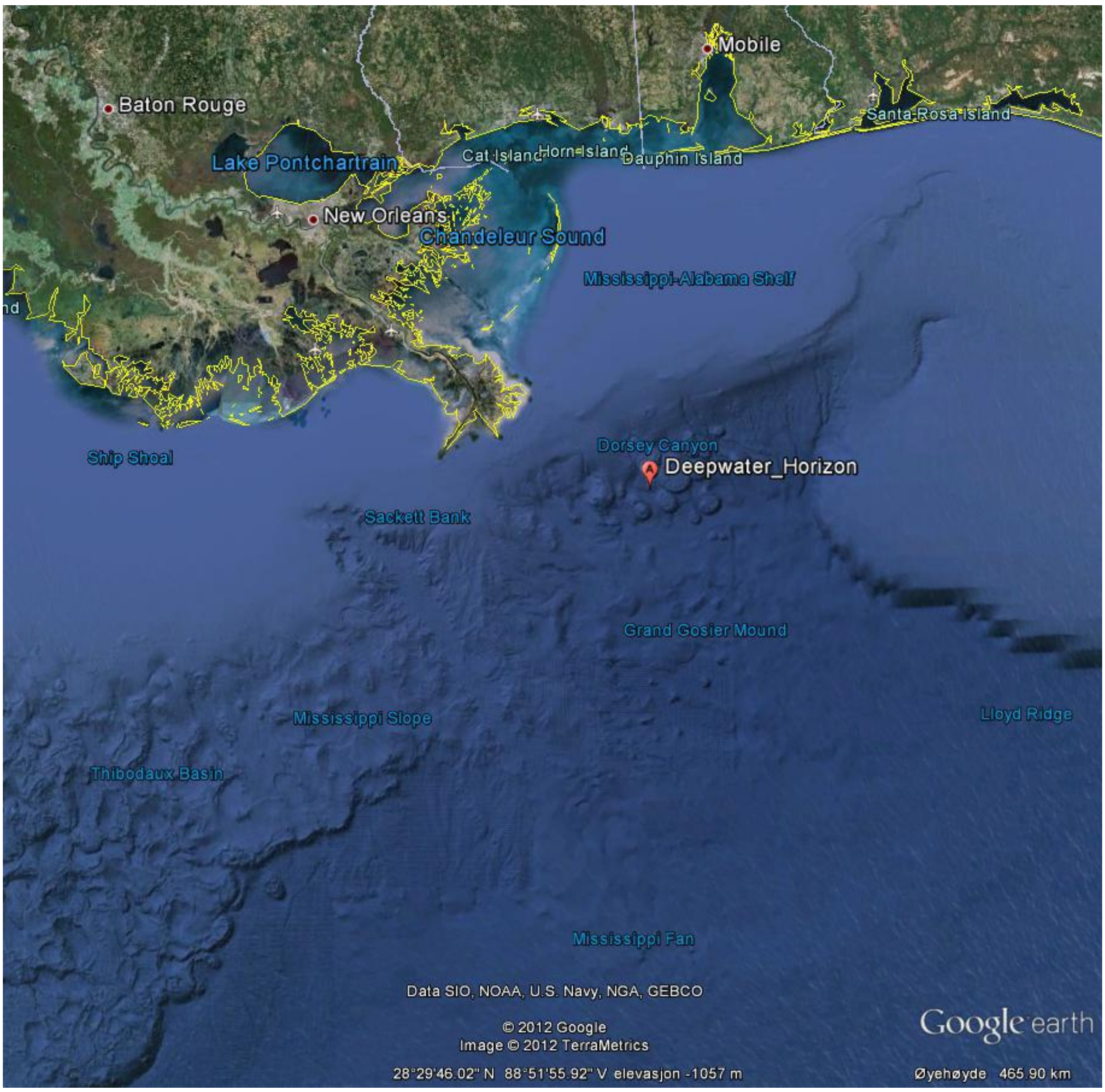
REPORT SNO 6283-2012

Environmental effects of the Deepwater Horizon oil spill - focus on effects on fish and effects of dispersants



Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

REPORT

Main Office
Gaustadalléen 21
NO-0349 Oslo, Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

Regional Office, Sørlandet
Jon Lilletuns vei 3
NO-4879 Grimstad, Norway
Phone (47) 22 18 51 00
Telefax (47) 37 04 45 13

Regional Office, Østlandet
Sandvikaveien 59
NO-2312 Ottestad, Norway
Phone (47) 22 18 51 00
Telefax (47) 62 57 66 53

Regional Office, Vestlandet
Thormøhlens gate 53 D
NO-5006 Bergen Norway
Phone (47) 22 18 51 00
Telefax (47) 55 31 22 14

Regional Office Central
Pirsenteret, Havnegata 9
P.O.Box 1266
NO-7462 Trondheim
Phone (47) 22 18 51 00
Telefax (47) 73 54 63 87

Title	Report No..	Date
Environmental effects of the Deepwater Horizon oil spill - focus on effects on fish and effects of dispersants	6283-2012	07.03.2012
	Project No. O-11205	Pages Price 16
Author(s) Hilde C. Trannum Torgeir Bakke	Topic group Oil pollution	Distribution Open
	Geographical area Gulf of Mexico	Printed NIVA

Client(s)	Client ref.
The Norwegian Oil Industry Association (OLF)	Egil Dragsund

Abstract

NIVA has conducted a literature study on environmental effects of the Deepwater Horizon accident for the Norwegian Oil Industry Association, and the present report summarizes this work with particular focus on fish and dispersants. The report also briefly discusses relevance for Norwegian waters. In the literature, negative effects on the population level of fish have not been reported, although there is evidence of effects on the cellular level of fish. Several exploited species were even characterized by notably higher catch rates during 2010. Despite this, the economic losses for the fishing industry were huge due to an extensive closure of fisheries and effects in the marked. Following the oil spill, large amounts of dispersants were used, mainly Corexit, and for the first time, the dispersants were added under the sea surface. It is not clear whether the dispersants were successful in reducing the overall impacts of the oil. Furthermore, there are indications that the dispersants had the potential to inhibit the natural degradation of oil. Although the use of Corexit was criticized, laboratory studies have shown that Corexit generally tends to be less toxic than several other dispersants.

4 keywords, Norwegian	4 keywords, English
1. Deepwater horizon-ulykken	1. Deepwater horizon accident
2. Miljøeffekter	2. Environmental effects
3. Fisk	3. Fish
4. Dispergeringsmidler	4. Dispersants

Torgeir Bakke
Project Manager

Mats Walday
Research Manager

Kristoffer Næs
Research Director

ISBN 978-82-577-6018-2

Environmental effects of the Deepwater Horizon oil spill

- focus on effects on fish and effects of dispersants

Preface

NIVA has been engaged by OLF to regularly review the environmental effects of the Deepwater Horizon accident, and has conducted a literature study based on peer-reviewed journal articles and technical reports released by scientific agencies and research institutions. The study focuses on the marine environment, but also includes commercial effects related to seafood. The present report sums up the main conclusions regarding known environmental effects until the end of 2011, with main focus on fish and effects of dispersants. However, also effects on other ecosystem compartments are briefly summed up.

Grimstad/Oslo, 29. February 2012

Hilde C. Trannum

Contents

Summary

On 20 April 2010 the Deepwater Horizon drilling platform in the Gulf of Mexico experienced an explosion, and oil and gas leaked out from the oil well at depths of 1500 m until 15 July when the well was sealed. In total, approximately 4.9 million barrels (780 000 m^3) of crude oil were released to the water. The oil was spread widely and caused damage to marine and wildlife habitats and to the Gulf's fishing and tourism industries. Large amounts of dispersants were used, and for the first time, the dispersants were partly added directly at the wellhead. NIVA has been engaged by OLF to conduct a literature study regarding effects of the accident on marine life, and the present report is a summary report on documented effects until the end of 2011. The focus is on effects on fish and effects of dispersants, although effects on other ecosystem compartments briefly are summed up.

There have been observed effects on the cellular level of fish, but there is no evidence of any effects on the population level. The 2010 cohorts of both non-exploited and exploited fish species were not negatively affected by the accident, and in fact tended to increase. At the same time, the economic consequences for the fishing industry were huge. Large areas of federal and state waters were closed to fishing as a precautionary measure to ensure the safety of seafood. Furthermore, there was a change in the seafood demand which caused additional effects in the marked.

It is not known whether the extensive use of dispersants, mainly Corexit, in fact was successful in reducing the overall impacts of the oil. There were even indications that the dispersants could inhibit the natural degradation of the oil. At the same time, however, laboratory studies have shown that Corexit generally is less toxic than several other dispersants. Although dispersants and dispersant:oil-mixtures clearly have a toxicity potential for marine organisms, there is yet no data showing toxic effects of dispersants in the field after the accident.

In several of the papers, it is emphasized that it is still too early to assess long-term effects of the accident. Furthermore, several authors claim that there is a lack of field data prior to the accident, which makes it difficult to evaluate the change in several ecosystem compartments.

Sammendrag

Tittel: Miljøeffekter av Deepwater Horizon-ulykken – fokus på effekter på fisk og effekter av dispergeringsmidler
År: 2012
Forfattere: Hilde C. Trannum, Torgeir Bakke
Kilde: Norsk Institutt for Vannforskning, ISBN 978-82-577-6018-2

20. april 2010 inntraff en eksplosjon på boreriggen Deepwater Horizon i Mexico-gulfen, hvorpå olje og gass lekket ut fra oljebrønnen i et dyp på ca. 1500 m frem til 15. juli da brønnen ble avstengt. Totalt lekket om lag 780 000 m^3 råolje ut i havet. Oljen spredde seg betydelig og forårsaket skade på marine habitater og villmarksområder og på fiskeri og turisme. Store mengder dispergeringsmidler ble benyttet, og for aller første gang ble disse delvis tilsatt direkte ved brønnen. NIVA har av OLF fått i oppdrag å foreta en litteraturstudie på effektene av ulykken på marint liv, og den foreliggende rapporten er en sammendragsrapport på hva som var dokumentert av effekter til og med desember 2011. Fokuset er effekt på fisk og effekt av dispergeringsmidler, selv om effekter på andre økosystemkomponenter kort er oppsummert.

Det har blitt observert effekter på cellulært nivå hos fisk, men det er ingen indikasjoner på effekter på populasjonsnivået. 2010-årsklassen av både høstede og ikke-høstede fiskearter ble ikke redusert som følge av ulykken, og det var faktisk tendens til økning av disse årsklassene. Imidlertid var de økonomiske konsekvensene på fiskeriindustrien store. Store fiskeriområder ble avstengt for å sikre at all sjømaten var trygg. Videre ble etterspørselen etter sjømat endret, hvilket medførte ytterlige konsekvenser i markedet.

Når det gjelder dispergeringsmidler, hovedsakelig Corexit, er det ikke kjent hvorvidt de fungerte etter hensikten og reduserte effektene av olje. Det var til og med indikasjoner på at dispergeringsmidlene kunne redusere den naturlige nedbrytningen av olje. Samtidig har laboratoriestudier vist at Corexit generelt er mindre giftig enn flere andre dispergeringsmidler. Selv om dispergeringsmidler og blandinger av dispergeringsmidler kan være giftige for marine organismer, er det ingen dokumentasjon på toksiske effekter av dispergeringsmidler i feltsituasjonen etter ulykken.

I flere av artiklene understrekes det at det fremdeles er for tidlig til å vurdere langtidseffektene av ulykken. Videre hevdes det at feltdataene som forelå i forkant av ulykken var mangelfulle, hvilket gjør det vanskelig å evaluere endringer på flere av økosystemkomponentene.

1. Introduction

On 20 April 2010 the Deepwater Horizon drilling platform experienced an explosion, and oil and gas leaked out from the platform at depths of 1500 m until 15 July when the well was sealed. In total, approximately 4.9 million barrels (780 000 m^3) of crude oil were released to the water in the Gulf of Mexico. The oil was spread widely and caused damage to marine and wildlife habitats and to the Gulf's fishing and tourism industries. Large amounts of dispersants were used, and for the first time, the dispersants were added under the sea surface. The use of dispersants has been controversial, as the dispersants themselves may cause toxic effects in marine organisms.

NIVA has been engaged by OLF to regularly review the environmental effects of the accident, and has regularly delivered technical memos to OLF which describes the findings of the latest published literature on this topic. The literature includes peer-reviewed journal articles and technical reports released by scientific agencies and research institutions. The present report sums up the main findings regarding recorded environmental effects until the end of 2011, with main focus on fish and effects of dispersants. More details, including references, can be found in the memos, which can be provided on request. It is important to be aware of the fact the environmental impacts reported here still are considered incomplete, and more facts will continue to come the next years.

2. Effects of the spilled oil

2.1 Fate and degradation of the oil

Crude oil was released from the well, which is not a homogenous material, but contains a mixture of chemical compounds that interact differently when exposed to the environment. This particular crude oil was a light oil, and relatively degradable. Furthermore, it had the potential to evaporate more readily than other crude oil.

An estimate of the fate of the spilled oil is shown in Figure 1. The estimate is very imprecise, and there is particularly large uncertainty regarding the category “other”, which e.g. includes oil on or just below the surface as light sheen and weathered tar balls, oil washed ashore and oil buried in sand and sediments. The fate of the oil that remained in the Gulf is not yet fully clarified.

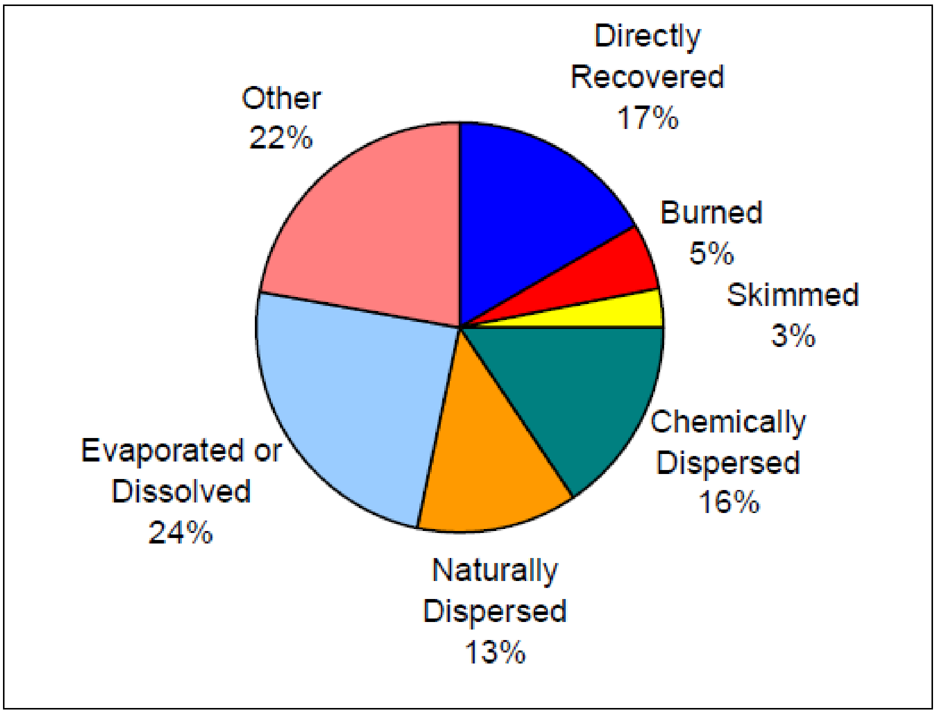


Figure 1. Schematic illustration of the fate of the spilled oil, after Ramseur (2011). The estimates were based on calculations made July 14, 2010.

Microorganisms played a significant role in degrading the oil in the water, and this was assumed to be important in reducing the overall environmental impact of the oil spill (bioremediation). Microbial activity has been observed to be five times higher within an oil plume than in the water-masses outside the plume. In the Gulf of Mexico, the microbial communities are likely to be particularly adapted to hydrocarbon exposure as this area experiences numerous natural seeps of oil and has been the site of other spills from drilling rigs, such as the IXTOC well blowout of 1979. It has been claimed by some authors that although there were several attempts to remove or dissolve the oil, it was the microorganisms that played the major role in decreasing the environmental impacts of the catastrophe.

Also gases, mainly methane, were released during the oil spill. As the blow-out occurred on very deep water, these gases to a large extent remained in the water rather than being evaporated to the atmosphere. In the deep hydrocarbon plumes where much of the discharge was interleaved (1000 -

1200 m), the temperature was low (~4 º C), but nevertheless methanotrophic bacteria adapted to this low temperature degraded the hydrocarbons to a large extent. These enriched taxa of bacteria have representatives that degrade hydrocarbons or are stimulated by the presence of oil in cold environments. Although cell densities were higher in the plume, taxonomic richness was lower than outside.

Specialists within the diverse bacterial communities exhibited rapid boom-and-bust cycles, but background levels of the various species were observed as early as 60 days after the blowout.

2.2 Plankton

While the oil was a boon for certain bacterial types, both the oil and oil biodegradation process could affect phyto- and zooplankton negatively through e.g. inhibition of air-sea gas exchange and reduced light penetration, hypoxia caused by the intense degradation and through toxic responses. It was observed that the oxygen-concentration in oil-plumes was lower than in surrounding waters, but there were no signs of hypoxia. Dissolved oxygen concentrations were still about three times higher than the level at which fish would be threatened.

It was speculated that phytoplankton community structure changed and biomass increased due to a combination of the detrimental effects of oil contamination and the beneficial effects of decreased predation. It was also speculated that zooplankton recovered rapidly due to their short generation times and high fecundity, their ability to avoid oily patches, and their recruitment from unaffected areas. However, the data material prior to the accident was rather scarce, which complicates interpretation of oil-related effect, and makes these assumptions uncertain.

Regarding zooplankton, it has been documented that oil carbon was incorporated into to the planktonic food web. This was observed for two different size classes of zooplankton, where the largest class feed on the smaller, which indicated trophic transfer of oil components in the planktonic food web. Here it should be noted that biomagnification not has been reported. The final fate of these compounds is not known, but negative impacts on the plankton community level in the Gulf of Mexico have not yet been reported in the scientific literature. Elevated concentrations of hydrocarbons within planktonic organisms were only recorded approximately 2-4 weeks after the accident. In October 2010, half a year after the accident, there were normal concentrations of oil compounds and normal plankton communities in the affected area.

The conclusion of effects on plankton, is that direct effects only seemed to be of short duration, but that possible effects due to bioaccumulation or indirect effects due to changes in e.g. food supply or predation is too early to assess.

2.3 Fish and seafood

There are several potential effects of oil spills on fish and fisheries; direct effects on fish species, closure of fisheries and lastly effects in the market.

Early-stage survival of fish species, including commercial species, in seagrass nursery habitat within the oil-affected region was not negatively affected by the accident. Although many of these species spawned during spring-summer, and produced larvae vulnerable to oil-polluted water, the catch rates were high in 2010 after the spill relative to the previous four years. Several exploited species were even characterized by notably higher juvenile catch rates during 2010 following large-scale fisheries closures in the northern Gulf, although the data were statistically ambiguous. Thus immediate, losses of 2010 cohorts were largely avoided, and no shifts in species composition occurred following the spill. Furthermore, no impacts on the commercial fish stocks were observed approximately one year later.

The western Atlantic bluefin tuna, a commercially important and endangered species, exhibit spawning in the oligotrophic waters of the lower continental slope in the Gulf of Mexico, including the affected area. The spawning period is from April through June, and thus coincided with the oil spill also in time. Both crude oil and weathered oil byproducts are highly toxic to fish eggs and larvae. In addition the larvae may suffer indirect effects due to an altered food supply. Fortunately, the spawning hotspot in the west was apparently unaffected by the discharge. In total, less than 10% of the spawning area and less than 12% of the larval habitat was located in oil-contaminated water. However, it should be emphasized that possible long-term effects on the population still may occur.

However, there have been documented effects of the spilled oil on genome expression and tissue morphology on a resident marsh species (killifish). Larval and adult fish also showed aberrant protein expression in gill tissues. The effects persisted for over 2 months after exposure. Notably, these effects occurred despite of low concentrations of toxins in the water and low body burdens. Since the sediments may leak out contaminants for a considerable period of time, long-term monitoring is needed to fully document such effects. It is important to be aware of the fact that effects on the population level of fish not yet have been observed.

Regarding seafood contamination, PAHs and the dispersant component dioctyl sodium sulfosuccinate were found in only low concentrations or below the limits of quantitation. When detected, the concentrations were at least two orders of magnitude lower than the level of concern for human health risk. Approximately 6 months after the capping of the wellhead, no PAH were detected in oysters from oil-exposed sites. In this context it should be noted that some researchers have claimed that the FDA (Food and Drug Administration) risk assessment not sufficiently protects vulnerable population groups such as pregnant women and children. Furthermore, it has been pointed out that risk assessment following such accidents also should include metals. Lastly, knowledge on toxicity of mixtures (PAH, metals, dispersants) is considered to be inadequate.

Over 100 species of fish, crustaceans, molluscs and other invertebrates are commercially fished in the Gulf of Mexico. Gulf menhaden, Eastern oysters, brown shrimp, white shrimp and blue crab represent the largest landings. The fisheries in the area were closed after the accident due to risk of contamination of sea food, and in May 2010 an area of 118 000 km^2 was closed. This closure had of coarse huge economic consequences. On average, 22% of the annual U.S. commercial catch in the Gulf and 24% of the corresponding annual landed value was derived from the area that was closed to fishing, and it was estimated that the loss for the fishing industry was approximately 4.36 billion $. Once an area closed to fishing was free of visibly floating oil and all sensory and chemical results for the seafood species within an area met the criteria for reopening, that area was eligible to be reopened. In April 2011, the last area in federal waters closed to fishing due to the oil spill was reopened. However, as of November 9, 2011, some state waters off the Louisiana coast (Barataria Bay and the Delta region) remain closed to fishing.

Although the fisheries mostly are reopened, there still appears to be effects in the market, as the consumers remain sceptical. This causes further loss for the fishing industry. A study in Louisiana reported that 70% of consumers expressed some level of concern about seafood safety following the Gulf oil spill and 23% have reduced their consumption of seafood. The length of time it will take to regain markets and consumer trust remains an open question.

To conclude, there have been documented effects on the cellular level of fish, but not on the population level. The 2010 cohorts of fish in fact seemed to be strengthened rather than weakened.

Large fisheries were closed to protect the consumers from contamination, but at the same time the levels of PAH in seafood have not exceeded LOC. Although these existing data are optimistic, it is important to be aware of the fact that effects may be time-delayed due to effects on e.g. growth and reproduction and indirect effects due to effect on other ecosystem compartments. Additionally, oil stored in the sediments may continue to leak out for several years, which may lead to a chronic exposure.

2.4 Coastline

While effects of the accident on ecosystems in the water-masses seemed to be only marginal both in space and time, the situation in coastline has been more adverse. In august 2010, oil was recorded on more than 10% of the coastline in the Gulf of Mexico, and in January 2011 remnants of oil were still recorded on beaches. By then, the PAH concentrations in weathered oil was reduced by 86-98%. At the same time there is a concern that tar mats may persist for years, with unknown fate. It has been stated that aquatic and wildlife resources may experience a greater threat from further cleanup-operations than from the oil that still remains on the beaches. The oil contamination from the spill was found to have a profound impact on the abundance and community composition of indigenous bacteria in Gulf beach sands, and particular oil-degrading bacteria strains have been isolated. Thus microbial communities adapted rapidly to the spill both in the water-column and on the beaches, which is considered an important factor in reducing the impacts of the oil.

Marshes in the affected coastlines have been found to have a high natural recovery potential, evidenced by new shoots of marsh vegetation in heavily oiled areas one year following the accident. At the same time, it has been emphasized that possible effects on ecological processes in the marshes still are not known.

2.5 Birds, sea mammals and sea turtles

Up to 25 million migratory birds a day pass through Louisiana during the period of northern migration, and more than 70 percent of US waterfowl spend time in the Gulf of Mexico. In April 2011, in total 2 303 dead birds and 2 086 birds that were still alive had been recorded with oil remnants. 517 dead sea turtles and 456 alive sea turtles with oil had been recorded. Only 10 dead sea mammals with oil and two alive sea mammals with oil were found. It is important to be aware of the fact that several more dead animals were found, but as they had not any visible oil on them, the mortality could not necessarily be attributed to the accident. Additionally, the actual number of deaths due to the spill may be much higher than the number of recovered carcasses.

There has been conducted a comparison of mortality of seabirds from the Deepwater Horizon and Exxon Valdez accident. Despite the total amount of oil was much larger from the Deepwater Horizon, the mortality was highest in the Exxon Valdez accident, which had a shorter duration.

3. Effects of dispersants

Large amounts of dispersants were used, approximately 1.8 million gallons. For the first time, the dispersants were added at the wellhead in addition to the surface. The use of dispersants has been controversial, as the dispersants also may pose a toxicity risk. Oil spill dispersants are complex mixtures of two basic components; of one or more surfactants that can emulsify oil and a hydrocarbon-based solvent mixture that helps break up large lumps of high molecular weight, more viscous oil. There is limited information on the potential of dispersants to cause acute or long-term toxicity in aquatic species or humans.

The dispersant Corexit 9500 was the primary dispersant used during the Deepwater Horizon oil spill. Corexit 9527, a dispersant of similar chemical composition, was used to a lesser extent early in the spill response. Overall, the amount of Corexit used was over 8 000 000 L, where approximately 5 300 000 L was released at the surface and 2 915 000 L in subsea applications between May 15 and July 12, 2010.

The fate of DOSS (diactyl sodium sulfosuccinate), an anionic surfactant commonly used in dispersants, was studied in deepwater oil plumes. It was found that DOSS was sequestered in the plumes at 1000-1200 m depth, and not intermingled with surface dispersants application. The degradation rate was negligible, and it persisted in the plume for a long time. It is not clear whether the dispersant application was successful in reducing the oil droplet size or in increasing the sequestration of oil in deep water in the Gulf of Mexico.

Prior to acceptance of dispersants in the US, they need to be tested in standard toxicity tests, and thus there exist some data prior to the accident. Specifically, acute toxicity estimates (median lethal concentrations, LC50s) must be determined for the dispersant alone and in a 1:10 mixture with a fuel oil in standardized tests with marine species (fish and shrimp). Through such datasets it has been found that dispersants alone are generally less toxic than oil for these two species, but that most dispersant:oil mixtures are more toxic than oil alone. It is not clarified why the dispersants cause increased toxicity of oil, but it seems like the dispersants alter the toxicity of the oil components and possibly also increases bioavailability. In comparative tests with several dispersants, conducted after the accident, it was found that Corexit 9500 had similar toxicity as other available dispersants when tested alone, but was generally less toxic than other dispersants toxic when mixed with oil.

In a laboratory study conducted after the accident, Corexit 9500 was found to decrease hatching success of mallard ducks. With tests performed with an earlier formulation of Corexit (Corexit 9527) on mallard duck eggs, it was observed that the toxicity of the oil:Corexit 9527 mixture was larger than Corexit 9527 alone.

Another concern with dispersants is that degradation products may cause endocrine disruptions. This was tested for Corexit 9500 and other dispersants by *in vitro* bioassays. In contrast to other dispersants, Corexit 9500 did not cause estrogen activity. At the same time at initiated generalized oxidative stress in high concentration in line with other dispersants.

Bacteria from an oiled beach where shown to be inhibited by Corexit 9500, and it was suggested that the use of dispersants had the potential to diminish the bioremediation capacity of the microbial community.

DOSS has been recorded in seafood, but only in low concentrations, below human risk levels. However, it has been suggested to follow up monitoring to investigate whether DOSS remains in the environment.

In the literature, it has been emphasized that the primary concern associated with the use of dispersants is not the toxicity associated with a dispersant alone, but rather with dispersed oil and the increased bioavailability of oil components. Predicting the interactions between oil and dispersant components is difficult, therefore mixture studies are required to estimate risk. Both dispersants and oil are composed of multiple components, which vary according to source and weathering, which necessitate well designed experiments. In the literature, the relevance of the test organisms has also been questioned. The species have been selected due their ease of culture, availability of life stages and relative sensitivity to a wide range of chemical contaminants. Expansion of test species for organisms at risk to oil exposures should be considered based on habitat and geographic location to ensure adequate information. Unique to this spill was the injection into the oil plume. Due to the limited knowledge of life histories for most deepwater pelagic and benthic animals, little is known on the impact on these organisms. As a last point, the need of more long-term tests and tests on species higher in the food-chain (e.g. seabirds) has been requested.

To summarize, it is not known whether the extensive use of dispersants in fact was successful in reducing the overall impacts of the oil. Actually, there are indications that the dispersants could inhibit the natural degradation of oil. The use of Corexit was strongly criticised, but the existing data show that Corexit generally tends to be less toxic than several other dispersants. Lastly, it should be noted that although dispersants and dispersant:oil-mixtures clearly have a toxicity potential for marine organisms, there are no scientific data showing toxic effects of dispersants in the field after the accident, as far as we know.

4. Relevance for Norwegian waters

It may be argued in several ways that the experience from the Deepwater Horizon blowout may be relevant for potential wellhead blowouts in Norwegian waters. The bottom temperature in the deeper parts of the GoM is reported to be around 4°C. Such temperatures are encountered at around 300-500 m depth at the mid-Norway shelf (Nilsen and Nilsen 2006). The temperature is rapidly reaching 0°C below that at typically 600 – 700 m depth. Temperature differences may have an effect on the viscosity and hence dispersability of the oil at release, but it may be assumed that other properties such as inherent viscosity (heavy or light crude), dispersability (content of hydrocarbons containing sulphur, nitrogen and oxygen), oil temperature, rate of release etc. may override the effect of recipient temperature. As for microbial degradation is has been shown that all waters, also in cold regions, contain oil degrading organisms adapted to that temperature.

Surface conditions are however quite different. One must expect that low temperature will reduce evaporation, but this may be counteracted by stronger winds. The estimated atmospheric loss of Macondo oil of 25 % is in the range suggested by Mackay (1985) during the first 10 days in a generic oil spill under Arctic conditions. AMAP (2010) suggested an evaporative loss of oil of 40% in open cold water, and 20-25 % in sea ice areas. The variation around such figures must be expected to be large for a range of reasons, but they still suggest that evaporative loss of the lighter components of the oil in Norwegian waters may be comparable to that from Deepwater Horizon.

The frequent harsh wind conditions in Norwegian waters would lead to a stronger physical dispersion of oil into surface waters than during the Deepwater horizon spill, where the weather was reasonably calm. Leaving out the difficulties of active oil recovery by physical means, this may expose pelagic organisms to much larger concentration of oil particles than during the Deepwater Horizon spill. This difference may be less than anticipated due to the extensive chemical dispersion in the latter.

One may assume that the main factor creating differences between an oil spill in the GoM and at the Norwegian shelf lies in the risk of contact between oil and valuable resources. This contact is dependent on the distribution of such resources in space and time. Seasonal variability in production, reproduction and geographical distribution of valuable resources is particularly strong in northern regions. Typical are the seasonal and patchy aggregation of seabirds in nesting colonies, spawning fish stocks (e.g. cod and capelin), and aggregation of marine mammals. One may expect that this will enhance the variability in immediate effects of a single oil spill at the Norwegian coast compared to the GoM where there is less seasonal variability and more evenly dispersed resources. A spill under the optimal situation (e.g. winter season away from bird colonies) may cause insignificant impact; the same spill hitting a nesting/breeding colony of seabirds may cause high immediate mortality and possibly severe population decline. Similar arguments may be presented for a more variable effect when fish eggs and larvae are strongly aggregated in surface waters, although the effects of dispersed oil on larval populations are less well known, and even less so the significance of one year class reduction for the harvestable stock.

We may assume, however, that difference in seasonal/spatial impact between the Norwegian shelf and the GoM will be less from a blowout of the Deewater Horizon magnitude and duration that from a shorter term spill. Oil from a blowout is likely to sweep a large part of the coast and for a longer period of time, therefore affecting both sensitive and non-sensitive sites and periods. Whether this will render the Norwegian coast more or less vulnerable to blowouts than the GoM, is difficult to judge.

There may be practical lessons to be learned from the extensive use of dispersants during the Deepwater Horizon blowout, and which could be of value in judging optimal combat strategy during a Norwegian blowout. The environmental advantage/disadvantage of chemical dispersion compared to natural dispersion is not that clear. The general impression is that oil and dispersants together are more toxic than oil and dispersants alone, which could be a mere result of more oil being dispersed and dissolved in the water. There may be a trade-off between a short term elevated toxicity and earlier onset of recovery on one side, and less toxic effects but of longer duration (slower recovery) on the other. This is, however, not an inherent difference between Norway and GoM, rather a difference in oil dispersability and weather conditions for application. One could argue that dispersants would be preferable if the aim is to protect seabirds and the coastline, and “leave at surface” if the aim is protect fish eggs and larvae.

In summary, there are practical lessons to be learned from the Deepwater Horizon blowout and how that was handled. The link between the accident itself and its environmental and economic/societal consequences is difficult to use with any confidence to predict what would happen in a similar spill situation in Norway.

5. Reference

AMAP (2010) Assessment 2007: Oil and Gas Activities in the Arctic - Effects and Potential Effects. Volume 2:vii+277 pp.

Mackay, D (1985) The physical and chemical fate of spilled oil. Chapter 2 in Engelhardt FR. (Ed). Petroelum effects in the arctic environment. Elsevier App. Sci. Publ. LTD, London.

Nilsen, JEØ and Nilsen F (2006) The Atlantic water flow along the Vøring Plateau: detecting frontal structures in oceanic station time series. Manuscript submitted to Elsevier Science.

Ramseur, JL (2011) Deepwater Horizon Oil Spill: The Fate of the Oil. Congressional Research Service. CRS Report for Congress, 26 pp.

NIVA: Norway's leading centre of competence in aquatic environments

NIVA provides government, business and the public with a basis for preferred water management through its contracted research, reports and development work. A characteristic of NIVA is its broad scope of professional disciplines and extensive contact network in Norway and abroad. Our solid professionalism, interdisciplinary working methods and holistic approach are key elements that make us an excellent advisor for government and society.

Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no