ per drilling operation for oil blowouts, and $3,1 \times 10^{-4}$ for gas/condensate blowout. The probability for well release is $2,3 \times 10^{-3}$ per drilling operation. The blowout statistics are based on incidents from the US Gulf of Mexico outer Continental shelf (US GoM OCS), Canada east Continental shelf and North Sea (British, Dutch and Norwegian shelf) and cover both gas and oil blowouts for the period 1985 through 2004. The statistics for well releases are based on data for the Norwegian sector for the last 20 years. The blowout probabilities are adjusted according to probability for oil vs. condensate in this assessment.

A majority of the historical blowouts originate from the Gulf Of Mexico (GOM) and only a few incidents from the North Sea are found in the statistics, the West Vanguard blowout in 1985, the Ocean Odyssey blowout in 1988 and Snorre subsea incident in 2004. The Bravo blowout on the Ekofisk field in 1977, is no longer included in the statistics. In addition, several less severe accidents involving uncontrolled releases have occurred in the North Sea, but with respect to major blowouts where for instance a relief well is required, the basis is limited.

As the drilling operation is undertaken from a jackup rig with the BOP placed onboard, a potential blowout from the well at Pi will occur topside at the rig. Also well releases will occur on the rig. Thus only surface blowouts are considered in this assessment.

The potential duration of blowouts are subjected to significant uncertainty. Based on available statistics, Scandpower (2007) estimate duration of topside blowouts, shown in Figure 5. Statistics for surface durations are not included in the figure. The probability for longer blowouts are higher for subsea blowouts, and thus they more likely have to be stopped by drilling a relief well.

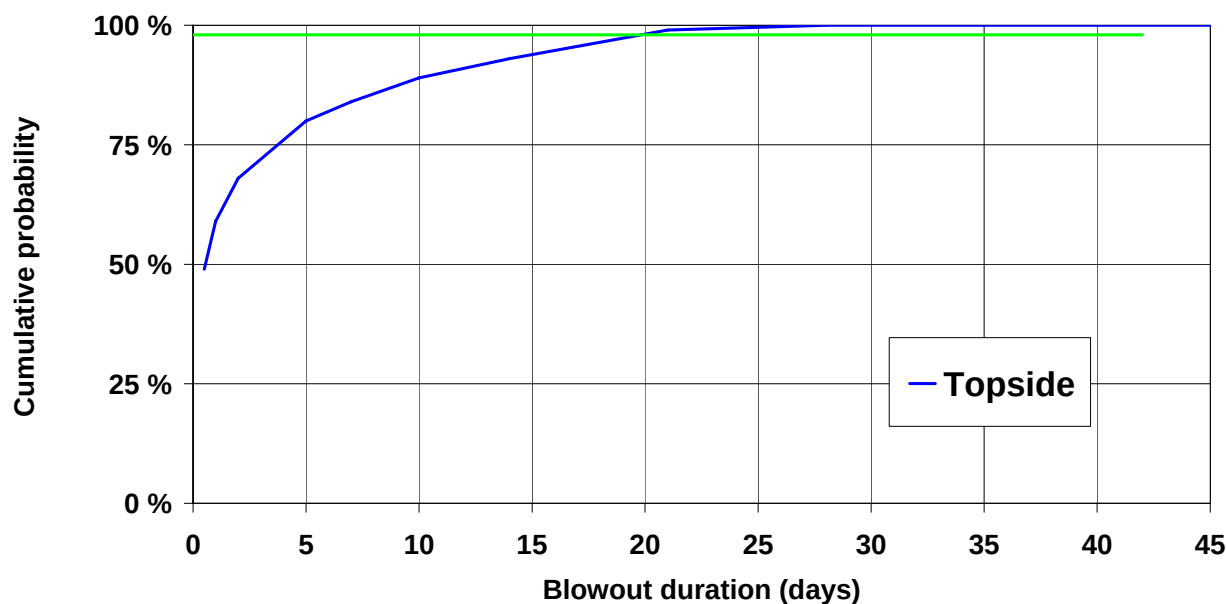


Figure 5. Duration probability distribution for topside blowouts (based on data from Scandpower 2007).

According to the statistics (Scandpower 2007), the duration probabilities for a surface blowout lasting more than 2, 15 and 42 days is 32%, 7 % and 0% respectively. All surface blowouts statistically are stopped before 28 days, and thus there should not be any need for drilling a relief well for a surface blowout from a jackup rig. The maximum duration of well releases is 15 minutes.

Well Flow Dynamics also estimate the blowout duration. They use their experience from well killing operations and do not use the SINTEF Blow out Database as a basis for duration estimates. They estimate durations of 2, 15 and 42 days with a probability distribution of 47%, 25% and 28% for both an oil and a condensate blowout. According to Well Flow Dynamics their experience does not indicate that wells in the North sea will collapse during a blowout. For this reason they estimate a higher probability for long lasting blowouts than the statistics presented by Scandpower (2007). The duration probability estimated by Well Flow Dynamics has been used in the oil drift simulations and in the risk assessment, which is considered to be a conservative approach. This imply that some of the risk indexes and the environmental risk values may be overestimated in the assessment, compared to what the result would have been if the duration probabilities by Scandpower (2007) had been applied.

1.6.2 Blowout scenarios

The blowout rates for Pi have been estimated based on model simulations (WFD 2007), based on available information about reservoir characteristics and drilling program / well design.

Three blowout scenarios have been defined:

- Scenario 1: Blowout through drillpipe – topside release
- Scenario 2: Blowout through annulus – topside release
- Scenario 3: Blowout through open hole – topside release

Figure 6 - Figure 8 show the three blowout scenarios that have been used in the calculations.

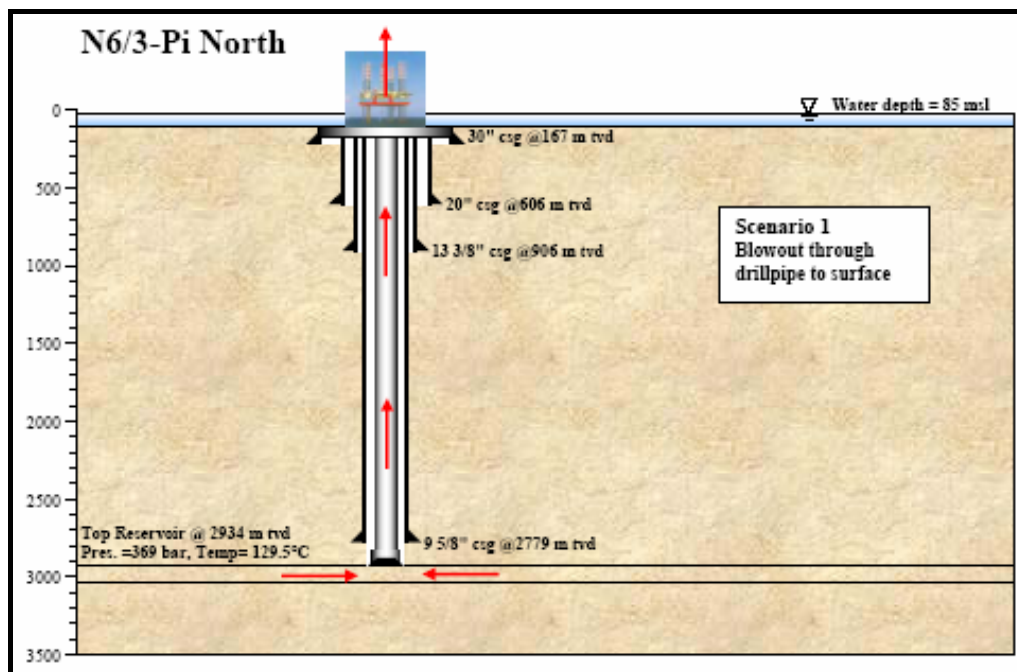


Figure 6. Schematic illustration blowout scenario 1 (WFD 2007).

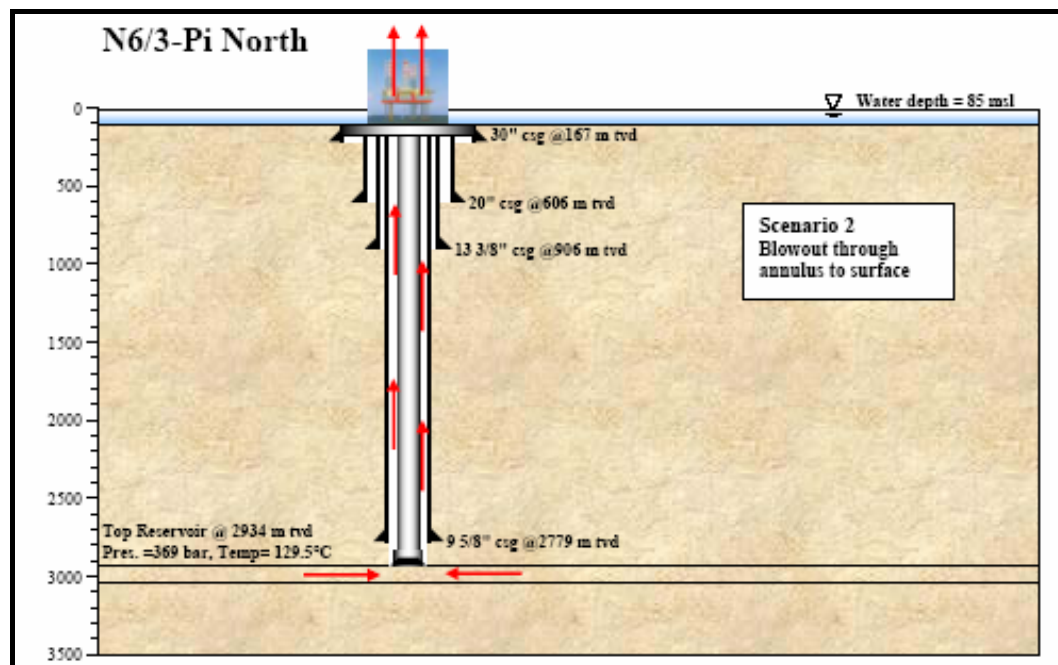


Figure 7. Schematic illustration blowout scenario 2 (WFD 2007).

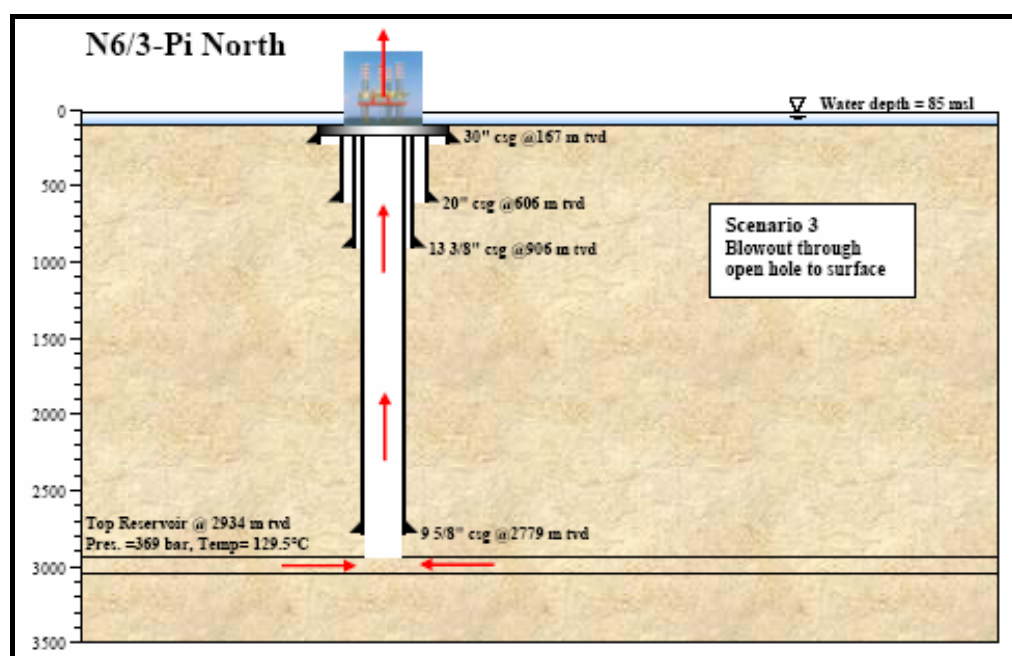


Figure 8. Schematic illustration blowout scenario 3 (WFD 2007).

The following distribution is used between the three **blowout scenarios** (WFD 2007):

1. Blowout through drillpipe, 11% probability
2. Blowout through annulus, 78% probability

3. Blowout through open hole, 11% probability

The following distribution has been made related to **exposed reservoir**:

- Only top of the formation has been penetrated, 55% probability
- Entire reservoir has been drilled through, 45% probability

Furthermore, the following distribution has been made related to the **outlet restriction**:

- 5 % flow area relative to full opening, 70 % probability
- No restriction, 30 % probability

The most likely fluid that may be discovered at Pi is condensate. BG consider the probability for oil to be low, but it has not been possible eliminate this probability. Thus oil cannot be excluded. Therefore an oil case have also been considered and Well Flow Dynamics performed blow out simulations for both the condensate and the oil case. In this assessment the probability distribution for oil vs. condensate is set to 10% and 90% respectively and the blowout frequencies have been adjusted correspondingly.

The oil is assumed to have properties similar to the Varg oil. Blowout rates have been calculated for both a condensate and an oil case and simulations have been performed for a dynamic kill operation by using a relief well with direct intersection into the blowout well. This is done as a worst case consideration, although the probability for this case is considered to be very small

For an incident requiring a relief well, the duration will consist of the time it takes to drill the well (including ranging runs) and the mobilization time for the rig. The relief well are assumed to be drilled with the same rate in m/d as the exploration well, but in addition, time required to run the electromagnetic ranging tools has to be taken into account. Table 3 shows the assumed total number of days required to drill the relief wells.

Table 3. Estimated time to drill relief wells to last casing shoe.

	Depth	Drilling	Ranging	Total
	m	days-	days	days
Intersection below 9 %	2800	25	10	35

A duration of **42 days** has been estimated for the relief well drilling (Figure 9) for well N15/12-Pi. This is assuming an additional 7 days to get a replacement rig from the area. If it is possible to regain control from the rig drilling the well (ii) a maximum duration of up to **15 days** is assumed. (WFD 2007).

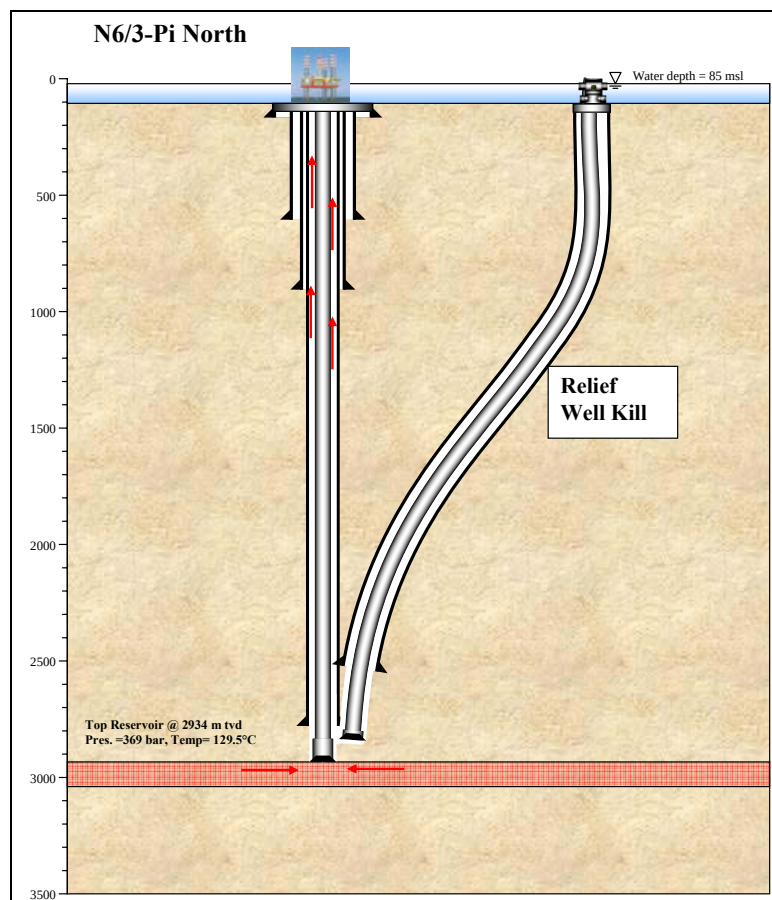


Figure 9. Illustration of the relief well drilling (WFD 2007).

Well Flow Dynamics have also calculated the rate distribution for both the condensate and the oil case. The resulting simulated blowout rates and probability for the rate are summarised in Table 4 and Table 5. Note that the probability distribution is shifted towards longer duration than the Scandpower statistics indicate.

Table 4. Summary of blowout rates for Pi, condensate case (WFD 2007).

©WFD 2006, Based on Sintef Offshore Blowout Database and OLF guidelines							GOR = 1680		Time to drill Relief Well: 42 days			
Scenario	Scenario Dist. %	Penetration Depth Dist.%	top/entire	BOP Opening Dist %	Opening	Total Dist. %	Oil Sm3/d	Gas MSm3/d	Distribution - Duration			Weighted Duration
									t<2 days	t~15 days	t~42 days	
1 - Drillpipe	11	55	Top	30	Open	1.8	1 195	2.01	50	25	25	15
				70	5% open	4.2	732	1.23				
				30	Open	1.5	1 474	2.48				
		45	Entire	70	5% open	3.5	812	1.36				
2 - Annulus	78	55	Top	30	Open	12.9	1 812	3.04	50	25	25	15
				70	5% open	30.0	1 400	2.35				
				30	Open	10.5	2 856	4.80				
		45	Entire	70	5% open	24.6	1 866	3.14				
3 - Open Hole	11	55	Top	30	Open	1.8	2 568	4.31	25	25	50	25
				70	5% open	4.2	2 012	3.38				
				30	Open	1.5	7 145	12.00				
		45	Entire	70	5% open	3.5	3 357	5.64				
Totals and weighted rates:						100	1 870	3.14	Weighted duration:			16

The dimensioning blowout rate for the condensate case is defined to 1870 m³/day.

Table 5. Summary of blowout rates for Pi, oil case. (WFD 2007)

©WFD 2006, Based on Sintef Offshore Blowout Database and OLF guidelines						GOR = 178		Time to drill Relief Well: 42 days				
Scenario	Scenario Dist. %	Penetration Depth Dist.%	top/entire	BOP Opening Dist %	Opening	Total Dist. %	Oil Sm3/d	Gas MSm3/d	Distribution - Duration			Weighted Duration
1 - Drillpipe	11	55	Top	30	Open	1.8	1 818	0.32	50	25	25	15
				70	5% open	4.2	1 287	0.23				
		45	Entire	30	Open	1.5	4 102	0.73				
				70	5% open	3.5	2 166	0.39				
2 - Annulus	78	55	Top	30	Open	12.9	2 071	0.37	50	25	25	15
				70	5% open	30.0	1 815	0.32				
		45	Entire	30	Open	10.5	7 502	1.34				
				70	5% open	24.6	4 797	0.85				
3 - Open Hole	11	55	Top	30	Open	1.8	2 228	0.40	25	25	50	25
				70	5% open	4.2	2 035	0.36				
		45	Entire	30	Open	1.5	16 095	2.86				
				70	5% open	3.5	7 954	1.42				
Totals and weighted rates:						100	3 640	0.65	Weighted duration:			16

The dimensioning blowout rate for the oil case is defined to 3640 m³/day. The oil case has been used as basis in the oil spill contingency assessment.

1.6.3 Minor spills of oil and chemicals

Minor incidents include small spills of diesel (from the rig or from supply vessels), water based drilling mud (from the rig or during transfer from supply vessel), and hydraulic oil (from the rig).

The frequency for minor spills

All acute spills of hydrocarbons and chemicals are reported annually to SFT and OLF. In available statistics the spills are grouped in two categories: oil and chemicals/drilling fluids.

- **Oils:** diesel, heating oil, crude oil, waste oil and other oils (incl. hydraulic oil).
- **Chemicals/drilling fluids:** corrosive substances, environmental hazardous substances, oil based drilling fluid, other drilling fluids (incl. water based) and flammable substances.

The spill statistics are not easy to convert to expected spill frequencies because of differences in activity type and duration between drilling operations. Statistics from the period 2000-2005 has been assessed as basis for the risk assessment. During this period there were 109 exploration drilling operations. Among chemical spills water based drilling mud constituted 18% (only statistics from 2005). Among oil spills diesel and other oil spills (e.g. hydraulic oil) constituted 17% and 41%, respectively. In the years 2000-2005 there were 65 spills of chemicals and 24 spills of oils during exploration drilling operations, giving an expected spill frequency of:

- Diesel spill: 0,10 per operation
- Hydraulic oil spill: 0,09 per operation
- WBM/OBM spill: 0,02 per operation.

The statistics for “other oils” multiplied with 50% has been used to represent hydraulic oil. Based on judgments the expected spill volumes has been set to 1 m³ for diesel and hydraulic oil, and 50 m³ for water based drilling mud (WBM).

1.6.4 Operational discharges

More detailed information on the operational discharges is presented in the discharge application prepared for the Pi well (BGN document 15/12-P-BGNO-S-0003).

Drilling mud

Water based drilling mud will be discharged to sea during the drilling operation, mainly during drilling of the upper sections. The planned discharge to sea is totally approx. 181 tonnes, containing 132 tonnes yellow substances. The density of WBM is in the range 1,4-1,6 s.g. The planned use of oil based mud will give no discharge to sea. The mud contain one component in the red category.

Drilling cuttings

In total approx. 371 m³ (1001 tonnes) of cuttings will be discharged to sea from the two top-hole sections (36" and 17,5" holes) with WBM hanging on. The total cuttings discharge including WBM are estimated to 551 m³ (1230 tonnes).

Cementing chemicals

The planned discharge of drilling cement is 224 tonnes, whereof 6 tonnes are components in the yellow category, and the rest is PLONOR components.

Rig chemicals

Rig chemicals that are planned discharged to sea are jacking grease (Statoil Multidope) with 2,0 tonnes which is a red chemical (68 % red fraction; 1,3 tonnes), and approx. 4,0 tonnes rig cleaning chemical (Cleanrig HP) which is a yellow chemical (0,5 tonnes yellow fraction). No hydraulic fluid is planned discharged. The planned discharge of drillpipe dope (Bestolife products) is approx. 29 kg, which contains approx. 14 kg red substance.

Planned discharge of testing chemical

Drill Stem Tests (DST) are planned and also fracturing and stimulation processes. The planned discharge of chemicals is 45 tonnes, whereof 23 tonnes are in the yellow category, and no PLONOR or red chemicals.

1.6.5 Summary of acute spill calculation and operational discharges

A summary of the potential spill scenarios and operational discharges during the drilling operations is shown in Table 6 and Figure 8.

Table 6. Summary of scenario statistics – acute spills to sea and operational discharges.

DSHA no.	Scenario description	Frequency (per operation)	Discharge quantity (m3)	Discharge Index	Fraction of discharge index
1	Topside oil blowout	2,9E-05	59 514	1,7	0,28 %
2	Topside condensate blowout	2,8E-04	30 575	8,5	1,39 %
3	Well release - oil case	2,3E-03	38	0,1	0,01 %
4	Diesel spill	0,1	1,0	0,1	0,02 %
5	OBM spill	0,02	1,0	0,0	0,00 %
6	WBM spill	0,02	50,0	1,0	0,16 %
7	Hydraulic oil spill	0,1	1,0	0,1	0,01 %
8	WBM discharge	1,0	120,7	120,7	19,61 %
9	Drill cuttings discharge	1,0	370,7	370,7	60,25 %
10	Cement discharge	1,0	77,2	77,2	12,55 %
11	Jacking grease	1,0	1,5	1,5	0,25 %
12	Rigwash chemical discharge	1,0	3,6	3,6	0,59 %
13	Testing chemical discharge	1,0	30,0	30,0	4,88 %

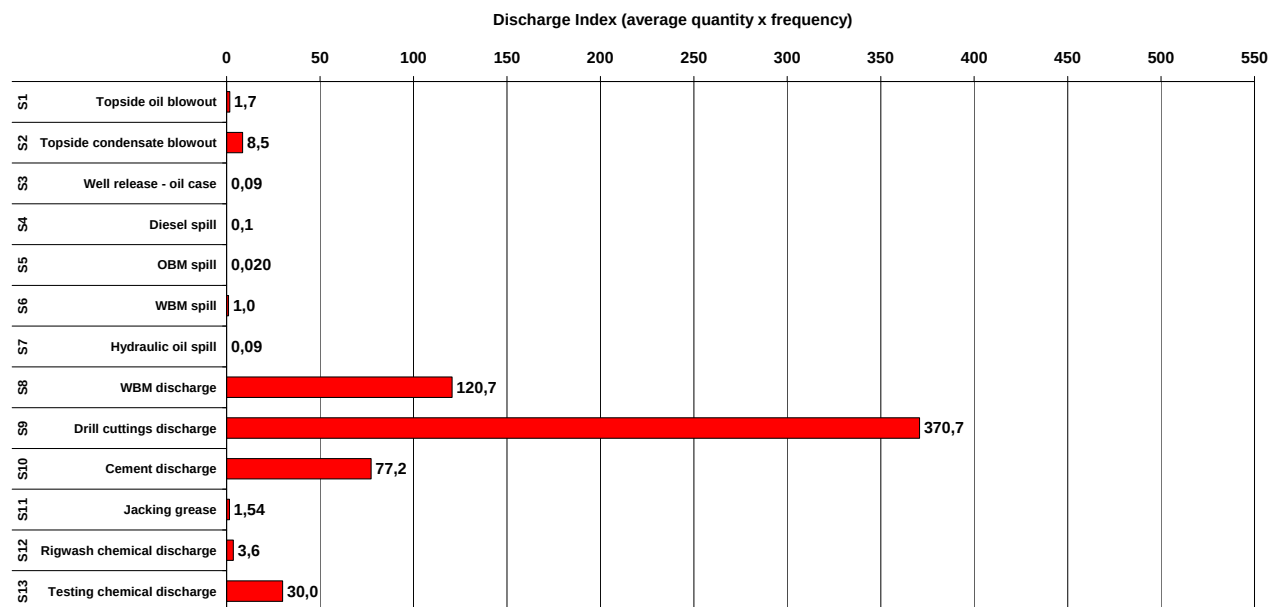


Figure 10. Discharge index representing the combination of quantity and frequency

The discharge index based on frequency and discharge quantity summarises as follows:

- Blowouts and well releases (#1-3): 1,7 %
- Acute minor spills (#4-7): 0,2 %
- Operational discharges (#8-13): 98,1 %

1.7 Fluid characteristics and weathering properties

When petroleum hydrocarbons are discharged to sea a number of weathering processes will start, such as evaporation, mixing into the sea, dilution and emulsification. The rate of the processes depends particularly on oil characteristics and weather conditions. Eventually, relatively stable oil-in-water emulsions will form, with up to 80% water content. Usually, such an emulsion slick will be distributed on the sea with approx. 90% of the oil quantity in 10% of the slick area. After some time on the sea surface, downmixing rates will be very slow.

Oil at Pi is assumed to be similar to the Varg oil. This oil is a parafinic oil, with density of 845 kg/m³. After 1 day at sea under winter conditions and with 10 m/s wind 32% is evaporated and about 20% is naturally dispersed. The oil will form stable emulsion with a maximum water content of about 50% under winter conditions. The viscosity will increase to approx. 25000 cP (winter conditions). (SINTEF 2000, SINTEF 2004). The wax content is approx. 5,5%. Thus under situations with calm sea and low temperatures, the oil may stiffen. This indicate the need for Hi-Wax skimmer.

The density of the Pi condensate is estimated to 776 kg/m³ based on reservoir data evaluations (WFD, 2007). The density values for condensate from the nearby Rev field (former Varg South) is 790 kg/m³.

1.8 Oil Drift simulations

Det Norske Veritas (DNV 2007) has performed statistical oil drift simulations caused by a top side release of both oil and condensate at well N15/12-Pi North in position -270055 m E, 6503940 m N (UTM zone 33). The oil drift simulations are carried out with the oil drift model OILTRAJ. The model calculates among others oil pollution probability, mass factors (evaporated, dispersed and remaining part of oil) and drift time in a 10×10 km grid.

The simulations are performed for the whole year (300 simulations pr month) for release durations 2, 15 and 42 days with probability distribution 47%, 25% and 28% for both the oil and condensate release (WFD 2007). For the oil and condensate blow-out scenarios the rates 3469 Sm³/d and 1871 Sm³/d are used respectively.

For the oil case scenario the shortest drift time to the coast is 7,2 days. Figure 11 shows that 95% of the drift times to the coast are longer than approx. 13 days while Figure 12 shows that the stranded amount without any contingency systems in place are less than approx. 770 m³ in 95% of the simulations.

For the condensate release the influence area is much smaller than the oil release case. The slicks from the condensate release will experience stronger evaporation and down mixing and the condensate slicks will have shorter existence on the surface. None of the 3600 simulations result in stranding of oil.

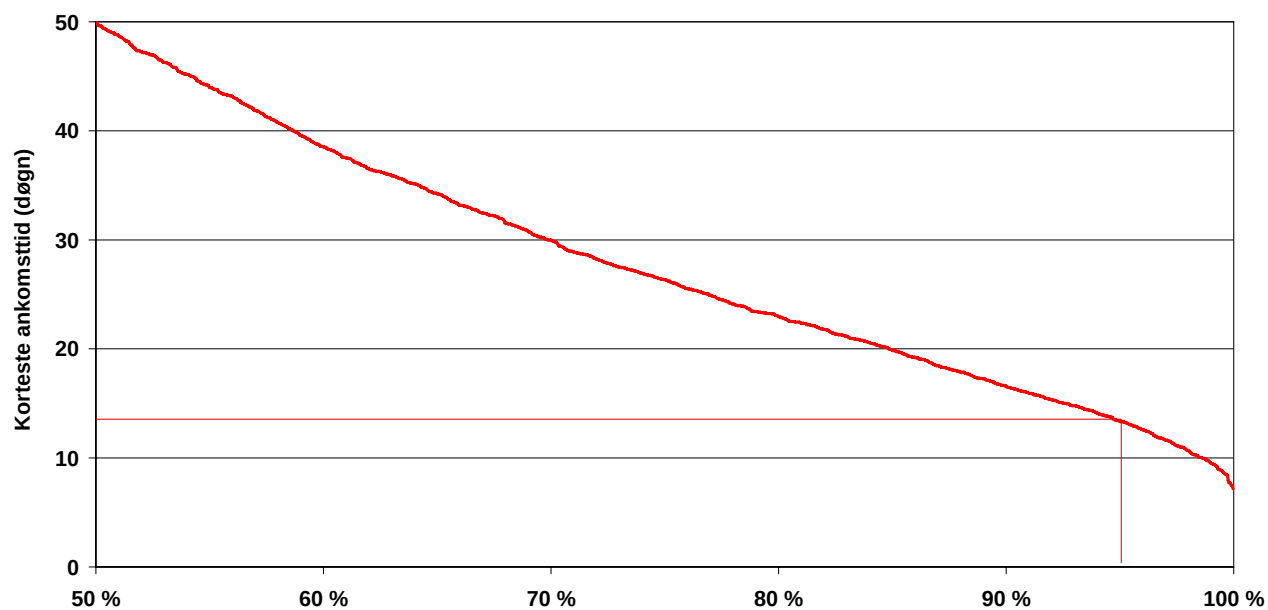


Figure 11. Statistics for drift time to shore (oil case, all simulations).

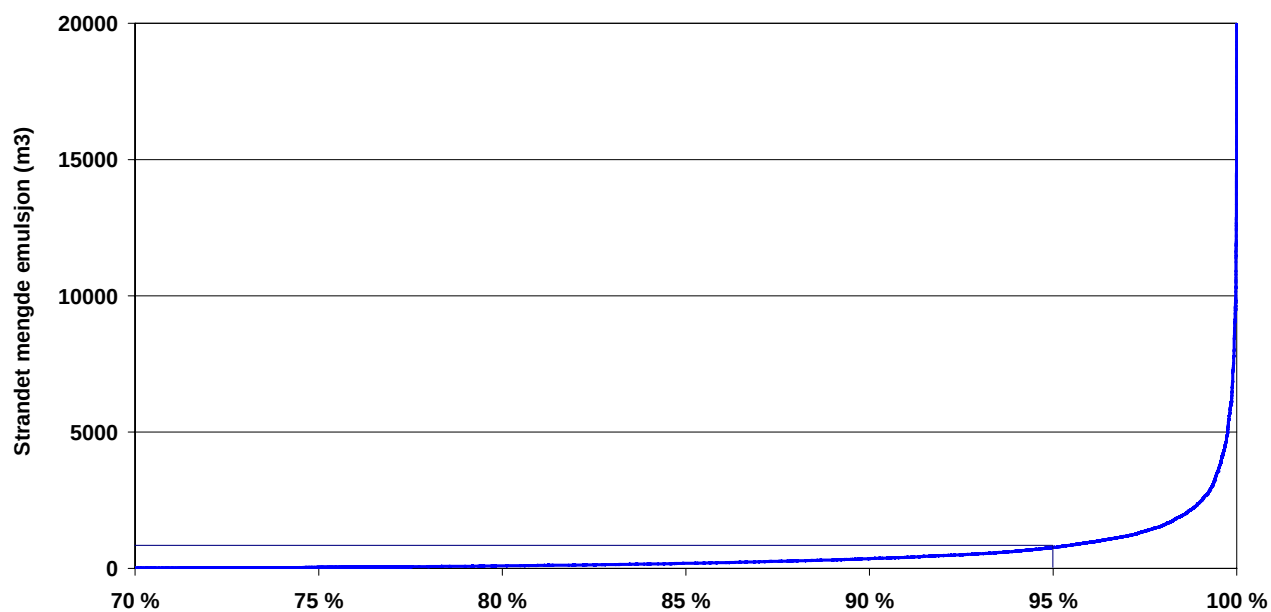


Figure 12. Statistics for stranded emulsion without any contingency systems operating (oil case, all simulations).

1.9 Area of influence

Although Pi is expected to be a condensate field and the probability for oil versus condensate is expected to be only 10%, the area of influence has been defined based on oil drift simulations. The simulations were done for the whole year with 300 simulations pr month for both the oil and the condensate case. The simulations were run with the dimensioning rate of 3460 m³ oil/day and 1870 m³ condensate/d and for release durations 2, 15 and 42 days with a probability distribution 47%, 25% and 28% for both the oil and condensate release (Well Flow Dynamics (WFD) 2007).

The result from the oil drift simulations for Pi are presented in Figure 13. The area of influence is defined as the area with more than 5% probability for more than 1 tonne of oil within a 10x10km area. The figure shows the probability for pollution with > 1 tonne oil in any square of the influence area.

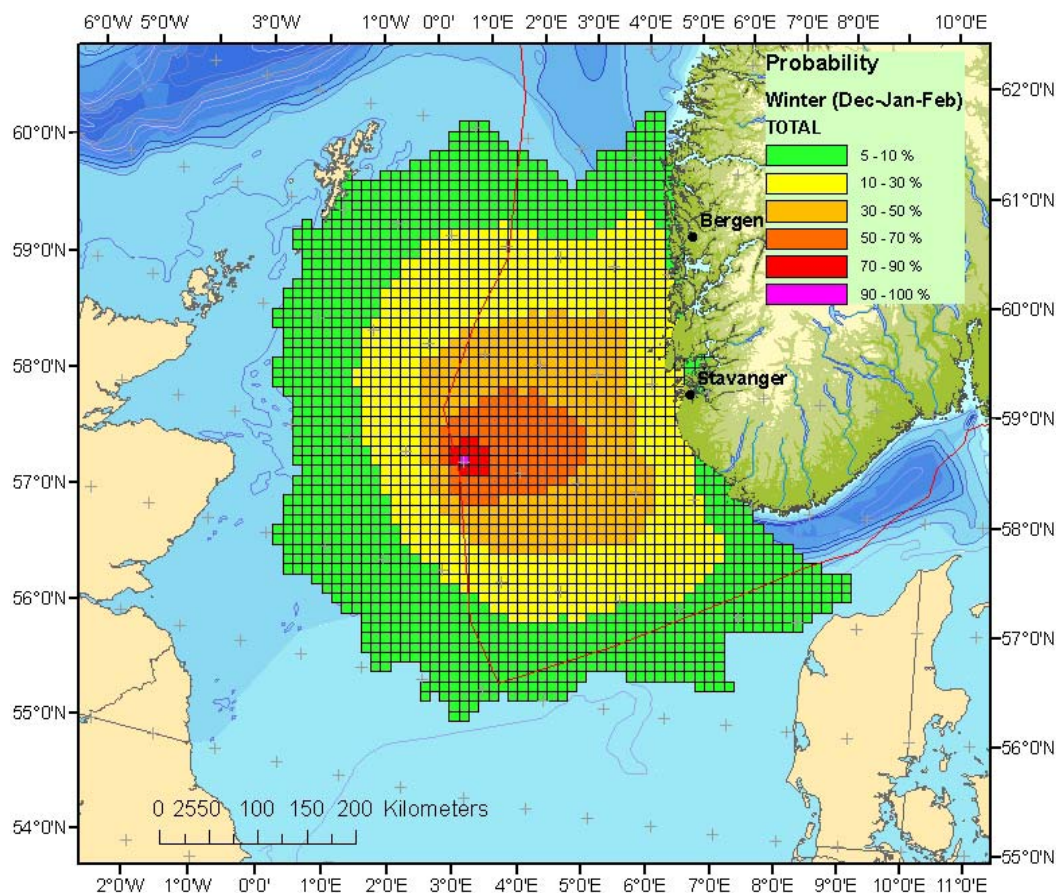


Figure 13. Area of influence for a potential blowout from Pi, with probability for pollution with > 1 ton pr 10*10 km square.

The area of influence is larger than what is usually experienced in an Environmental Risk Analysis. The reason for the large influence area is the relatively high probability of long duration blowouts that has been applied based on recommendations from Well Flow Dynamics.

2 Environmental description

2.1 Water masses

The area is dominated by Atlantic water masses. The direction of the currents in the drilling location is mainly from west. During winter the water masses are mixed from surface to bottom. During summer there will be a pronounced stratification of the water masses, with a 20-40 m surface layer of water with high temperatures (14-18°C) and a colder bottom layer with somewhat colder water (around 10°C). Such stratification is not apparent in the winter season.

The temperature of the water masses at 10 m depth changes during the year, and the average temperature in each season is:

- Winter: 7-9°C
- Spring: 5-8°C
- Summer: 10-13°C
- Autumn: 12-15°C

For the water masses; winter season, according to definitions in Levitus 94, is November, December, January and February, spring is March and April, summer is May, June and July and autumn is August, September and October. Data from Levitus94 web database.

2.2 Weather statistics

Wind

Wind speed, wind direction and wave heights in the North sea are variable throughout the year. The prevailing winds in the Pi area are from the SW directions (statistics from Sleipner).

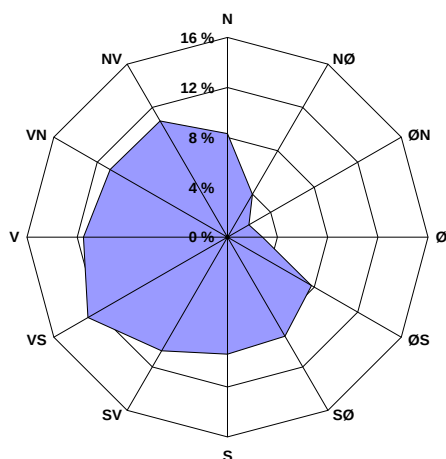


Figure 14. Wind directions in the North Sea, January-March (location Sleipner).

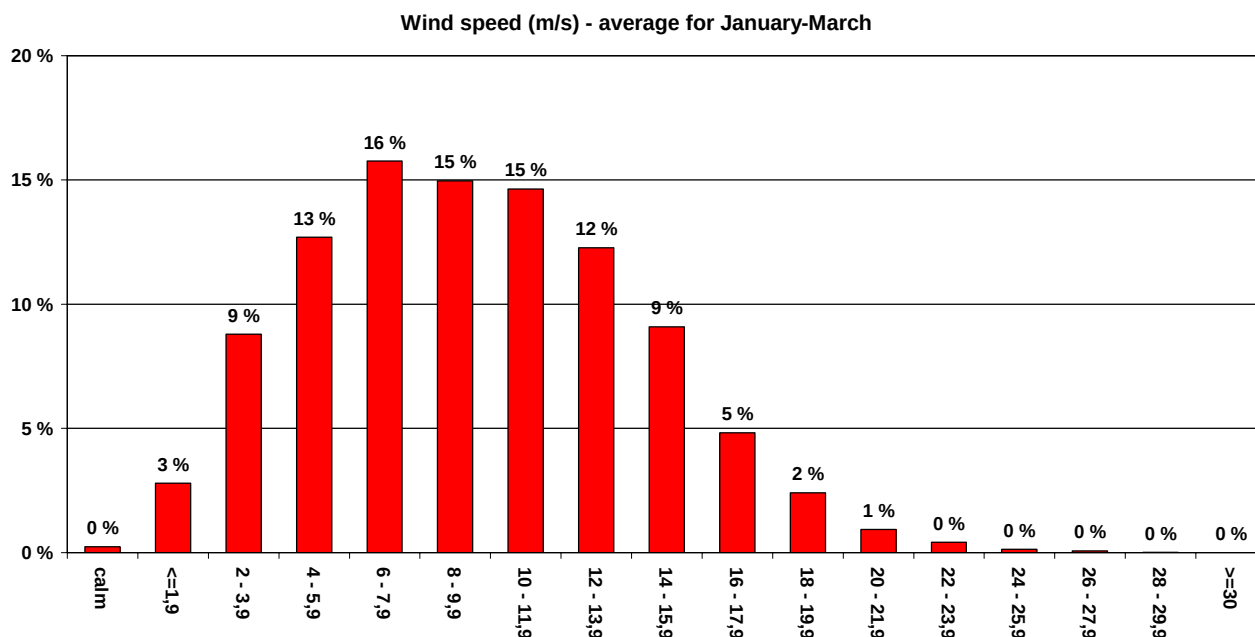


Figure 15. The wind speed from Sleipner (1995-2005) for January-March.

The wind rose shown in Figure 14, indicates that winds in January-March are from the northwest, west, and southwest for more than 50% of the time. Periods exist for calm in approx. 0,2% of the time.

Figure 15 shows that the wind speed is less than 14 m/s in 82% of time. A wind speed of 15 m/s is set as a limitation for the use of mechanical recovery systems, while ship dispersion systems may be used up to 20 m/s.

Waves

At significant wave heights above approx. 4,5 m, oil spill contingency actions will be ineffective. Wave statistics (MI weather statistics database; Sleipner) show that wave height is above 4,5 m for different period of time during the seasons as follows:

- Spring (March-May): 8 %
- Summer (June-August): 0 %
- Autumn (September-November): 14 %
- Winter (December-February): 25 %
- Annually: 12 %

For all other parameters than water masses the seasons are defined as above.

Statistics for wave heights from Sleipner (1995-2005) is shown in Figure 16.

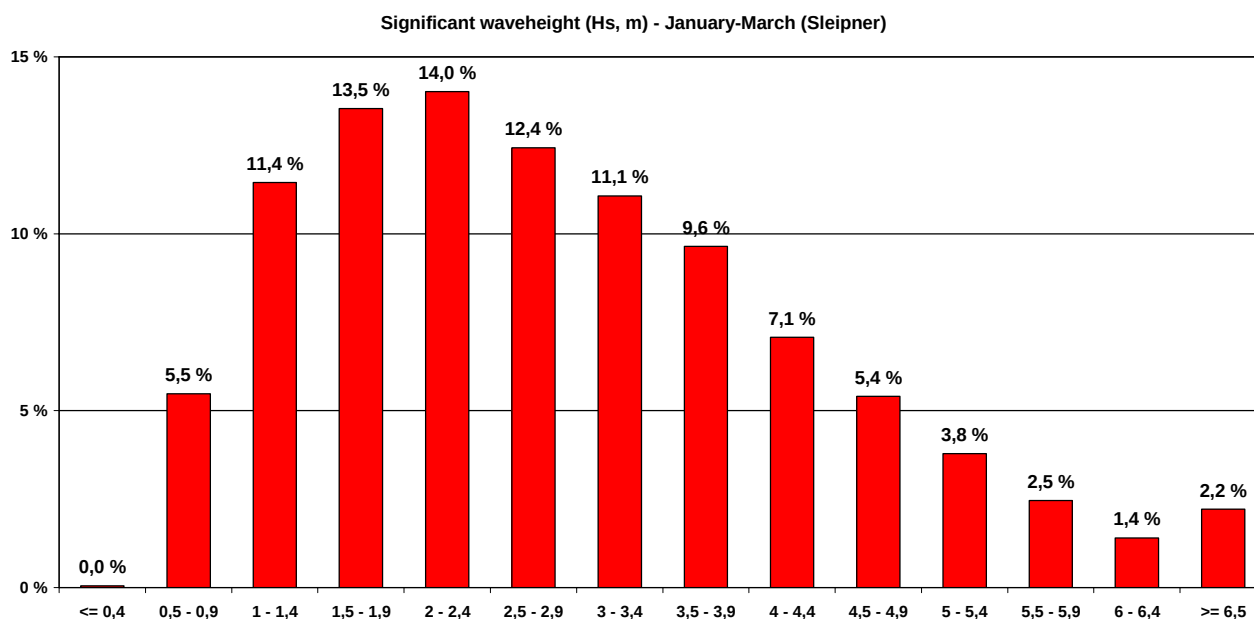


Figure 16. Wave statistics from Sleipner – January-March.

In the periode January-March the wave height (Hs) is statistically more than 4,5 m in approx. 15% of the time.

Daylight

Daylight is of importance for oil spill contingency actions. The daylight period is defined as the fraction of time during the day (24h) where the sun is above 6° under the horizon. During the seasons the fraction of daylight is varying as follows at 58° latitude:

- Winter: 36%
- Spring: 68%
- Summer: 83%
- Autumn: 46%

2.3 Salinity and water Quality

The salinity of the North Sea reflects the mixing of fresh water from rivers and from the Baltic Sea with the marine influxes from the Atlantic and from the English Channel. Seasonally and year on year the salinity contours in the North Sea can change. Since 1970 the central North Sea mean sea bottom salinity has remained stable in the range 34,8-35,2‰. Salinity can vary in relation to water depth. In the Central North Sea, seabed salinity can be 0,6 ‰ greater than surface salinity in winter. The difference is less pronounced in summer.

2.4 Sediments

The sea bottom is dominated by loose sand with patches of coarser material, probably shell or gravel banks. The area is not a deposition area and the sea depth is between 80 - 90 m. The benthic fauna in the open sea areas consist mainly of animals and bacteria that are dependent on food supply from the upper waters. The benthic fauna consist normally of species rich communities

dominated by polychaetes. However, there are large occurrences of mussels, crustaceans and echinoderms (e.g. brittle stars). These animals are characterised by relatively high reproduction rate and multi-annual life cycle. The biomass decreases normally with the depth and consist of an average of 20 g/m² for deep water societies. The fauna form an important food source to benthic fish species like haddock and plaice.

2.5 Cold water corals

There are no registrations of cold water corals (*Lophelia* communities) in the area of the drilling location, the closest one being close to Bømlo in the county of Hordaland.

2.6 Seabirds

The vulnerability of seabirds has been thoroughly assessed (Anker-Nilssen 1994, AMBIO 2006). The seabirds at highest risk include pelagic diving seabirds such as Guillemot, Puffin, Razorbill, Little Auk, and coastal diving seabirds such as Eider, Cormorant, Shag, Long-tailed Duck, Common Scooter, Velvet Scooter, Black Guillemot, Red-throated Diver, Black-throated Diver, Grebes.

The species that have the strongest connection to the open sea include members of several families, most notably auks, gulls, petrels and gannets. Some of these birds come only ashore to breed and even in the breeding season many of them spend the majority of their time feeding at sea, often tens of kilometres away from their colonies. Inshore birds include seaduck, divers, cormorants and terns, as well as some gull species and one auk (black guillemot). These birds normally occur within sight of land although they may move further offshore, especially in areas of shallow waters. Although some breed in substantial numbers, the North Sea is of greatest importance to most inshore species in autumn and winter. (Carter *et al.* 1993). Birds that feed on inter-tidal areas such as sand and mud flats are the most coastal bird species. The North Sea is particularly suited to these species because of its large tidal amplitude and relatively mild climate, which prevent mud flats freezing for most of the winter. The North Sea is mainly a staging post for some species of birds on passage between breeding grounds to the north and wintering areas further south. Other species spend the winter along North Sea coasts.

Areas with vulnerable seabird in the North Sea is presented in Figure 17, based on data from the Marine Resource DataBase (MRDB 2006). These data indicate that spills from the drilling location to a little extent will affect areas with high vulnerability for sea birds to oil spills at open sea in the winter months (February). This is corresponding to the common consideration in most Environmental Impact Assesments done for this area.

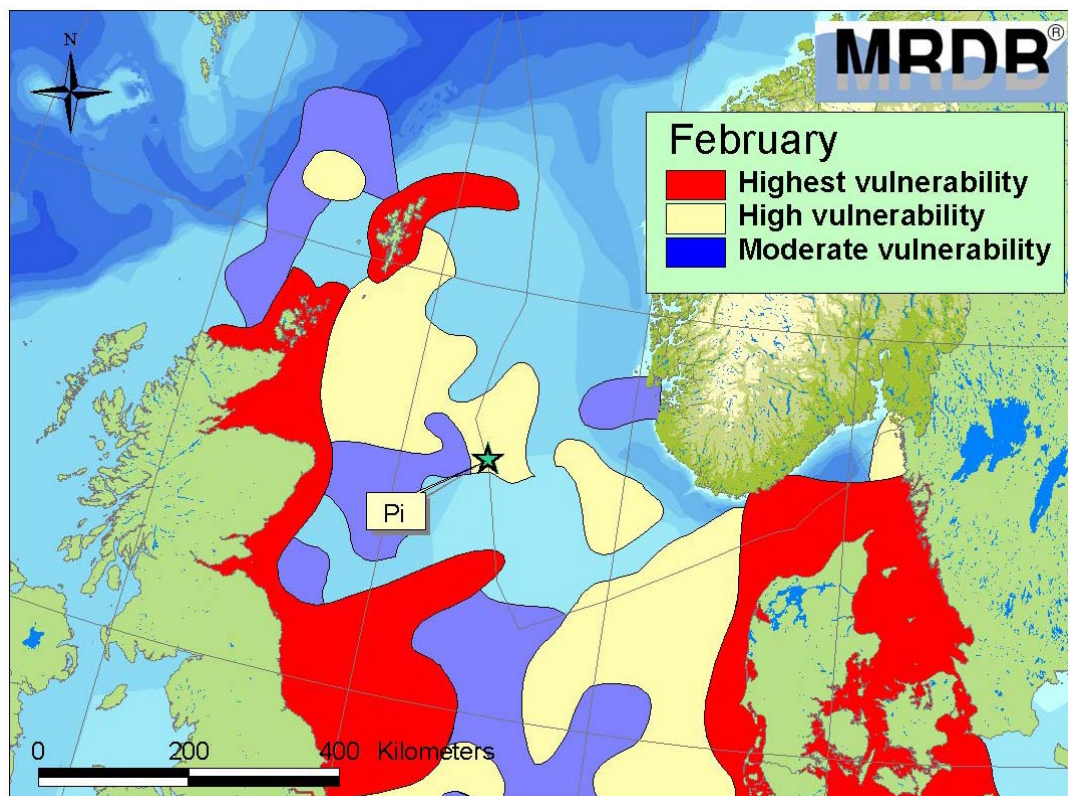
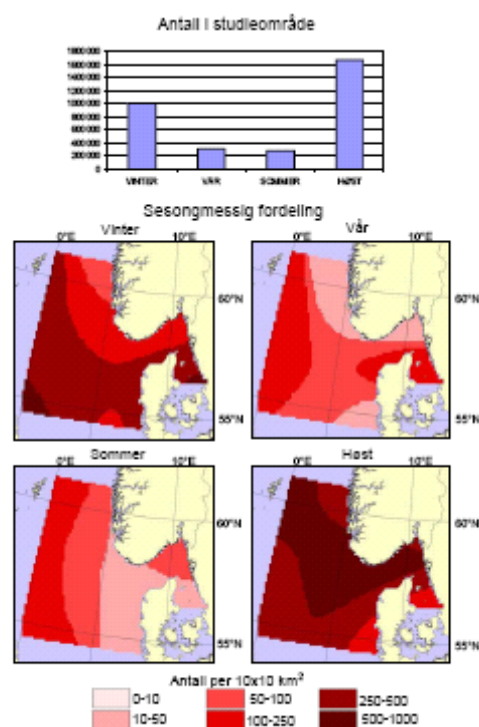


Figure 17. The most important seabird areas in the North Sea presented in the winter season (February) vulnerability. Red = highest vulnerability, yellow = high vulnerability, blue = moderate vulnerability (MRDB®).

However NINA (2006) has recently described the distribution of seabirds in the Norths sea based on observations and modelling efforts. One example of the results from this investigation is given in Figure 18 which shows the seasonal variation and expected density of common guillemot in the North Sea and Skagerrak area. The highest density are found during autumn, when as much as 1.6 million guillemots may be present in the influence area of Pi. During winter, the numbers are lower (about 1 million guillemots) and the density are highest in the southern parts of the investigation area, but still there may be high densities in the area where Pi is located.

Figure 18. Seasonal variations and predicted average density of common guillemot in Skagerrak and the North Sea (NINA 2006).



Furthermore the 2nd Strategic Environmental Assessment for offshore activities in the North Sea (SEA2 2001) both describes the overall and seasonal vulnerability of seabirds, shown in Figure 19. The right side of the figure shows that the vulnerability is very high at least in some months (autumn and winter) in areas close to Pi, although the overall vulnerability is higher closer to the British coast.

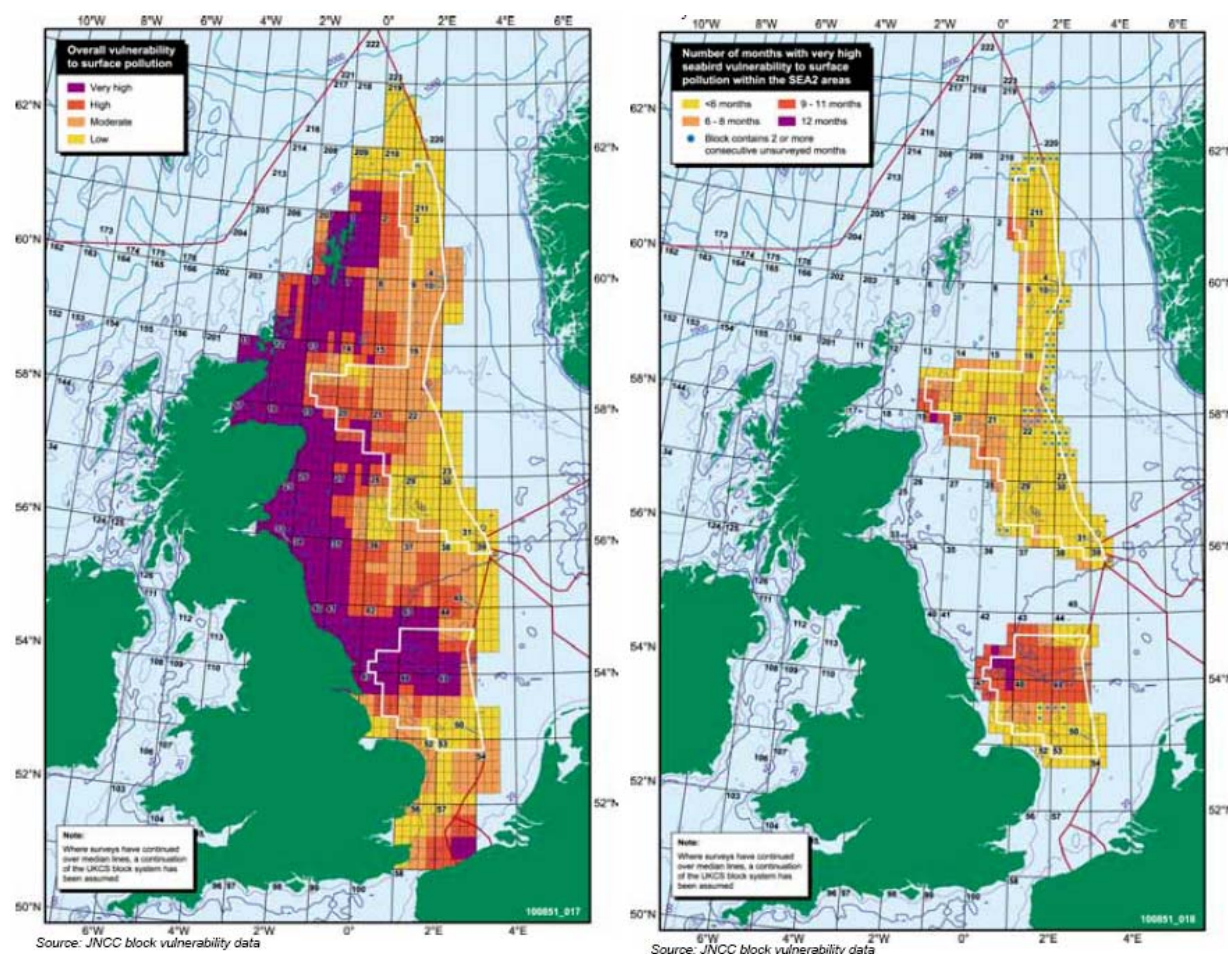


Figure 19. Overall (left) and seasonal (right) vulnerability of seabirds in the UK sector of the North Sea (SEA 2 2001).

Therefore we consider the probability for polluting areas with large number of seabirds if a blowout should occur at Pi as relatively large. However the seabirds tend to gather in large flocks and there is large variation in their presence in an area at any time. Thus predicting the impact or risk to seabirds is a fairly complex and difficult issue. In some cases many birds may perish as a result of a small oil spill (e.g. Styliis 1981), while in other cases only few birds die even under large oil spills.

2.7 Sea mammals

There are several species of whale and seals in the area of influence of the drilling location. Common whale species are Porpoise, Killer whale, Sperm whale and Minke whale but these are not considered vulnerable to oil spills or chemical spills or operational discharges from the drilling operation.

Common seal species are the Harbour seal (“steinkobbe”) and the Grey seal (“havert/gråsel”). Grey seals occur mainly in the outer parts of the coast of Norway and UK, and give birth on very exposed skerries in the period September-December. In this period the new born are vulnerable to oil pollution. The grey seal colony at Kjør outside Rogaland has about 10-30% probability to be affected by a accidental top side oil spill.

Harbour seals occur more frequently in the inner parts of the coastal zone, including fjords. The whelping period is in the summer time (June-July), and neither adults nor youngster are considered vulnerable with respect to oil or other spills from the drilling location in the winter period.

Otters are not considered at risk from potential spills from the drilling location.

2.8 Fish resources

For fish species it has been shown that eggs and larvae may be very vulnerable to oil concentrations in the waters, while larvae larger than ca. 2 cm (6-8 weeks old) are vulnerable to a lesser extent. In the North Sea the spawning products are spread over larger areas and time periods compared to Norwegian areas further north. It is primarily the zone closest to the spawning areas that may have the largest potential to harmful effects to fish stocks (Havforskningsinstituttet 2006). Recently hatched saithe larvae are especial vulnerable to oil pollution. Eggs and larvae of cod are also quite vulnerable; however larvae of herring in laboratory tests have proven less vulnerable.

Many commercially important fish species spawn and have their breeding areas in the North Sea. Spawning areas for species important for the Norwegian fishery in the North Sea are presented in Figure 20. The Pi drilling location is located within the spawning areas for Norway pout and mackerel, and close to the spawning areas for saithe and mackerel. The peak spawning periods for these species are presented in Table 7. As the drilling according to the plans will start in September these species is not expected to be affected.

In its 2006-report on marine resources and environment the Institute of Marine Research describes a weak recruitment over the last 3 – 4 years to the stocks of sandeel, Norway pout, cod and to a certain degree herring in the North Sea (Havforskningsinstituttet 2006). This development is mainly due to changes in physical and biological conditions, but the cod and sandeel stocks also suffer from overexploitation. According to the Institute the cod fishery in the North Sea should have stopped several years ago. Furthermore, illegal landings and dumping of catches makes it difficult to estimate the species’ size, especially mackerel and cod.

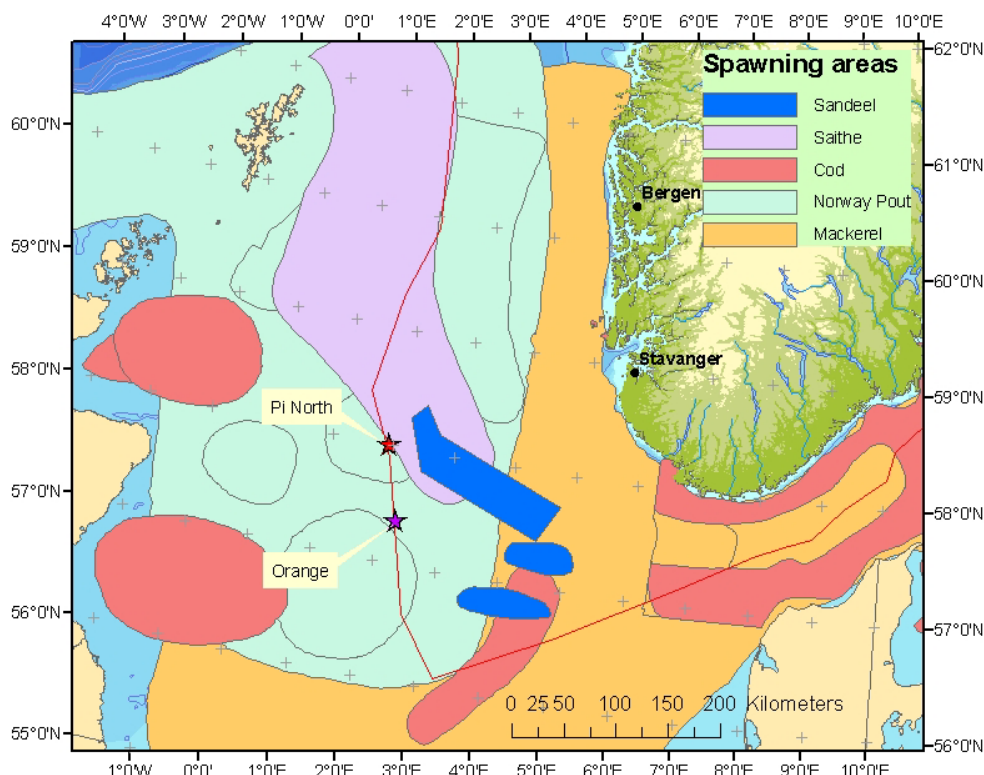


Figure 20. Spawning areas for commercial important fish species in the North Sea (MRDB® 2006 edition).

Table 7. Spawning periods for species spawning in area surrounding the drilling location (Havforskningsinstituttet 1991).

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Norway pout												
Mackerel												
Cod												
Saithe												
Sandeel												

The fishery for reduction to fish meal and oil is mainly based on sandeel, Norway pout and blue whiting. Due to a high percentage of fats and good quality of the meal, sandeel is the most sought after species. Fishmeal and oil are important as food in the fish farming industry. Sandeel plays an important role in the marine ecosystem as it is important as food for several fish species and whale. For the time being the sandeel stock is very weak. The sandeel fishery is closed, and will only be reopened if a planned research fishery shows an increased stock. The Norway pout stock is at a historically low level, combined with a risk for low recruitment. The fishery for Norway pout was closed in 2005, and remained closed in 2006. The blue whiting stock seems to be inside safe biological limits. All year classes after 1995 are strong, or very strong, compared to the recruitment in the period 1991 - 1994.

The most important species in the purse seine fishery are herring and mackerel. The herring stock is harvested inside safe biological limits. But the three latest year classes are the weakest since the stock collapsed in the 1970-ies. This weak recruitment calls for a special attention to secure the

stock in the coming years. The north-east Atlantic mackerel stock has been decreasing since 1998. The catch level is much higher, perhaps the double, of the reported catches. This leads to a very high uncertainty on the real stock level.

In the whitefish trawl fishery with bottom (otter) trawl the main catches are a mix of cod, haddock and whiting. The trawl fishery for reduction purposes and the beam trawl fishery for flatfish both cause a high mortality for the youngest year classes of these species. The spawning stock for North Sea cod is at a historical low level, and the harvesting is not within sustainable limits. ICES have recommended a full stop in the cod fishery. The spawning stock of saithe is in good condition, and the mortality is inside safe biological limits.

2.9 Fishing activity

It has been collected data on the trawl and purse seine catches in the area surrounding the exploration well from the Directorate of Fisheries. The trawl and purse seine catches in the area surrounding the exploration well are presented in Table 8. The table shows that no whitefish trawling has been conducted in this specific area in recent years. According to the Directorate of Fisheries it was earlier an important foreign, mainly Scotch, fishery in the area. The foreign fishery has decreased in recent years, and is today limited to a sporadic British trawl fishery and a sporadic Danish fishery with Danish seine (Kolle 2005).

Table 8. Norwegian catches in the area surrounding the exploration well. The locations include areas in the UK sector. Catch in 1000 tonnes live weight (Fiskeridirektoratet).

Trawl catches	Block 7/7 to 7/12 Location 4172			Total Norwegian catches in the North Sea ³⁾		
Year	-97	-00	-04	-97	-00	-04
Trawl catches:						
- consumption ¹⁾	-	-	-	36,5	23,5	47,9
- reduction ²⁾	2,1	0,3	0		252,1	161,0
Purse seine		-	0,3		231,0	263,5

1) The main part of the trawl catch for consumption is saithe.

2) The main part of the trawl catch for reduction in/near the Ekofisk area is sandeel.

3) Catch in statistical areas 08, 28, 41 and 42, corresponding to the North Sea between 53°30'N and 62°N, and east of 4°W.

On the North Sea banks sandeel is the most important species in the trawl fishery for reduction purposes. Some sandeel catches are reported in the fishery statistics location where the exploration well is located. These catches will be related to the northeast corner of this statistical location (block 7/7 to 7/12), been close to the sandeel areas further northeast. Possibly some of these catches are misreported in this specific location. No regular sandeel fishery is conducted near the exploration well.

In fisheries with purse seine or mid-water (pelagic) trawl for herring and mackerel the fishing areas will depend on both the stocks migration and regulations conducted by the authorities, both varying from year to year. As a result, these fisheries are generally considered as not affected by drilling activities. According to the fishery statistics it was caught 300 tonnes herring in 2004 in the location corresponding to block 7/7 to 7/12. This confirms that this area has not been important for purse seine fishery in recent years.

2.10 Aquaculture

Several aquaculture sites are located within the area of influence for PI. Potential impact to such sites are considered to be associated with cleanup and restrictions on production and sale, and not direct toxic impact to the fish stock. Approx. 550 sites are registered within the area of influence (Figure 21). During a spill it is assumed that maximum 10% of the sites can be affected if the oil spill enters coastal areas to a significant extent.

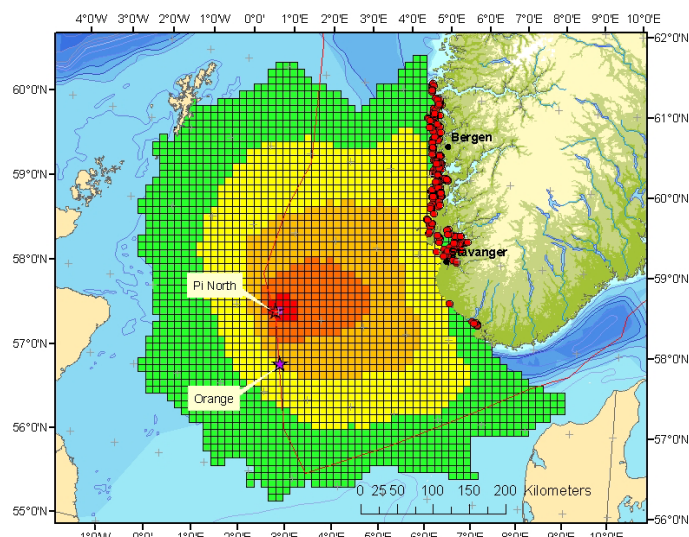


Figure 21. Location of registered aquaculture sites within Pi area of influence. (MRDB® 2006)

2.11 Important coastal areas

NOFO Planverk describes important areas for high priority during combat actions (Figure 8). These areas are locations with high occurrences of environmentally prioritised locations and which are important for designing of oil spill contingency systems (NOFO Planverk, <http://planverk.nofo.no>). Accidental spills from the exploration drilling are may affect some of these areas.

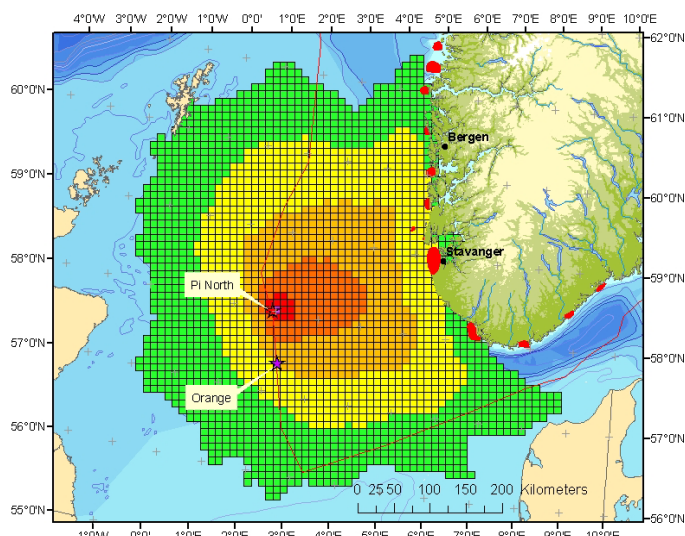


Figure 8. NOFO Planverk's important coastal areas.

The coastal areas of Norway, and particularly in the southern parts, are widely used for recreational and outdoor activities. Oil pollution can potentially cause extensive inconvenience to a large number of people, particularly in the spring and summer, and to a lesser extent in autumn and winter months. Particularly valuable areas for recreational activities are listed as “secured” (“sikrede”) area, but no such areas are within the area of influence for the well.

The concept of SMO (“spesielt miljøfølsomme områder”) has been developed by SFT and DN (SFT & DN1999). Based on the most recent scientific data on occurrences of natural resources, the criteria developed provides a tool for identification of the areas and resources that are considered to be the most sensitive to oil pollution incidents. Hence the SMO data provides a prioritization of the mapping and description of resources in the previous sections. However the information about SMO areas are not available through MRDB, thus it has not been used in the assessment.

2.12 Recreational areas

The coastal areas of Norway, and particularly in the southern parts, are widely used for recreational and outdoor activities. Oil pollution will almost in any circumstances cause extensive inconvenience to a large number of people, particularly in the spring (partly), summer and autumn (partly) months. In winter the inconvenience will be less, depending on the extent and duration of oil pollution.

Particularly valuable areas for recreational activities are listed as “secured” (“sikrede”) area. Nearly Approx. 293 such areas in the outer coastal zone are identified within the influence area for the Pi drilling operation (Figure 22). Lista and the beaches of Jæren (“Jærstrendene”) are particularly important recreational areas.

During a spill it is assumed that maximum 10% of the sites in the influence area can be affected if the oil spill enters coastal areas to a significant extent.

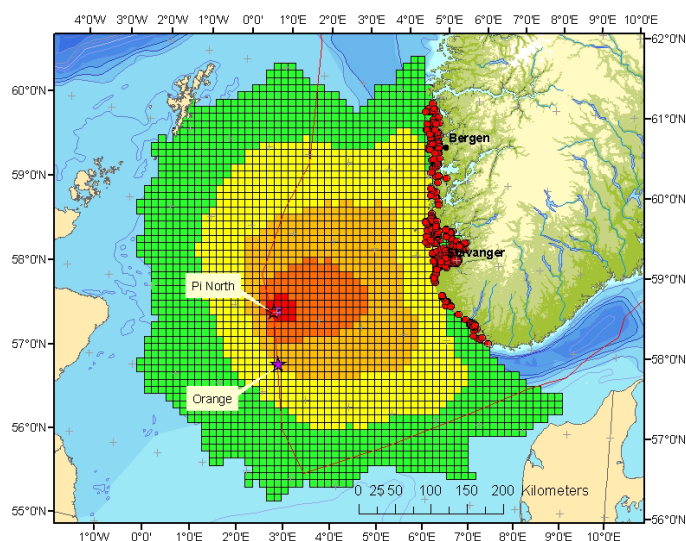


Figure 22. Secured outdoor life sites within the area of influence of Pi. (MRDB®2006)

2.13 Background pollution

The background pollution level must be described as basis for assessment of potential effects of oil spills or other discharges (ref. the Management Regulations §16).

A comprehensive quality status report describes the pollution status and input to the North Sea and Skagerrak area (OSPAR 2000).

Inputs of heavy metals occurs both from rivers (e.g. 36-64 tonnes/year cadmium and approx. 1000 tonnes/year lead) and from the atmosphere (e.g. 15 tonnes/year cadmium and approx 1500 tonnes/year lead).

The “natural” background levels (BRC) and ecological assessment criteria ¹ (EAC) in sea water of some priority heavy metals are:

	BRC	EAC	Factor above EAC
• Cadmium (Cd)	5 – 25 ng/l	0,01 – 0,1 ng/l	50 – 2500 x
• Mercury (Hg)	0,1 – 0,5 ng/l	0,005 – 0,05 ng/l	2 – 100 x
• Lead (Pb)	5 – 20 ng/l	0,5 – 5 ng/l	1 – 40 x
• Copper (Cu)	50 – 360 ng/l	0,005 – 0,05 ng/l	1000 – 72000 x

For both cadmium and copper the levels are alarming high. However, it has not been reported negative effects on marine organisms in the open waters of the North Sea.

Other pollutants such as polychlorinated biphenyls (PCB) that are persistent and bioaccumulate, can be found in all biota in the North Sea, but the levels are not as alarming high as in arctic areas. Because of the prohibition to use PCB the levels are generally being reduced.

Other synthetic pollutants (such as dioxins, furans, hexachlorbenzene, pesticides) mainly represent a problem in some coastal and fjord areas.

PAH (polyaromatic hydrocarbons) are discharged to the North Sea from offshore installations, oil spills and ship transport. The ranges of background/reference concentrations (BRC) and Ecological assessment criteria of PAHs in the surface sediments for the northern North Sea and Skagerrak has been reported by OSPAR (2000):

	BRC	EAC	Factor above EAC
• Benzo(a)pyrene	8,8 – 112 µg/kg dw	0,1 – 1 µg/kg dw	9 – 1120 x
• Fluoranthene	14 – 160 µg/kg dw	0,5 – 5 µg/kg dw	3 – 320 x
• Benzo(b+k)fluoranthene	46 – 434 µg/kg dw	-	-
• Pyrene	11 – 128 µg/kg dw	0,05 – 0,5 µg/kg dw	22 – 2560 x

PAH have very low water solubility and will tend to bind to particulate material and sediment in fall-out areas such as the Norwegian trench. The levels of PAH in sea water are either at the BRC level or lower. Although the levels of PAH are high, the risk of negative effects on marine organisms are reasonable low due to the fact that most organisms have well-developed enzymatic or other means for metabolising and excretion and of PAH compounds.

¹ EAC is defined as the concentration level of a substance above which concern is indicated.

Other sources of discharge of petroleum hydrocarbons are riverine inputs from the countries surrounding the North Sea and also produced water discharges from offshore installations. The total volume of discharged produced water in the Norwegian sector was 177 million m³ in 2005, an increase of 53% since 2000 (OLF 2006). None of the major contributors are in the near vicinity of the drilling location.

3 Environmental risk assessment

The environmental effects of oil when spilt to the sea are numerous, and depend on the combination of oil type and quantity, weather conditions, and the presence of vulnerable resources.

The potential effects of oil in Norwegian offshore/onshore areas have been assessed during a large number of studies and assessments. An important basis is the factual reports to the recently updated “Regional KonsevensUtredning for Nordsjøen” (RKU 2006), the RKU (1999), and the “Oil spill impact review” by SFT (1993).

3.1 Impact assessment

When petroleum hydrocarbons are discharged to sea a number of weathering processes will start, such as evaporation, downmixing, dilution, emulsification. The rate of the processes depends particularly on oil characteristics and weather conditions. Eventually, relatively stable oil-in-water emulsions will form, with up to 80% water content. Usually, such an emulsion slick will be distributed on the sea with approx. 90% of the oil quantity on 10% of the slick area. After some time on the sea surface, downmixing rates will be very slow.

The environmental effects of oil are numerous, and depend on the combination of oil type and quantity, weather conditions, and the presence of vulnerable resources. Important factors used in semi quantitative assessment of environmental impact of spills and operational discharges are briefly described below. In the assessment each of the factors are evaluated by an expert panel for each of the scenarios defined. The numbers below are the parameters listed in Table 9.

1. **Recovery time**; estimated time from discharge to the environment (biological resources) are recovered (comparable to pre-spill situation taking into account natural variation). The recovery time is evaluated according to principles described in MIRA (OLF 2005). This parameter is used standalone for evaluating environmental risk against the defined acceptance criteria. The other parameters are used for an additional relative risk ranking of all defined discharge scenarios.
2. Number of environmental and economical **resources affected**: resource types (in total 17 types) are defined as seabirds, sea mammals, fish, phytoplankton, zooplankton, shoreline habitats (littoral zone and beaches), coral reefs, seabed fauna and sediments, fisheries, aquaculture, tourism, water resources, ports and marinas, other industrial activity. This is done by a standardised counting matrix
3. **Ecological/conservation value/interest** of affected resources. The impact values are evaluated according to principles described in MIRA (OLF 2005) and information from MRDB (2006). Definitions of conservation values are also defined in the MOB model (SFT 2000). If a resource of a given value (e.g. national) according to table 9 is present, the impact value is set corresponding to the value of the resource (e.g. iv = 4) for the scenario considered.
4. The estimated **size of affected areas** in open sea and in the coastal zone (based on site and activity specific oil drift simulations). The spill is assumed to affect 10 times the area of the spill volume distributed with an average film thickness of 1 mm.
5. The **degradability** of the pollution (biological and/or mechanical/chemical) indicates the duration of harmful effects. The evaluation includes assessment of fluid characteristics and

weathering properties (gas, condensate, crude oil, diesel, hydraulic oil), and potential for degradation of the released chemicals etc.

6. The estimated **quantity** of pollution on shorelines based on oil drift simulations. The 95 percentile of the stranded amount from the oil drift simulations is used in the assessment.
7. The estimated size of **areas with harmful concentrations** of pollution in water masses (e.g. oil concentrations > 30-50 µg/l). As 90% of the oil amount are found in 10% of the slick area, we assume that harmful concentrations will occur in a 10 m thick water mass under 10% of the affected area.
8. The estimated size of **areas on the sea bed** with harmful concentrations or amounts of pollution (e.g. persistent substances that can bioaccumulate). The volume is distributed by a 10 mm thick layer.
9. **Transfer** of effects to other parts of the ecosystems or new generations, e.g. the potential of bioaccumulation of pollutants with potential harmful effects on reproduction on survival, particular in relation to key species in the ecosystem. This is an evaluation of the potentials for trophic level or generational transfer of effect.
10. The significance for **fisheries** expressed as number of the affected vessels in combination with level of importance of the fisheries (local, regional etc). The impact values are evaluated based on relevant information from catch statistics, results from satellite tracking of fishing vessels etc. e.g. if a nationally important fishery takes place in the influence area in the actual period, the impact value is set to 5 (see table 9).
11. The significance for **aquaculture** expressed as the number of potentially affected fish/shellfish farms affected in combination with site specific information on the located farms (ref. Fisheries Directorate). 10% of the sites in the influence area of a given scenario is assumed to be affected.
12. The significance for the **recreational/outdoor** life expressed as the number of potentially affected areas with a "value" based on whether they are secured as recreational areas ("sikrede friluftsområder"). 10 of the sites in the influence area of a given scenario is assumed to be affected.
13. The significance for **ports and marinas** expressed as the number of vessels/boats potentially affected (effects such as cleaning of vessels). This is an evaluation of the size of the affected area (community, county, region,...)

The following impact factors are not directly used for the environmental impact assessment, but intend to provide additional factors and a wider basis for the decision making process within the company ("company impacts"). Inclusion of these factors will in general increase the total calculated risk.

14. Additional **workload** in the company related to investigations, correspondence and communication with authorities, follow-up and planning of mitigation and restoration measures. This is an evaluation of the workload that the company may face for the various scenarios.
15. The effect on the company **reputation** caused by the incident or planned operational discharges. Pre-planning and risk reducing measures, and contingency measures as well as management and follow-up of incidents may affect the company's reputation among authorities and the public in general. This is an evaluation of to what extent each of the scenarios may affect the company reputation.

16. **Economic costs** in relation to spill combat and mitigation, fines and compensation, investigations and research activities etc. Not included internal costs, administration etc. We assume a cost of 0,1 mNOK pr ton oil that must be recovered plus an additional 0,1 mNOK pr ton oil that are stranded for each scenario.

For all parameters available quantitative information on volumes, dissolution, drift, spreading and presence of environmental resources have been used in the assessment. Please note that the method applied are under development, thus changes and improvements in the methodology may be visible from one analyses to another, and for the same reason a full documentation of the method have not been prepared at the current stage.

Table 9. Impact matrix.

Nr.	Impact category Impact parameters	0	1	2	3	4	5	Weighting factors
1	Recovery time (year)	Not detectable	< 1 month	< 1 year	1- 3 year	3-10 year	> 10 year	15 %
2	Number of resources	None	1-2	< 5	< 10	< 15	> 15	5 %
3	Conservation Value of affected resources / areas	None	Local	Regional	County	National	International	5 %
4	Size of affected area on sea surface (km ²)	< 0,1	< 0,5	< 5	< 50	< 150	> 150	5 %
5	Fluid degradability (weathering properties)	Not relevant	Very fast (hours)	Fast (days)	Moderate (weeks)	Slow (months)	Very slow (months-years)	10 %
6	Shoreline quantity (tonnes)	<1	<10	<100	<1000	<5000	>5000	5 %
7	Area with harmful water concentrations (km ²)	< 0,1	< 0,5	< 5	< 50	< 150	> 150	5 %
8	Area with harmful sediment concentrations/amounts (km ²)	None	< 0,1	< 0,15	< 0,3	< 0,6	> 0,6	5%
9	Transfer of effects (to new generations etc)	None	No	-	Uncertain	-	Yes	10 %
10	Importance for fisheries	None affected	Locally, few vessels	Locally, many vessels	Regionally, few vessels	Regionally, many vessels	Nationally	5 %
11	Importance for aquaculture	None affected	<5 farms affected	5-10 farms	10-20 farms	20-50 farms	>50 farms affected	5%
12	Importance for outdoor life (secured areas regional/county level)	None affected	1-2 secured areas affected	3-5	6-10	11-20	>20	5%
13	Importance for harbours and marinas (boats)	None affected	Only few boats affected	Many boats, locally	Many boats in the municipality	Many boats, regionally	Many boats, county level	2,5%
14	Additional administrative effort/work in the company	Insignificant	Little extra work, short duration	Moderate extra work, short duration	Moderate extra work, long duration	Considerable extra work, short duration	Considerable extra work, long duration	2,5%
15	Company reputation	No effect	Small effect	Moderate effect	Considerable, short duration	Considerable, long duration	Serious effect	10%
16	Economic costs, mill. NOK	< 0,05	< 0,5	< 2,5	< 5	< 10	>10 mill. NOK	5 %

Classification and weighting of impact parameters are shown in the Impact Matrix (Table 9), while the specific evaluations and resulting impact assessment for Pi acute spills and operational discharges are shown in Table 10 and Figure 23.

The impact matrix has been used for assessment of the spills and operational discharge. The average impact values (AIV) in Figure 23 is calculated by multiplying each impact value (for the 16 impact parameters) with its weighting factor (the sum of all weighting factors is 100%), and then summarising as shown in the equation below:

$$AIV = \sum_{i=1}^{16} (impactvalue)_i \times (weightingfactor)$$

Table 10 show the impact evaluations for the 13 scenarios and the 16 impact parameters considered.

Table 10. Impact evaluations for the 13 scenarios.

DFU Major acute spills			DFU minor acute spills				Operational discharges						
	1	2	3	4	5	6	7	8	9	10	11	12	13
Parameter no	Topside oil blowout	Topside condensate blowout	Well release - oil	Diesel spill	OBM spill	WBM spill	Hydraulic oil spill	WBM discharge	Drill cuttings discharge	Cement discharge	Jacking grease	Rigwash chemical discharge	Testing chemical discharge
1	4	2	1	1	1	0	1	0	0	0	0	0	0
2	4	2	2	2	2	2	2	2	2	1	1	1	1
3	5	3	1	2	1	0	1	1	1	1	1	1	1
4	5	5	1	0	0	0	0	0	0	0	0	0	0
5	5	3	2	1	2	1	2	2	2	0	3	0	0
6	3	0	0	0	0	0	0	0	0	0	0	0	0
7	4	3	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	1	1	1	0	0
9	3	1	1	1	1	1	1	1	1	1	1	1	1
10	5	5	1	1	1	0	1	0	0	0	0	0	0
11	5	0	0	0	0	0	0	0	0	0	0	0	0
12	5	0	0	0	0	0	0	0	0	0	0	0	0
13	5	0	0	0	0	0	0	0	0	0	0	0	0
14	5	5	5	2	2	2	2	1	1	1	2	1	1
15	5	4	3	1	1	1	2	1	1	1	3	1	1
16	5	5	1	0	0	1	0	0	0	0	0	0	0
AIV	4,2	2,4	1,2	0,8	0,8	0,5	0,9	0,6	0,6	0,4	0,9	0,3	0,3

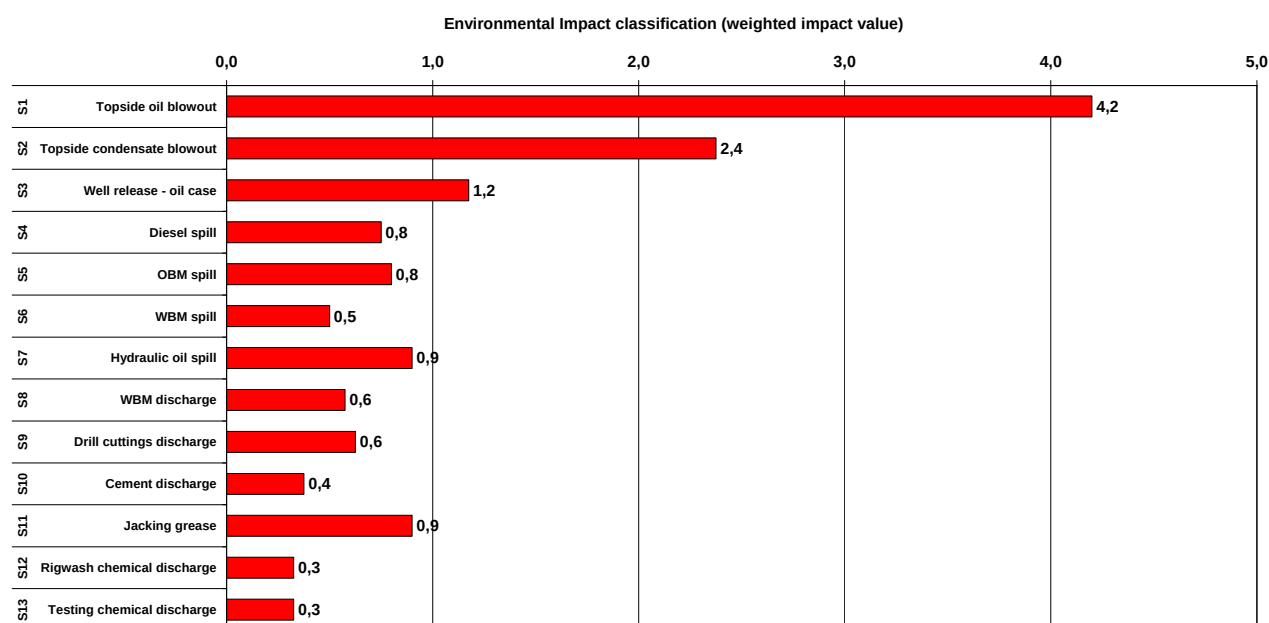


Figure 23. Impact classification – Average Impact Value (AIV) - for acute spills and operational discharges.

The blowout scenarios (S1-S2) are the most serious incidents with respect to potential environmental impact. A topside blowout with oil have an overall classification of serious impact (impact value 4-5), while a condensate blow out are considered to cause moderate impacts (impact value 2-3). A well release (S3) is expected to cause minor environmental impact (impact value 1-2).

The minor spill incidents (S4-S7) are considered to give some impacts, however the overall classification of these spills are evaluated to be in the category insignificant (impact less than 1).

The operational discharges (S8 – S13) cause some environmental impact, but the overall effects are classified as insignificant. Some of the scenarios (acute spills of hydraulic oil, oil based mud and diesel) and the use of jacking grease in red category are classified close to the category minor impact.

3.2 Activity specific environmental risk

The environmental impact expressed on basis of recovery time is only applicable for the acute spills. Only these scenarios are considered to have a potential to cause effects on a population or community level and hence are relevant to consider with respect to environmental risk acceptance criteria. The frequency of the scenarios and the resulting impact value for these scenarios for this parameter are compared with the acceptance criteria.

It is only the scenarios S2 and S1 that are considered to impose consequences covered by the acceptance criteria, ref. Table 10. However, the frequency of these scenarios are well below BG's acceptance criteria for minor and considerable impact, with values of 28% and 29% respectively of the acceptance criteria. No specific attention except from a good risk management system during drilling and an appropriate oil spill contingency are necessary regarding these scenarios.

In addition to the risk comparison with the acceptance criteria, a Risk Index² is calculated by dividing the square of the Average Impact Value (AIV) for all 16 impact parameters with the negative logarithm of the frequency of the scenario (F):

$$RI = \frac{K^2}{-\log(F)}$$

For methodology and mathematical reasons, the frequency for the operational discharges is set to 0,5³. This is a reasonable value, as the operational discharges will occur only during parts of the operation. The rationale for the assessment method is to give a wider perspective on environmental risk. The Risk Indexes are shown in Figure 24.

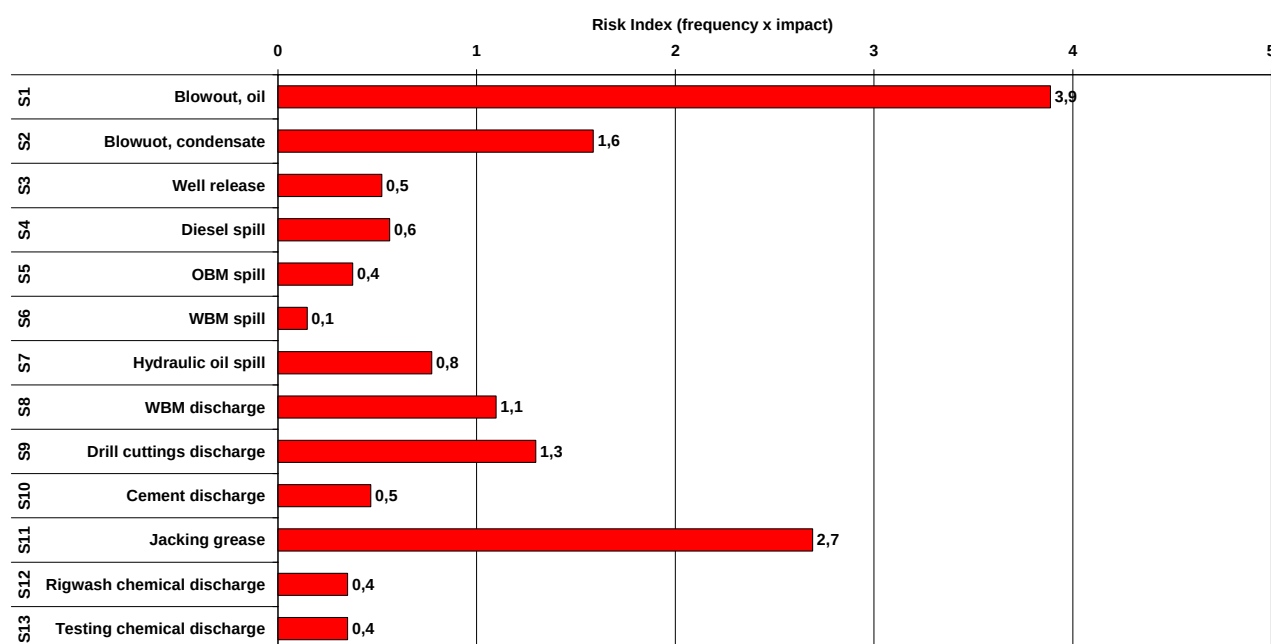


Figure 24. Ranking of environmental risk for 13 spill and operational discharge scenarios (the three blowout scenarios and the well release scenario have been summarised) for the Pi exploration well based on the Risk Index.

Compared to the impact classification (Figure 23) this provides a somewhat different picture. The oil blowout are ranked with the highest risk (considerable risk), followed by the discharge of jacking grease (moderate risk), the condensate blow out, the cuttings discharge and the VBM discharge (minor risk). However, the overall picture are a reasonably low environmental risk level for the drilling operation, but attention should be given to reduce the risk related to jacking grease, e.g. by substituting the product with one less harmful, if technically feasible.

² The Risk Index has been calculated differently than in previous comparable risk assessments, as a result of method development. In order to increase the importance of high impact values, the square of the Impact Value has been divided with the logarithmic value, instead of taking the square of the divided value. One other consedation of the calculation is to provide comparable values.

³ Using a frequency of 1 result in a division by 0. Using the value 0,5 is considered to give a reasonable risk ranking of the scenarios.

3.3 Regional environmental risk

In the area there are permanent installations in the vicinity, and there may be other drilling activities ongoing at the same time in the area.

All petroleum installations, including the exploration drilling operation, contribute to the probability for oil pollution in the region, and thus to the environmental risk. Compared to the total number of installations and activities in the region, the contribution from the drilling operation at Pi is marginal. The activity specific environmental risk should therefore form a sufficient basis for identifying risk reducing measures including oil spill contingency systems.

3.4 Risk reducing measures

During the detailed planning phase and the subsequent management of the drilling operation, risk reducing measures will be identified and implemented based on the results of the environmental risk analysis. Risk reducing measures may be either probability reducing or impact reducing.

In the following sections it is indicated which types of measures that are relevant and that are being or will be considered:

Risk item	Description of measures
Major spills of oil or condensate, well releases	The frequency of these incidents are low, but the consequences may be high if they occur. The main risk reducing measures is a good risk management system and control with the drilling operation. The measures are the same as those that are applied to prevent loss of control with the well, with double barriers such as sufficient mud weight and a BOP valve. However the risk is also reduced through impact reducing measures, e.g. oil spill contingency. This is addressed in the oil spill contingency analysis.
Use of jacking grease	The jacking grease is classified in the environmentally red category, thus substitution plans has to be established for this product according to the HES regulations. Maersk Contractor AS is considering the use of a jacking grease classified in the yellow category. This jacking grease is under qualification, and final decision on future use is expected in third quarter 2007. The substitution will reduce the risk value.
Acute spills	Procedures and operational logistics for prevention of acute spills on the drilling rig should be in place, and be subject to attention during rig inspections.
Use of rig wash detergent	The procedures and operational logistics for use of the rig wash detergent Cleanrig HP on the drilling rig will be verified. Routines are in place to ensure controlled usage of chemicals.
OBM spills	Procedures for transport and handling of both new and used oil based drilling mud are established, with requirements for inspection and closing of all drains that could result in OBM being routed to sea.
Use of drilling mud (WBM) and cementing chemicals	Procedures to ensure effective use of chemicals, and re-use if possible are established. Several chemicals are described in substitution plans

	and work is ongoing to find replacement chemicals with less environmental effect potential.
Use of testing chemicals	No measures are identified

4 Oil spill contingency analysis

4.1 Introduction

If acute oil spill occurs, established oil spill contingency plans will come into force. BG Norge will establish a contingency system based on NOFO's resources with sufficient capacity to combat the oil at sea and to prevent stranding of oil in the coastal zone. The contingency system covers successive phases of a combat action:

- Alerting/notification
- Mobilisation
- Combating
- Restoring
- Monitoring
- Normalisation.

The NOFO oil spill contingency systems forms the basis for the contingency.

4.2 Combating strategies

Oil spill to sea will be combated with available methods and systems to minimize environmental damage. The combat strategy is primarily based on mechanical cleanup close to the source. Factors that affect the choice of strategy are discharge conditions, weather conditions, oil characteristics and spreading/weathering conditions, and the presence of vulnerable environmental resources.

To ensure appropriate choice of combating strategy, it is important to monitor or predict the transport and fate of the oil.

The philosophy in the combat strategy is to establish several barriers between the source of spill and environmental sensitive resources. The contingency analysis covers all these barriers if necessary and analysis the requirements that must be set to those of the barriers that are required:

- Barrier 0: Monitoring and detection
- Barrier 1: Combating in open sea (field systems and NOFO systems)
- Barrier 2: Combating in the coastal zone (NOFO/coastal systems)
- Barrier 3: Protection of environmental priority areas (coastal systems)
- Barrier 4: Combating in the tidal zone / shoreline (beach refurbishing).

For each of the barriers systems for remote monitoring and post-spill investigations will be considered.

The use of chemical dispersants has not been considered as an adequate combating strategy during the drilling operation. The motivation is that the oil type characteristics are not known in detail, NOFO has not established a general dispersant strategy for the offshore oil industry, and the weather conditions in parts of the drilling period does not favour effective use of dispersants.

The result of the contingency analysis result in performance standards for barriers and systems for remote monitoring and post-spill investigations, including response time requirements.

4.3 Equipment, capabilities and effectiveness

Primary resources (equipment, personnel and vessels) are available from NOFO bases at Stavanger and Mongstad. Further, three NOFO systems are normally located at Troll/Oseberg and Jotun/Balder as part of the area response plan, both with both overflow and drum skimmer available. The response time from Jotun/Balder to Pi is approx. 6 hours including mobilization of the equipment, while approx 12 hours is required for systems from Troll / Oseberg area.

Locations of depots are shown in Figure 25. A description of available resources at these depots is given in the following of the section.

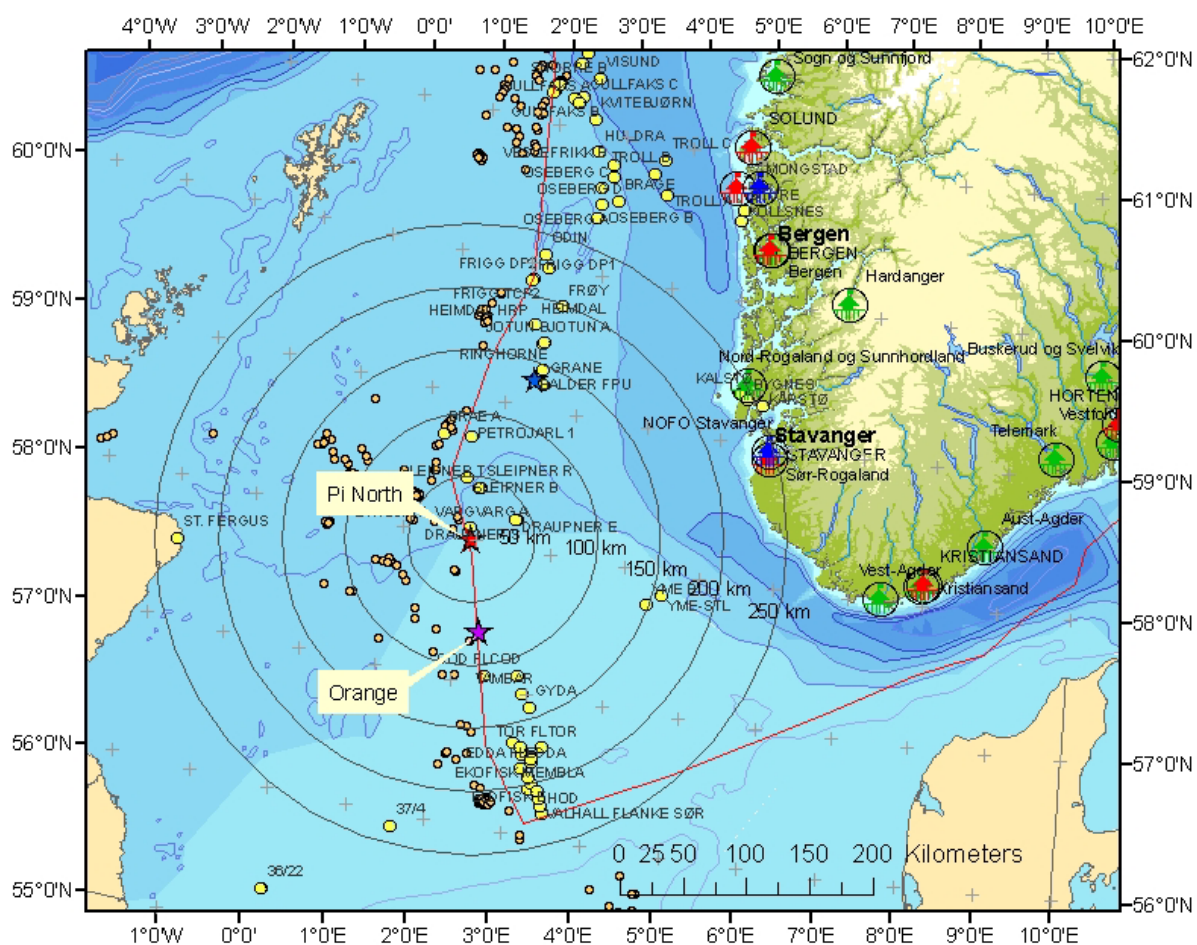


Figure 25. Location of NOFO, and Kystverket (KyV) and IUA depots.

NOFOs “Regionale Planverk” contains a database over location and available equipment for oil spill combat in Norway (http://planverk.nofo.no/OV_ress.htm). The NOFO depots in Stavanger and Mongstad are the primary sources for offshore actions. There are presently 8 traditional systems at these depots, and in addition 4 Hi-wax systems (Table 11), with in total 3200 m Ro-Boom offshore booms.

Table 11. Equipment at NOFO depots.

Depot	Equipment	Type	No.	Capacity	Unit
NOFO Stavanger	Framo Transrec 350	Overflow skimmer	2	350	m ³ /h
NOFO Stavanger	Roboom 3500	Offshore boom	2	400	m
NOFO Mongstad	Framo Transrec 350	Overflow skimmer	6	350	m ³ /h
NOFO Mongstad	Framo Hi-Wax	Drum skimmer	4	160	m ³ /h
NOFO Mongstad	Roboom 3500	Offshore boom	6	400	m
NOFO Mongstad	BP 100 WD	Dispersant	30	1	tonne
NOFO Kristiansund	Framo Transrec 350	Overflow skimmer	3	350	m ³ /h
NOFO Kristiansund	Framo Hi-Wax	Drum skimmer	2	160	m ³ /h
NOFO Kristiansund	Roboom 3500	Offshore boom	3	400	m

The theoretical uptake capacity of the NOFO systems is documented at the “NOFO Regionale Planverk” website (<http://planverk.nofo.no/kapasite.htm>). For Transrec 350 a capacity of 2400 m³ oil/day emulsion is defined, and for Hi-Wax skimmers the capacity is set to 1900 m³/day.

The efficiency of mechanical uptake in relation to area specific conditions for wave height and daylight have been calculated based on weather statistics from Sleipner (data periode 1995-2005).

The NOFO system efficiency in relation to wave height is shown in Table 12, based on field trials as documented in the NOFO Planverk.

Table 12. Uptake efficiency of NOFO systems in relation to wave height.

Significant wave height, Hs (m)	Uptake efficiency (absolute efficiency)
0 – 1 m	85 %
1 – 2 m	75 %
2 – 3 m	65 %
3 – 4 m	55 %
4 – 4,5 m	15 %
> 4,5 m	0

Efficiency during low light conditions, defined as the time periode when the sun is below -6° under the horizon, is defined by NOFO to 65% compared to daylight efficiency.

The total efficiency of a NOFO system for each month of the year has been calculated based on these values (Figure 26).

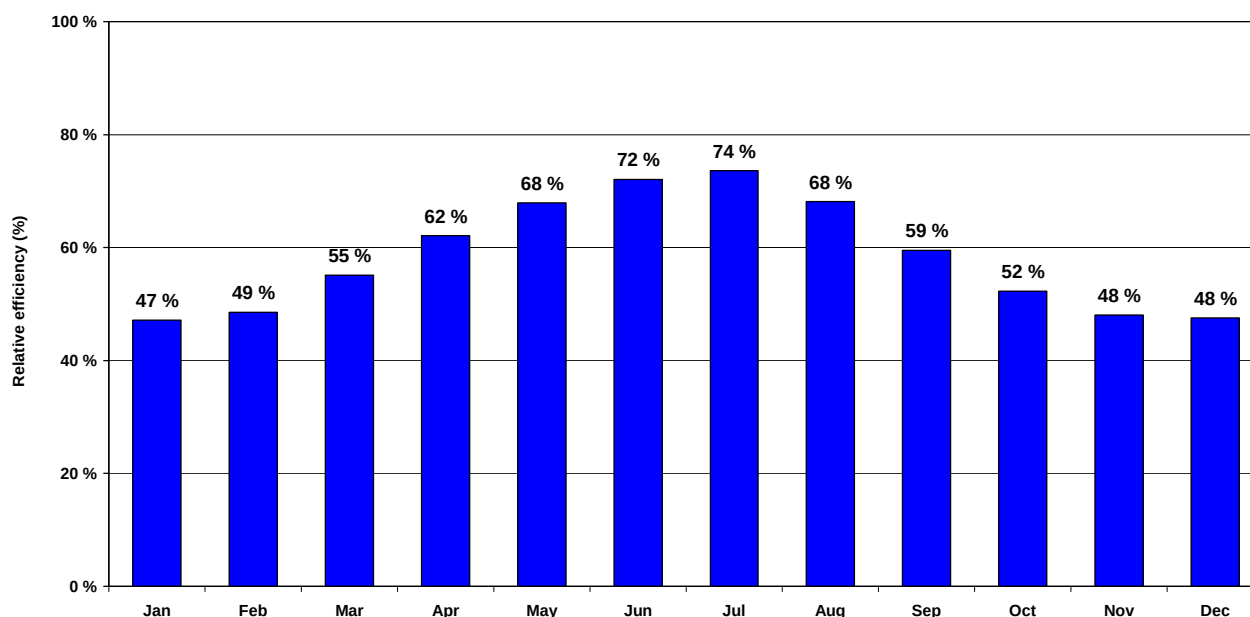


Figure 26. Efficiency for mechanical uptake as a function of time of the year.

The average uptake efficiency in the periode December-January-February based on these values is calculated to 50%. If this weather efficiency correction factor is applied, the resulting NOFO system efficiency is reduced to $(2400 \text{ m}^3/\text{d} \times 0,50) = 1200 \text{ m}^3/\text{d}$.

Relevant depots at the Norwegian Coastal Authority ("Kystverket") are located in Stavanger, Bergen, Fedje and Solund. For the potential blowout scenarios for Pi, the probability for having to mobilise equipment from these depots are considered negligible, and further assessment of these systems have not been done. Same accounts for IUA depots.

Although the probability for oil is low, the possible oil type is assumed to be comparable to the Varg oil. A fire hazard is expected for oil that has been less than 5 hours at sea. With an average wind speed of 5 m/s and resulting drift velocity of 3% of wind speed, a safety distance of minimum 2,5 km from the source to barrier 1 should be established.

4.4 Barrier 0 – monitoring and detection

Monitoring and detection of spill incidents are based on visual and manual observation of well configuration and rig activities during the drilling operation. No other systems are considered to be required for the initial detection of acute spills. Requirements for alerting and notification will be described in both rig and operator specific emergency response plans, and the BG oil spill contingency plan.

4.5 Barrier 1 and 2 – combat actions in open waters

BG Norge has established the following performance requirements to the oil spill contingency:

- Barrier 1 shall have the capacity to combat the emulsion resulting from the dimensioning discharge rate per day, taking into account evaporation and natural dispersion at the relevant weather conditions. A fully developed barrier shall be established within 24 hours after the start of the spill.
- Barrier 1 and 2 shall have the capacity to combat all emulsion available for uptake on the sea, within 95% of the drift time to coastal areas, taking into account evaporation and natural dispersion at the relevant weather conditions. The barriers shall be fully developed within 48 hours after the start of the spill.
- If Barrier 1 and 2 are not able to combat all emulsion available within 95% of the drift times to coastal areas, a fully developed barrier 3 shall be established with a capacity to combat the remaining oil within 95% of the drift times to coastal areas.
- The oil spill contingency analyses shall verify that these requirements are met.

The dimensioning oil blowout rate is 3640 m³/day. In order to calculate a dimensioning uptake rate for oil emulsion on sea the following parameters has been assumed:

- Evaporation rate: 30% after 24 hours.
- Downmixing rate: 20% after 24 hours⁴ (topside spill)
- Water content in emulsion: 50% (maximum)
- Available amount of oil for uptake: 90% (10% sheen/rainbow).

This provides a dimensioning uptake requirement of 3670 m³ emulsion/day (3640 m³/d x (1-0,30) x (1-0,20) x (1/(1-0,50)) x 0,90).

The NOFO systems can be mobilised in sequence from different locations/depots, based on following assumptions:

- All vessel speeds are 14 knots.
- Mobilisation time at depot is 10 hours (loading of equipment and personnel).
- The first system from a base have available vessel at the depot (no additional sailing time).
 - Sailing time from Stavanger depot: 10 hours (139 nm).
 - Sailing time from Mongstad depot: 13,5 hours (189 nm).
- The second vessel from a base requires time to go to base to load equipment, the travel time is based on the assumption that the vessel is in transit from a field/installation.
 - Additional time to Stavanger depot: 5 hours (70 nm).
 - Additional time to Mongstad depot: 3 hours (42 nm).

⁴⁾ SINTEF reports natural dispersion rates in moderate weather conditions of 0,5-2% per hour during the early phase of a spill, corresponding to approx. 11-38% downmixing after 24 hours.

- The third vessel from a base requires time to go to base for load equipment, the travel time is based on the assumption that the vessel is located at a field/installation.
 - o Additional time to Stavanger depot: 10 hours (140 nm).
 - o Additional time to Mongstad depot: 6 hours (84 nm).
- The time required for deploying oil booms into sea is approx. 45 minutes.

Based on a NOFO system efficiency of 50% the uptake capacity has been calculated to 1200 m³/d, 3 systems are required to combat the dimensioning rate and 4 systems have sufficient capacity to combat all emulsion available at sea. Thus 3 NOFO must be allocated to barrier 1 while NOFO system no. 4 should be allocated to barrier 2. Figure 27 shows the uptake capacity of barrier 1 while Figure 28 shows the uptake capacity of barrier 1 and 2. taking into account the delay from the start of a spill till the different systems are operative and the 24 vs 48 hours response time for fully developed barriers.

The resulting best available response times for the 4 systems including mobilisation of the equipment (45 min) are estimated to:

- 1 system from Balder/Jotun (distance 136 km/73 nm): 7 hours.
- 2 systems from Stavanger (distance 278 km/150 nm):
 - o First system: 21 hours.
 - o Second system: 26 hours.
- 1 system from Mongstad (distance 420 km/227 nm):
 - o First system: 24 hours.

In Figure 27 the actual response times for each system have been used for calculation of the barrier capacity (fully developed barrier within 24 hours), while in Figure 28 the response time for barrier 2 has been set to 48 hours (fully developed barrier).

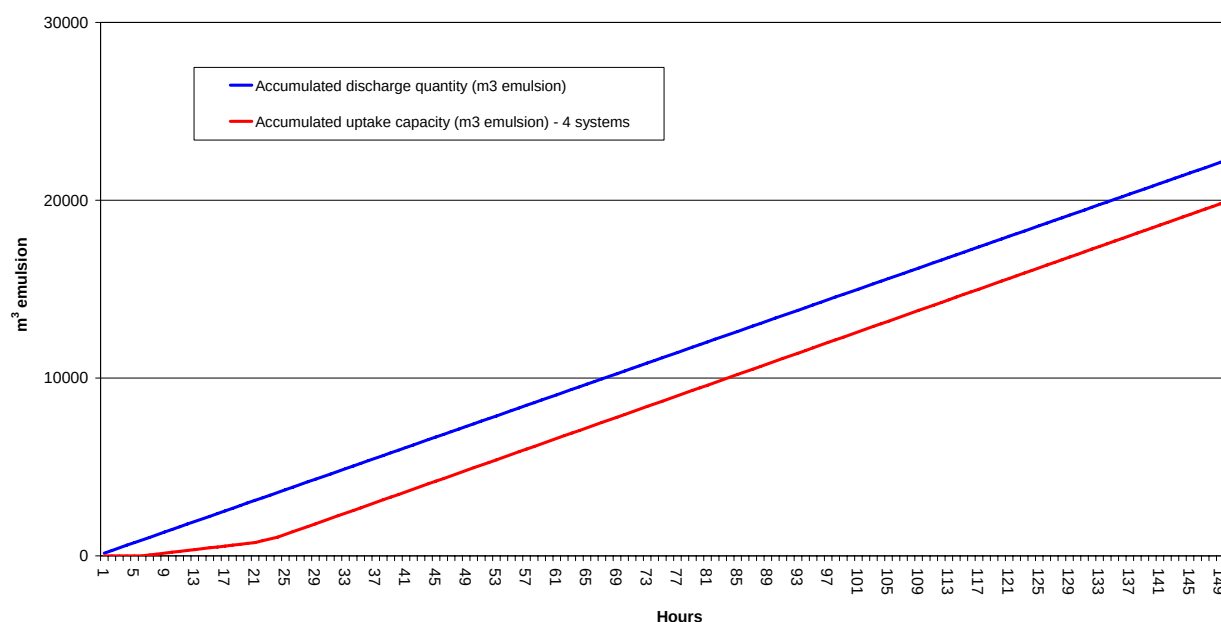


Figure 27. Calculated accumulated discharge quantity (m³ emulsion available for uptake, blue line), vs. accumulated uptake capacity (m³ emulsion, red line) for 3 NOFO systems in barrier 1.

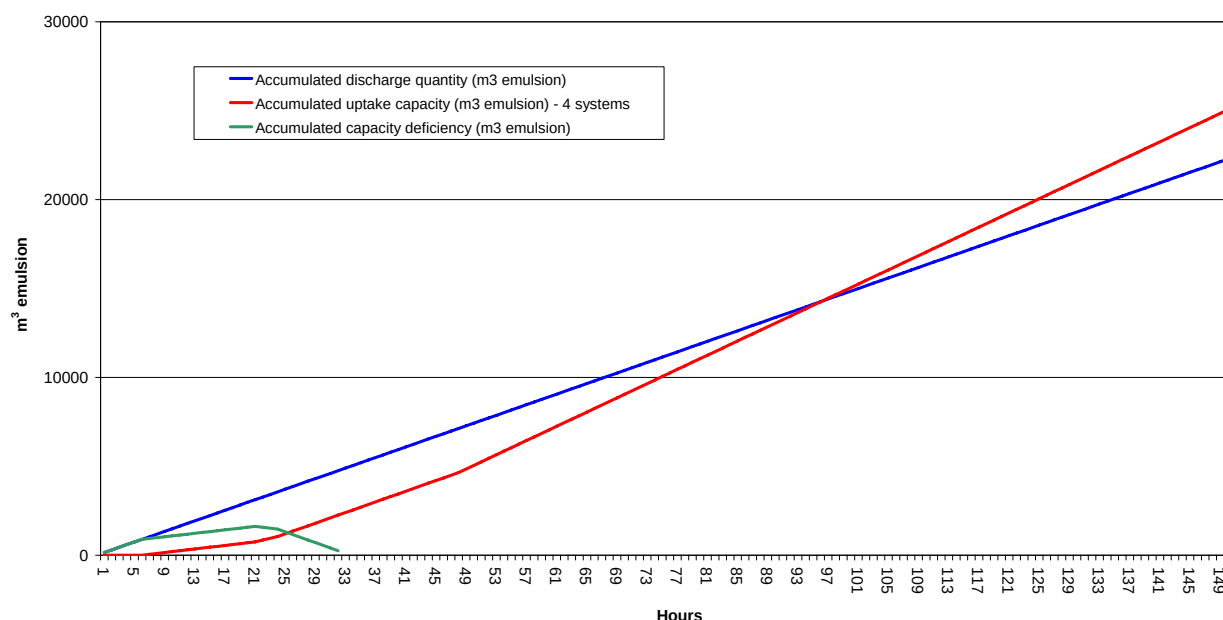


Figure 28. Calculated accumulated discharge quantity (m³ emulsion available for uptake, blue line), vs. accumulated uptake capacity (m³ emulsion, red line) for 4 NOFO systems. The capacity deficiency (m³ emulsion) during the initial phase is indicated by the green line.

The four systems in barrier 1 and 2 have the capacity to removing all oil from the surface, including the deficiency during the first 30 hours at approximately 4 days after the start of the spill. The 95% drift time to the coastal area is 13 days, and the absolute shortest drift time is about 7 days, Thus it is concluded that BG's performance requirements are met with good margin.

The following response time requirements are defined for 4 NOFO systems:

Barrier 1 fully developed within 24 hours with 3 NOFO System

Barrier 2 fully developed within 48 hours with 1 NOFO system

Note that best obtainable response time for system 4 is 26 hours, indicating that the actual oil spill combat contingency will perform better than estimated.

4.6 Barrier 3 – combat actions in coastal areas

Dimensioning of systems in the coastal zone is usually performed on basis of oil drift simulations and estimations of arrival quantities. As the contingency calculations demonstrate that all oil emulsion is combated at sea, thus coastal areas areas will not be impacted by a spill from Pi and a detailed planning on combat actions in coastal waters has not been included.

If the weather situation in an actual spill scenario indicate rapid drift to the coastal areas, the resources available through NOFO's agreements with Kystverket and IUA's will be mobilized.

4.7 Barrier 4 – combat actions at environmental priority areas

The same comments made for combat actions in coastal waters are also valid for fighting oil spills impacting environmental priority areas. NOFO has listed special vulnerable areas and has defined plans for fighting oil threatening these areas. NOFO has also agreements with IUAs and other resources that will be utilised if necessary.

4.8 Barrier 5 – combat actions on the beach

No detailed plans for beach cleaning have been included as no oil is expected to enter the coastal shores during an oil spill.

BG Norge will however mobilize the necessary resources if a beach cleanup operation is required.

4.9 Systems for remote monitoring during an oil spill

Systems for remote monitoring implies technologies and routines to ensure that oil slicks on sea can be detected and monitored independent of visibility, light and weather conditions, including mapping of position, area and oil quantity (ref. The Activity Regulations §52). Such systems shall cover both open sea and coastal areas.

Relevant systems for remote monitoring are:

- Visual observation from vessels and helicopters.
- Visual observation from aeroplane (LN-SFT/Kystverket).
- Helicopter with IR/Downlink systems (part of NOFOs systems).
- Aerostat and aeroplane with SLAR/IR/UV (part of NOFOs systems, and LN-SFT/Kystverket).
- Satellite images (NOFO has agreement with Kongsberg Satellite services (Ksat)).
- Weather reports from Meteorological Institute (MI), and onsite weather observations.
- Oil drift simulations at MI (part of NOFOs Planverk).

In the following assessments are given for the different technologies and routines with respect to relevance, capacity and specific requirements for the two wells.

Visual observation:

Available systems are vessels on the field, helicopters and aeroplane (LN-SFT). Existing systems are considered sufficient, and no specific requirements are set to detection time. All upset or hazard situations during the drilling operation will be detected immediately.

Helicopter:

NOFO have agreements with Helicopter Service for mobilisation of helicopters with several technologies for remote monitoring, including common video camera and FLIR (Forward Looking Infrared camera) suitable for use in bad light conditions. The NOFO oil spill contingency vessels have equipment for immediate downloading of observation data. Response time requirements for helicopters are set to 24 hours.

Aeroplane (LN-SFT):

Surveillance aeroplane from Kystverket (LN-SFT) has common video camera and still photo camera, and SLAR type radar (Side-looking airborne radar). The observation area is within 40 km to each side of the aeroplane flight line. The aeroplane is a useful supplement to other monitoring systems. No specific response time requirements are set as there is not specific formal agreement between NOFO and Kystverket for the mobilisation of the plane.

Satellite images:

NOFO has established an agreement with Kongsberg Satellite Services (Ksat) for delivery of satellite images from the Norwegian sector. As per today the use of satellite images is not considered to be a proven and effective technology for detection and monitoring of oil spills at sea. This technology is available, but no specific performance standards are defined.

Weather forecasts and observations:

Routines are established for regular receipt of weather forecast reports from MI, in addition to onsite observational data. There has also been established a website service with direct access to weather forecasts for the North Sea area (<http://metoc.met.no:8080/metoc/menu.jsp>). The weather forecast from DNMI is also used directly in the oil drift simulations for prediction of transport and fate of oil slicks.

Oil drift simulations:

NOFO has an agreement with DNMI for carrying out oil drift simulations. A standard ordering form is established which is sent DNMI per fax. The results from the simulations shall be submitted within 30 minutes after the order is received. The simulations are carried out on basis of the provided oil properties and weather forecast for the relevant period. New oil drift simulations are ordered if the circumstances changes or new information is available.

4.10 Post-spill investigations

Post-spill investigations include chemical and biological mapping of the extent and effects of the oil spill. The results are used both during the combat and restoration phase. Authority requirements for post-spill investigations are given in the Activity Regulations §53. SFT has also published guidelines for accomplishment of such investigations (SFT 1999:05).

NOFO has an agreement with SINTEF for carrying out post-spill investigations according to the SFT guidelines. The mobilization time requirement is set to 72 hours.

4.11 Performance requirements

Based on the assessments in the above sections, a set of performance standards have been identified for defined barriers and contingency systems. These performance standards form the basis for development of an Oil Spill Contingency Plan containing specific Action Plans and necessary agreements.

Requirements – Barrier 0 – Detection and monitoring	
Visual observation from the rig, vessel, helicopters	Shall be notified immediately to the Platform Manager.

Requirements – Barrier 1 – Open sea (field / NOFO contingency systems): Open sea, near source	
Uptake capacity, nominell	2400 m ³ oil-in-water emulsion per day
System requirements	3 Transrec 350 NOFO systems.
Equipment – primary	NOFO Transrec 350 and 400 m Ro-Boom 3500 Atlantic oilboom
Response time, Barrier fully developed	3 NOFO systems in operation after 24 hours
Thin oil films	NOFO strategy for double oil boom systems shall be available.
Thick oil capabilities	Hi-Wax drum skimmers shall be available within the response time requirements.
Operational weather conditions	The oil recovery equipments shall be able to operate effectively in minimum 2,5 m significant wave height and ocean currents up to 1,5 knots.
Darkness and reduced visibility	Equipment for operation in darkness and reduced visibility (e.g mist) shall be available. This includes IR camera and FLIR down-link. Response time as for the fully developed barrier.
Prioritised environmental resources	Priority to combat actions on slick that threatens large concentrations of seabirds at sea.

Performance requirements – Systems for remote monitoring (NOFO, KyV, MI)	
Visual observation from rig and vessels	Immediate notification to the platform manager (OIM).
Helicopter	Shall be mobilised within 24 hours (Helicopter Service). The helicopter shall have systems for remote monitoring including common video camera and IR camera (FLIR).
Aerostat	No requirements are set to the use of aerostat (NOFO). May be a supplement to other remote monitoring systems. To be evaluated by the action leadership.
Surveillance aeroplane	It is required to have access to a surveillance aeroplane such as LN-SFT, but no specific requirements are set to response time or monitoring capabilities. The technologies available must include common video camera, still picture camera and radar (SLAR).
Satellite images	May be used during an action. No specific requirements.
Weather observations	Updated weather forecast shall be available on a regular basis during an action.
Oil drift simulations	Oil drift simulations from MI shall be ordered if the oil spill is above approx. 100 m ³ . Information about the spill shall be submitted on standard scheme by fax to MI. The results shall be available 30 minutes after the order has been received.

Performance requirements – Post-spill investigations (Sintef, other scientific institutions)	
Chemical and biological investigations	Equipment and personnel for sampling and analyses shall be mobilised within 72 hours according to NOFO agreement with SINTEF.

5 Summary and conclusions

BG plans to drill the exploration well Pi using the jack-up rig Maersk Guardian, starting in Januar 2008. The drilling will be conducted using water based mud (WBM) in the upper sections and oil based mud (OBM) in the lowest section. Only chemicals from the upper sections will be discharged.

No black chemicals will be used but the operation plan for use of two red chemicals, both are included in the rig chemicals (Statoil Multidope and Bestolife products) and will partly be discharged. Total discharge of red chemicals is estimated to be approx. 1,3 ton, mostly related to the jacking grease.

The most likely hydrocarbon in the reservoir is condensate. A probability distribution of 90% vs 10% is defined for condensate and oil. The dimensioning blowout rates are 1870 and 3640 m³/day respectively. If a blowout should occur, the probability for stranding is estimated to be in the order 10 - 30 %.

Based on the Environmental Risk Assessment, the highest risk from the drilling operation is related to an oil blowout. The risk levels are well below the BG's acceptance criteria for environmental risk, with values > 30% of the acceptance criteria. Among the operational (planned) discharges, the use of jacking grease is considered to represent a moderate environmental risk. Substitution of this product should be investigated.

The risk assessment has been used as basis for planning and identifying risk reduction measures for the drilling operation as basis for the oil spill contingency analyses.

In general the operation is considered to represent an environmental risk similar to other comparable drilling operations in the North Sea. The overall risk level related to the drilling is considered to be low.

The oil spill contingency analyses indicate a need for 3 NOFO systems in barrier 1, with a barrier response time of 24 hours and 1 additional NOFO system in barrier 2 with a barrier response time of 48 hours. BGs performance requirements are met with this contingency.

6 References

- AMBIO Miljørådgivning AS 2006. Regional konsekvensutredning Nordsjøen – Beskrivelse av miljøtilstanden offshore, økosystem og naturressurser i kystsonen samt sjøfugl. Rapport nummer: 20137-1.
- Anker-Nilssen 1994. Identifikasjon og prioritering av miljøressurser ved akutte oljeutslipp langs norskekysten og på Svalbard. NINA Oppdragsmelding 310: 1-18.
- BG xxxx. Project HSE Objectives
- BG xxxx. Project HSE Plan
- BG Norge 2007. Application for discharge permit to SFT for Well N 15/12-Pi.
- Carter et al. 1993. Seabird concentrations in the North Sea: An Atlas of vulnerability to surface pollutants. Joint Nature conservation Committee. ConocoPhillips, 2004. Miljørisikoanalyse for Ekofisk-regionen. Acona rapport NO-04-105 1.12.2004.
- DNV 2007. BG Norge ltd. Oil drift simulations at well N6/3 – Pi. DNV report 2007-0870.
- Havforskningsinstituttet 1991. Tilgjengelighet av seismiske aktiviteter i forhold til sårbare fiske-ressurser. HELP-rapport nr. 38, Havforskningsinstituttet 1991
- Havforskningsinstituttet 2006. Havets ressurser og miljø 2006. Havforskningsinstituttet - Fisken og havet, Særnummer 1
- Jødestøl, K.A., 2004. Miljørisikoanalyse for Ekofisk-regionen. Acona rapport NO-04-105, rev.7.
- Kolle, J., 2005. Personal communication, fagkonsulent Jarle Kolle, Fisheries Directorate, 19.04.2005
- MRDB 2006. Marine Resource Data Base 2006
- NINA 2006. Utbredelsen av sjøfugl i Skagerrak, Kattegat og Nordsjøen. NINA rapport 171, 2006.
- NORSOK Z-013. Risk and emergency preparedness analysis; rev. 01, mars 1998 – utkast rev. 02, januar 2001; <http://www.standard.no/imaker.exe?id=1507>.
- OLF 2005. Metode for Miljørettet Risiko Analyse. Revisjon januar 2005. OLF
- OLF 2006.
- OSPAR, 2000. OSPAR Quality Status Report. OSPAR Commission, London.
- SEA2 2001. Strategic Environmental Assessment of the Mature areas of the Offshore North Sea. SEA 2. Departement of trade and Industri 2001.
- SINTEF 2000. Varg råolje. Egenskaper og forvitring på sjøen relatert til beredskapstiltak. Sintef rapport nr. STF66 F99105.
- SINTEF 2004. Varg råolje. Resjekk av forvitringsegenskaper. SINTEF rapport xxxxxxxxx.
- Scandpower, 2003. Utredning av konsekvenser av helårig petroleumsvirksomhet i området Lofoten-Barentshavet. Studie 7-e: Sannsynlighet for hendelser med store oljeutslipp. Rapport nr. 27.730.001/R1. Dato: 11.06.2003.

ScandPower 2007. Blowout and Well release Frequencies – Based on SINTEF

SFT, 1993. Skadevirkninger av akutte oljesøl. Marint Miljø. TA-nr. 1019/1993.

SFT & DN, 1999. Spesielt Miljøfølsomme Områder (SMO) og petroleumsvirksomhet. Implementering av kriterier for identifikasjon av SMO i norske farvann med fokus på akutt oljeforurensning.

SFT 2000. Modell for prioritering av miljøressurser ved akutte oljeutslipp langs kysten.

RKU 1999. Regional Konsekvensutredning for Nordsjøen 1999

RKU 2006. Regional Konsekvensutredning for Nordsjøen 2006

WFD 2007. Blowout and kill study. BG Norge AS. N6/3-Pi-North. Well Flow Dynamics 2007.