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A web based system for regional oil spill contingency and emergency response planning

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Abstract

In 1998, the Norwegian Clean Seas Association for Operating Companies (NOFO) initiated the development of a regional system for oil spill contingency and emergency response plans.

The aim of the project was to establish a cost-effective, flexible and documented system allowing Norwegian operators to analyze, evaluate and implement measures at sea, in coastal waters and at the shore.

Key elements in the approach comprise:
- A systematic review of relevant reports and analyses prepared by individual operators
- Identification, discussion and agreement on key factors, relevant data and assumptions in the analyses
- Design standard methodology for use of data, analyses and documentation of results, as well as standards for reporting data to the system
- Identification of information types, analytical tools and sources for successful implementation of the system
- Development of tools, web databases and interfaces
- Communication and coordination with other relevant ongoing processes within the industry and regulatory bodies

At the completion of the first phase, a knowledge base, a web-based interface and a GIS tool kit are developed, allowing all offshore operators on-line access to relevant information for analysis, planning and response.

Main elements of this knowledge base and toolkit include:
- General and specific technical and environmental background information
- Basis for establishing regional plans
- Regional plans
- Overall action plan

As a supplement to the system, a suite of GIS tools and datasets have been developed and compiled, enabling users to visualize and analyze response strategies, results from oil drift modeling, distribution of sensitive environmental resources and priority sites for oil spill combat. This ContAct GIS toolkit is available for all operators, as well as the Norwegian Pollution Control Authority (SFT).

The geographical extent, information content and range of tools applied are significant. NOFOs system will be further refined and developed throughout the year 2000, with a schedule for full implementation by the second quarter of year 2001.

Introduction

Norway is among the worlds main producers of oil and gas. In 1999, 168 600 000 Sm^3 of oil and 48 257 000 000 Sm^3 of natural gas were produced[1].

A total of 47 fields were in production, and 30 exploration wells and 129 development wells were started in 1998.

Drilling, well operations and loading of tankers are the main contributors to the overall probability for oil spills from offshore sources.

Due to the high activity level, the long and complex coastline, the abundance of sensitive environmental components and the extensive commercial fisheries, a high level of emergency preparedness has been established.

Only one uncontrolled blowout has occurred on the Norwegian shelf, at the “Bravo” field in 1977. Contamination of the coastline and concomitant environmental impacts from oil spills have not been observed from offshore sources, but

several incidents of grounded ships have taken place in recent years[2].

According to Norwegian Law, any industry with a potential for polluting the environment must have an emergency preparedness, proportional to the probability and consequence of the event.

This law also applies to offshore petroleum activity. Based on oil drift simulations, oil from blowouts offshore has the potential for environmental impact, and an emergency preparedness is thus required.

Oil Spill Emergency Preparedness in Norway has traditionally been a joint effort. Through the Norwegian Clean Seas Association for Operating Companies, Norwegian operators maintained an emergency response system for oil spill combat on the open sea. Near the coast, and onshore, the Norwegian State Pollution Control Authority (SFT) maintained emergency preparedness, based on a number of governmental and intermunicipal depots along the Norwegian coast.

As part of planning and preparation, individual operators undertook environmental risk analysis and oil spill contingency analysis, identifying the resources required for establishing an oil spill contingency plan. The contingency plans assumed that NOFO coordinated the offshore oil spill combat operations, and that SFT coordinated and commanded the nearshore/onshore operations.

In 1998, SFT notified Norwegian operators that they were required also to plan, coordinate and command operations also in nearshore and onshore oil spill combat and cleanup operations. The Norwegian Oil Industry Association (OLF) assumed this responsibility, and commissioned the implementation to NOFO.

The present paper describes the approach chosen by NOFO in order to fulfill these obligations, integrating offshore, nearshore and onshore emergency preparedness.

Objectives

As the temporal and the spatial variations in exploration and exploitation are significant, it was realized that the planning system would need to be dynamic.

To operate a dynamic system, routines for updating relevant information were required, addressing update intervals for each information source.

In order to ensure system integrity and credibility, documentation was identified as a vital part of the system.

Further, the analytical approach should properly reflect differences in oil spill response requirements between activities and regions.

In order to reach this objective, standards for methodology as well as assumptions, technical specifications and data sets on biophysical conditions and environmental sensitivity were needed. In order to move the focus for discussion from technical details to the more significant issues, consensus between operators and SFT was important.

The value of establishing a comprehensive and detailed system would be limited unless it would actually be used. A main objective was thus to establish an easy understandable and navigable interface to the user.

Approach

Organization

The organization of the process is depicted in **Fig. 1**. NOFO established a reference group for evaluating the system development, comprising personnel from major operators with significant experience in the various aspects of oil spill response analysis, planning and combat. In meetings with this group, relevant issues were discussed and agreed. Major issues were also discussed in the OLF/NOFO project group. In this group, SFT participated as observers.

At regular intervals in the development process, draft versions of the system were published on the Internet, for online comments from the reference group. Comments and actions on comments were filed *in extenso*.

Scope

The scope for the system was comprehensive, following a "cradle to grave" philosophy. This implies that the system should cover all relevant aspects from the initial phase of an oil spill through oil spill combat operations, cleanup operations and waste disposal to chemical and environmental effects monitoring after all operations are completed.

Review

At an early stage in the project, a systematic review of activity specific oil spill contingency analyses and plans was undertaken. A template for relevant information was established and used in the review.

Standards

The initial review of activity specific analyses and plans revealed significant "white spots" in relevant data. To alleviate this, a standard notification sheet for reporting key data was developed.

The use of results from oil drift simulations was another area where practice varied significantly. A standard was thus defined also for this issue, detailing parameters to be included, as well as formats for digital reporting of results.

Data collection and organization

Several information types and information sources were identified as relevant in the early, screening phase of the project. Major types and the rationale for selection are given below.

For evaluation of effectiveness of mechanical recovery: historical data on wind velocity and direction; historical data on wave height distribution; oil properties; nominal and operational capacities of oil spill combat equipment.

For evaluation of oil behavior nearshore: Establishment of a national standard 10-km grid; analysis of shoreline length, sea area, shoreline complexity and exposure within individual grid cells.

For evaluation of potential environmental impact: GIS implementation of a national mapping of areas of particular environmental sensitivity.

For identification and evaluation of sensitive sites and areas: GIS implementation of a model for prioritizing; preparation of oil spill contingency maps for entire Norwegian coastline.

For documentation: Information from testing of equipment in laboratory as well as in the field. Further, results from offshore exercises on mechanical recovery and chemical dispersion of oil slicks.

Consensus

The need for focussing on the larger issues, i. e. the results of analyses and corresponding plans, were identified at an early stage of the project. To accomplish this, consensus between operators and authorities on assumptions and methods would be important. Among the key issues were

- Operational capacities and windows of operation on oil spill combat equipment.
- Criteria for identification and prioritizing sensitive resources
- The use of simulation models and monitoring

On these and other issues, "white papers" were submitted to SFT, citing current status, rationale, and conclusions. These were discussed in meetings of the project group.

Methodology

A documented methodology for undertaking oil spill contingency analyses was identified as a prerequisite for a dynamic system. The method would need to address the sources for data, subsequent use and analysis, as well as input data on oil spill combat resources needed to fulfill the needs identified.

The methodology should also address the need for individual operators to identify gaps in preparedness for individual activities, e. g. nearshore exploration drilling.

Organizing the system

Web- and GIS technology were key factors in the approach to design, development and maintenance of the system.

A wide range of potential users of the system was identified, from analysts to on-scene commanders to infrequent browsers. Two main user groups were targeted in the further development; one being the user with knowledge of the field and a clear idea of the information needed, but not necessarily with comprehensive computer skills. The other targeted user was the specialist with experience in analysis and planning of oil spill contingency, and with experience in using GIS tools.

To provide a user interface for these targeted user groups, the system is designed with a web interface as well as a GIS interface.

Web interface

This part of the system should provide a point-and-click interface for the type 1 user. Navigation and orientation should be simple and intuitive, and the user should be able to retrieve all information on approaches, data sources and current regional plans.

GIS interface

Users of this part of the system would also use the web interface. However, this user group will in addition have the option of undertaking on-the-fly screening and analysis of new activities. Through this interface, all georeferenced information collected and administrated by NOFO should be available.

Cost effectiveness

A comprehensive and dynamic system necessarily requires updated information. Cost effectiveness should be achieved by a systematic identification of update frequencies and information sources. In addition, systematic reviews, archiving and dissemination of new results and studies of relevance were addressed.

Another factor in cost effectiveness is the use of electronic media, enabling immediate availability to all parties of updates of the system.

Presentation of data and results

Review of existing data

From the review of existing site- or activity specific analysis, it was concluded that these were of limited value. Use of different oil drift models, variations in interpretation of oil drift data, different approaches and insufficient documentation of assumptions made comparisons difficult, and only some parameters were selected for inclusion in further work.

A review of the various oil drift models were addressed by a separate working group in OLF, and the harmonization resulting from this work is expected to simplify future comparisons.

In order to provide a common data basis for blowout frequencies and event duration, results from a recent study[3] were chosen.

With regards to other information types, relevant sources were identified and additional studies undertaken as needed. These will be further described under the relevant parts of the system below.

System structure and content

The overall system structure is depicted in **Fig. 2**. Detailed descriptions of system components are given below.

Overall web organization

The planning web system is organized in four main levels (**Fig. 3**). In addition, a link to the ContAct web is provided.

Overall action plan – describing organization, notification, mobilization, combat, normalization and monitoring for an oil spill combat operation. The structure of this plan is identical for all five contingency regions (**Fig. 4**) and linked to retrieval of information specific for the region addressed.

Regional plans – describing specific plans for each contingency region. Each plan describes activity levels, results from oil drift simulations, sites and areas of environmental sensitivity and oil spill prevention and cleanup resources needed. Each plan is dynamic and will be updated as new analyses are undertaken.

Plan basis – describing the basis for establishing the regional plans, including analytical methodology, assumptions, strategies and results from the regional oil spill contingency analyses.

Library and guidelines – containing data bases, data sets, standards, technical guidelines and instructions, as well as general relevant information

In addition to these main levels, direct access is provided to the ContAct web, containing predefined oil spill contingency maps including environmental sensitivity. In this web, information and routines are provided for users undertaking additional analyses.

Access to information on the project and the development process, including logs on comments on all draft versions are included. Also, search facilities, table of contents and instructions for use of the system in various contexts.

Below, the main components, i.e. sub-levels of the main levels, are presented.

Overall action plan

The overall action plan is the initial starting point for use in an emergency situation, i. e. an oil spill event. The plan describes the overall organization (**Fig. 5**), as well as positions and tasks for all involved personnel. Further, lists of authorities, operators and organizations to be notified are automatically retrieved from the corresponding database, as is also the case for nominated personnel.

The action plan also addresses combat options and strategies, cleanup options and guidelines, as well as requirements and recommendations of monitoring during and after operations. At all levels, links to relevant parts of the web are provided.

Regional plans

The five contingency regions are presented in (**Fig. 4**). For each region, key information is presented, including length of coastline, tides and locations of depots.

Links are further provided to predefined maps of high priority sensitive environmental sites and areas, for summer and winter conditions, respectively.

From a relational database system, information is retrieved on depots for storage of oils spill combat resources, as well as tabular presentation of main items available.

For all fields within each region, oil types are identified and listed.

As the area covered by the plans reaches from 56 to 75 Latitude, significant differences in climate are observed. This is reflected in variations in estimated efficiency of mechanical recovery and chemical dispersion within the different regions.

Results from oil drift simulations and the presence of sensitive environmental resources provide information needed for dimensioning the oil spill contingency for a region.

From the above, the plan describes what resources are drawn upon to establish an adequate oil spill response for the region.

Plan basis

An essential part of establishing the regional plans are to sign written agreements with all parties involved in the successful implementation of the plan as well as implementation of oil spill plans. Issues include access to equipment, availability of personnel and vessels, and monitoring of operations.

The methodology applied in the oil spill contingency analyses as well as the results from the analysis are presented in full in this part of the web.

Decision criteria are also grouped here, and address all parts of the operations.

Documentation is also placed in this part of the web. This includes results from more than 20 oil-on-water exercises, where equipment and procedures for mechanical recovery and chemical dispersions has been tested.

In this part of the web, all assumptions used in analysis and planning are presented, along with alternative strategies for oil spill response.

Procedures and manuals for monitoring are also included in this part of the web. These include airborne monitoring, surface and subsurface chemical and environmental monitoring, as well as monitoring of nearshore and onshore environments.

Library and guidelines

In this part of the web, a general library of relevant information is provided. Standards and detailed technical information on major recovery systems are also presented here.

The essential aspect of this part of the web is however the interactive access to a collection of databases containing information pertinent for the advanced user. The main databases are briefly described below.

Site specific libraries, containing key information on all contingency analysis undertaken by individual operators for fields and exploration drilling. Full bibliographic references on all associated reports are provided.

Archive of oil drift simulations on a standardized format, facilitating repeated use and analysis of data.

Statistical wind data for 31 stations along the Norwegian coast, provided by the Norwegian Meteorological Institute.

Database on oil spill combat resources, including location of more than 100 depots along the Norwegian coast, detailed information of more than 250 types of equipment, including illustrations. The database also includes number of items of each equipment type stored in each depot.

Weathering characteristics for 27 different oil types on the Norwegian Shelf[4] provided with an interactive interface to selected information.

Detailed information on 35 reference areas along the Norwegian coast, with high environmental sensitivity. Additional information includes depth and navigation, access to the sea for equipment transported by road, tidal changes and recommended strategies for oil spill combat.

ContAct web

The ContAct[5] web contains information relevant for users undertaking evaluations and assessments of new activities, as well as users retrieving information relevant for the immediate phase of an oil spill incident. Some of the main elements are described below.

Species and habitat library, including scientific, English and Norwegian names, vulnerable stages and monthly vulnerability indices. For selected species and habitat types, illustrations, photos and video clips are included.

Module for on-line calculation of resource requirements. Input parameters include release rate of oil, evaporation and emulsification, output parameters are number of system units required.

Contingency map atlas, comprising overview and detailed maps of the coast of Norway. Map sheets include environmental priority areas, graticules and explanatory text and associated tabular information

In addition, this web contains photos and maps of selected sensitive sites and areas along the coast.

GIS toolkit

The ContAct GIS toolkit was developed to allow the experience user access to georeferenced information, and to facilitate the use of GIS in evaluation and analysis of oil spill contingency.

Base maps

Base maps were established from a series of public domain data sets, converted to ArcView shapefile format and projects to Universal Transverse Mercator Zone 33. Data include:

- General Bathymetric Chart of the Oceans - as line and polygons
- World Vector Shoreline - as polygons
- Digital Chart of the World as point, line and polygon.

GIS data sets

A 10 by 10-km analytical grid in UTM 33 was established, forming an industry standard for use in oil drift modeling and aggregation of information on environmental sensitivity.

To provide additional information for this grid, GIS routines were applied to calculate land area, sea area, and length of coastline, coastline complexity and wave exposure for each grid cell. The calculations were made from the most detailed data set with a national coverage, to obtain the highest possible resolution.

Establishing prioritized data sets on sensitive sites

SFT has developed a model for prioritizing environmental resources in an oil spill context[6]. The model defines four numerical factors, the product of which defines the priority. This model was implemented in a series of GIS routines[7] and was applied on MRDB™, which is a comprehensive database on vulnerable marine resources in Norway[8]. The resulting data sets form input to the regional plans, and are presented on the predefined oil spill contingency maps.

Map module

This module was developed for facilitating standardized map generation, including a meta data base for frequently used map themes. Additional routines include standardized presentation formats

Oil drift module

This is a module for automatic import, classification and presentation of results from oil drift simulation, on statistical and scenario basis. The module also calculates oil mass per sea area and coastline for predefined study areas.

Contingency planning module

Based on user input and predefined values of mobilization time, transport speed and mode, response contours from selected bases and harbors are calculated. In addition, the module calculates total response time to any installation or well position on the Norwegian shelf, and mobilization time for selected vessels and bases.

Environmental sensitivity module

A national project on identification of areas of particular environmental sensitivity was carried out by SFT and DN in 1998 and 1999[9]. Selected results from this work were incorporated in a module for interactive evaluation through a GIS interface.

Examples of the use of the GIS modules are given in **Figs. 6, 7.**

Navigation

The web system is navigated according to Internet standards, following hyperlinks. Although the web structure is hierarchical, the user may navigate between different parts and levels of the web at will.

While this functionality is powerful, it also presents a challenge for the developer to provide orientation for the user. This is addressed by using subheads on each page, presenting a vertical cross section through the web leading to the current page. In addition, information on pages on the same level as the current page is provided, as well as underlying pages.

Static links to the main levels are provided at all levels in the web.

With regard to the use of GIS toolkits, these may be accessed through links from the web to a standard GIS project containing all GIS modules (extensions). Users also have the option of opening existing GIS projects and access the GIS extensions from these.

Distribution

Web projects and GIS toolkits are distributed to all members of NOFO via CD on completion of versions. The most updated versions may be accessed through the Internet, on a designated web site. Standards, files and GIS toolkits may be downloaded for installation on the local computers as required.

Consensus and sharing

NOFO and SFT have decided to share the database on oil spill combat resources. In this process, consensus on capacities and applicability vs. different oil groups are established.

NOFO and SFT have also agreed to jointly upgrade the operational oil drift model operated by DNMI, establishing a mutual format for digital reporting for subsequent use in GIS.

NOFO has decided to adopt SFTs guidelines for monitoring during and after oil spills[10], as well as the guidelines and handbook for onshore oil spill cleanup[11].

The ContAct web and the GIS toolkit have been made available for SFT, as will also be completed parts of the web system.

Applications

The web system and the associated GIS toolkit have several applications. While analysis, identification and implementation of regional oil spill response plans are the immediate area of application; the system also serves as a tool in tabletop exercises and training.

Operators apply the system for analysis, evaluation and planning of new activities, including development and exploration drilling. By drawing on information in the databases and GIS, on-the-fly screening of whether or not a new activity is within the emergency preparedness established for the relevant region. If gaps are identified, e.g. for nearshore drilling, the needs for additional resources may be swiftly identified.

Conclusions

As of early 2000, Norwegian operators have an operative web based system for regional oil spill contingency and emergency response planning. Lessons learned in the development and implementation process are outlined below.

Initial review and screening showed that there were a potential for significant improvement in standardization of methods and data sets.

Harmonization and standardization were essential elements of the work, and a prerequisite for undertaking analysis and planning reflecting differences between activities and regions.

Developing the system over a relatively long period of time allowed formulation, discussion and maturing of the various elements of the plan, resulting in a better product.

Sharing of data and achieving consensus on plan elements have moved the focus to the significant issues, i. e. the results from analyses and the corresponding plans. Sharing of information between operators, and between operators and authorities have proved cost-effective and have also provided transparency of the decision making process.

Web technology has proved well suited for such a system. When information is updated, changes are immediately available for all parties involved. Another aspect is that the system may be accessed from any computer with an Internet connection.

The use of GIS extensions designed for specific tasks in oil spill contingency planning provides an easier GIS user interface, and adds functionality also to existing GIS projects.

The system has already been applied in analysis and planning by NOFO as well as individual operators. The web system and associated toolkit will be further developed throughout the year 2000, and fully implemented for the entire Norwegian shelf by the second quarter of the year 2001.

Software applied

FrontPage 98™ was applied in web development. Databases were created and developed in ACIUS´s 4th Dimension™, and converted to Microsoft Access™ format on completion. The GIS toolkit was developed in ESRIs ArcView GIS™, and distributed as extensions.

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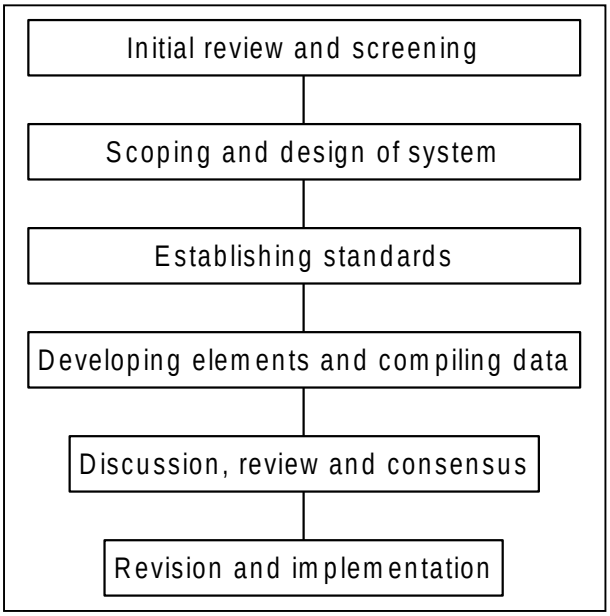

Figure 1. Organisation of the work process in development of the system.

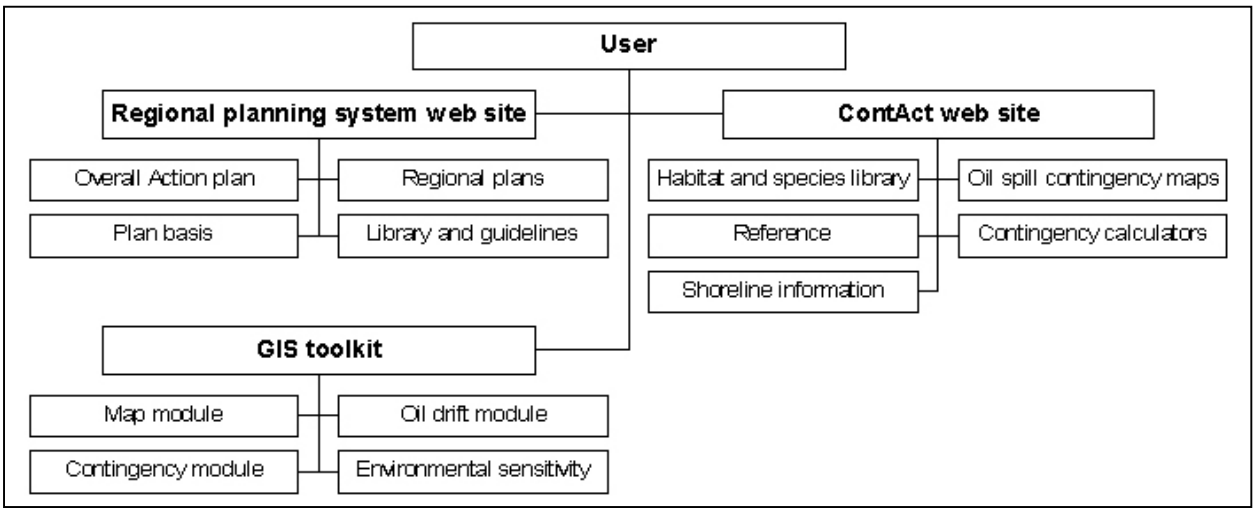

Figure 2. Overall system structure, illustrating the content of the two web projects and the GIS toolkit. User may access the toolkit directly, or from links provided in the web projects.

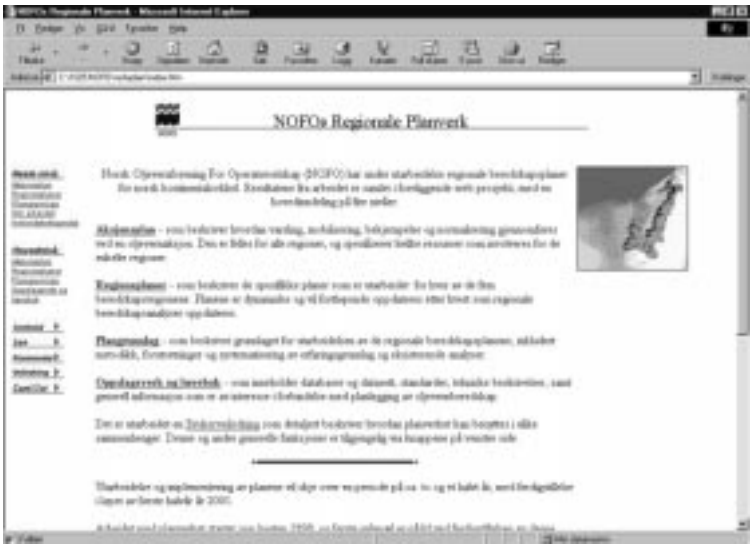

Figure 3. The web portal to the planning system, providing access to the four main levels; overall action plan, regional plans, plan basis and library and guidelines.

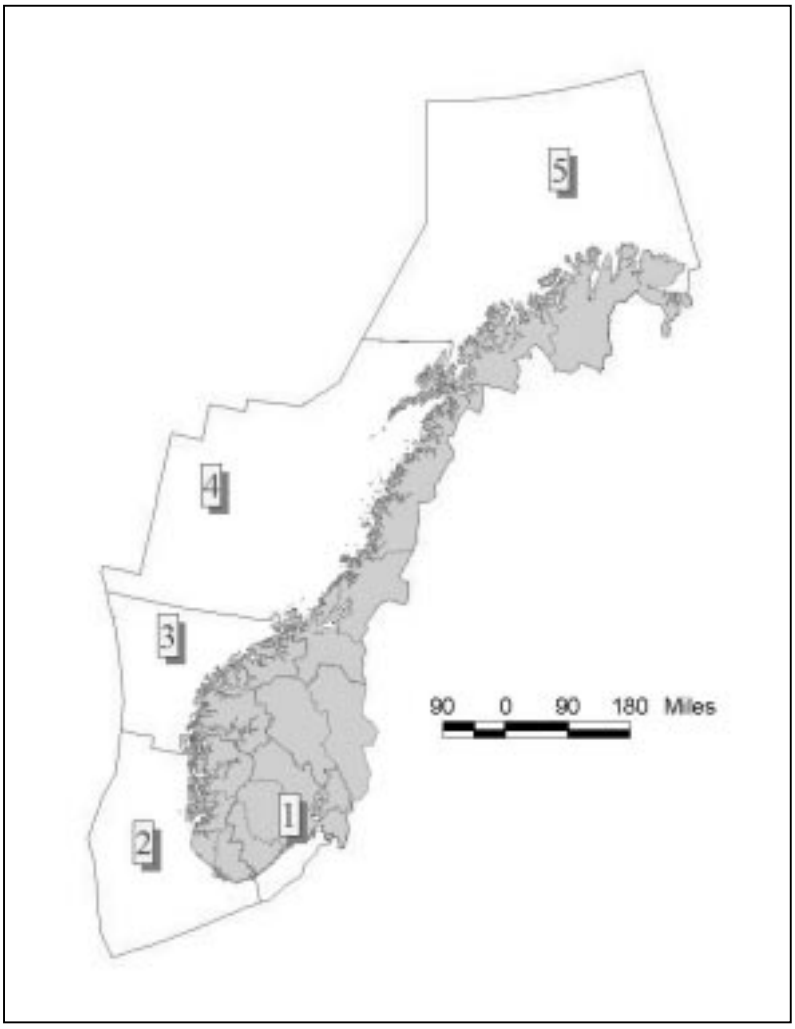

Figure 4. Map illustrating the five contingency regions of the Norwegian continental shelf.

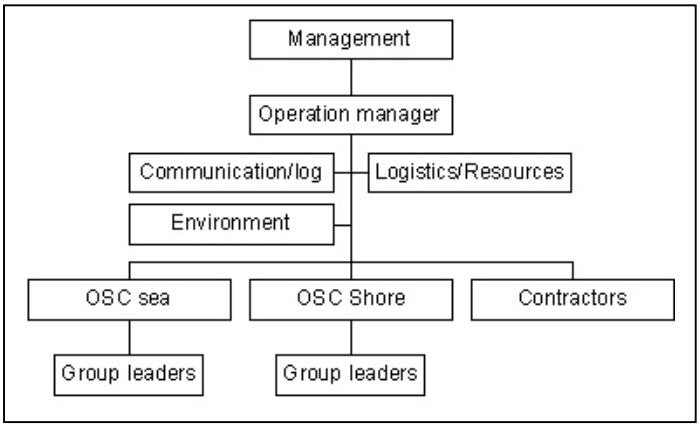

Figure 5. Organizational structure of an oil spill combat action.

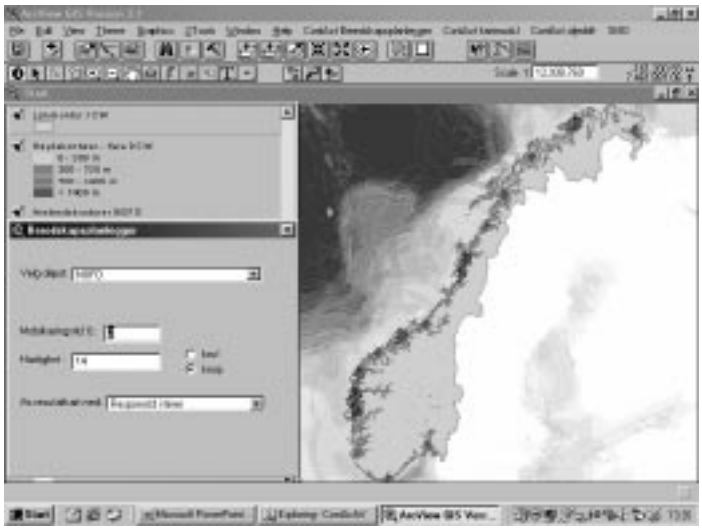

Figure 6. Example of use of the GIS contingency planning module. Response contours given input on mobilisation and transport speed are drawn from individual depots along the coast.

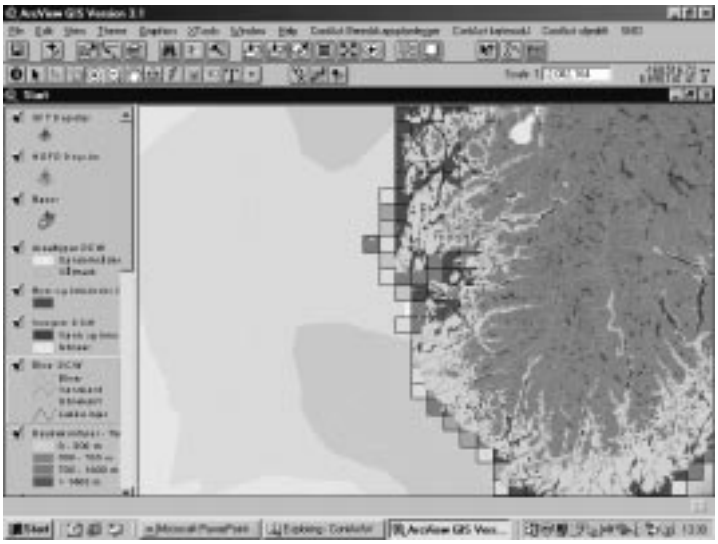

Figure 7. Example of use of the GIS map module, illustrating coastline complexity in the 10 by 10 km grid applied in oil spill modelling.