Oil spill risk in the Barents Sea – oil industry vs maritime sector

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Future potential production of hydrocarbons in the Norwegian Sector of the Barents Sea, and Russian/Norwegian export and maritime transport of oil and gas will lead to increased risk for oil pollution in the area.

Despite a declining trend in oil spill incidents in the maritime industry the last 20 years, global oil pollution from oil transport by tankers is still significantly higher in volume as well as in number of incidents, compared to exploration and production of hydrocarbons.

For the medium activity scenario in the Barents Sea, as described by Ministry of Oil and Energy in Norway, oil spill risk caused by associated tanker traffic is estimated to be ten times higher than that of the exploration and production activities; even if planned preventive measures are included.

The difference in environmental risk associated with the two separate activities in this region is even higher. This is attributed to the fact that tanker spills are associated with shorter distance to shore (and closer to the most vulnerable environmental resources), greater probability of fuel oil spills, and an expected lower effectiveness of oil spill response.

In the specific Barents Sea case if was found that the introduction of a Norwegian oil industry with it's associated high level of oil spill response, will lead to a reduction of the total environmental risk level in the area. This is attributed to the present and future risk represented by the oil export from Russia, that presently is unmatched by adequate oil spill response solutions.

Key words: Oil spill risk, environmental risk, oil exploration, vessel traffic, Barents Sea

Introduction

The Barents Sea region is a unique environment that forms part of the arctic ecosystem. In the past, vessel traffic in the area has been very limited, except for fishing vessels; and the oil spill risk has been correspondingly low. Recently, however, several classes of industrial activity both in Russia and Norway have altered the situation. All-year exploration of petroleum in the Norwegian Sector of the Barents Sea was approved by the Government in December 2003. In the Russian sector and in West Siberia there are several onshore and offshore fields in production, under development or planned for exploration. Export of oil and gas will lead to an increase in tanker traffic, which together with growth in the seafood industry, cruise traffic and export of other types of cargo will change the risk for oil pollution in the area.

As input to the political process, risk assessments have been carried out for the various commercial activities in the Barents Sea, including various levels of petroleum activity and future scenarios for oil export from Russia. Tanker traffic and offshore field development/production both introduce a risk of oil pollution. However, the associated risk, the nature of a potential spill and the resulting environmental risks are very different for the two activities. The paper identifies and discusses these differences.

Today's activities

Traffic in the northern Norwegian Sea and the Barents Sea, when measured in sailed nautical miles, is today relatively low and clearly dominated by fishing vessels (Fig. 1).

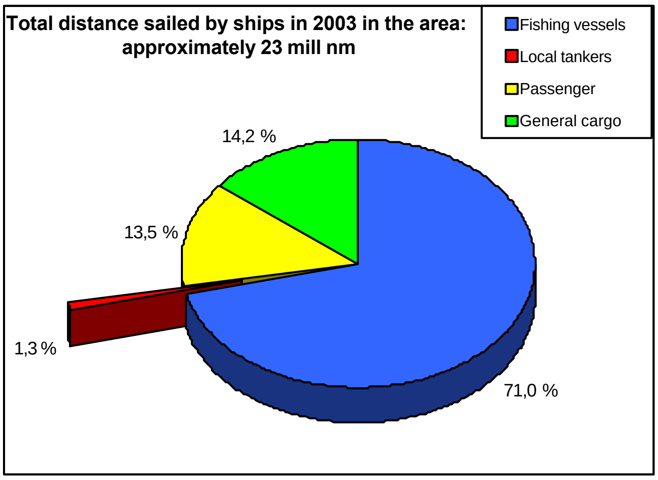

Figure 1. Total distance sailed by ships in the Norwegian sector of Barents Sea and Norwegian Sea not including export from Russia. Based on DNV, 2002a; TØI, 2002 and DNV, 2003b.

The present oil transport along the Norwegian coast mainly involves diesel and marine heavy fuel, which is transported from two refineries in the southern part of Norway by small coastal product carriers. The product transport constitutes approximately 0.2 million nm per year in the Norwegian and Barents Sea. Other traffic in this area is mainly general cargo and passenger vessels.

Offshore exploration activity has been low. The Norwegian sector of the Barents Sea was opened for exploration in 1979, and 62 wells have been drilled until now. The gasfield Snøhvit is decided to be developed and production will start in 2006.

In the Russian sector there are several plans for offshore exploration and production (E&P), but no offshore production today. All export is from refineries and on land oilfields.

International maritime traffic in the Barents Sea and northern part of the Norwegian Sea is principally tankers exporting crude and bunker from Russian ports such as Murmansk, Arkhangelsk and Vitino. Earlier, this traffic was dominated by small tankers (15 000 – 30 000 dwt) exporting oil and fuel. However, export is growing rapidly causing more calls and involving larger vessels (DKN, 2003). Approximately 170 tankers were involved in this export in 2002. Estimated sailed distance in Norwegian waters was 100,000 nm. In 2003 sailed distance was approximately 150,000 nm by 240 tankers causing close to 100%

increase in transported hydrocarbon volume (4.3 mill. tonnes in 2002) (DKN, 2003). At least 20% of the vessels transported bunker oil and other heavy fuels.

Today's risk picture

Statistics (DAMA, 2002), as presented in DNV (2002), show that in average 16.6 accidents have occurred annually along the Norwegian coast in the Barents Sea. The dominating accident type is grounding which amounts to over 70% of the incidents, followed by collision with roughly 13%.

Globally the number of ship accidents has declined the last 20 years. Along the Norwegian coast, however, number of accidents seems to be stable and groundings of vessels larger than 500 grt seems to have increased (Fig. 2). The tendency for smaller vessels is declining. This difference may be caused by increased traffic of larger vessels on the Norwegian coast, but DNV (2002) did not find data that supported this assumption.

The declining trend is depending on many factors, e.g. technological improvement, higher awareness, increased safety culture, experience, better defined rules and increased competence

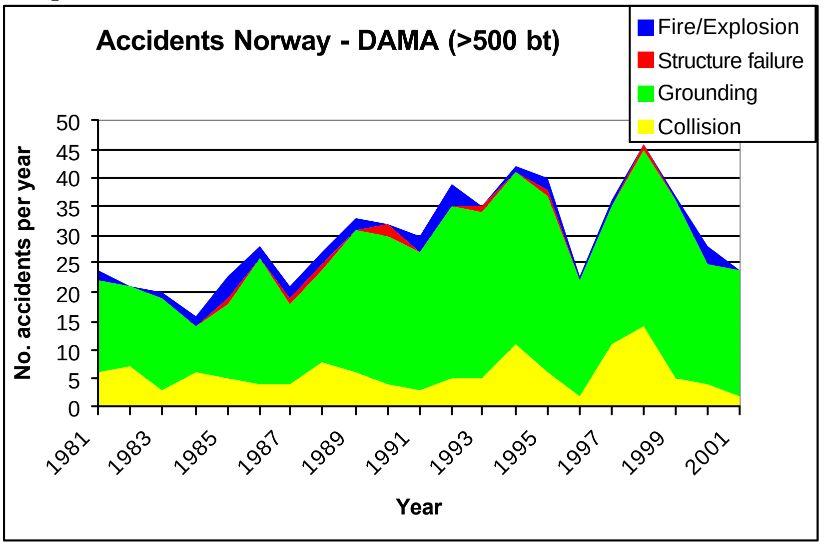

Figure 2. Total number of ship accidents in Norway (vessel size>500 gt). Data from DAMA (2002).

The accident consequences vary from minor damages to very severe damages with loss of lives and environmental impacts. The majority of the accidents have no or minor environmental consequences. The pollution statistics from Norwegian Pollution Control Authority (NPCA) for a ten year period as referred in DNV (2002) show that there are in average 2.6 oil spills annually from vessels along the Norwegian coast in the Barents Sea. The spilled volumes are less than 50 tons and are thus labelled as small. Typical oil type is diesel or other light products. The spills are quite evenly distributed along the coast, but with a slightly higher tendency to be in the southern most part of the area, as this area has higher traffic density.

There have been no incidents or oil spills caused by offshore drilling activities carried out in this area. In general offshore exploration and production activities have been a minor contributor to total oil spills globally (Etkin et al., 1999).

Expected future activities

Norwegian activities

The production of LNG/LPG from the field Snøhvit outside Hammerfest is planned to start in 2006 causing approximately 90 calls at the coastal terminal. Hydrocarbons have been found in several other areas, but are still not proved to be commercial. In this paper we will use the medium activity scenario as defined by the Norwegian Ministry of Oil and Energy as basis for the environmental impact assessment (OED, 2002). Exception is Nordland VI which was not included in the Governmental approval December 2003 (Fig. 3) and consequently is excluded in this assessment.

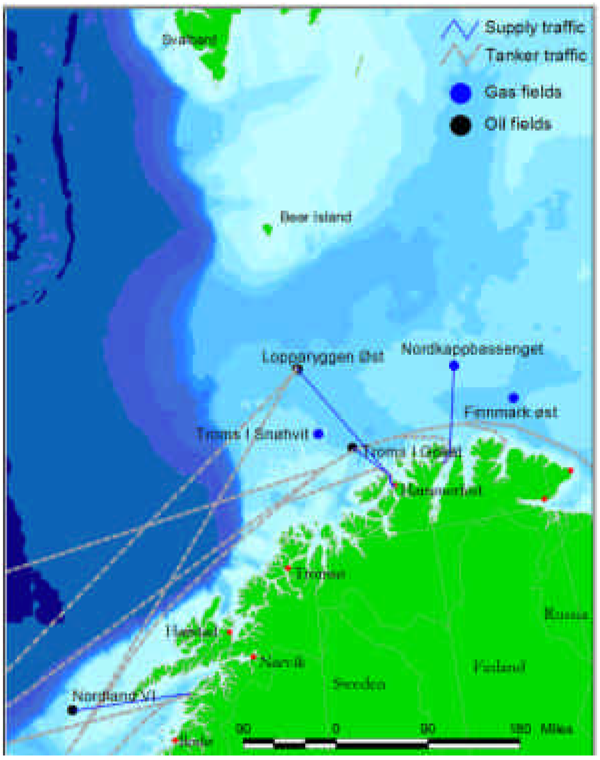

Figure 3. Planned and fictive oil and gas field used in the regional EIA for the Lofoten – Barents Sea area (OED, 2002). Nordland VI is not included in this assessment.

In 2015 approximately 400 tankers are assumed to be involved in export of petroleum (crude oil, LNG, LPG/condensate) sailing approximately 0.4 mill. nm (Fig. 4). In addition there will be an increase in shipping due to support vessels, supply and other commercial coastal traffic.

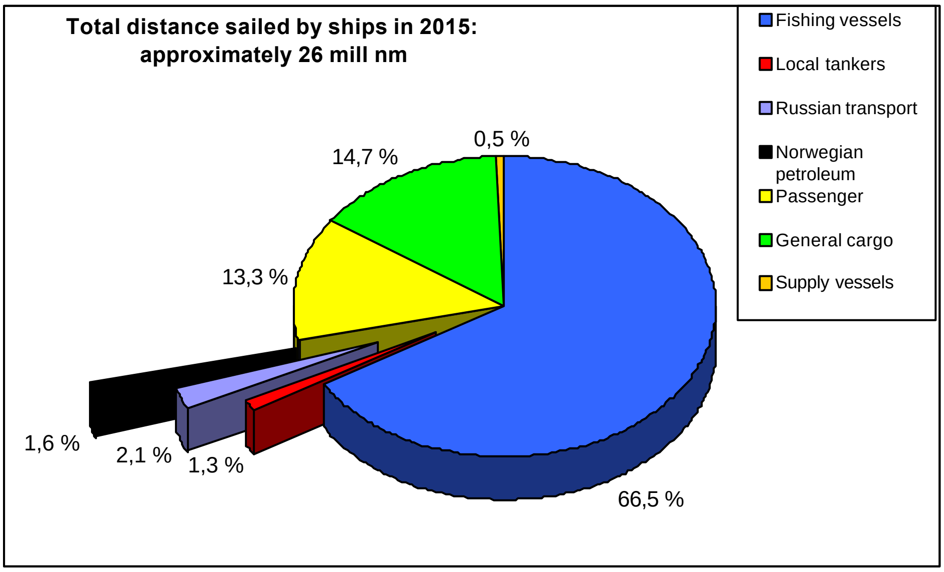

Figure 4. Total estimated traffic in sailed distance by categories of vessels in 2015 in the Norwegian sector of the Barents Sea. Figures generated based on data from Kystverket, 2003; TØI, 2003; and DNV, 2003a.

Total sailed distance in the region will increase from today's 23 mill. nm to approximately 26 mill. nm in 2015 including Russian export.

Russian activities

Russian oil export has increased by 10% annually the last four years and is now approximately 10% of the global production, the second largest in the world after Saudi Arabia. Studies (e.g. Kystverket, 2003; CNIIMF, 2003; DNV, 2003a; Frantzen & Bambulyak, 2003) have estimated the annual export from the regions Timan – Pechora and west Siberian to be between 40 and 110 million metric tons in less than 10 – 15 years depending on export facilities. Crude and products from this area are now exported via ports in the Black Sea; Baltic Sea and Barents Sea. In addition to new pipelines as well as a general upgrading of pipelines and terminals in Baltic and Barents Sea there are plans to use pipelines to Mediterranean ports (Croatia).

In this assessment we have assumed that the export in 2015 from Barents Sea ports will amount to 80 mill tons crude and products, 20 bill. Sm^3 gas and 1 mill Sm^3 LPG/condensate. Associated traffic is estimated to be approximately 650 calls per year distributed on size classes from 25 000 dwt to 280 000 dwt.

Risk assessment – future activities

This paper is based on environmental risk assessments presented in reports to the Directorate of the Sea and the Norwegian Ministry of Oil and Energy (DNV, 2003c; DNV, 2003d). A number of assumptions regarding e.g. ship lane between 12 and 20 nm from the coast, size distribution of cargo tanks, spill rates and duration were made in order to carry out the risk assessment as described in these reports. Risk assessment methodology used for ship traffic is presented in some more detail in Motrøen & Wentworth (2004).

Oil spill risk for the scenario for offshore exploration and production in the Norwegian sector presented here are calculated by Scandpower (2003).

Based on an assessment of the statistics for ship accidents, which shows a declining trend; frequencies for grounding, collision and fire/explosion are reduced by 10 %. For structural failure there is no statistics indicating a future decrease, and the accident frequency is therefore not changed.

Increased traffic along the Norwegian coast has resulted in several risk reducing measures to be implemented or planned by the Norwegian authorities. The effects of some of these are included in the risk calculations. These are:

- Territorial water expanded to 12 nm from coast
- Electronic Chart Display and Information System (DNV, 2003e)
- Automatic Identification System (DNV, 2003e)
- Traffic separation (DNV, 2003e)
- Vessel Traffic System (DNV, 2003c)
- Tugs (Kystverket, 2003b; DNV, 2003c)

It is likely that new risk reducing measures are available and deemed realistic by 2015, but this has not been included in the assessment.

Norwegian activities

Potential sources of oil spill as results of offshore hydrocarbon exploration and production are mainly blowouts at the field, pipeline releases, FPSO incidents and ship incidents. Total frequency of large oil spills from the three first sources is less than 10% of the frequency of comparable spill categories from the associated tanker traffic (fig. 7).

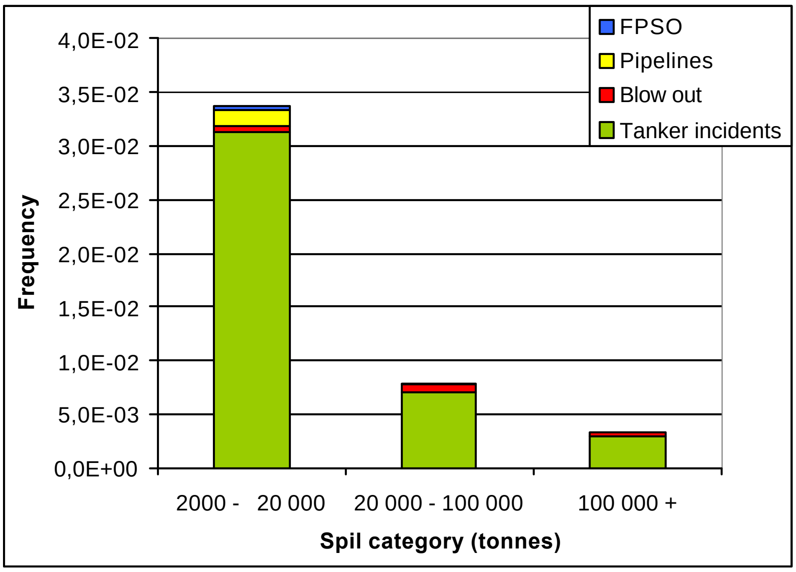

Figure 7. Estimated spill frequencies for the most important sources associated with the exploration and production of hydrocarbons in the Norwegian sector of the Barents Sea (data from Scandpower, 2003; DNV, 2003d).

These results are comparable to statistics on oil spills globally (Etkin et al., 1999; Etkin, 2001) which shows that oil tanker traffic is a major contributor compared to general E&P activities.

Norwegian vs. Russian export of hydrocarbons

In 2015 the number of tankers involved in Norwegian export of hydrocarbons is estimated to be approximately 400, while similar traffic associated with Russian export is expected to include 650 vessels. As the Norwegian export likely will be dominated by gas and the distance sailed along the Norwegian coast by vessels involved in Russian export is longer, oil and bunker spills from Norwegian export is estimated to be only 20% of the spills from Russian export (Fig 8).

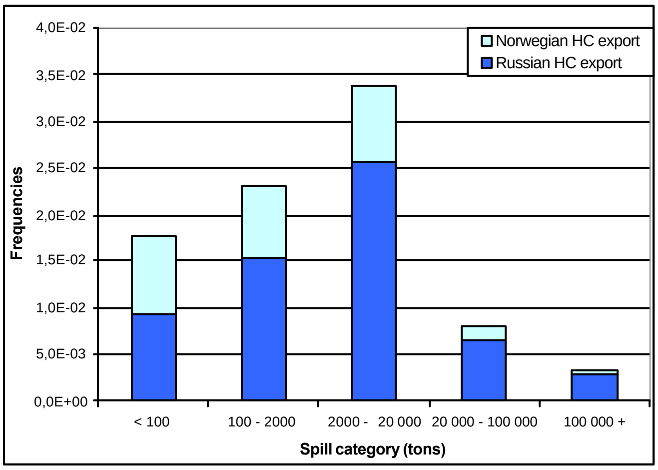

Figure 8. Total oil cargo and bunker spill frequencies calculated for Norwegian and Russian tanker traffic in the Barents Sea in 2015.

The higher relative portion of spills in the smaller spill categories from the Norwegian export is associated with bunker spills from the relative large traffic of gas tankers.

Spill location

Comparing the four incident categories, the study shows that the combined grounding accidents dominate oil spill incidents, followed by collision (Fig. 9). The result is expected since the traffic density of large vessels in the region is fairly low. Higher general traffic density and more intersecting ship lanes will increase frequency of collision.

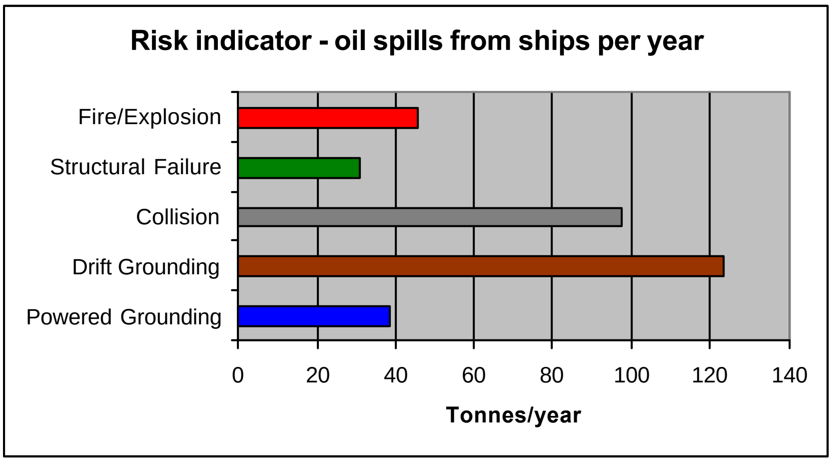

Figure 9. Oil spill risk expressed as frequency multiplied by volume categorised into five types of incidents.

Fire/explosion and structural failure is evenly distributed along the ship lanes. The frequency of collisions will be highest in intersection between ship lanes. Thus, all these categories will mainly be located in the ship lanes 10 nm or more from the coast.

Oil spill response

Future field developments and oil production in the Norwegian sector of the Barents Sea will have associated oil spill contingency arrangements in accordance with Norwegian regulations. The primary objective of these will be to handle oil spill situations related to production, field development and transportation. However, it must be expected that the capability may also be mobilised to respond to acute spill incidents from vessels trafficking to/from the Russian sector.

This section indicated capability levels, expressed as mean fraction recovered of the total spill volume, for the following spill situations:

- Blowout from fields in Norwegian sector
- Spills from tankers transporting hydrocarbons from Norwegian fields
- Spills from tankers transporting hydrocarbons from Russian sector

The NOFO oil spill response systems include as a minimum a dedicated oil spill response vessel (supply vessel), tow boat, 400 m ocean boom, Tranrec 350 and/or Framo HiWax skimmer. There are 14 such systems stationed at depots along the Norwegian coast. It is assumed that the required number systems will be stationed in the Barents region to establish spill response capability comparable to other parts of the continental shelf. In addition, all production installations will have individual (or jointly with neighbouring fields) first line spill response capability.

Over the years, some common practices have been developed in Norway on the quantitative estimation of oil spill response performance (in m^3/h). These practices take into account mobilisation time, meteorological/oceanographic conditions, light conditions and experience with the NOFO systems from many years of exercises. For the Barents region typically 30-40% of the spill volume caused by a blowout situation is expected to be recovered.

In the event that the NOFO will be used to respond to a vessel spill, the following additional assumptions/ conditions are used:

- The oil spill recovery performance of the NOFO systems (in m^3/h), for a long term vessel spill in open water, will be comparable to that expected for a blowout situations offshore (for the same oiltype).
- Spill response performance, is affected by meteorological conditions and light conditions according to standard assumptions for such effects.
- NOFO's spill contingency will operate close to the source of the spill. No operation is expected close to the shoreline.
- At least one new NOFO depot will be established in addition to the existing
- An area spill contingency will be established, with a minimum of one vessel, that may be mobilised to the spill location for a vessel and be in operation after 12 hours.
- Two additional NOFO vessels can be at a vessel spill location within 24 h. Another two systems within 48h.
- Very low recovery capability is expected for heavy bunker oils
- For most tanker spills, it is assumed that 50% is spilled immediately, while the remaining 50% is spilt over the next 24 h. For the largest spills (100,000 tons) it is expected that 50% is spilt during the first 24 h while the remaining 50% is spilt over the next 6 days.
- Spill recovery capability per system is assumed to be 2000 tons pr day.
- All capacity estimates listed above apply to spill response close to the source. Spill response performance at greater distance from the source (widely spread and thin oil films) is set to 10%.

Fig. 10 shows the spill response capability (responding to vessel spill) as a function of time, indicating a capacity of 1000 tons/day from 12 to 24 hours after the spill. After 24 h the capability has increased to 4000 tons/day and continues to increase to 8000 ton/day after 48 hours.

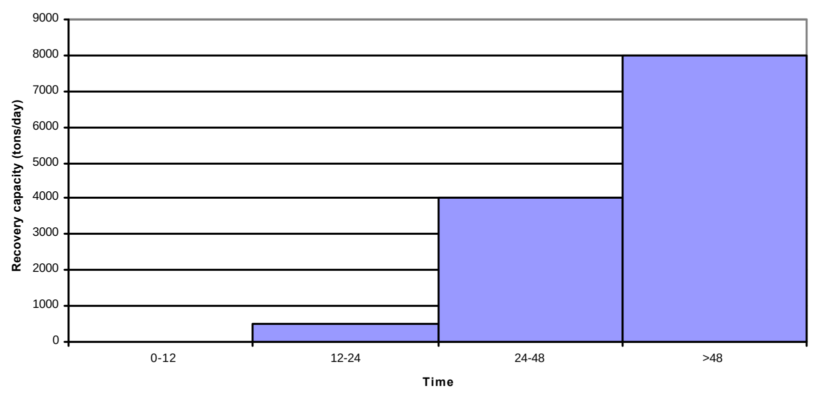

Figure 10. Spill recovery capacity in responding to a vessel spill, as a function of time.

Obviously, groundings will in most cases occur close to shore. Powered grounding can occur with vessels deliberately being within the 12 nm zone or by serious malnavigation. Stranding of oil can not be avoided if current conditions indicate drift towards land.

Drifting grounding will normally be a result of engine failure in combination with unfortunate wind and current-directions. If engine failure occurs outside the 12 nm zone, drift time to shore will typically be around 24 h, potentially allowing mobilisation of tug.

Due to the short distance to shore, the expected response capability for a grounding incident is set to 10%. All other incident types are expected to occur outside the 12 nm zone. The below table summarises expected recovered fractions.

Table 1 Estimated percentage recovered for various spill incidents from tankers and platform

Source	Incident type	Spill size (tons)	Percentage recovered
Tanker traffic	**Grounding**	2.000 – 100.000	10%
	Collision	10.000	20%
		20.000	15%
		100.000	25%
		2500(ballast)	25%
		5.000 (ballast)	25%
	Structural failure	5.000 (ballast)	25%
		100.000	25%
	Fire and explosion	<100	35%
		4.000	25%
		12.000	15%
		100.000	25%
		1.000 (ballast)	35%
Platform	Blowout		40%

Environmental risk

The last 30 years of research on environmental impacts of oil spills has shown that the main factors determining the gravity of impact and rate of recovery are:

- Type of oil
- Biological, physical and economic characteristics of the spill location
- Amount spilled and rate of spillage
- Time of the year
- Effectiveness of the clean-up

In the following some of these factors will be discussed in relation to the future perspective in the Barents Sea and differences between offshore activities and the related maritime activities.

Type of oil

Highest clean up costs and most persistent effects have been found after spills with heavy crudes or heavy fuel oils, examples being ERIKA, NAKHODKA and PRESTIGE. Oil spilt from offshore activities will involve varying qualities of crude oil, while statistically 50% of oil spilt by vessel traffic will be heavy fuel oil from bunker tanks (Fig. 11).

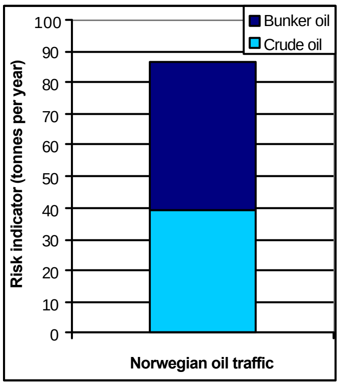

Figure 11 Total risks from Norwegian export of hydrocarbon from the Barents Sea divided on type of oil released.

Severe acute toxic effects are generally associated with lighter crude oils and condensate in particular when they include high concentration of aromats. However, the most toxic component are also those that evaporate most rapidly once the oil is released, even at relatively low temperatures.

Spill location

The highest densities of vulnerable resources are generally found close to the coast. This is also the case in Northern Norway where high densities of resources vulnerable to oil pollution and with high economic and/or environmental values are found closer than 30 nm from the coast (DoF, 2002a; 2002b; IMR, 2002; IMR & NP, 2003; Systad et al., 2003).

Nearly all spills from tankers will be in this area and consequently the probability for environmental damage is high. In contrast, most of the oil and gas fields in the Barents Sea are expected to be located more than 50 nm from the coast (Fig. 3) reducing the probability for severe impacts. Oil drift numerical modelling has estimated the probability for oil stranding to be approximately 30% (DNV, 2003f) for several of the spill locations.

Effects of contingency on total risk

In this section, oil spill risk is expressed as spill frequency multiplied with volume spilled. As described in the last chapter, the effectiveness of oil spill preparedness systems in response to spills from ships are relative low compared to effectiveness to e.g. blow out (SINTEF, 2003). The oil spill recovery performance of the NOFO oil spill contingency arrangement discussed above (summary presented in Tab. 1) is used to calculate the total oil spill risk for the two scenarios:

1. No development or oil production in the Norwegian sector and therefore no NOFO contingency arrangement. Export of oil from Russia as the main contributor to oil pollution risk.
2. Hydrocarbon exploration and production in the Norwegian sector together with export of oil from Russia. NOFO oil spill contingency established.

The results are presented in Fig 12.

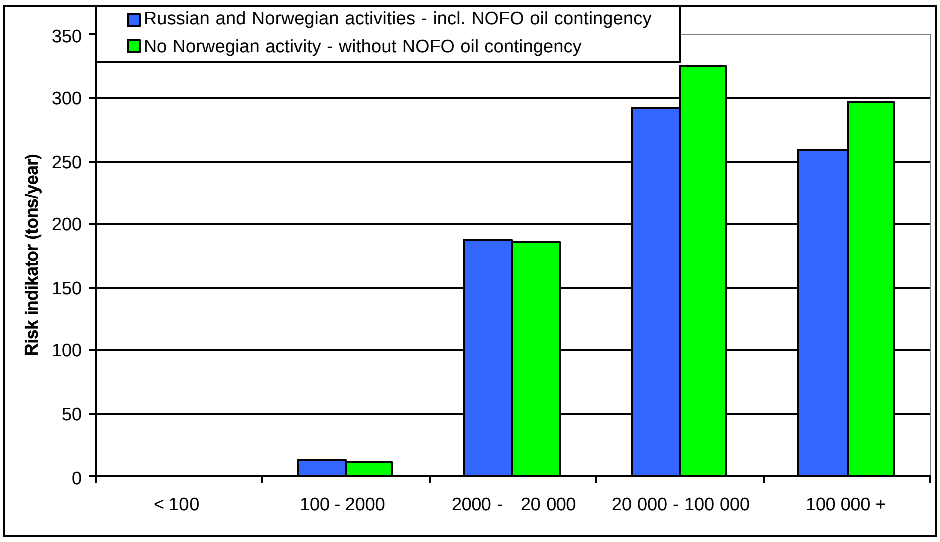

Figure 12 Estimated effects of NOFO oil spill preparedness systems in relation to the total environmental risk in the Barents Sea compared to environmental risk with no hydrocarbon exploration or export in the Norwegian sector and no NOFO system.

Effect of the oil spill contingency system is evaluated to be relatively low for small spills with short duration. Efficiency increases with size of spill and duration and is highest if spill location is far from the coast and spill duration is long. In spite of the higher risk for oil spills associated to the additional activities in oil exploration and production in the Norwegian sector, environmental risk will not increase correspondingly. The NOFO contingency resources are estimated to reduce environmental risk with approximately 10%.

Conclusion

Offshore field development and production in the Norwegian sector of the Barents Sea introduce together with the associated tanker traffic higher risk of oil pollution. For the medium activity scenario in the Barents Sea, as described by Ministry of Oil and Energy in Norway, oil spill risk caused by associated tanker traffic is estimated to be ten times higher than that of the exploration and production activities; even if planned preventive measures are included.

The difference in environmental risk associated with the two separate activities in this region is even higher. This is attributed to the fact that tanker spills are associated with shorter distance to shore (and closer to the most vulnerable environmental resources), greater probability of fuel oil spills, and an expected lower effectiveness of oil spill response.

In the specific Barents Sea case if was found that the introduction of a Norwegian oil industry with it's associated high level of oil spill response, will lead to a reduction of the total environmental risk level in the area. This is attributed to the present and future risk represented by the oil export from Russia, that presently is unmatched by adequate oil spill response solutions.

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