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Norwegian Clean Seas Association for Operating Companies (NOFO) – Research and Development Program for Next Generation Arctic Recovery Equipment

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Abstract

The Norwegian Clean Seas Association for Operating Companies (NOFO) was established in 1978, in the aftermath of the "Bravo" offshore blowout incident in April 1977.

The harsh environmental conditions in Norwegian waters are a challenge for oil spill response equipment. Since the early days, NOFO has continually focused on development and improvement of offshore oil spill response equipment.

Today, the Norwegian Continental Shelf may be considered to be in a mature stage of development, with oil production primarily located in areas far from the shore, allowing a significant time interval for near shore response in the case of an oil spill.

Looking towards future activities and taking into account the blocks included in the most recent licensing round, the trend seems to be that the exploration activities will be located closer to the shore, as well as further to the north than the present oil producing installations.

Another trend is an increasing diversity of oil types produced over existing installations, as satellite fields are developed. This requires increased flexibility of oil spill response measures and strategies.

Anticipating these developments, the Norwegian Clean Seas Association for Operating Companies in 2000 initiated an R & D program for development of more flexible and robust equipment. This program includes redesign of skimmers, development of new booms and boom concepts, allowing higher towing speeds, as well as redesign and improvement of helicopter based dispersant systems.

In June 2003, prototypes of this equipment were tested in NOFO's large scale oil – on – water exercise.

Introduction

Since 1978, NOFO has been an active part in the development of oil spill response equipment, in part by funding research and development, but also through active participation in testing and design. Milestones include:

- First generation of offshore booms in 1978
- First generation of offshore skimmer: 1978
- Further skimmer development (Artic skimmer): 1980
- Norwegian Oil Trawl concept: 1984
- Transrec systems: 1986
- Hi-Wax skimmer: 1998

At present, NOFO has 14 complete Transrec and heavy boom systems, operated by 14 dedicated Oil Recovery vessels, assisted by 14 towing vessels. In addition, a total of 9 Hi-Wax skimmers are available for operation from the OR vessels.

There are at present several trends that call for adjustments and refinements of the Norwegian oil spill combat strategy:

- NOFO has as of 2001 an overall responsibility coordinating oil spill response, including coastal and near shore areas, as well as the shoreline (see Rødal *et al.*, 2003)
- Areas opened for exploration drilling are to a large extent located closer to the coast and in the northern part of the shelf, in the Arctic.
- As small reservoirs are tapped and produced over existing installations, the diversity of oil types and difference in mode of release increases.
- Norwegian authorities has recently included chemical dispersants as an option in oil spill combat, where net environmental benefit analyses show this to be the better option.

Reviewing the potential implications of these trends, NOFO initiated a major R&D program in 2000. This program includes redesign of skimmers, development of new booms and boom concepts, as well as redesign and improvement of helicopter based dispersant systems.

Arctic conditions

The part of the Norwegian Continental Shelf (NCS) that is opened for petroleum activities extends from latitude 56° N to 74° 30' N. While there exist many different definitions of "the Arctic", the most relevant in our context is the area north of the Arctic Circle, which is located at latitude 66° 32' N. This area is shown in Figure 1, where also the two northernmost NOFO bases are located.

Due to the Gulf stream, driving relatively warm water northwards along the Norwegian coast, the climatic conditions in the Arctic areas of Norway is not as extreme as those found at these latitudes in Russia, Canada and North America. Within the area opened for petroleum activities on the NCS, the climatic conditions are not as different as may be imagined from the span in latitude. Some key factors are further discussed below.

Sea temperature

In the western and southern part of the area, sea water temperatures are not very different from what is found further south along the northern part of Norway. However, as we move north and east, sea temperatures drop. At the northern extent of the area, sea temperatures are below 0° C six months of the year (Figure 2).

Sea ice

In the northern part of the area, sea ice is a seasonal occurrence. Although the major extent is north of the area opened for petroleum activities, sea ice is encountered within the area in winter and spring, posing a challenge for offshore oil spill response. The maximum and minimum extent of sea ice is shown in Figure 3.

Light and visibility

There are no significant differences in horizontal and vertical visibility within the arctic region and areas further to the south on the NCS.

The availability of daylight however, is an aspect particular for the arctic area, with the sun above the horizon 24 hours a day in mid summer, and below the horizon 24 hours a day in mid winter, as illustrated in Figure 4. Taking into account the period of civil twilight, availability of operational light is higher in this area than further south on the NCS.

Other factors

With regards to winds and waves, the southern and middle parts of the NCS have the harshest conditions. Of the five NOFO contingency regions on the NCS, region 5 (which is the area located in the Arctic), is ranged as number three in terms of frequency of high waves (Hs > 4 m).

Icing is a phenomenon that may occur in the Arctic area, although only a few incidents has been reported. There is no systematic reporting of icing, but efforts are under way to quantify the frequency of icing conditions through modeling, as input to the planning of oil spill response operations.

Environmental sensitivity

The Arctic part of the NCS is an important area for marine mammals, fish and seabirds. In summer, populations of breeding seabirds are of international significance, and the region is considered as the most sensitive of the Norwegian contingency regions. In winter, the environmental sensitivity is reduced, and the southern contingency regions are considered as most sensitive during this part of the year.

An in depth discussion on environmental sensitivity is not within the scope of this paper. To provide the reader with some indications on the conditions within this area, results from the initial level of Net Environmental Benefit Analyses is presented in Figure 5, for the months of July and January. Areas of high concentrations of fish eggs and larvae is indicated in red, near shore areas and high concentrations of seabirds offshore is shown in green, while areas of high concentrations on both seabirds and fish is shown in yellow. The two maps clearly illustrate the seasonal variations.

NOFO R&D Program - Equipment

When initiated in year 2000, three distinct phases were defined. An initial phase with pilot studies, a second phase with full scale testing, and a third phase including a replacement of older equipment (Figure 6).

Initial phase

The initial phase comprised several activities, related both to properties and location of technical equipment. Main activities were:

- Development of a helicopter based dispersant system
- Redesign of the high-capacity skimmer used in offshore operations
- Development of two different concepts for offshore booms
- Review of the current distribution of mobilization bases and oil spill response equipment.

This phase is discussed in detail in a paper given at the 2003 International Oil Spill Conference (Brekne *et al.*, 2003). Please confer this for further detail.

Second phase

Based on the results from the initial phase, pilot versions of the new equipment were tested in the NOFO 2003 Oil on Water exercise. From the test results, NOFO administration made recommendations to the NOFO General Assembly on how to proceed in the third phase.

An added element in this phase was the inclusion of a pilot study on the feasibility of increasing effectiveness of offshore oil spill combat operations in conditions of reduced light and visibility.

Third phase

This third phase comprises a) modification of selected pilot versions tested in the preceding phase, and b) purchase of a number of units of the modified version over a period of several years. By the end of this period, all skimmers and booms currently in use by NOFO should be replaced.

This third phase also includes a continuation of the project to enhance effectiveness of offshore oil spill combat under conditions of low light and visibility. The ultimate aim of this project is to achieve daylight effectiveness of recovery also in total darkness and/or low visibility.

The NOFO 2003 Oil on water exercise

The exercise took place June 16th to 19th 2003, at the Frigg field in the Norwegian sector of the North Sea, approximately 150 km off the coast of mainland Norway. A total of eight vessels were involved in the exercise, and 40 observers from a number of nations followed the experiment from the largest vessel.

Norwegian authorities had given their consent to a total release of 260 m^3 of oil emulsion during the exercise, in a series of experimental releases (see Figures 7 and 8). Each release was strictly controlled and monitored, and mass balance calculations were performed for each individual release. For more detailed information, confer Brekne *et al.*, 2004).

Conclusions from testing during phase 1 and 2

- Helicopter based dispersant system: This system is currently operational on the Norwegian Shelf, and no further modifications are planned.
- Skimmer: The prototype tested in June is now in operation on the offshore oil spill response vessel in the Norwegian Sea. A series of modifications will be made to the prototype design in the course of 2004.
- Offshore boom # 1: The concept of having submerged webbing between the two arms of the boom is abandoned based on the results from the full scale test. However, the basic design will be maintained in a further development process, with the objectives of having a prototype available for testing in the course of 2004.
- Offshore boom # 2: Redesign of the guide booms is already initiated. A revised prototype will be completed and tested in the course of 2004.

These conclusions were presented to the NOFO General Assembly in 2003, as input to decisions on an investment plan.

Development of support systems

Increased efficiency in reduced light and visibility

As limited operational light in the winter season is one of the major challenges for arctic oil spill response, NOFO initiated a project in 2003 to evaluate the potential for increased effectiveness of oil recovery under such conditions.

In this project, several technologies and approaches were evaluated, including:

- Infrared video and infrared scanners
- Micro Wave Radiometer (MWR) and Laser Fluoro Sensor (LFS)
- Satelitte based radar (Synthetic Aperture Radar - SAR)
- Airborne radar (Side Looking Airborne Radar - SLAR)
- Traditional maritime radar with post processing of data
- Low light cameras and light sources outside visible spectrum
- Drift models, Metocean buoys and sonars

In a systematic approach, the above items were evaluated against a standard set of criteria; Detectability, Classification, Operativity, Personnel safety, and Cost Benefit. In addition, the potential for integration with other technologies were addressed.

Based on the conclusions from this project, NOFO has embarked on a project to develop and implement a ship based radar system for detection of oil spills. This project is the first step towards the goal of achieving an oil spill response that is independent of light and visibility. In the course of 2004, this project will be completed and the results will form input to an evaluation of further phases of development.

Decision support systems

When an oil spill occurs in coastal waters, the situation can rapidly develop and increase in complexity. Depending on the characteristics of the spill, oil slicks spread and travel in different directions as a result of local winds and tidal currents. Each individual slick may require specific response measures, based on the resources at risk. If oil reaches the shoreline, the coastal characteristics will determine restoration and protection priorities, including cleanup strategies.

To meet this challenge, a computer-based system has been developed and implemented integrating GIS (Geographical Information Systems) and web components. This system is based on high resolution sea charts, as well as detailed national data sets on vulnerable coastal locations. A special user-interface has also been developed and tailored specifically for the needs of oil spill command-centers.

Based on input from a range of sources, digital maps present the estimated oil slick formations and track the movement of the spilled oil. Sensitive sites and shoreline characteristics are also depicted on the maps, which serve as a quick reference for oil spill responders. From this critical information, priorities can be made, response efforts identified and marked on the map. This information is then distributed to the relevant parts of the oil spill response organization and to the general public, as appropriate.

This decision support system is described in detail in another paper presented at the Interspill 2004 conference (Skeie *et al.*, 2004), and the reader is referred to this for details.

The initial geographical focus of this system was the coastline of northern Norway and the southern Barents Sea, where it now is fully operational.

Conclusions

The Arctic environment in the northern part of the Norwegian Continental Shelf represents a challenge for oil spill response operations. Compared to other parts of the NCS, limited light in winter, sea ice in the northern part, low water temperatures and high environmental sensitivity in summer are all important factors.

Meeting this challenge is one of the objectives of NOFOs extensive R&D program. From the results of the first two phases, NOFO has decided to continue development of equipment as well as support systems. Further, a gradual replacement of existing equipment is planned for the years 2004 through 2007.

Although development is ongoing, products from the initial phases of the program are already available, and will form valuable components of the oil spill response established for exploration drilling in the Arctic areas of the NCS in 2004.

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Figures

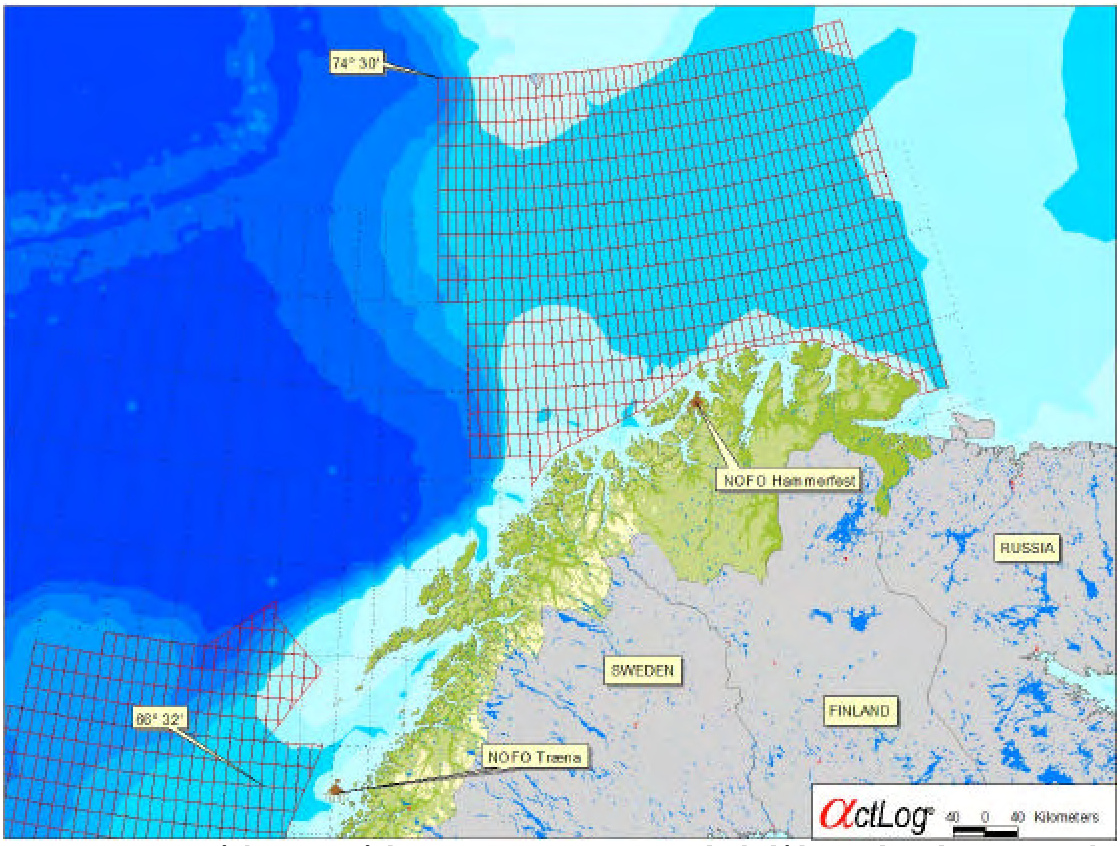


Figure 1. Map of the area of the Norwegian Continental Shelf located in the Arctic. The petroleum block grid is indicated, as well as the two NOFO bases at Træna and Hammerfest.

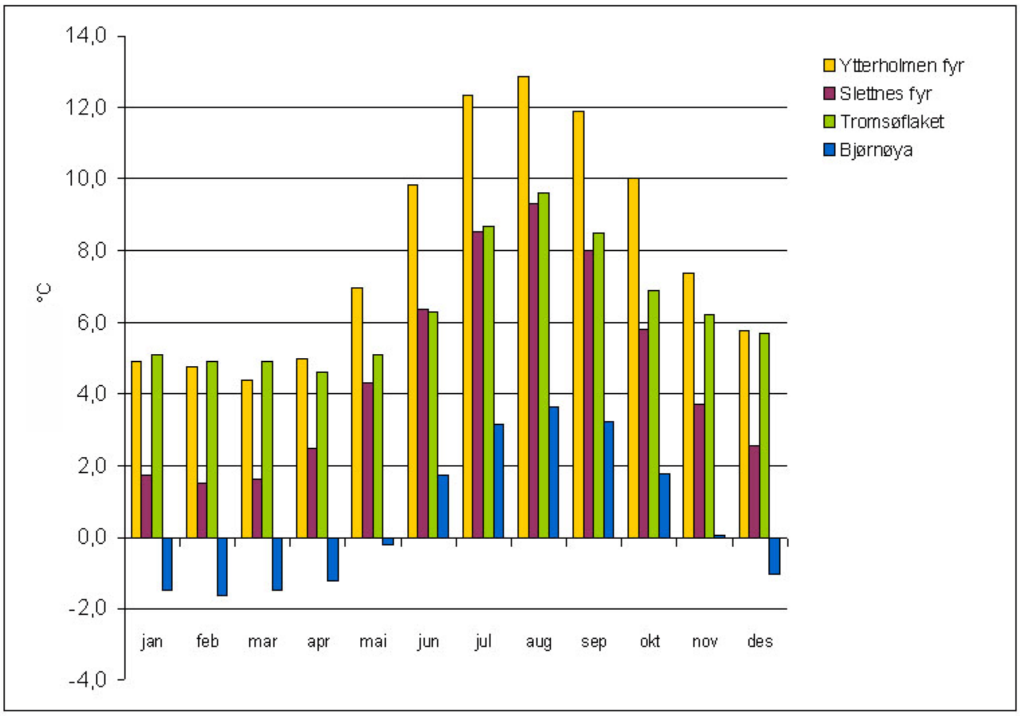


Figure 2 Mean sea water temperatures at selected meteorological monitoring stations within the Arctic part of the NCS. Ytterholmen fyr is located on the western part of the coastline, while Slettnes fyr is located further to the east. Tromsøflaket is an offshore monitoring stations, while Bjørnøya (Bear Island) is located at the northern extent of the area. Data supplied by the Norwegian Meteorological Institute.

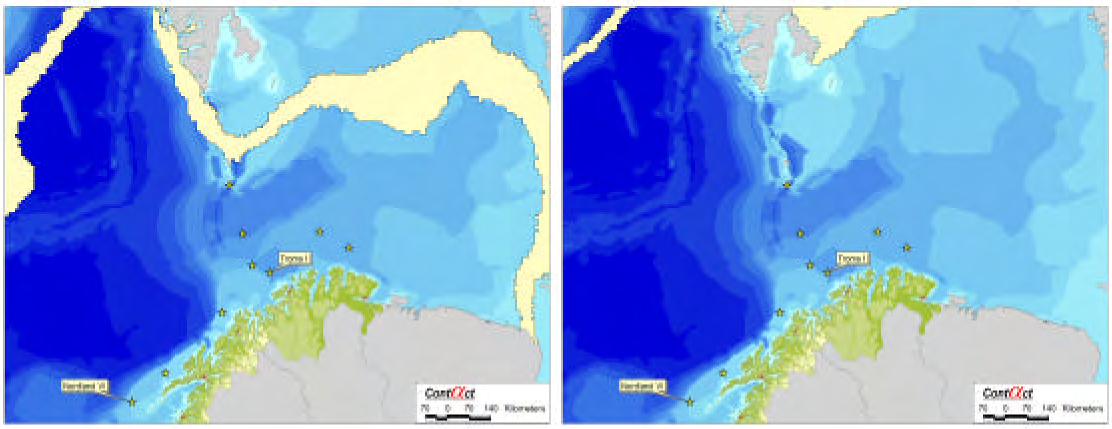


Figure 3. Maximum (April - left) and minimum (October – right) extent of sea ice in the Barents sea. Pale yellow areas show areas of 40 – 80 % probability for sea ice, based on historical data from the Norwegian Polar Research Institute.

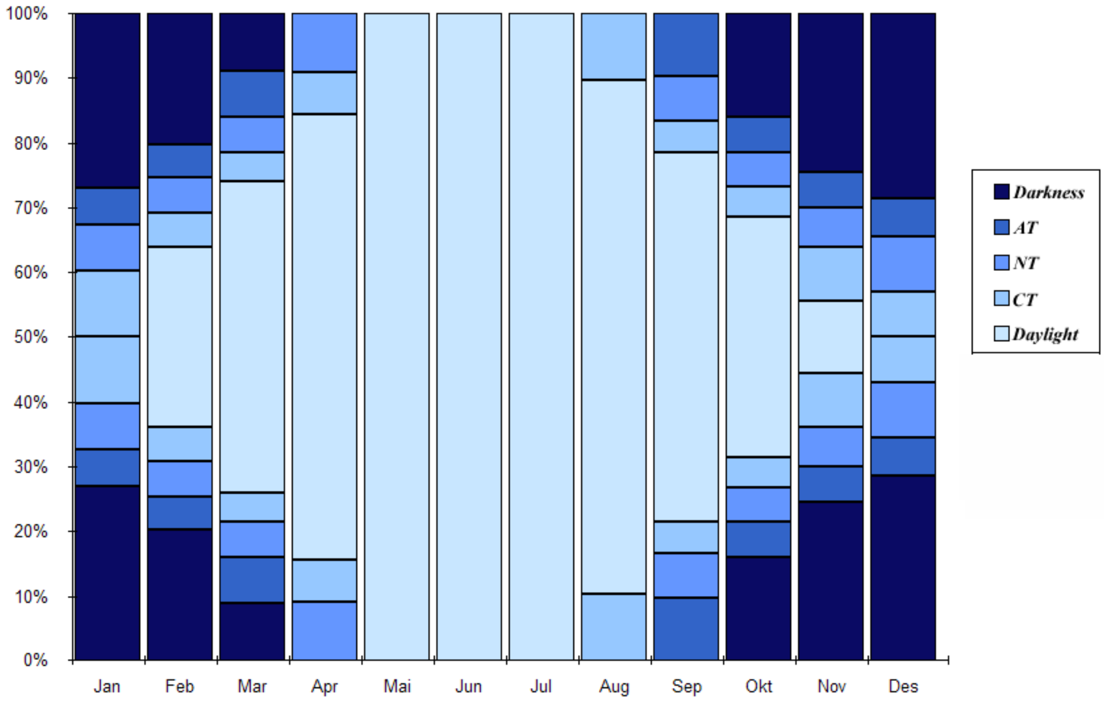
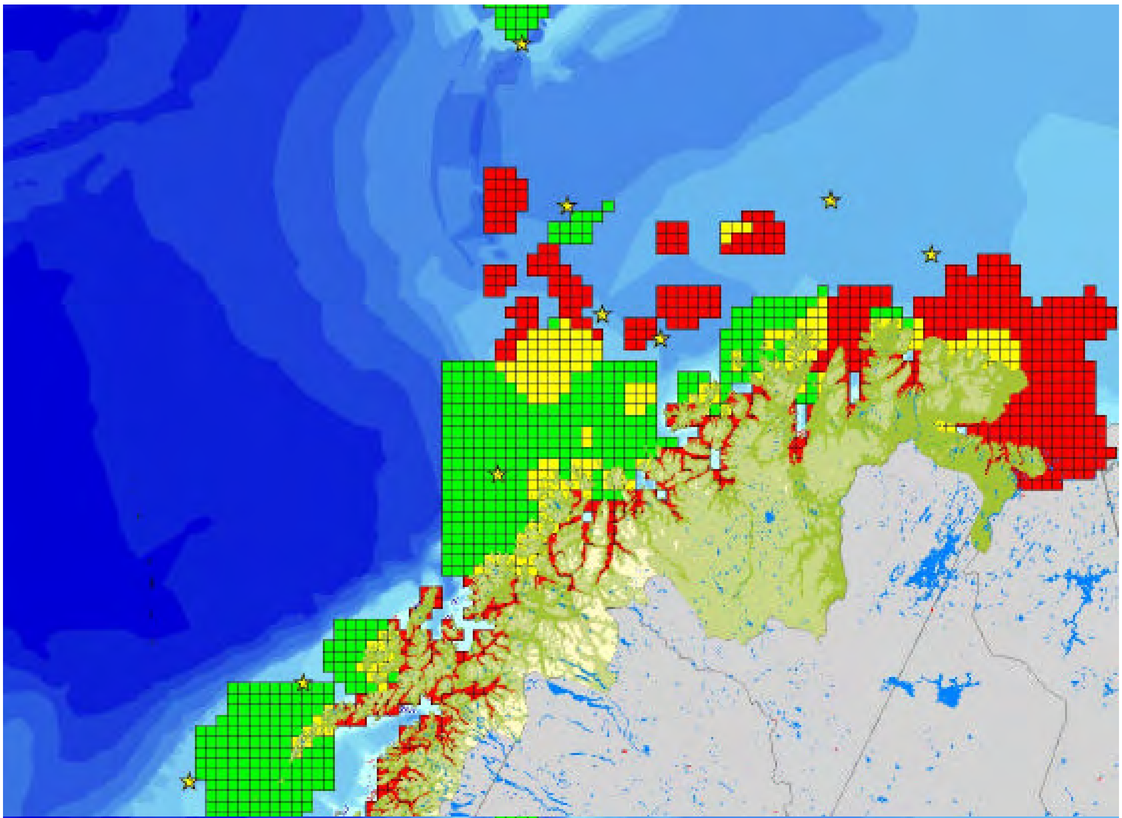


Figure 4. Annual variations in light conditions on the northernmost part of the Norwegian coastline. AT = Astronomical Twilight, NT = Nautical Twilight, CT = Civil Twilight. Operational light for oil spill response operations is defined as the period of Daylight and Civil Twilight.



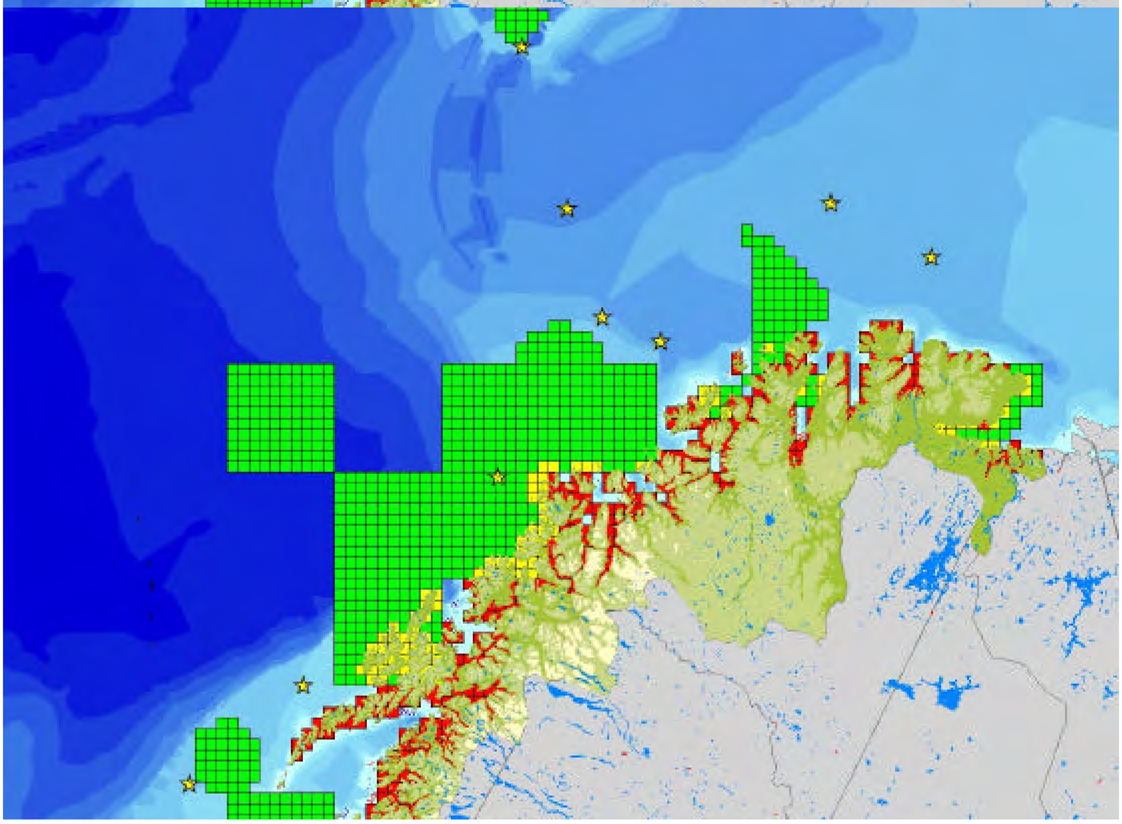


Figure 5. Results from the initial level of Net Environmental Benefit Analyses for the months of July (top) and January (bottom).

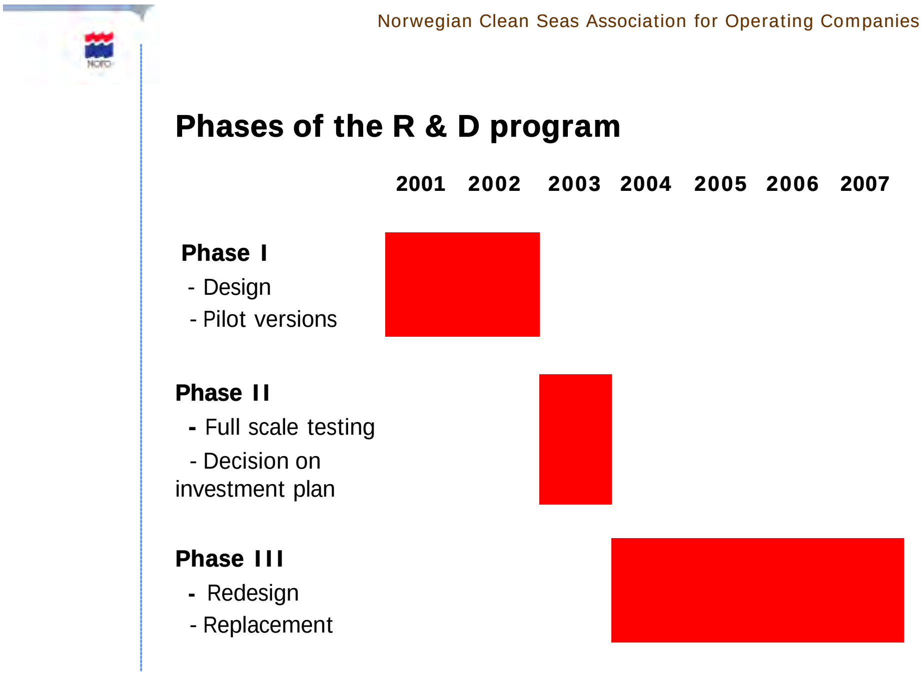


Figure 6. The three phases of the NOFO R & D program.

Figure 7. Testing of offshore boom # 1. Oil is released, and the test at increasing towing speeds is about to commence.

Figure 8. Recovery of oil from the sea surface using the redesigned skimmer.