The nature of the spillage problem for oils and chemicals[1]

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1 Abstract

The Norwegian Continental Shelf is one of the most challenging offshore oil producing areas in the world. The daily production rate is close to 3 million barrels and Norway has become the world's 2nd largest exporter of crude oil. Today, exploration activities move into water depths exceeding 500 metres and new regulations, model tools and oil spill response capabilities are required.

The paper gives a general introduction to the Norwegian oil spill response contingency and legislation, with special focus on the responsibilities of the petroleum industry, municipalities and governmental authorities. In addition an introduction to the wide range of crude oils produced in Norway is given. An assessment on the performance of both mechanical recovery and chemical dispersants, exemplified by how oil spill response can be taken into account in environmental risk analysis and contingency analysis, is included. A brief introduction to the new regulations concerning safety, health and the environment in the offshore industry as well as a description of challenges related to climatic conditions and deep sea oil exploration is given.

2 Norwegian contingency today

2.1 Geography, weather & climate

The Norwegian economical zone is located between 56 and 82 degrees North and covers 2 million square kilometres. While the land area constitutes 324 220 square kilometres only, the total beach line - fjords and islands included - is close to 57 000 kilometres. At this northern latitude, huge variations in weather and light conditions prevail and while some parts of the country have arctic climate, mild winters with temperatures above freezing is common in mainland coastal areas. All this, in combination with extensive shipping and petroleum exploration, production and transport, represent a risk of severe environmental impact from oil and chemicals.

2.2 The Pollution Control Act

The Norwegian Pollution Control Act of 1981 chapter 6 "Acute Pollution" includes specific requirements related to contingency in cases of acute pollution. The industry and municipalities have to comply with the following obligations:

- to establish and maintain a contingency organisation and a contingency plan,
- to notify when acute pollution is observed,
- to take immediate action to limit environmental impact and consequences,
- to assist the government in case of national emergencies.

The "polluter pays" principle is also implemented in the Act.

[1] Opinions and assertions expressed in this paper are solely those of the authors and does not necessarily represent the views or policies of the Norwegian Pollution Control Authority (SFT).

2.3 The national contingency system

The Pollution Control Act states that the national contingency system is divided into private (industry), municipal and governmental contingency with specific areas of responsibility. In Norway, all contingency plans and organisations are standardised and co-ordinated. Hence, in case of a major national emergency, the national contingency system for response to acute pollution will work as a single integrated response organisation. In addition Norway is a member of the Bonn Agreement, Copenhagen Agreement and other international agreements concerning mutual notification and assistance in case of major environmental emergencies.

2.4 Industry and transport

2.4.1 The petroleum industry

In the North Sea and Norwegian Sea, almost 3 million barrels of crude oil is produced daily from more than 50 floating and fixed installations. The crude oil is transported from offshore installations on shuttle tankers and through pipelines to several oil terminals on land, both in Norway and in the UK from which very large crude carriers embark. 10% of Norway's GNP and 36% of all export is originating from this industry. Annually about 2500 tonnes of oil is discharged, of which 90% is produced water with an average oil content of 25 ppm. The remaining 10% of this annual volume originate from about 150 acute oil spills, most of which have a spilled volume of less than 1 m^3. The volume of produced water is increasing, as production wells grow older. In addition more than 150 000 tonnes of production chemicals is released annually. Such discharges require a release permit from the Norwegian authorities in addition to compliance with contingency requirements forwarded by SFT.

2.4.2 On shore industry

Some 80 industrial enterprises have received individual contingency requirements from the SFT, in addition to the general obligations laid down in the Pollution Control Act. Based on environmental risk analysis, specialised contingency is established including a contingency plan, regular training of personnel and response equipment. Typical enterprises of this category are oil terminals, refineries and chemical factories. In addition to the industry there are more than 300 000 underground petroleum storage tanks in Norway, of which 1% is believed to leak at any given time. New regulations aiming at quality control and the prevention of such releases came into force in 1998.

2.4.3 Sea transport

Because Norway is one of the most rural populated countries in the world, small communities along the coast depend on ships transport. Petroleum products are transported by ships between more than 400 tank facilities, for further distribution by tank lorries. In 1998 the total amount of goods transported on internal sea-lanes in Norway was 16 million tonnes, 3 vessels was totally lost, and 63 vessels were partially lost due to grounding [1]. The amount of spilled oil from vessels in 1999 comprised 223 m^3 from 101 incidents [2].

2.4.4 Land transport

In Norway, rail and road transport of chemicals and petroleum products is common. Each year about 40 accidents involving petroleum and chemical cargo take place, some causing environmental impact to rivers and soil. In 1998 14,5 million tonnes of petroleum products and 4,5 million tonnes of chemicals were transported on-road [3]. The amount of spilled oil from land transport in 1999 comprised 53,3 m^3 of petroleum products from 28 incidents and 4,2 m^3 of chemical products from 5 incidents [2].

3 Crude oils in Norway

The behaviour of spilled crude oils and refined oil products depends on the prevailing conditions (e.g. temperature, sea-state, and currents) and on the chemical composition of the oil. Large variations in crude oil properties cause different behaviour when spilled at sea. For example, the Gullfaks crude ("Braer" spill in the Shetlands) has a low wax and asphaltenes content, while others (the "Amoco Cadiz" and the "Metula" spills) form persistent water/oil-emulsion contaminating the shorelines for years after the initial spill [4].

The increasing variation in types of crude oil coming into production, and the large number of petroleum products transported under different environmental conditions along the Norwegian coastline, calls for a more diversified oil spill contingency. A methodology to characterise the weathering properties of different oils has been developed at SINTEF [5,6], and the Norwegian crude oils can roughly be grouped into the following 4 categories;

3.1 Waxy crude

Norne crude is categorised as a "Waxy" crude oil. Norne crude has a pour point of + 21^{0}C (fresh). At low temperatures these oils may solidify on the sea surface, especially if the sea water temperature is more than 10 - 15°C below the oils pour point. This can give additional challenges when it comes to recovery. "Waxy" crude oils often have high viscosity in the non-emulsified stage. The viscosity of fresh Norne is 1968 cP (13^0 C, 10 s^{-1}). If the content of asphaltenes is low, as for Norne crude, the oil can form relatively unstable emulsion with lower viscosity compared to the water-free oil residue. [4]

3.2 Asphaltenic crude

Grane crude is categorised as an "Asphaltenic" crude oil. This category is characterised by a high content of heavier components, mainly asphaltenes but also resins. The content of lighter components is correspondingly low, reflected by high density and low evaporation. The wax content is normally low leading to low pour point values. Due to a high content of heavy components, these oils form stable emulsions with high viscosity [4].

3.3 Napthenic crude

Gullfaks crude is categorised as "Naphthenic" crude. Naphthenic crude oils generally have a very low content of n-alkanes different to the more "paraffinic" crude oils. This is often due to a partly biodegradation of the oil in the reservoir. This category contains oils with low contents of paraffins that often lead to high densities. The content of waxes and asphaltenes is generally low. This lead to a generally low pour point. Naphthenic crudes normally form emulsions with low stability and low viscosity. This will again lead to a relatively high degree of natural dispersion rate into the water column (as in the Braer Incident) [4].

3.4 Paraffinic crude

Statfjord crude is categorised as a **"paraffinic"** crude oil. "Paraffinic" crude oils are characterised by a high content of paraffins. These oils often have a relative low density, which reflects a high content of lighter paraffins. Wax, which is an important sub-group of paraffines, belongs to the heavier components that remains practically unaffected by evaporation. This category of oils covers a large range of North Sea crudes [4].

4 Models and tools

4.1 Oil drift-, trajectory- and plume models

For almost 20 years, the Norwegian Meteorological Institute (DNMI) has delivered an oil trajectory and drifting model service. Based on parameters such as location, oil quantity and oil type model results will be forwarded to the oil industry, the SFT or other customers within 20 minutes. This service is operational 24h a day. A major upgrade of the model will be completed in the near future, taking into account deep-water blow out (oil plumes in the water column) as well as interaction with enhanced weather forecast models.

4.2 Aerial and satellite surveillance

Since 1980, a dedicated oil pollution surveillance aircraft has been in daily operation in Norway. The on-board Side Looking Airborne Radar (SLAR), IR/UV line scanner, photo and video equipment can detect and assess oil pollution at sea. The aircraft has all weather capabilities due to a high altitude performance and long range. A digital image transfer system between the aircraft and the governmental operational command centres in Horten, Bergen and Tromsø is included.

Since the early 1990s, radar images from ERS and RADARSAT has been used for early warning and flight planning purposes. Each year the combined use of aircraft and satellites cover more than 10 million square kilometres of sea surface detecting more than 150 oil spills.

4.3 Oil weathering models

In Norway, a research organisation has developed an oil database containing extensive laboratory analysis of about 60 different types of oil [5]. In addition, detailed crude assay data for 200 crude oils in Norway and abroad is included. Hence, the SFT has immediate access to oil weathering information (dispersion rate, evaporation rate, etc., as function of time, temperature and weather) for a wide range of crude oils. Information from such models combined with field trials is vital to risk assessment as well as contingency planning.

4.4 Environmental Risk Analysis

According to national regulations, oil spill contingency related to oil production or exploration must be established based on the following 3 steps: An environmental risk analysis (ERA), a contingency analysis and the development and implementation of a contingency plan. Among the most important criteria related to ERA, environmental damage to selected indicators (bird populations etc) lasting more than 10 years shall not occur more frequent than 1 out of 40 000 drilling operations. National standards for ERA and contingency analysis based on a Net Environmental Benefit Analysis (NEBA) approach has been in use for several years.

4.5 Contingency planning tools

Recently the Norwegian Pollution Control Authority has conducted an assessment of the governmental contingency response capability based on environmental risk assessment. In this work a contingency planning simulation tool was used to assess spill scenarios at different locations.

First, environmental risk analysis (probability of oil spill & environmental impact) was established for six regions. Then a number of "most probable" scenarios were defined in each region. For each scenario a thorough description was made, including the position of the oil spill, discharge conditions, flow rate and the total amount of oil at sea. Finally, a response plan was established for each scenario.

For each of the six scenarios, the effectiveness of oil spill response was simulated. The simulations provided us with the amount of oil recovered, naturally dispersed, stranded and evaporated. After several iterations, the response resources necessary to achieve the goals in the response plan were identified given by the number of mechanical oil recovery systems, response time, the number of shoreline cleanup teams etc.

The recommended level of contingency is now being compared to the present contingency level identifying the need for re-location of depots, more response equipment etc.

5 Training and exercises

A vital part of the preparedness is training and exercises. The types of courses and exercises described in this chapter are those conducted by SFT to uphold and increase the competence of the national contingency system in Norway. In addition SFT also arranges training courses for chemical spill response.

5.1 Training

The training courses are adapted to the following functions in the oil spill response organisations, in addition to specially tailor made courses:

- Introduction (basic) training course
- Team leader course
- On-scene commander level course (OSC-Sea, OSC-Coast and OSC-Land)
- Management level course
- Course for governmental depot task force and technical supervisors

The basic training course is designed for all personnel involved in the contingency organisation, and is usually conducted by the organisation itself. The team leader level is given a 4-day training course consisting of two days of lectures and two days of practical training. During the practical training one day is solely for hands-on exercises using booms and skimmers at sea and from the shoreline. The course for the on-scene commander level (OSC) focuses on operational management and tactical use of response equipment during an operation, and is a combination of lectures and practical training tailored to fit the needs of the various geographical response areas (i.e. at sea, coast or on land). The management level of an oil spill response operation is given a three-day training course consisting of one day of lectures and two days of practical training; divided into a tabletop exercise and a role-playing exercise.

5.2 Exercises

In Norway, exercises conducted by SFT are adapted to the needs of the municipal and the governmental contingency organisations.

Within the governmental contingency there are exercises arranged over a wide area to uphold the preparedness. Several large integrated exercises are arranged annually in which personnel and resources from the private industry, the municipalities, the government and the Coast Guard is taking part verifying that the national contingency system is operational.

On the international level a number of exercises are arranged annually based on different international obligations such as the Bonn agreement and the Nordic Copenhagen Agreement.

6 Oil recovery and chemical dispersion

The use of oil recovery equipment and chemical dispersion, as part of an oil spill response strategy, will often be a discussion of performance. The manufacturer rates the equipment with a theoretical performance but this is not necessarily a measure of how the equipment will perform during an oil spill incident. In this chapter we try to describe the theoretical performance, the constraints in performance and exemplify this through a scenario. As in-situ burning is not a part of the current Norwegian strategy, it is not covered in this chapter.

6.1 Theoretical performance

The theoretical performance of oil spill response systems is given by the theoretical recovery (pump) rate, or for dispersants, the theoretical maximum volume of oil that can be treated by a given volume of dispersant.

6.1.1 Skimmers and pumps

For skimmers the theoretical performance is a function of the working principle of the skimmer and the type of pump involved. Furthermore the performance will depend on the thickness and viscosity of the oil, the working principle of the skimmer and pump and the flow of oil towards the skimmer. The table below illustrates, in a general way, how the performance for skimmers depends on the viscosity of the oil.

	Recovery rate (m^3/h)		
Viscosity (cP)	Brush skimmer, 100 cm diam., 61 cm wide.	Disc skimmer, 38 cm diam., 30 discs.	Weir skimmer, Transrec 350.
1000	3,8	2,0	305
6000	7,5	1,25	235
10000	10,5	1	193

Table 1. Recovery rates of brush, disc and weir skimmers running at optimal speeds as a function of viscosity [7]. The results for the Transrec skimmer are from reports from NOFO field trials in 1987, 1989 and 1990 using crude oil emulsions.

6.1.2 Booms

To prevent the rapid spreading of oil on the water surface and render mechanical recovery possible, booms are used. The booms must be able to withstand the towing forces and dynamic loads imposed by the waves and currents. These forces can be quite significant for large offshore booms, and demand strong tension members and good boom connectors. In addition the wave following ability of the booms, i.e. the heave response, should be as good as possible. In practice this is achieved by ensuring buoyancy to weight (B/W) ratio of at least 10:1, as this will give lower drag forces and better wave following characteristics than booms with lower B/W ratio [8]. Another limiting factor in boom design is the ability to hold oil in currents. In general oil will start escaping under the boom when the currents are in excess of 0,7 knots. This is called "entrainment loss" and occurs because oil droplets start breaking away from the underside of the upstream head wave of the contained oil slick. An increase in current above 0,7 knots will result in increased loss of oil.

6.1.3 Dispersants

The effectiveness of dispersants is dependent on the viscosity of the oil/emulsion, the water content and stability of the emulsion. Since the dispersability of oils in general are assessed in laboratories under ideal conditions and small amounts, the challenge is to correlate these results with real applications during an oil spill. Under ideal conditions a given amount of dispersants may effectively disperse a given volume of oil. This theoretical performance is dependent on perfect dosage and distribution of the chemical, perfect mixing energy at the sea surface, perfect droplet size of the dispersant, an even oil layer thickness, no waste of chemical due to wind etc. Hence, the true performance of a dispersant is probably even more difficult to assess than for mechanical recovery.

6.2 Response efficiency – environmental risk analysis

Estimating the true performance of mechanical oil spill response is an extremely complex task. The ultimate question is, by how much do oil pollution contingency reduce the risk of environmental impact? One approach already demonstrated by some oil companies is to assume that the effect from oil spill contingency on a scenario can be represented by a reduction in the true discharge volume (Vtrue). The new equivalent volume (Veq) may be defined by:

Veq = Vtrue – (Vtrue * NBRF)

Where NBRF is the Net Benefit Response Factor taking into account 7 different operational constraints as described below. Hence, we assume that the environmental impact from a given oil spill of volume Veq <u>without</u> response, equals the environmental impact an oil spill of volume Vtrue <u>with</u> response. By introducing NBRF, model simulations for (risk of) environmental impact can be performed *as if* no response was ever conducted.

How do we calculate NBRF for a given spill? Should it be a standard set of values given by the environmental authorities, or should it be based on a methodology taking into account….

1. NBRF1: Release conditions & duration of the spill
2. NBRF2: Visibility/surveillance/darkness
3. NBRF3: Type of oil
4. NBRF4: Response potential (amount of response resources available)
5. NBRF5: Infrastructure / geography / logistics
6. NBRF6: Weather & climate (icing)
7. NBRF7: Mechanical breakdown

Each factor, of which some are correlated, contributes to NBRF.

6.2.1 Example

An exploration platform is located 100 km from the Norwegian coastline at 71 degrees North in November. Imagine a blow out rate of 2000 tonnes a day (Vtrue) and that we have all necessary data and statistics related to the 7 topics listed in 6.2. A possible formula is:

NBRF = NBRF1*NBRF2*NBRF3*MNRF4*NBRF5*NBRF6*NBRF7

Imagine that a standard set of NBRF's as a function of parameters related to weather statistics, visibility, regional assessment of infrastructure etc has been established by the industry or authorities. This may lead to the following equation:

NBRF = 0,9 * 0,7 * 1,0 * 0,7 * 0,9 * 0,4 * 0,9 = 0,14

And an equivalent blow out rate of:

Veq = Vtrue - (Vtrue*NBRF) = 2000 - (2000 * 0,14) = 1714 tonnes per day.

Conclusion: Given the location, weather statistics, oil type, infrastructure, response potential etc. in this case the environmental impact of a spill of 2000 tonnes per day with response, is equal to the impact from a spill of 1714 tonnes per day without response. This simplification is acceptable when related to the quantification of environmental risk. While risk analysis usually do not include contingency efficiency, this may be more common in the future as methodology is further developed. This example was just a demonstration of how a Veq may be calculated in the future.

6.3 Response efficiency – contingency analysis

The following scenario is taken from the assessment of the governmental contingency response capability based on environmental risk assessment as described in chapter 4.5.

6.3.1 The incident

15 000 tonnes of Balder crude oil and 300 tonnes of bunker C is spilled in two hours as a result of a shuttle tanker running aground. The incident occurs close to the shoreline with an estimated shortest drift time of 18 hours for the first oil to reach the shoreline. The Balder crude oil is generally categorised as an asphaltenic crude oil with a density of 914 kg/m^3. Based on oil weathering studies less than 20% will evaporate and the oil will have reduced dispersablility after 24 hours. When stranded, the oil will have a water content of 80%.

6.3.2 Simulation with no response efforts

This simulation was performed without any response efforts. After two days 3000 tonnes of oil are in the littoral zone. Total contaminated beachline is 75 km. After 5 days all oil, i.e. 11000 tonnes pure oil corresponding to 60 000 m^3 of emulsion, is within the littoral zone. At this time approx. 200 km of shoreline are contaminated.

6.3.3 Simulations with oil spill response efforts

In these simulations, oil spill response efforts (mechanical recovery and use of dispersants) were used in two ways. The first based on an optimistic approach as to availability and response time, the second based on enhanced use of dispersants and shorter response time for the first mechanical recovery systems. The different response methods were downgraded by the use of Net Benefit Response Factors (NBRF) as described previously. The table below illustrates the results of the different simulations in terms of amount of pure oil in the littoral zone (free-floating and beached).

	No response efforts	1. simulation with response efforts	2. simulation with response efforts
Amount of recovered and dispersed oil (tonnes)	0	4800	6800
Total amount of oil in the littoral zone (tonnes)	11000	7200	5600
Amount of oil in highest sensitive areas (tonnes)	9000	4000	3500

Table 2. Comparison of the simulations. All numbers are given as pure oil.

The results of the simulations will be off importance when assessing the total contingency in a given area, an assessment that is currently in process at SFT.

7 Future challenges

7.1 New off-shore regulations

New regulations concerning safety, health and environment for the petroleum industry will be put into force in 2001. Requirements related to regional and local environmental risk will be established. Based on an environmental risk analysis and a contingency analysis, response equipment, personnel and a response organisation will be established. Contingency regulations based on local and regional environmental risk represent a major challenge to model tools, contingency designers and the authorities.

7.2 Deep water oil exploration

In Norway, oil exploration is moving into deeper waters. Oil from a deep-water blow out may become a possible spill scenario. The challenge to the oil spill response brought on by this is the relative uncertainty of whether or not the oil will reach the surface, and the time, position and consistence it will surface in. Some of these issues are due to underwater currents, differences in salinity, formation of hydrates and pressure/temperature at deep water. Experimental releases of oil from 840 metres were performed in June 2000 and model tools and scenarios will be revised based on these findings.

7.3 Oil recovery in low visibility

The light conditions in Norway are unique. In North-Norway there is 24h daylight during the summer and 0 hours during the winter. As oil exploration and production moves off North-Norway new challenges are put forward. Mist and low clouds that reduce infrared sensor performance hamper the use of sensors. Therefore the ability to recover oil during darkness and low visibility is vital to oil spill contingency in the future.

8 Conclusions

In this paper we have tried to give a description of the Norwegian contingency today, and some of the future challenges that has to be addressed by the authorities. Furthermore the use of models and tools for contingency planning and response planning are described. In the latter part of the paper the performance of oil recovery and chemical dispersion is described by the theoretical performance and how the actual performance will assessed both by environmental risk analysis and by contingency analysis. The term NBRF (Net Response Benefit Factors) is introduced as a method of downgrading the theoretical performance of an oil spill response. The results of this downgrading is used in two ways; by assessing the environmental impact through models and by assessing the contingency needs (equipment etc) necessary to give the desired reduction in the environmental impact.

9 References

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10 Biography

Jørn Harald Andersen

Jørn Harald Andersen was born in Drammen, Norway, 24. March 1965 and holds a Master of Science degree in Naval Architecture from the Norwegian Institute of Technology (NTNU/NTH) 1988. He joined the Norwegian Pollution Control Authority (SFT) in 1990 after several project assignments within deep sea diving and design of naval vessels.

Within SFT he has been responsible for a 4-year research and development programme as well as development of Norwegian satellite and aerial surveillance services. He is now a Senior Executive Officer, Section of Contingency Regulations.

Bjørn Bratfoss

Bjørn Bratfoss was born in Tønsberg, Norway 26. June 1962 and is educated at Tønsberg Maritime Collage and Royal Norwegian Naval Academy. After holding positions as crew on merchant ships and navigation officer, executive officer and commanding officer on board Norwegian Coast Guard vessels he joined the Norwegian Pollution Control Authority (SFT) in October 1999.

Within SFT he has worked with contingency planning and oil spill response operations, and is now a Senior Executive Officer, Section for Emergency Preparedness and Response.

Johan Marius Ly

Johan Marius Ly was born in Oslo, Norway 18. January 1967, and graduated from the Royal Norwegian Naval Academy as a Naval Engineer in 1991. After holding various at sea and onshore positions in the Royal Norwegian Navy he joined The Norwegian Pollution Control Authority (SFT) in 1996.

Within SFT he has worked with contingency planning and equipment projects related to the Norwegian governmental oil spill contingency in addition to international co-operation. Since 1998 he has been responsible for SFT's training programmes, and is now a Senior Executive Officer, Commercial Services Unit.

sft: Oil Spill Contingency

The nature of the spillage problem for oils and chemicals.

Presentation at "Interspill 2000"

Johan Marius Ly,
Senior Executive Officer,
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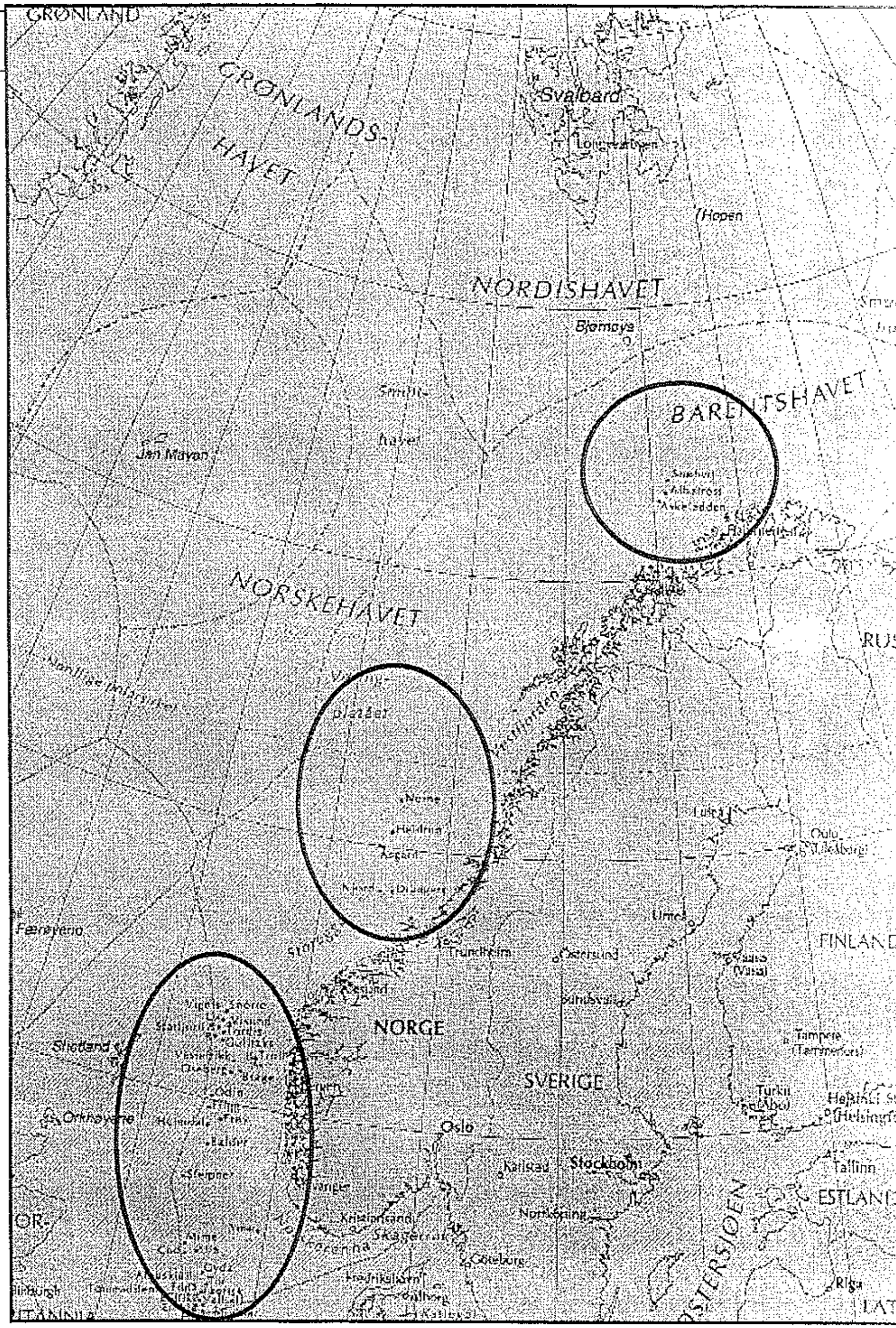
Outline of presentation

- Norwegian contingency today
- Crude oils in Norway
- Models and tools
- Oil recovery and chemical dispersion
- Future challenges

Norway - facts & figures

- Geographical features:
  - Shortest distance North - South: 1752 km
  - Distance of coastline: 57 000 km (including islands and fjords)
  - Climatic variations form arctic in the north to coastal in the south.
- Shipping industry:
  - 7th largest fleet, approx. 33 mill DWT, (approx. 4,4% of total world fleet, 1999).
- Petroleum industry:
  - Daily production rate: approx. 3 mill. barrels.
  - Approx. 90 % is exported
  - Three main production areas.



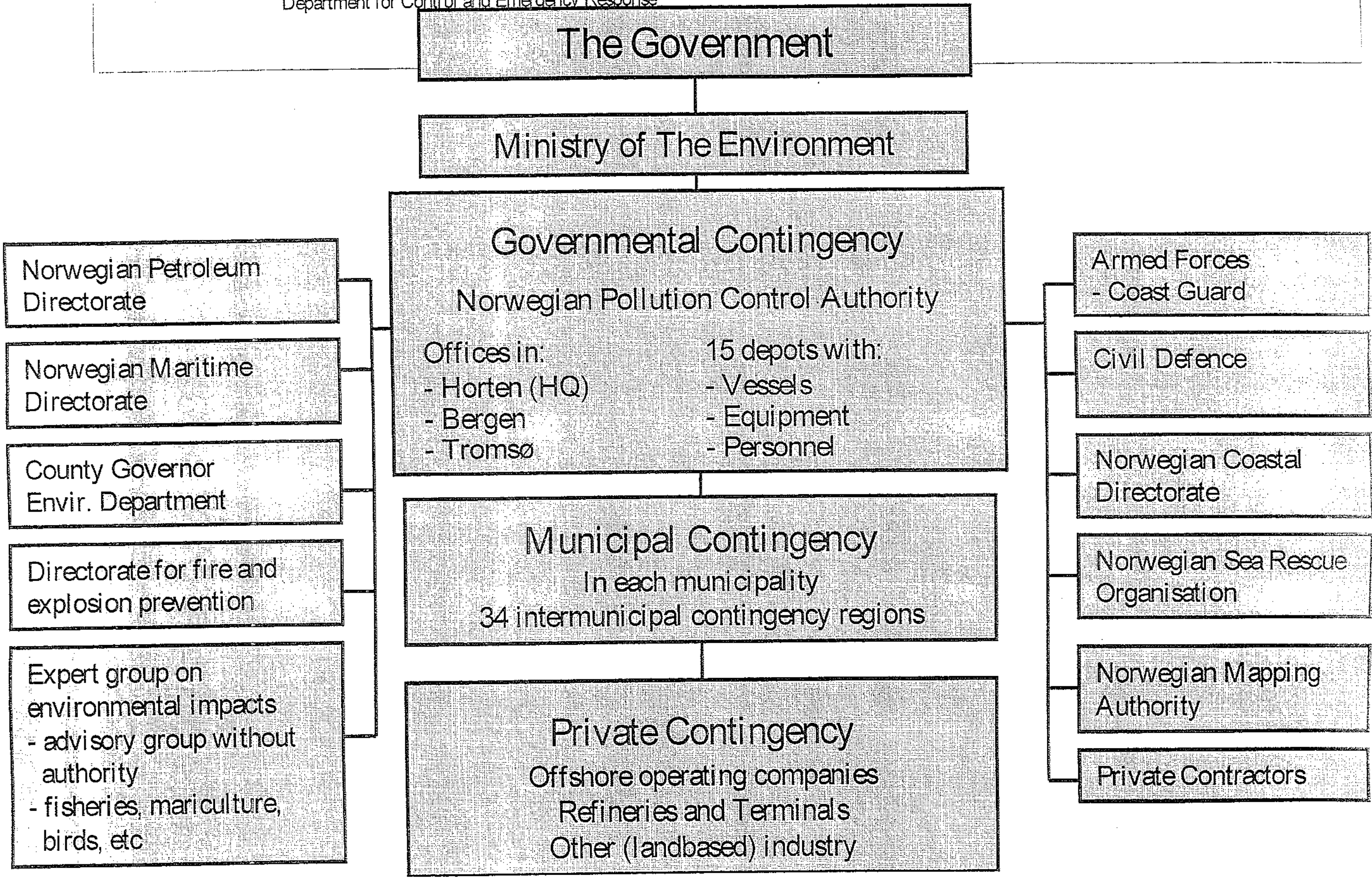
The Pollution Control Act (1981)

Main principles - acute pollution:

- "Polluter pays" - principle.
- Obligation to notify.
- Contingency planning requirements.
- Obligation to provide assistance.
- Obligation to provide information.

Norwegian Contingency

Department for Control and Emergency Response



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Crude oils in Norway

Norwegian crude oils can roughly be categorised as follows:

- Waxy crude.
  - High content of wax, e.g. Norne with a pour point of +21 deg C.
- Asphaltenic crude.
  - High content of heavier components, e.g. Grane.
- Napthenic crude.
  - Very low content of n-alkanes, low content of paraffins, wax and asphaltenes, high rate of natural dispersion, e.g. Gullfaks.
- Paraffinic crude.
  - High content of paraffins, e.g. Statfjord and a large range of North Sea crudes.

Models and tools

- Oil drift-, trajectory and plume models.
- Aerial surveillance and satellite surveillance.
- Oil weathering models.
- Environmental risk analysis.
  - Net environmental benefit analysis (NEBA)
- Contingency planning tools

Oil recovery and chemical dispersion

- Theoretical performance
  - Skimmers and pumps
  - Booms
  - Dispersants

Response efficiency - enviro. risk analysis

- Qualification of environmental risk by reducing a true discharge volume (V_{true}) to an equivalent volume (V_{eq}) for use in assessing the environmental impact:

  $V_{eq} = V_{true} - (V_{true} \times NBRF)$

- NBRF is the Net Benefit Response Factor and consist of different operational constraints:
  - Release condition & duration of spill
  - Visibility/ surveillance/ darkness
  - Type of oil
  - Response potential (amount of resources available)
  - Infrastructure/ geography/ logistics
  - Weather and climate
  - Mechanical breakdown

Environmental risk analysis - example

- Qualification of environmental risk by reducing a true discharge volume (V_{true}) to an equivalent volume (V_{eq}) for use in assesment of environmental impact.
- Spilled amount, (V_{true}): 2000 tonnes
- NRBF factors: 0,9* 0,7* 1,0* 0,7* 0,9* 0,4* 0,9
- Equivalent volume, (V_{eq}): 1714 tonnes
- Use in models etc to assess the impact.

Response efficiency - contingency analysis

- Scenario specific
- Comparison of the effects of different response actions
  - O-response (monitor and evaluate)
  - Use of mechanical recovery (varying amount of equipment)
  - Use of dispersion (varying amount of equipment)
- Assessment of resources
  - Currently available
  - Necessary to achieve the environmental objectives by the use of an acceptable amount of money.
- Additional resources - change in strategy
  - Shifting resources between depots
  - New resources - higher level of contingency

Comparison of simulations

	No response efforts	1. simulation with response	2. simulation with response
Amount of recovered and dispersed oil	0	4800	6800
Total amount in littoral zone	11000	7200	5600
Amount in highest envir. sensitive area	9000	4000	3500

Future challenges

- New regulations for offshore industry
- Deep water oil exploration.
- Oil recovery in low visibility.

Conclusions

- Norwegian contingency
- Environmental risk analysis and contingency analysis
- Net Response Benefit Factors
  - Downgrading the theoretical performance