Statens forurensningstilsyn
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A pilot study on knowledge gaps and availability of data for the North Sea – focus on discharges

KNOWLEDGE STATUS AND GAPS FOR THE NORTH SEA – FOCUSING ON DISCHARGES

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Preface

This report is based on a project financed by the State Pollution Control Authorities (SFT) and has been implemented by the Norwegian Institute for Water Research (NIVA) and Akvaplan-niva, contract number 5007189.

The pilot project aims at mapping data that should constitute the scientific basis of an integrated, regional and ecosystem based management plan for the North Sea. A first overview of the data needed to understand the interaction between land, coastal waters and ocean and identification of specially vulnerable and valuable areas is presented. Data from a wide range of sectors is required and this pilot study focuses on gaps in knowledge with emphasis on discharges and vulnerable areas, and does not deliver a complete overview of the data currently available. If needed, future studies should address this further.

The project started in December 2007 and there have been three project meeting between NIVA and SFT, of which one was an open workshop where relevant national research institutes was invited to provide input and comment to the project. The following institutions participated in addition to SFT and NIVA: Akvaplan-niva, Directorate for Nature Management, Institute of Marine Research, The Norwegian Meteorological Institute, Geological Survey of Norway, Norwegian Institute for Nature Research, Norwegian Institute for Air Research, The Norwegian Water Resources and Energy Directorate and The Institute of Transport Economics. Minutes from the meeting are available from SFT.

Project manager from SFT, Marianne Kroglund, has contributed with comments and input to the report during the whole project period.

The project has received many valuable inputs from several of the institutes listed above. The following has contributed with text in the report:

Akvaplan-niva: Nina Mari Jørgensen og Lars Henrik Larsen.
NIVA: Are Folkestad, Eivind Oug, Øyvind Kaste, Tone Kroglund, Jarle Molvær, Henning Wehde, Bent Barman Skaare (presently at Institute for Energy Technology), Tor Gunnar Jantsch, John Rune Selvik og Kari Nygaard.

Kari Nygaard has been project leader, Are Folkestad has been editor and Jarle Molvær has been responsible for quality control of the report.

SFT, Oslo, May 2008

Marit Kjeldby
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Contents

1. Summary and key messages

The Norwegian government will develop a management plan for the Norwegian sector of the North Sea. Data and facts should constitute the scientific basis of an integrated, regional and ecosystem based management plan for the North Sea. Data from a wide range of sectors are required.

The project focuses on mapping the data requirement, availability and knowledge gaps related to discharges and their impact on the environment in the Norwegian part of the North Sea (part of OSPAR's Region II, Greater North Sea). Information from other countries and regions within the North Sea is also included. Mapping of the data requirement related to the interaction between land, coast and ocean and identification of specially vulnerable and valuable areas are included.

OSPAR is developing a Quality Status Report for the North Sea area entitled the QSR 2010. QSR 2010 is based on regional assessments while this report is a pilot project aiming to identify additional data required for an upcoming management plan for the North Sea. OSPAR QSR 2010 will develop an assessment for the North Sea, however this will probably not be area specific enough to fulfil the needs for a management plan. In addition to the QSR 2010 there will be a need to develop regional plans based on collaboration between the NS countries. EUs directives, conventions and agencies supply a network of laws, directives and agreements relevant for a future management plan for the North Sea.

This report aimed to identify gaps in knowledge related to the understanding and management of all discharges to the North Sea. While we tried to be as thorough as possible, these are not complete and further mapping is needed.

Relevant sources of data and overall estimates of the amounts of nutrients and pollutants discharged from Norwegian sources into the North Sea are presented. An assessment of the knowledge status is given for individual sectors, with a particular focus on areas where present knowledge or data availability is considered insufficient. Effects of discharges on vulnerable and valuable areas are discussed in the context available data from monitoring and future needs to fill the gaps.

Input and discharges of nutrients and organic matter. On a national scale, monitoring data are generated through the National monitoring programme on River Inputs and Direct Discharges (RID) and comprehensive modelling of nutrient export is performed using the TEOTIL model. The RID sampling programme in its present form represents a 'minimum solution' in order to produce high-quality estimates of total nutrient inputs to Norwegian coastal waters. In order to obtain improved estimates the following is recommended:

- To obtain improved estimates, by strengthening the temporal and spatial resolution of the Riverine Inputs and Direct Discharges (RID) monitoring programme. This may be undertaken using automated sampling systems, sensors and models at selected sampling sites.
- The spatial and temporal resolution in reported nutrient discharges is too low to detect seasonal variation and act as input figures for hydrophysical- and effect-modelling in receiving waters.
- Appropriate area runoff coefficients for agricultural areas (divided according to the type of land use) should be obtained in order to suit the higher resolution in the present TEOTIL model framework.

- A nationwide, high-resolution land cover map should be developed.
- Effects of climate change on runoff and nutrient cycling are understudied and needs future attention.
- There are no established national programmes to monitor the impact of nutrients and organic input from aquaculture despite concerns expressed by the scientific community and an expected 100% increase in production over the next 10 years time. Hence, a large scale monitoring programme should be implemented as soon as possible.
- Also, nutrient fluxes related to water exchange between fjords and coastal waters require additional investigation, both in terms of measurements and modelling.

Input and discharges of metals and organic pollutants. The RID programme provides an estimate of riverine inputs of metals and selected micro-pollutants to Norwegian coastal waters. For industrial discharges and municipal wastewater entering directly into marine waters or to rivers below the RID sampling sites, estimates are based on data from effluent control programmes assembled in national databases. Recommendations:

- The RID programme provides estimates of the riverine input of metals and selected micro-pollutants (lindane and PCB) to Norwegian coastal waters. This programme should be strengthened by increasing the spatial and temporal resolution. In addition, the list of variables should be expanded in order to be in line with the marine monitoring and assessment programmes (especially with regard to organic pollutants).
- Estimates for industrial discharges and municipal wastewaters directly released to marine waters or rivers downstream of RID sampling sites, are based on data from effluent control programmes assembled in national databases. In principle discharge-monitoring of heavy metals are only made on larger waste water treatment plants (approx. 50 plants), micropollutants on fewer and with lower frequency. For the metals approx. 55% of discharges seem to be covered by this approach (2006 data), and the geographical distribution of remaining 45% is unclear.
- The input of metals from non-monitored areas is not included, since the present TEOTIL model does not include metals.
- The further development of reporting routines for metals and organic pollutants as well as improved temporal resolution would be beneficial to the assessment of the effects of these contaminants on the marine environment and would help to increase our understanding of land-ocean-interactions.
- All substances of importance are not reported regularly. Tightening-up of reporting requirements is needed.
- The importance of natural leakage of oil in the North Sea is not known, but this knowledge is important in respect to the possible impacts of the offshore industry discharges and the necessary regulations.
- Aquaculture has a relatively high, yet stable discharge of copper related to its use as an antifouling agent applied on net cages, however discharges are not considered problematic by Norwegian Pollution Control Authority.
- There is uncertainty in estimates of legal operational discharges of oily bilge water and cargo residues (slop water), black water, grey water and garbage, because of uncertainty in both the waste production factors and the fractions discharged to sea vs delivery to shore.

Discharges from outside Norwegian territorial waters - Input of nutrients and pollution to the North Sea from non-Norwegian sources and from transboundary transport.
Recommendations:

- In terms of riverine input by far not all riverine sources are monitored regularly. Processes that are important for the transport into the North Sea are mostly not considered in the estimates (i.e. retention within the rivers/fjords).
- Common activities are undertaken across Europe for the monitoring of direct discharges. However these activities lack deeply of common methodologies and quality control procedures and the integration of European wide-efforts is strongly needed.
- Sources of data on atmospheric deposition of contaminants are too scarcely distributed to enable realistic deposition rates to be obtained. A common data quality control procedure is missing and the integration of European-wide efforts is important.
- Regarding contaminant transport within the North Sea there is a lack of knowledge related to the estimation of circulation patterns in the North Sea region. Validation of model systems is not satisfactorily conducted for all models and needs to be improved through the amelioration of the models and more adequate validation procedures.

Land – ocean – interaction: A significant proportion of a discharge usually remains in the fjord. Except for estimates based on expert judgement, few facts and data describing the extent of the retention of polluting substances in the Norwegian coastal zone exist.
Recommendations:

- Typically 80-95 % of organic micro pollutants and metals and, to a lesser degree, nutrients are associated with particles (with large variations between summer and winter according to phytoplankton biomass). To a large extent these particles sink and form bottom sediments, thus retaining associated pollutants in harbours and fjords where they were emitted. More monitoring data is needed and further development of models is needed.
- With the implementation of the Water Framework Directive, data aiming to improve our knowledge of land-ocean interaction is to be collected. However, the WFD implementation plan proposed for the period until 2010 includes very few river basins that also includes fjords and coast relevant for the to the North Sea area. More focus on the marine part of the river basin districts is needed.

Effects of discharges on vulnerable and valuable areas include work from several large institutions related to the North Sea e.g., ICES, OSPAR, EEA and EUs programmes. Several large compilations of knowledge and status for the sea exists that also identify major knowledge gaps. The REGNS assessment did not cover all of the North Sea areas. Skagerrak was not included. As a basis for integrated management, this assessment is also somewhat limited since several key ecosystem components were not taken into account, e.g. macrophytes and benthic fauna. Summary and recommendations:

- Improved monitoring of biology and especially benthic organisms offshore in the Skagerrak is needed.
- Improved monitoring of algae other than toxic algae is needed.
- Improved monitoring of intertidal benthic fauna is needed.
- Improved monitoring of non-commercial fish species is needed.
- Improved monitoring of biology and particularly of the longer-term impacts of fisheries as well as the monitoring of trends are needed.
- Increased temporal and spatial resolution of water quality monitoring in coastal and oceanic areas.

- The OSPAR QSR 2000 indicated limitations in knowledge regarding the evaluation of the importance of human impacts. In short, these comprise issues such as:
    - consequences of climate change
    - lack of data on inputs and biological effects of chemicals and organic hazardous substances
    - lack of reliable quantitative information on sources and inputs of nutrients
    - budgets and fluxes of substances both within the North Sea and between the North Sea and adjacent waters
    - longer-term impacts of fisheries and trend monitoring.
- No programme focuses particularly on inshore coastal waters or freshwater-sea transitional areas.
- The Norwegian Directorate for Nature Management has published two reports on monitoring needs for the coast and ocean areas of Norway. Together, these reports provide advice on monitoring of biological diversity in sea areas included in Norwegian national jurisdiction. These should be taken in to consideration in the future management plan for the North Sea.

Gaps in knowledge regarding alien species are particularly related to the effects and ecological consequences of the alien species. Summary and recommendations:

- Insufficient monitoring of invasion of non-indigenous species from ballast waters to Norwegian waters.
- Gaps in knowledge are particularly related to the effects and ecological consequences of the alien species.
- The methodology used for risk analyses needs to be further developed and improved.
- Further, it is important to set up appropriate routines for reporting and documenting new discoveries of alien species.
- Essentially, the most efficient measures will be to prevent introductions.
- Such an approach will require more information and knowledge than that exists today. In particular, knowledge about alien species in neighbouring countries which have not been found in Norway, so-called “door-knockers”, and their possible routes of dispersal may be crucial to prevent their establishment.

The eutrophication status for the entire Norwegian North Sea coast has recently been identified using the OSPAR Common Procedure for Identification of Eutrophication Status of Maritime Areas. Summary and recommendations:

- The Common Procedure identifies the variable data quality and lack of monitoring data as major gaps in knowledge. There is a definite need for systematic monitoring with a long-term perspective, especially of Category II-III effects (direct and indirect effects on ecosystem e.g., plankton blooms and reduction in oxygen), and with a focus on selected Potential Problem Areas.
- The study concludes that if future studies prove that the disappearance of sugar kelp is not related to eutrophication, then the classification should be revised. Multiple effects related to eutrophication and climate change needs to be studied further.

Hazardous substances are regulated globally, regionally and at national levels within national registers available on the internet. Summary and recommendations:

- The national focus is on monitoring effects and levels of the substances regulated by protocols and conventions. Knowledge on levels of other substances is scarce, and

there are reasons to believe that a variety of substances not yet regulated or listed in these protocols and conventions affect the environment at present.
- What the actual effect of a measured level of a certain contaminant is on an organism is mostly unknown. Research on actual effects has only been carried out for a few substances.
- Synergistic effects of exposure to multiple contaminants are also mostly unknown.
- In general significant research and mapping of contaminants in the southern parts of the North Sea appears to be conducted, whereas in the Norwegian area the focus is primarily on the effects of the petroleum industry. As a result, there is a need first to map, then to monitor the contaminant levels or body burden in species living in various habitats in the North Sea. These include the deep trench close to the Norwegian coast, as well as the shelf. Mapping and subsequent monitoring should focus on both commercial and non-commercial species on a broad range of ecosystem levels.

The **Oil and gas** industry in the North Sea discharges into the sea drill cuttings, man-made chemicals and produced water with oil-associated compounds and other substances. The industry is regulated by, among others, the Norwegian Pollution Control Authority, SFT. Summary and recommendations:
- Gaps in knowledge are related to the transport of contaminated sediments, especially from oil cutting piles. These cutting piles, (containing so-called legacy contamination) diminish slowly as they are exposed for an increasing number of years. In shallow regions such as Ekofisk, heavily oil-contaminated sediments are weathered down by the sea. The actual resulting levels of contamination and the significance of this transport are not known.
- In general, the link between monitoring using biomarkers and risk assessments is required.
- There is also a need to improve field methods for the monitoring of produced waters to ensure that these methods are an appropriate sensitivity.

Fisheries activity affects the ecosystems in various ways. These include the removal of biomass and reduction of fish stocks, the physical impacts of benthic habitats from use of trawls and other bottom gears, and the effects of operational and accidental discharges. Summary and recommendations:
- Improved knowledge of effects of fishing out large amount of biomass from the ecosystem.
- Improved knowledge of physical impacts on benthic habitats may result from the use of trawls and other bottom gears are needed.
- Other effects include operational and accidental discharges and loss of fishing gears as e.g. gillnets from the fishing fleet is sparse.

The most important ecosystem effects of **shipping** to Norwegian coastal and offshore areas are the introductions of non-indigenous species, effects of antifouling substances, and spills and discharges of oil and other substances. Summary and recommendations:
- It is recommended to establish a ‘warning list’ of species that may be introduced into Norwegian waters and to develop methods to treat ballast waters.
- It is also recommended to monitor the situation and reduce the risk until measures of the IMO ballast water convention are implemented.
- Effects of antifouling agents on shell-bearing snails in subtidal and offshore areas outside Skagerrak are poorly known.

Several **directives mandatory for EU member states** are applicable to states with North Sea coastal boundaries. Norway is an exception where the adoption of directives is negotiated under the EEA agreement. Three major directives, that have recently been proposed or are currently being implemented, aim to stop further deterioration of the environment including coastal and marine areas. Of them only the WFD is a part of the EEA agreement so far. The degree of success of these three directives will depend on the MS ability to develop a trans-national and transparent implementation process.

Several conventions and agencies are involved both in the implementation of EU directives and in the work aiming to an improved the environmental status of the North Sea. All of these may contribute to a future management plan for the North Sea.

Climate change is only briefly discussed in this report. The focus related to climate has been on meteorological and hydrological changes such as temperature and runoff and scenarios for sea level changes and wave height, but far less research on ecological consequences in the marine areas has been conducted.

2. Contents and objective of the pilot project

2.1 Background

The Norwegian government is preparing a project aiming at an integrated, regional and ecosystem based management plan for the North Sea. Data and facts from a wide range of sectors should constitute the scientific basis of such a plan. The current project aims to map the data requirements and data availability, as well as the knowledge gaps that needs to be filled, in order to prepare an management plan for the Norwegian part of the North Sea and Skagerrak.

The project focuses on discharges and their impact on the environment in the Norwegian part of the North Sea (part of OSPAR's Region II, Greater North Sea), however information from other countries and regions within the North Sea is also included. Mapping of the data requirement related to the interaction between land, coast and ocean and identification of specially vulnerable and valuable areas are included. OSPAR is developing a Quality Status Report for the North Sea area entitled the QSR 2010. QSR 2010 is based on regional assessments while this report is a pilot project aiming to identify additional data required for an upcoming management plan for the North Sea.

A future management plan for the North Sea requires the involvement of all countries belonging to the North Sea area. Several institutions and conventions also contribute to this area. A short presentation of the major ones is included.

2.2 Objective and limitations for the pilot project

The pilot project aims at mapping the availability of data that should constitute the scientific basis of an integrated, regional and ecosystem based management plan for the North Sea. A first overview of the data needed to understand the interaction between land, coastal waters and ocean and identification of specially vulnerable and valuable areas is presented. Data from a wide range of sectors is required and this pilot study focuses on gaps in knowledge with emphasis on discharges and vulnerable areas, and does not deliver a complete overview of the data currently available. If needed, future studies should address this further.

This report also includes a brief discussion of existing institutions, conventions and large North Sea projects which could become important resources in the development of a future management plan for the North Sea.

2.3 Structure of the report

Information on Norwegian sources of input of nutrients and pollutants is presented in Chapter 4, while input of nutrients and pollutants from other countries in the catchments area, together with transboundary discharges, are presented in Chapter 5. Specific issues related to the interaction between land, coast and ocean are described in Chapter 6. The information currently available on the effects from pollution described in Chapters 4-6 is provided in Chapter 7, though it does not present a complete overview of existing knowledge for all sectors relevant to this area. In Chapter 8, the political framework for a management plan for the North Sea is discussed with emphasis on the implementation of some relevant EU directives. The impact of climate changes on the North Sea ecosystem and subsequently on its management plan is briefly discussed in Chapter 9. Chapter 10 provides a summary of the key messages of this report.

3. The North Sea

3.1 Delimitation

The Greater North Sea, defined as OSPAR's region II (Fig. 3-1), is situated on the continental shelf of north-west Europe. It is bound by the coastlines of England, Scotland, Norway, Sweden, Denmark, Germany, The Netherlands, Belgium, and France, and by "imaginary lines" delimiting the western approaches to the Channel (5° W), the northern Atlantic between Scotland and Norway (62° N, 5° W), and the Baltic in the Danish Straits. The open North Sea is often divided into the relatively shallow southern North Sea (including e.g. the Southern Bight and the German Bight), the central North Sea, the northern North Sea, the Norwegian Trench and the Skagerrak. The shallow Kattegat is seen as a transition zone between the Baltic and the North Sea. The Greater North Sea (including its estuaries and fjords) has a surface area of about 750 000 km^2 and a volume of about 94 000 km^3 (OSPAR 2000).

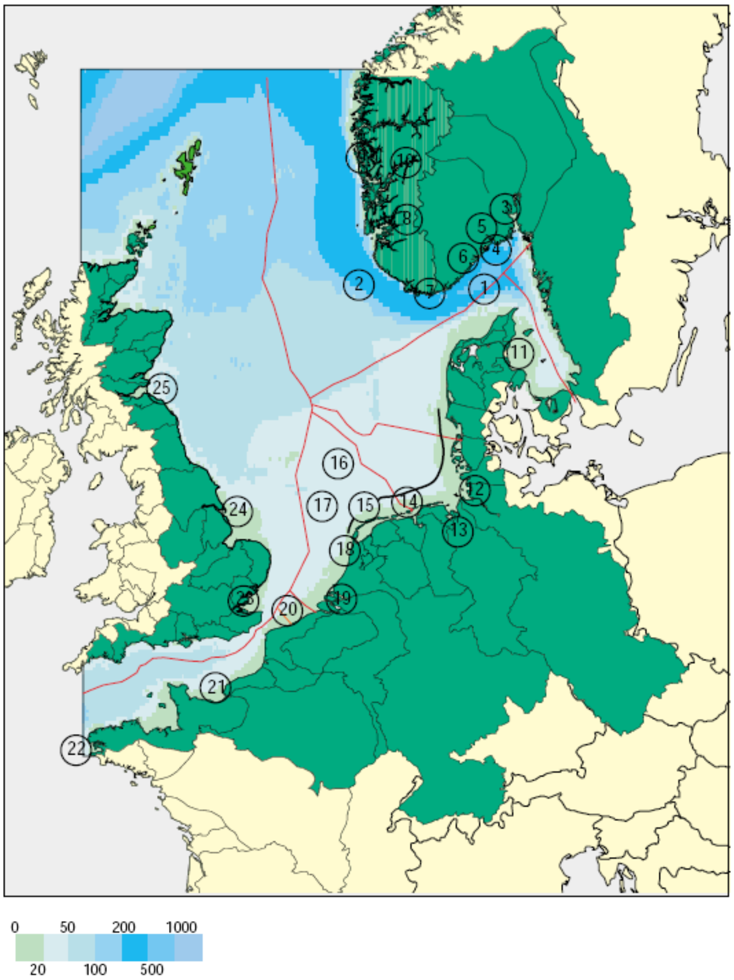


Figure 3-1. Bottom topography and catchment areas (green) of the Greater North Sea (OSPAR Region II). The numbers refer to focus areas of OSPAR but are not addressed specifically in this report. Red lines indicate the borders between national Exclusive Economic Zones (EEZ). From OSPAR 2000.

3.2 Main topographic and hydrological features

The importance of bottom topography is related to its effect on water circulation and vertical mixing. Flows tend to be concentrated in areas where slopes are steepest, with the current flowing along the contours. In the northern North Sea the depth increases towards the Atlantic Ocean to about 200 m at the edge of the continental shelf (Fig. 3-1). The Norwegian Trench, which has a sill depth (saddle point) of 270 m off the west coast of Norway and a maximum depth of 700 m in the Skagerrak, plays a major role in steering large inflows of Atlantic water into the Skagerrak (Fig. 3-2).

River systems that discharge into the Greater North Sea (Fig. 3-1) have a total catchment area of about 850 000 km^2, and the annual input of fresh water from these river systems is of the order of 300 km^3. The annual run-off, carrying anthropogenic contaminants to the sea from land-based sources, is highly variable and this is an important aspect of the transport of contaminants. Water from snow melt in Norway and Sweden constitutes about one third of the total run-off. The rivers Elbe, Weser, Rhine, Meuse, Scheldt, Seine, Thames and Humber are the most important in the catchment area. However, the dominating source of fresh water to the North Sea remains the rivers discharging into the Baltic Sea. The catchment area for these rivers is about 1 650 000 km^2 and the net fresh water supply to the Baltic is approximately 470 km^3/yr. This water leaves the Baltic with a salinity of about 10 and has a profound influence on the hydrography and water movements in the eastern parts of the North Sea. The inflow from the Baltic is an additional source of contaminants and nutrients to the North Sea (HELCOM, 1996).

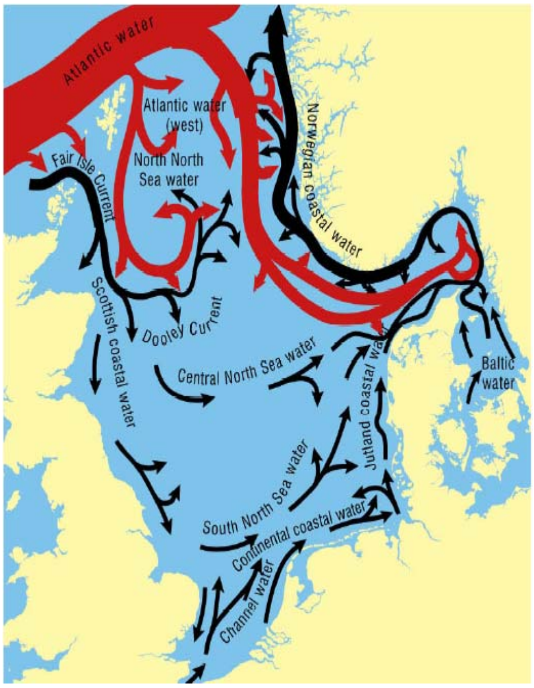
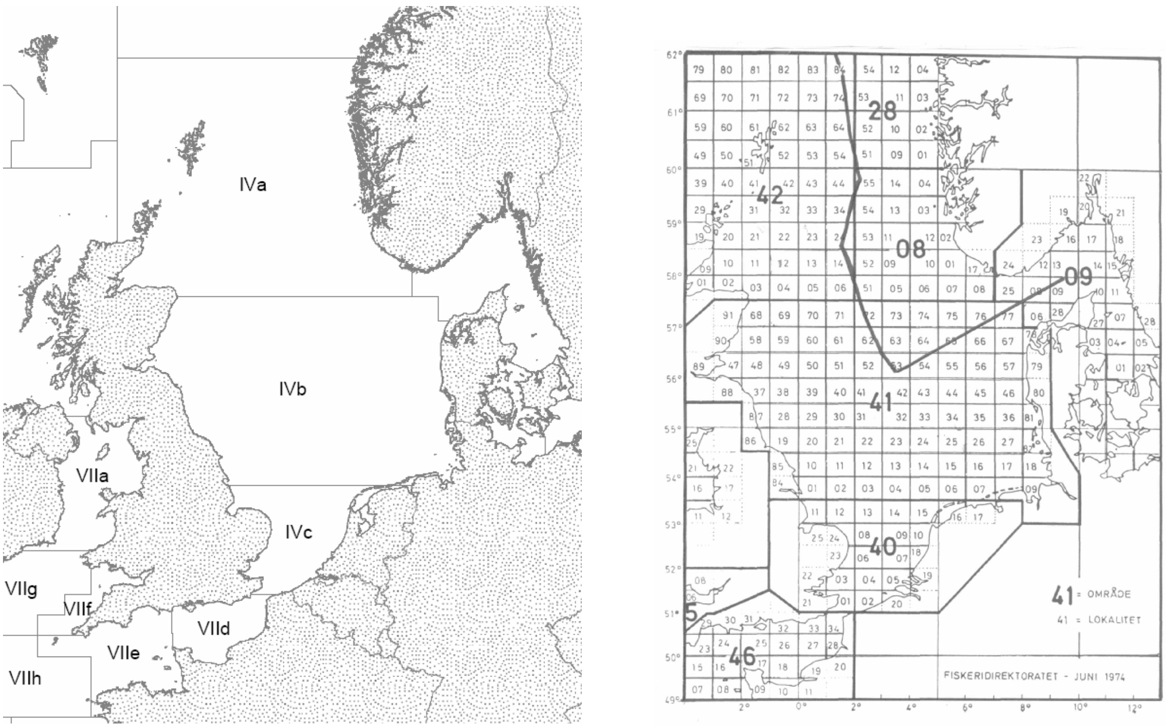


Figure 3-2. Schematic diagram of general circulation in the North Sea. The width of arrows is indicative of the magnitude of volume transport. Red arrows indicate Atlantic water. From Turrell et al. (1992).

3.3 Subdivision for resource monitoring

The North Sea has been subdivided in several ways with regards to various resource assessments and environmental monitoring programmes. Subdivisions are mostly related to topographic and hydrophysical conditions, but may also take national borders and economic zones into account. The subdivisions mostly used are those included in the systems produced by ICES and OSPAR (Fig. 3-3). In this system, the North Sea is divided into several sectors, and each sector is further subdivided into similar-sized squares. Sectors ("statistical areas") and squares ("statistical rectangles") are used as a basis for data registration. Fish catches are reported at a rectangle level. Major sectors broadly follow topographic and hydrographic characteristics with, for example, the sectors in the North Sea covering the most shallow part in the south, the middle deep in the centre and the deepest areas in the north. Often, the sections are divided further in an eastern and a western part making a total of seven main areas. Recently a system for dividing coastal waters into water types has been developed as a basis for monitoring of the Norwegian coast under the EU Water Framework Directive (Fig. 3-4).



(A) (B)

Figure 3-3. ICES subdivision of the North Sea and adjacent Atlantic waters (http://www.ices.dk). A: The OSPAR North Sea area is covered by the sectors IVa, b, c (North Sea proper), VIId, e (The Channel), and III (Skagerrak and Kattegat). B: subdivision of sectors in "statistical rectangles".

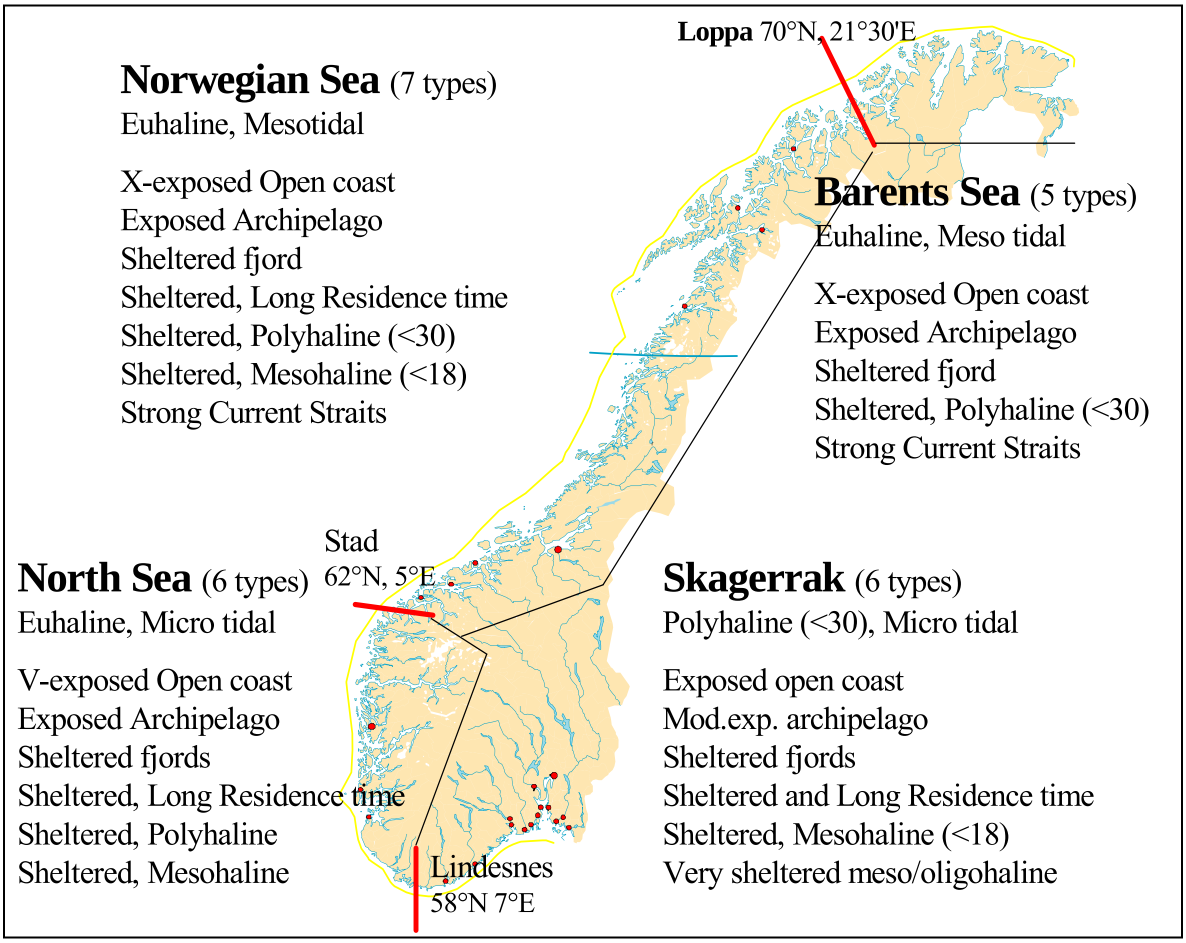


Figure 3-4. The Water Framework Directive typology for the Norwegian coastal waters. For the North Sea coast (including Skagerrak) from the Swedish border to Stad 12 different water types are suggested. From Solheim et al. (2005)

4. Input of nutrients and pollutants from Norwegian sources

This chapter presents relevant data sources and overall estimates of the amount of nutrients and pollutants discharged from Norwegian sources into the North Sea. An assessment of the status of knowledge is given for individual sectors, focusing on areas where present knowledge or data availability is considered insufficient. Actions to address gaps in knowledge are proposed. Discharges from countries outside Norway are presented in chapter 5. The effects from input of nutrients and pollutants are described in Ch.7.

Input from polluted sediments is not discussed in this report. A national action programme on polluted sediments has been established by the Norwegian government, with a consultancy group administered by the Norwegian Pollution Control Authority (SFT). Knowledge gaps and actions related to input from polluted sediments are handled through this programme, and a further investigation of these issues is therefore not considered necessary for a future integrated management plan for the North Sea.

4.1 Main data sources and discharge estimates

The Norwegian monitoring programme on Riverine Inputs and Direct Discharges (RID), administered by SFT, assesses annually the riverine and direct inputs of nutrients and selected pollutants to Norwegian coastal waters (Skarbøvik et al. 2007). Monitoring is part of a joint monitoring programme under the 'OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic' and has been conducted since 1990. Results are reported for the entire Norwegian coastline, as well as for two marine sub-regions relevant for this report; from the Swedish border to Lindesnes and from Lindesnes to Stad (Fig. 3-4).

In the RID programme, river borne inputs of nutrients, suspended particulate matter, total input of organic carbon, silicate, metals, PCB and the pesticide lindane to Norwegian coastal waters are quantified based on concentration and flow data from 10 main and 36 tributary rivers in Norway. For non-monitored rivers and coastal zones, diffuse losses of total phosphorus, total nitrogen, phosphates, nitrates and ammonium are estimated by using area-specific runoff coefficients as applied in the TEOTIL model (Selvik et al. 2007). For industrial discharges, municipal wastewater and fish farms directly into marine waters or to rivers below the RID sampling sites, estimates are based on data from effluent control programmes assembled in national databases.

4.1.1 Nutrients

Estimates of input of nutrients to Norwegian coastal are based on the RID programme and the TEOTIL model. The two approaches have somewhat different purposes. The RID programme, denominated by OSPAR as a "load-orientated approach" aims at providing optimum estimates for annual total inputs to Norwegian coastal waters for various substances. The TEOTIL approach, denominated by OSPAR as a "source orientated approach", only covers nutrients and aims at reflecting changes in the potential input of nutrients from different sources due to management actions leading to changes in agricultural practise, efficiency of sewage treatment plants, changes in aquaculture production etc. Given that climatic effects are only partially reflected by TEOTIL, it cannot be expected to produce identical results to the RID-approach. The two approaches are combined when producing best possible input estimates of nutrients for specific years; RID covers all monitored areas (approx. 70%), and TEOTIL covers non-monitored areas.

Nutrient inputs from various sources to selected coastal regions of Norway in 2006 based on the TEOTIL model are given in Table 4-1. The Skagerrak region is defined as a problem area with regard to eutrophication and is subject to the regulations by the OSPARs PARCOM recommendation 88/2 and the North Sea Declarations stating a 50% reduction of nutrient input from anthropogenic sources with 1985 as the baseline year. This requirement is met for phosphorus (>60 % reduction), but not for nitrogen (approx. 40 % reduction). Major industries and urban agglomerations are provided with satisfactory treatment facilities and inputs have dramatically reduced since 1985. Agriculture is presently the dominating source and constitutes somewhat less than 50 % of the total anthropogenic input of phosphorus and less than 60% for nitrogen. Aquaculture has been strictly regulated in the Skagerrak region and is not a significant source here.

The rapid growth of the aquaculture industry in the North Sea region between Lindesnes and Stad has led to this activity contributing as much as approximately 80% of the total anthropogenic input of phosphorus to this region. Aquaculture is also the largest source of nitrogen input, but to a lesser degree than for phosphorus (approx. 50%). Agriculture is the second largest source of nitrogen input (approx. 30% of anthropogenic input), whereas the general population is second largest for phosphorus (above 10%). The input from aquaculture is increasing and reflects the continuous economic growth of this sector.

Table 4-1. Example of nutrient discharge (tons) from various Norwegian sources to the North Sea in 2006, estimated by the TEOTIL model (Selvik et al. 2007).

Hydrometric area	*Aqua culture*	*Agriculture*	*Population*	*Industry*	*Backgr.*	*Total*	*Anthropogenic*
Phosphorus							
Swedish border – Lindesnes	7	241	178	110	164	700	536
Lindesnes - Stad	2397	198	343	73	198	3208	3010
Nitrogen							
Swedish border – Lindesnes	34	10592	6306	1319	15758	34009	18251
Lindesnes - Stad	11339	6968	2713	529	18634	40183	21549

4.1.2 Metals and organic pollutants

The total input of oil and micro pollutants from land to the Norwegian coastal and sea areas has recently been estimated and data is provided in two reports from SFT (Molvær et al. 2007a, 2008). These reports also identify gaps in knowledge and propose recommendations to improve the monitoring of the input of these substances (Table 4-2). These reports are based on industrial effluent data from the Norwegian Pollution Control Authority's own database (FORURENSNING), data on sewage plants from the KOSTRA-database of Statistics Norway and results from the RID monitoring programme. These reports also provide estimates of the input of oil and micro pollutants from petroleum activities, sediments, shipping and from other regions by ocean currents or by air. Figure 4-1 shows the input of cadmium to different oceanic regions within the Norwegian territory, and separates the contribution by different sources and activities. Table 4-3 shows the amount of direct input of THC, PAH, PCB, Cd, and Hg to different regions within the Norwegian part of the North Sea. Additional data for several more substances exist, and more information can be found in Molvær et al (2007a, 2008). The different sources as well as status and gaps in knowledge related to discharges of these pollutants are presented in chapter 4.2. A list of chemicals for which the use is to be ended or strongly reduced by 2005 or 2010 as prioritised by the Norwegian government is presented in Table A.2 (Appendix).

Table 4-2. Knowledge gaps on monitoring input of oil and micro pollutants to Norwegian marine areas.

Knowledge gaps	**Proposed actions to fill the gaps**
Insufficient monitoring of total input of oil and micro pollutants from land to the Norwegian coastal and sea areas	Recommendations are listed in Molvær et al. (2007a, 2008)

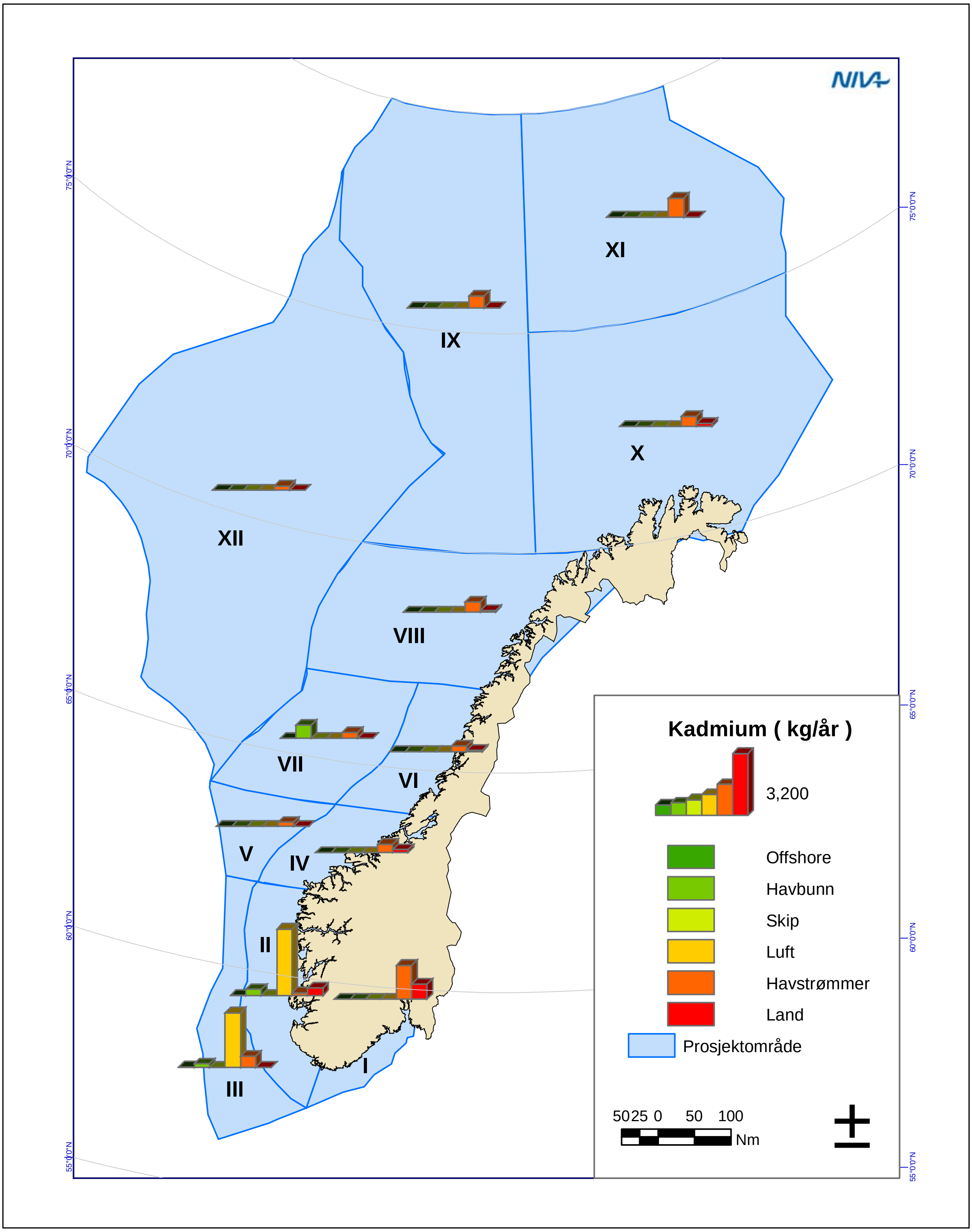


Figure 4-1. Discharges of cadmium from 6 sources to 12 regions (from Molvær et al. 2008).

Table 4-3. Direct input of THC, PAH, PCB, Cd and Hg to the Norwegian territory of the North Sea (Molvær et al. 2007a), presented for the following areas: Skagerrak (east of 8ºE), the Norwegian Coastal Current (NCC, south of 62ºN), and the remaining part of the Norwegian territory within the North Sea.

Region/areas	THC (m^3/year)	PAH (kg/year)	PCB (kg/year)	Cd (kg/year)	Hg (kg/year)
Skagerrak	15	224	15	2111	133
Norwegian Coastal Current	702	6490	6	1464	178
Remaining Norwegian part of the North Sea	2154	173020	83	1999	278

4.1.3 Knowledge gaps related to monitoring of riverine inputs

The Norwegian monitoring programme on Riverine Inputs and Direct Discharges (RID), in its present form, represents a 'minimum solution' in order to produce high-quality estimates of total nutrient inputs to Norwegian coastal waters. To obtain improved estimates, both the temporal and spatial resolutions of the programme should be strengthened (Table 4-4). The current monitoring programme, with 10 main rivers and 36 tributary rivers, covers about 50% of the Norwegian drainage area. Inputs from the remaining area are estimated from: a) historical data (13%) and modelled data from TEOTIL (37%). The spatial resolution of the programme is relatively high in the Skagerrak region, but considerably poorer for the North Sea, Norwegian Sea and the Barents Sea regions.

The main weakness, however, is related to the temporal resolution: Rivers are highly dynamic systems, with large variation in water flow and concentrations of solutes and suspended particles. With monthly sampling in the 10 main rivers (4 additional samples in Glomma and Drammenselva) and only quarterly sampling in the 36 tributary rivers, it is therefore very difficult to obtain representative load estimates. Besides increasing the general sampling frequency, it is recommended to introduce automated sampling devices, sensors, and combined hydrological and water quality models. To save resources, this can be implemented at a few selected "flagship" sites for environmental monitoring.

The present RID monitoring programme does not include all variables (especially organic pollutants) addressed in marine monitoring and assessment programmes (e.g., Green et al. 2007; Molvær et al. 2007a) (Table 4-4).

Table 4-4. Main knowledge gaps related to monitoring of riverine inputs.

Knowledge gaps	**Proposed actions to fill the gaps**
In principle discharge-monitoring of heavy metals are only made on larger water treatment plants (approx. 50 plants), micropollutants on fewer and with lower frequency. For the metals approx. 55% of discharges seem to be covered by this approach (2006 data), and the geographical distribution of remaining 45% is unclear.	Research on how to quantify non-monitored plants should be launched and subsequently implemented in the RID programme Improved implementation of present regulation should be made. Assessment on how to approach 100% discharge figures should be made.
The temporal and spatial resolution in reported nutrient discharges is too low to detect seasonal variation and act as input figures for hydrophysical- and effect-modelling in receiving waters	Temporal resolution could be improved by applying research on the method/procedures to produce time series with improved temporal resolution from existing monitoring regime or make recommendations for procedural changes. The spatial resolution should be increased by introducing automated sampling devices, sensors, and combined hydrological and water quality models

4.2 Status and knowledge gaps for individual sectors

In the following, an assessment of the status of knowledge is given for individual sectors, focusing on areas where the present knowledge or data availability is considered insufficient. Details on data sources (databases, reports etc) and ongoing projects relevant for the various sectors are listed in Table A.1 (Appendix).

4.2.1 Agriculture

Agricultural areas constitute only 3.7% of the Norwegian land area draining to the marine environments (Fig. 4-2). The primary agricultural point-source and non-point-source pollutants are nutrients (particularly nitrogen and phosphorus), suspended particulate matter and pesticides. Estimates of discharges of nutrients from this sector were presented in the previous section.

The estimates of input of nutrients and pollutant from non-monitored catchments with TEOTIL are based on the best available knowledge and empirical relationships between land use and runoff of solutes and particulate matter. Regression models applied by TEOTIL explains much of the variation in observed N and P runoff from the catchments of the Norwegian Agricultural Environmental Monitoring Programme (JOVA) (Pengerud et al. 2006). However, there is still a need for improvements both with regard to process understanding and modelling approach. Knowledge gaps are presented below and summarized in Table 4-5. Relevant data sources and ongoing research projects are listed in Table A.1.

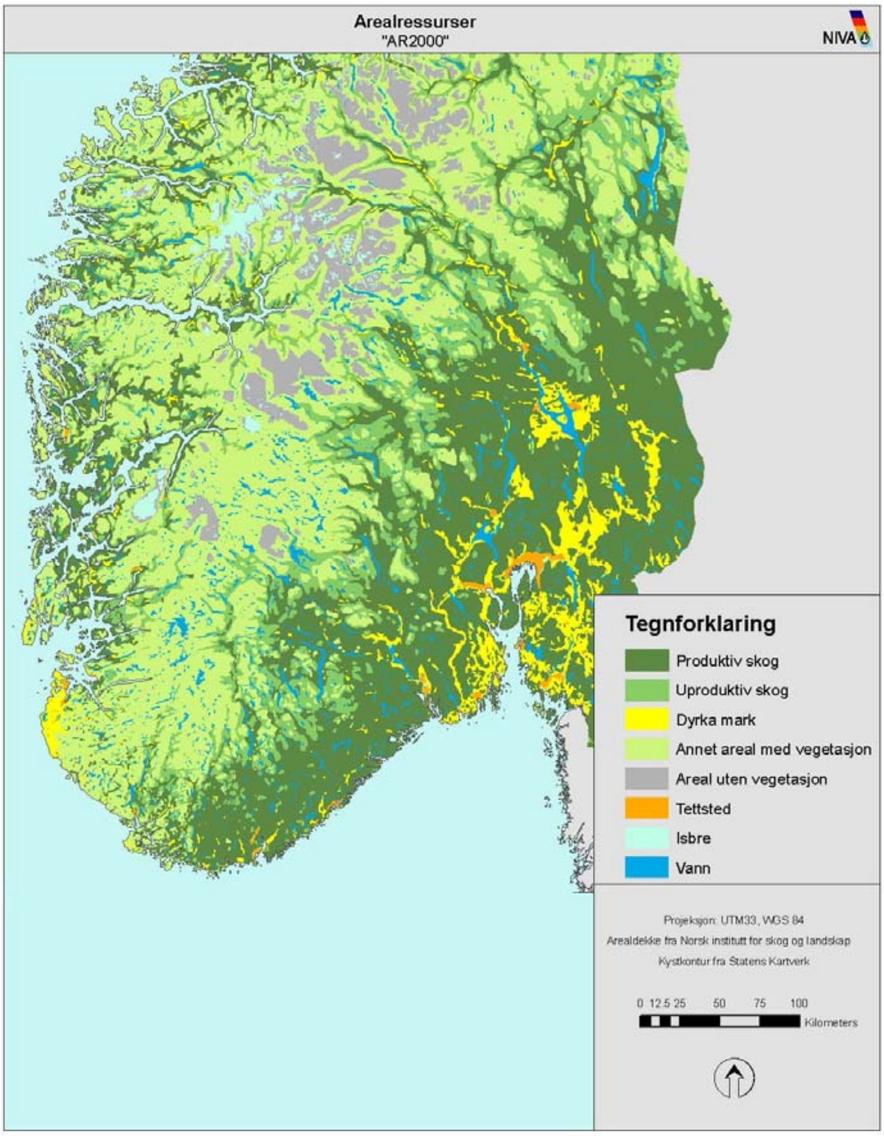


Figure 4-2. Land cover map of Norway. From the AR2000-map by the Norwegian Forest and Landscape Institute.

Research on catchment processes and mechanisms regulating losses of nutrients, soils and pesticides from agricultural areas is mainly carried out by Bioforsk, whereas the assessment of effects on water quality and biota in larger water bodies is usually performed by NIVA. Examples of research issues / knowledge gaps regarding the above-mentioned processes are:

- Climate change, winter hydrology and losses of nutrients and sediment;
- Modelling and upscaling of catchment processes;
- Risk assessments, soil erosion and nutrient losses;
- Pesticides – mobility in soil and water, and effects on biota.

More research questions and challenges are addressed on the Bioforsk website (www.bioforsk.no) where reports and scientific papers related to this issue are also displayed.

Simulation of agricultural runoff may be improved through further research and a number of adjustments to the existing TEOTIL model. Improvements may include better retention estimates (models) for river reaches and refinement of the use of REGINE and river segments (ELVIS) as basic units for TEOTIL (REGINE accomplished from 2007). The ultimate goal is to use river segments as basic units, to increase the spatial resolution and provide TEOTIL as a tool in the process of developing water management plans under the Water Framework Directive.

Furthermore, area runoff coefficients for agriculture need to be adapted to the recent developments of TEOTIL, with higher spatial resolution (REGINE units or river segments) and more differentiated land-use types. Climate variability factor and uncertainty analysis in area runoff coefficients should also be included, in order to harmonise TEOTIL estimates (theoretical) with those of RID (partly theoretical and partly based on measurements). A revision of the area coefficients for background runoff from natural areas were accomplished 4 years ago on the basis of monitoring data obtained since 1990. There is a need to revisit the coefficients to include recent data and improve the geographic balance in the underlying dataset.

The spatial resolution in nitrogen deposition estimates should be increased (through collaboration with NILU and/or Met.no/EMEP). There is also a need to use outputs from gridded models (climate, hydrology) as TEOTIL input. Complementary dynamic models should be used that are process-based and allow detailed studies of agricultural runoff processes and the inclusion of e.g. climate scenarios, and sensitivity / uncertainty analysis.

The TEOTIL model could also be used to simulate transport of other substances than nutrients (e.g., pesticides). This would require more extensive monitoring of pesticides in lakes and streams, or upscaling of existing monitoring data from the JOVA-programme (Pengerud et al. 2006). Finalisation of the national high-resolution land cover map would be extremely useful for modelling on different scales. Ponds and vegetated buffer zones are commonly established to reduce sediment and nutrient loss from agricultural fields. Effects of these are not included in current area runoff coefficients.

Table 4-5. Main knowledge gaps regarding discharges of nutrients from Norwegian agriculture.

Knowledge gaps	**Proposed actions to fill the gaps**
Process understanding and assessment of environmental consequences, including e.g. the extent to which climate changes will influence discharges.	Continue ongoing research projects (Appendix).
Improve the TEOTIL model for simulation of agricultural runoff.	Increase spatial resolution by using river segments as the basic unit. Loss coefficients for use in the TEOTIL2 model should be more differentiated for use in local studies. A nationwide, high-resolution land cover map would be extremely useful for modelling on different scales.
No process-oriented numerical model adapted as the national 'tool' for detailed agriculture studies.	Develop suitable model tools.

4.2.2 Aquaculture

Aquaculture includes commercial farming of fish, mollusc species (blue mussels and oysters) and crustaceans. Production systems that use artificial feed are the most relevant for input of nutrients to the surrounding environment. During the last two decades there has been an annual increase of 7-10% in total production from Norwegian aquaculture. The dominating aquaculture production in Norway is the farming of Atlantic salmon and rainbow trout. Cod is the third most important species. In 2006 the Norwegian production of salmon, rainbow trout and cod exceeded 600 000, 60 000, and 11 000 tons, respectively, together worth more than 16.5 billion NOK (Statistics Norway, 2007). Figure 4-3 shows an overview of Norwegian fish farms in the North Sea region.

Main discharges from the aquaculture industry are nutrients, organic matter and copper used as antifouling agent. Additionally, the escape of farmed fish is considered problematic from a genetic viewpoint. Another concern is that fish farms form the breeding ground for fish lice may influence migrating wild salmon. Inputs of nutrients (N, P) and organic matter from sea-based fish farming originates mainly from faeces, nitrogen excretion through the gills and feed waste. Much effort has been put into optimising feed composition in order to minimise the feed consumption relative to the accumulated biomass. Feeding regimes have also been improved to minimise feed waste. The total nutrient input from the aquaculture still increases, due to the high increase in the total production. Estimates of the nutrient discharge from aquaculture in Norway are presented in Table 4-1.

Production information from salmon farming (e.g. feed consumption, slaughtered fish and dead fish) is reported by each farmer on a monthly basis. NIVA receives production data from the Directorate of Fisheries each year and processes it to obtain nutrient loss estimates as input to the TEOTIL model. Nutrient losses from fish farming are also reported in the RID monitoring programme.

Since 1990 the anthropogenic nutrient load from land-based sources to the west coast has increased by approximately 120% (nitrogen) and 130% (phosphorus) (Molvær et al., 2008). However, this increase has not been accompanied by monitoring programs to observe possible effects. Only the fjords around Bergen, partly around Stavanger, the Karmsund and the Sørfjord in Hardanger have been monitored on a reasonably regular basis.

The present growth rate within the aquaculture business indicates a nearly 100% increase in nutrient losses over the next 10 years. This implies that a strategic environmental impact analysis should be carried out, and a large scale monitoring programme should be implemented as soon as possible (Table 4-6). Knowledge of nutrient fluxes related to water exchange between fjords and coastal waters should be improved in hydrodynamic models, and the mechanisms involved need further investigations. New species (e.g. cod) may introduce higher discharges of nutrients due to higher demand for protein in the feed and that feed composition and feeding regimes are not presently optimised. Climate changes (e.g. increased water temperature and changes in growth periods of aquaculture species) may influence both the discharge of pollutants and subsequent effects.

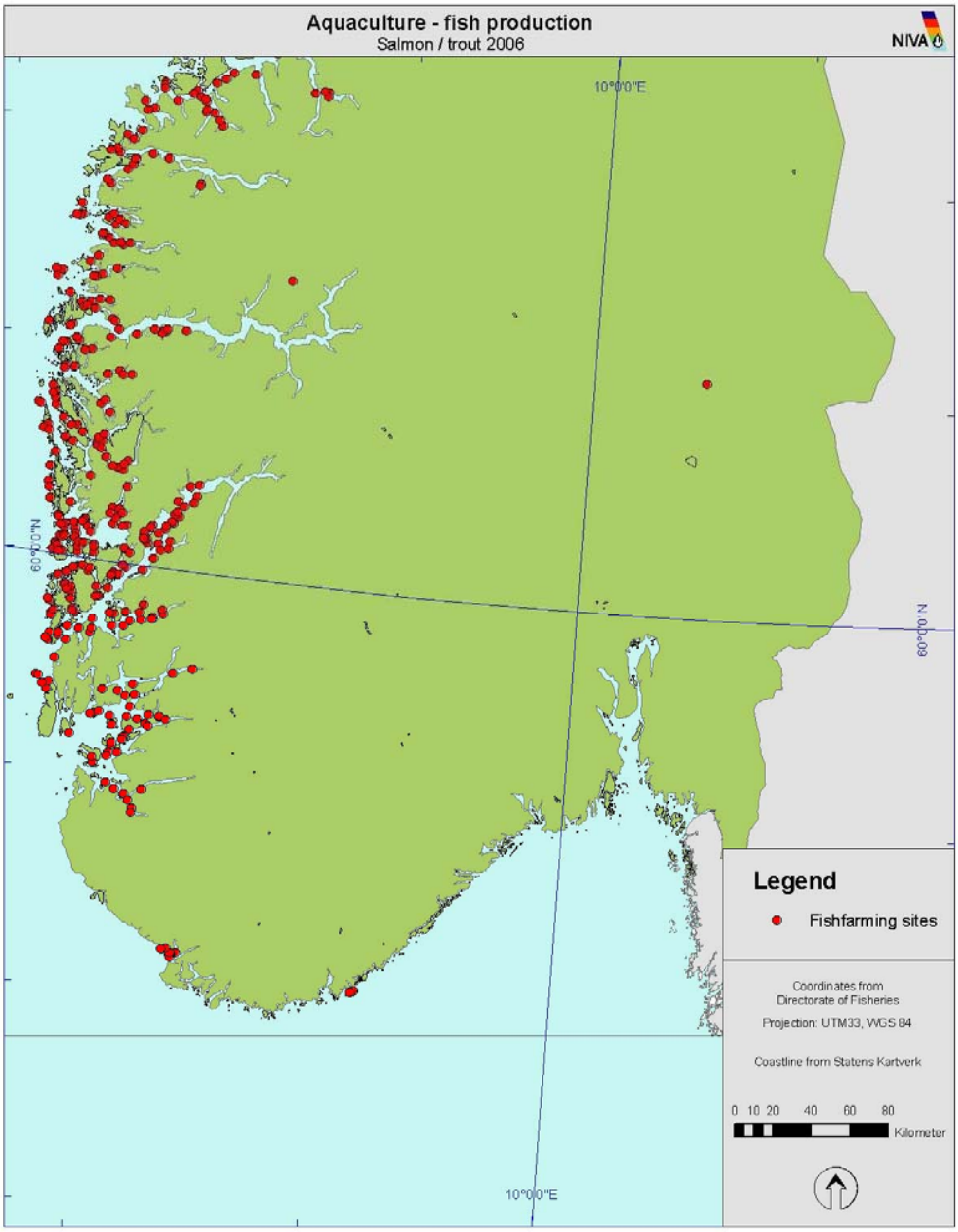


Figure 4-3. Norwegian fish farms in the North Sea region. Based on data from the Directorate of Fisheries/ Altinn. Derived from Selvik et al. (2007).

Table 4-6. Main knowledge gaps regarding discharges of nutrients and pollutants from Norwegian aquaculture.

Knowledge gaps	Proposed actions to fill the gaps
No national impact monitoring highly increased nutrient and organic input is established despite expressed scientific worries and an expected 100% production increase in 10 years time. The present state of eutrophication is poorly known (biological effects). The basis for assessing trends over the next 5-6 years is very weak.	A strategic environmental impact analysis is suggested. A large scale monitoring programme should be implemented as soon as possible.
Nutrient dynamics and eutrophication in the fjords. The relative importance of various nutrient loads (anthropogenic vs. transboundary loads).	Nutrient fluxes related to water exchange within fjords and between fjords and coastal waters should be improved and included in comprehensive nutrient budgets.
Consequences of new species. New species (e.g. cod) may introduce higher discharges of nutrients due to higher demand for protein in the feed and that feed composition and feeding regimes are not presently optimized.	Environmental consequences related to discharges needs to be studied.
Standard content of nutrients in feed for salmonids has not been updated for a number of years	New or updated standard content figures for salmonids and new emerging species should be established All aquaculture activity using artificial feed should be included in the reporting system via ALTINN.

4.2.3 Fisheries

Besides the direct impact on target fish species, the fishing fleet, like other vessels, has emissions to air, and operational discharges of grease, bilge, slop and organic waste. For emissions to air, data is obtained by Statistics Norway and reported in annual reports. For other operational discharges, information is sparse, and dedicated projects should be developed in order to generate such information. More information about the current status (types, amounts, distribution) can be found in sources of data and information presented in Table A.1 (Appendix). Mapping and assessing these impact factors in time, space and perturbation magnitude, together with assessing data coverage, will provide valuable status information to be included in the management plan.

Pollutants from the fisheries may be introduced to the marine environment through emissions to air, discharges of chemicals and organic matter to the sea, and dumping of waste and trash. Emissions to air consist mainly of CO_2, CH_4, N_2O, SO_2, NO_x, NH_3, NMVOC, CO and particles. The last updated information about emission to air from the fishing fleet is from 2005, and will be updated annually. Information from SFT indicates that discharges of grease, hydraulic fluids, slop water, and anti fouling paint from the fishing fleet are poorly mapped and can be identified as a gap of knowledge.

The fish processing industry discharges organic matter from land-based plants (particulate organic matter), and discharges from onboard processing of fish (e.g. gutting/cleaning and filleting). While these impact factors are difficult to quantify, the assessment of filet/meal/final products produced relative to the amount of fish landings provide rough estimates. During land-based and onboard fishing industry processing, water soluble and particulate organic materials are released to the environment. Generally this is not assumed to be a major problem, but locally this can contribute to pollution in the vicinity of land-based fish plants.

Waste and trash from fisheries may also constitute a problem, and this includes loss of fishing tools and deliberate dumping of worn and torn equipment. Records of waste oil and other liquid/solid waste delivered to harbour waste handling facilities are kept. Information on the amount of losses of fishing equipment such as gillnets from the fishing fleet is sparse, and is defined as gap in knowledge. While this problem is discussed in a report from the Fishery Directorate, the quantification of lost equipment and ghost fishing is not included in this report. However, the Directorate of Fisheries performs yearly operations for removing lost fishing gears, and ghost fishing is assumed to be a problem in the most important fishing grounds (R. Misund, Directorate of Fisheries, pers. com). Main knowledge gaps regarding discharges of pollutants from Norwegian fisheries are listed in Table 4-7.

Table 4-7. Main knowledge gaps regarding discharges of pollutants from Norwegian fisheries.

Knowledge gaps	**Proposed actions to fill the gaps**
Operational discharges to the sea (e.g. grease, hydraulic fluids, slop water, anti fouling paint) information is limited.	Monitoring of discharges.
The amount of lost fishing gears as e.g. gillnets from the fishing fleet is sparse	Mapping and monitoring.

4.2.4 Oil and Gas

Influence on the environment related to petroleum industry depends on the type of activity as well as the present physical and biological resources in the area in question. Some activities, such as seismic surveys and drilling, may proceed throughout the lifetime of an oilfield. Discharges from all these activities are reported to national authorities as well as to OSPAR.

Discharge of drilling fluids and drill cuttings have been a considerable source of contamination of the environment. The contamination is mainly due to the use and discharge of oil based mud (OBM) and discharges of OBM where therefore banned in the early 1990's. More information on international activities in the North Sea is given in chapter 5.2.

Discharges of produced water and chemicals may influence water quality and organisms in the water column and the seafloor. During the production phase water from the reservoir is pumped up with the oil, and contains various amounts of dispersed and dissolved oil compounds and other substances. The total amount produced water discharged to the North Sea in 2005 was 413 million m^3 (OSPAR 2007b). OSPAR has issued a demand of maximum oil content in produced water to sea of 30 mg/l, valid from 1.1.2007. Nevertheless, large volumes of produced water result in considerable discharges of oil. In 2005 the total amount of oil to sea from produced water in the North Sea was 13384 tons.

As oilfields matures, the production of water increases. Depending on the maturity of the oil and gas fields in the North Sea and the possibilities to re-inject the water, the discharge of produced water to sea may still increase in the years to come. To enable the monitoring and assessment of the effects of discharges, a number of assumptions needs to be further assessed. The background level of biological effect parameters used in biomonitoring programme and their seasonal variation should be mapped.

The petroleum industry is one of the major contributors of oil entering the North Sea. Worldwide, natural leakage of oil from i.e. oil seeps has been estimated to be the source of 47 % of the oil supplied to oceans (GESAMP 2007). The importance of such natural processes in the North Sea is not known, but this knowledge would provide an idea of the necessity of even stricter regulations for the offshore industry (Table 4-8).

Table 4-8. Main knowledge gaps regarding discharges of pollutants from Norwegian oil and gas industry

Knowledge gaps	**Proposed actions to fill the gaps**
The importance of natural leakage of oil in the North Sea is not known, but this knowledge is important in respect to the possible impacts of the offshore industry discharges and the necessary regulations.	Mapping of natural leakage. Background levels of contaminants and biomarkers.

4.2.5 Transport

The North Sea area includes some of the busiest shipping routes in the world. In 1996 about 270 000 ships entered the main 50 ports in the North Sea and Channel area. Shipping can have a negative impact on the marine environment due to discharges of oil and wastes, cleaning and venting tanks, air pollution, loss of cargoes containing harmful substances (50% of goods carried at sea can be described as dangerous), discharges of ships’ ballast water which may contain non-indigenous species, and the use of anti-fouling paints containing biocides (OSPAR 2000). Relevant substances from shipping are: oil (THC), tributyltin (TBT), triphenyltin (TFT), arsenic, lead, hexachlorobenzene (HCB), cadmium, copper, chromium, mercury, PCB, PAH, and trichlorobenzene (TCB).

As presented above, the total input of oil and micro pollutants from land to the Norwegian coastal and sea areas have recently been estimated in a report from SFT (Molvær et al. 2007a). Data on oil spills and oil slick detections can be found in annual reports from the Bonn Agreements (http://www.bonnagreement.org). In 2004, The Bonn Agreement aerial surveillance registered 65 oil spills from ships and oil installations with a total estimate of 50m^3 oil (Molvær et al. 2007a).

With regards to legal operational discharges of oily bilge water and cargo residues (slop water), black water, grey water and garbage, there is uncertainty in estimating these values because of uncertainty in both the waste production factors and the fractions discharged to sea as opposed to delivered to shore. With regards to other produced oily waste (solid and liquid) with a zero discharge limit, there is limited knowledge about the extent of illegal discharges. A programme for evaluating current discharge factors and fractions discharged vs. delivery on shore would be beneficial. This could include a programme for monitoring onboard waste production and discharges, together with onshore reception facility monitoring.

Transfer of non-indigenous invasive species with ballast water is considered to be one of the major threats to the ecological diversity of the marine environment. Although Norwegian waters appears relatively pristine, the risk of invasion of non-indigenous species is increasing, due to the expanding shipping trade to Norwegian waters, and measures should be taken to monitor the situation and reduce the risk until implementation of the measures of the IMO ballast water convention. The main gaps in knowledge regarding discharges of pollutants from the transport sector are listed in Table 4-9.

Table 4-9. Main knowledge gaps regarding discharges of pollutants from transport.

Knowledge gaps	**Proposed actions to fill the gaps**
There is uncertainty in estimates of legal operational discharges of oily bilge water and cargo residues (slop water), black water, grey water and garbage, because of uncertainty in both the waste production factors and the fractions discharged to sea vs delivery to shore. There is limited knowledge about the extent of illegal discharges of other produced oily waste (solid and liquid) with a zero discharge limit.	Programme for evaluating current discharge factors and fractions discharged vs delivery on shore. This could include a programme for monitoring onboard waste production and discharges, together with onshore reception facility monitoring.
Insufficient monitoring of invasion of non-indigenous species from ballast waters to Norwegian waters.	Measures should be taken to monitor the situation and reduce the risk until implementation of the measures of the IMO ballast water convention.

4.2.6 Industry

Discharges from the Norwegian industry (including waste disposal sites) are monitored and reported through a standardised national system. Land-based industry within “control group” 1, 2 and 3 (grouping according to pollution potential, 1=worst) reports discharges of various substances to SFT and the county governor via the Altinn database (www.altinn.no).
A new database with more detailed information will be available on www.sft.no in 2008. Collected data are available at www.sft.no. The industry reports annually on components regulated in their discharge permit and on other main substances related to the type of production. A map of industrial activities subjected to licensed monitoring are presented in

Fig. 4-3. Activities in this area are mainly represented by the chemical, petro-chemical and melting plants, and the wood processing industry. Advice on consumption of fish and other seafood in polluted areas is given by the Norwegian Food Safety Authority (at www.matportalen.no) and by SFT (at www.environment.no). Generally, organic compounds such as PAH and PCB are the main pollutants that restrict the advised consumption of fish and seafood.

Based on the experience of using data reported in the national nutrient discharge project with the TEOTIL model it appears that if a substance (e.g. nitrogen and phosphorus) is not regulated in the discharge permit the reported figures may sometimes not be as reliable (Selvik et al. 2007). The reporting requirements on parameters should therefore be tightened up. Furthermore, the temporal resolution in reported nutrient discharges is too low, and the resolution should be increased to enable monitoring of seasonal variation and input of data to hydrographical- and ecological effects models.

Errors have been observed in the reported coordinates for industry localisation and some discharge point coordinates are missing. In 2004 only 6% of individual 8150 industries had coordinates registered in the SFT database "Inkosys" (Selvik et al., 2005). Modern analytical approaches required good localisation. An improved coverage and quality of coordinates in the national register 'Forurensning'.

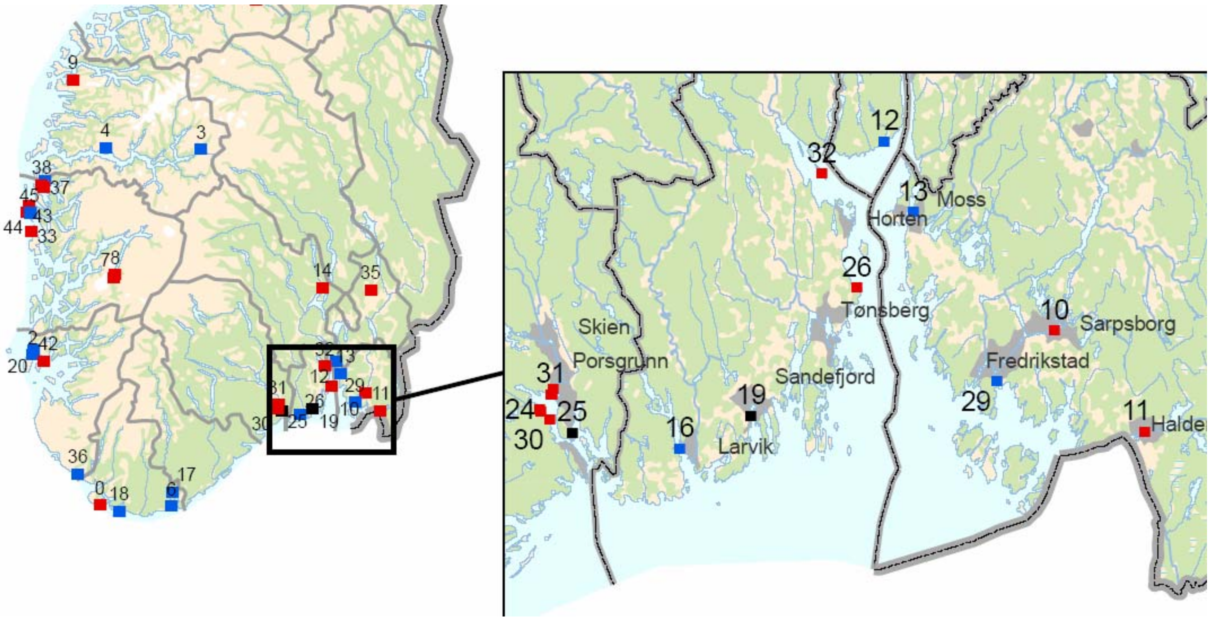


Figure 4-4. Map of industrial activities subjected to licensed monitoring (DN, 2007). Red indicates ongoing monitoring and blue sporadic monitoring. Black indicates that type of monitoring is not specified.

Main knowledge gaps on discharges from the industry sector are summarised in Table 4-10. Knowledge gaps related to weaknesses in the RID monitoring program presented in chapter 4.1.3 and Table 4-4.

Table 4-2. Main knowledge gaps regarding discharges of nutrients and pollutants from Norwegian industry.

Knowledge gaps	Proposed actions to fill the gaps
All substances of importance are not reported regularly	Tightening-up of reporting requirements
Low temporal resolution in reported nutrient discharges.	Introduce higher temporal resolution to enable monitoring of seasonal variation and input of data to hydrographical- and ecological effects models

4.2.7 Population

Discharges from the population are primarily nutrients, organic matter, bacteria and virus and particles but may also include small amounts of micropollutants. Municipal treatment plants and degree of phosphorus removal are shown in Fig. 4-5. Both the RID monitoring programme (Skarbøvik et al. 2007) and TEOTIL (Selvik et al. 2007) include estimates of direct discharges from municipal waste water and scattered dwellings (Statistics Norway/ KOSTRA database).

Considerable effort has been made to collect urban waste waters and apply appropriate levels of treatment. Nevertheless, even where households and industries are served by tertiary treatment systems, exceptional rainfall or tourism during the summer can reduce the efficiency of these systems. Measures relating to the reduction of nutrient inputs were adopted by the Paris Commission in 1988 and 1989 (PARCOM Recommendations 88/2 and 89/4). The EC Urban Waste Water Treatment Directive (Council Directive 91/271/EEC) of 1991 regulates the required level of treatment of waste water (OSPAR, 2000). The Norwegian regulation on sewage (Avløpsforskriften) covers international standards and demands and regulates cleaning of sewage in Norway.

The Norwegian Skagerrak coast is considered a problem area with regard to eutrophication in accordance with PARCOM recommendation 88/2 and the Bergen Ministerial Declaration (2002) and a 50% reduction target for anthropogenic nutrient discharges compared to the 1985 situation applies. The agreed goal under the Water Framework Directive to achieve Good Ecological status before 2015 was also considered. The inner Oslofjord and the coastline from the Swedish border to Strømtangen lighthouse have been given priority for tertiary nitrogen removal in accordance with the EU Urban Wastewater Treatment Directive and the Nitrates Directive. The treatment requirements are less stringent outside the Skagerrak area.

Sewage sludge dumping was completely phased out by the end of 1998 (OSPAR 2000). The dumping of chemical waste into the North Sea ceased in 1993. There has also been a decreasing trend in the amount of waste and related substances discharged during the period 1984–1994 by France, the United Kingdom, Germany, The Netherlands and Norway.

Knowledge gaps regarding discharges of nutrients and organic pollutants from the population are mostly related to weaknesses in the RID monitoring program presented in chapter 4.1.3 and Table 4-4.

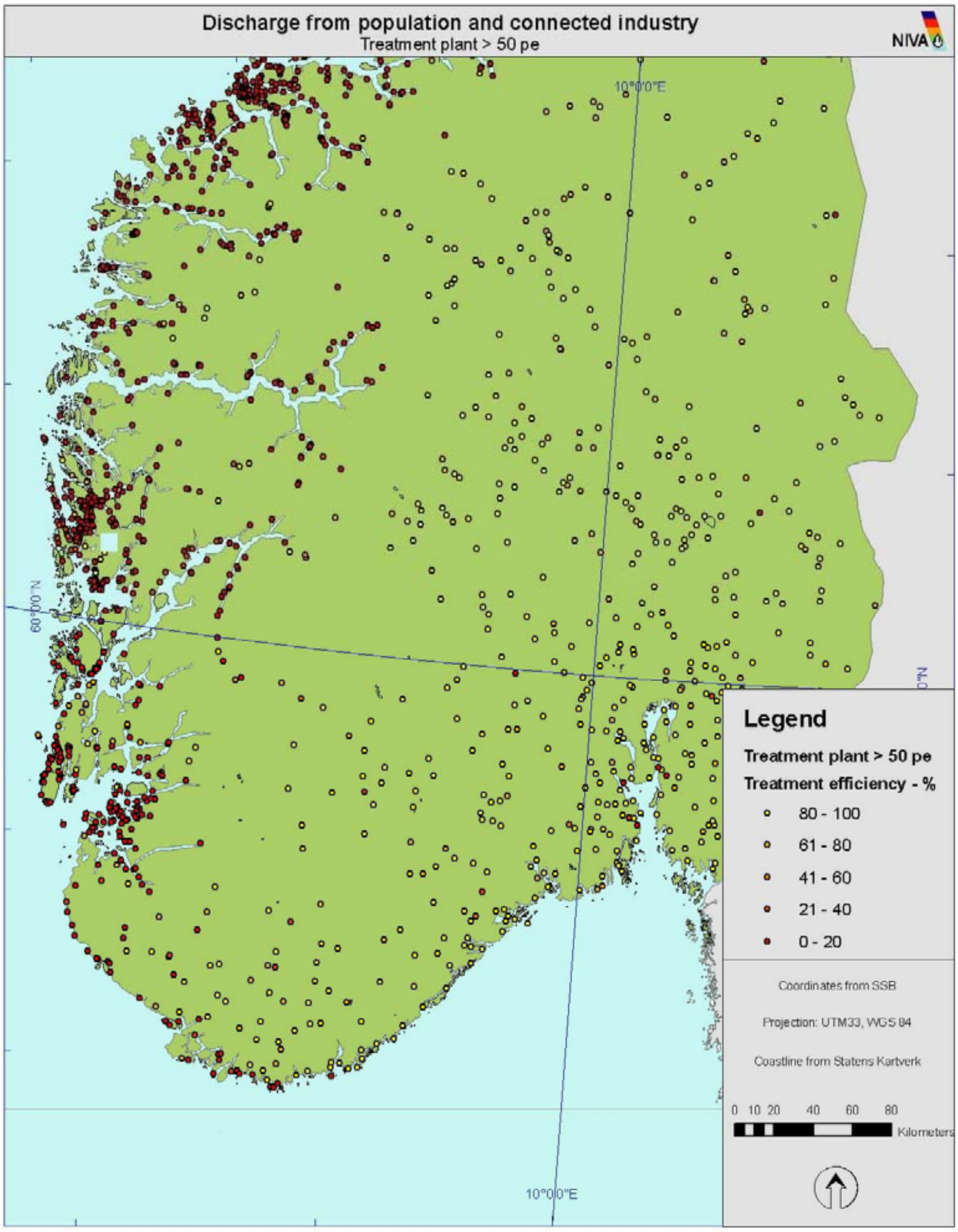


Figure 4-5. Position of treatment plants and degree of phosphorus cleaning for sewage from population and industry connected to public lines. Data from KOSTRA/SSB. Derived from Selvik et al. (2007).

4.2.8 Defence

Information about the current status of data and reporting of this sector are collected from The Norwegian Defence Estates Agency (Forsvarsbygg) (Grete Rasmussen, pers.comm.). All polluted sites are included in the Polluted Ground database at the Norwegian Pollution Control Authority (SFT) and organised per county and municipality. The database describes the current status of abatement measures and environmental monitoring, with reference to relevant reports. Status reports giving an overview of publications related to mapping projects, implementation of abatement measures and environmental monitoring are available at Forsvarsbygg. Data from shooting ranges are not yet included in the database. All monitoring data will be included in Norway Digital (Norge Digitalt), which is the Norwegian government's initiative to build a national geographic infrastructure. Initial data will be delivered in 2008. This includes data from monitoring programmes carried out by NIVA and Sweco Grøner (mainly metal concentrations in brooks and groundwater wells). The data comprises about 25 shooting ranges reported during 2007. The remaining shooting ranges are under monitoring, and the results will be reported next year. Some of these are located near the coast. Shooting ranges located in marine environments are not subjected to regular monitoring yet, and little data exists at the present time (Table 4-11).

Table 4-11. Main knowledge gaps regarding discharges of pollutants from the Norwegian Defence.

Knowledge gaps	**Proposed actions to fill the gaps**
Shooting ranges located in marine environments are not the subject of regular monitoring yet, and very few data exist at the moment	Establish regular monitoring.
Ship wrecks and ammunition deposition are potential sources of pollution, but the extent of these sources is not fully mapped.	Improve mapping.

4.3 Summary

A summary of the main pollutants from the different sectors as identified in Chapter 4.2 is given in Table A.2. The most important knowledge gaps are summarised below.

Input of nutrients and organic matter

On a national scale, monitoring data are generated through the National monitoring programme on River Inputs and Direct Discharges (RID) and comprehensive modelling of nutrient export is performed using the TEOTIL model. The RID sampling programme in its present form represents a 'minimum solution' in order to produce high-quality estimates of total nutrient inputs to Norwegian coastal waters. In order to obtain improved estimates, the temporal and spatial resolution of the programme should be strengthened. The simulation of agricultural runoff with the TEOTIL model should be improved through further research and a number of adjustments to the TEOTIL model. Area runoff coefficients for agricultural areas (divided in several land use types) should be adapted to a higher resolution in the present TEOTIL model framework. Process-based models may serve as useful tools in the preparation of such coefficients. No national impact monitoring from aquaculture nutrient and organic input is established despite expressed scientific worries and a probable doubling of production in 10 years time. Hence, a large scale monitoring programme should be implemented as soon as possible. Also, nutrient fluxes related to water exchange between fjords and coastal waters needs more investigation, both in terms of measurements and modelling.

Input of metals and organic pollutants
The RID programme provides an estimate of riverine inputs of metals and selected micro-pollutants (lindane and PCB) to Norwegian coastal waters. For industrial discharges and municipal wastewater entering directly into marine waters or to rivers below the RID sampling sites, estimates are based on data from effluent control programmes assembled in national databases, but only larger treatment plant report these substances. Inputs of metals from non-monitored areas are not included, as the present TEOTIL model does not include metals. The total input of oil and micro-pollutants from land to the Norwegian coastal and sea areas have recently been estimated in a report from SFT (Molvær et al. 2007a). The further development of reporting routines for metals and organic pollutants as well as improved temporal resolution would be beneficial for any effect assessment in the marine environment and increase our understanding of the land-ocean-interactions. Aquaculture has a relatively high, but stable discharge of copper due to the use of copper as an antifouling agent applied on net cages, but discharges are not considered problematic by The Norwegian Pollution Control Authority.

5. Input of nutrients and pollutants from non-Norwegian sources

An integrated overview on the state of input of nutrients and pollutants within the North Sea area is provided by the Quality Status Report from the OSPAR Commission which was first published in 2000 (OSPAR, 2000). The next issue of the report is aimed to be published in 2010. While this report collates all information, the OSPAR Commission publishes overview reports for specific monitoring programmes respectively reports dealing with specific pollutant sources with a higher frequency. Additionally riparian countries of the North Sea publish their monitoring results for the specific territorial areas on a regular basis. The following section provides a short overview of the current status of knowledge for the different sources. Main knowledge gaps are summarised in the end of this chapter.

5.1 Riverine Inputs and Direct Discharges

An overview of the currently available Riverine Inputs and Direct Discharge data for the North Sea region is given in Table 5-1 (OSPAR 2007a). Hereby it must be clarified that the direct comparison between the estimates for a specific country to another is difficult due to different measurement techniques with different detection limits. A crucial point that arises from these observations is that in many cases the concentration values of the various samples taken are below the detection limit. To account for this, upper and lower values are reported for the annual input value. In case of the concentration within an observation falling below the detection limit following the OSPAR principles two values should be provided; one is assuming that the concentration is zero and the other is assuming that the concentration is the limit of detection. However, no real proof is given that all the countries provide data in a unique manner. For a detailed insight in the difficulties arising, the reader is referred to the OSPAR report on Riverine Inputs and Direct Discharges (OSPAR 2007a).

Table 5-1 provides cumulative values for the riverine inputs and direct discharges. The distribution between the riverine inputs and direct discharges is displayed within Fig. 5-1for nitrogen and phosphorus. For nitrogen the Riverine Inputs form the major part of the total input. For phosphorus the fractions are more balanced, but still the riverine inputs are higher than the direct discharges. While the nitrogen and phosphorus results are only marginally influenced by the application of the different detection limits in the various countries, for the following substances several uncertainties occur by applying that method. The distribution of Cadmium inputs is different when using the upper and lower estimates. By using the upper estimate, riverine inputs are significantly higher than the direct discharges. The difference is less pronounced using the lower estimates. For Mercury the riverine inputs are significantly larger than those from direct discharges. The uncertainty caused by the use of the lower resp. upper estimate is high. Also for Copper the riverine inputs form the larger part of the total inputs, with the exception of Norwegian inputs, where the cleaning of fish cages in the fish farming industry cause a high amount of copper within the direct discharges. The uncertainty caused by the use of the lower resp. upper estimate is high. For Zinc the riverine inputs are an order of magnitude higher than the direct discharges. Here, due to the relatively high zinc concentration the use of lower and upper estimate is a less distorting factor.

Table 5-1. a) Lower and b) upper estimates of the sum of direct discharges and riverine inputs. Copied from OSPAR (2007a)

(a)

Country	Cd tons	Hg tons	Cu tons	Pb tons	Zn tons	g-HCH kg	PCBs kg	NH4-N kt	NO3-N kt	PO4-P kt	Total N kt	Total P kt	SPM kt
Belgium	0.8	0.3	31	21	193	4.5	0.32	3.2	25	1.2	31	1.3	250
Denmark	-	-	-	-	-	-	-	0.08	0.19	0.37	0.39	0.43	0
France	-	-	-	-	-	-	-	15.5	63	2.2	0.0	2.50	217
Germany	5.1	2.6	226	136	1056	23	4.3	8.8	146	2.3	189	9	1655
Ireland	0.26	0.06	67	23	368	-	-	1.68	83	2.09	124	5.8	745
Netherlands	3.8	1.3	204	105	815	14	-	6	176	5.1	231	10	1190
Norway	2.44	0.38	461	37.50	629	0.00	-	32.93	36.83	5.31	99.9	8.68	1291
Spain	1.6	0.2	15	7	280	2.6	0.0	15	18	2.7	60	4.2	701
UK	4.9	0.60	388	272	1611	19.6	0.7	47	210	20.0	281	24	2212

(b)

Country	Cd tons	Hg tons	Cu tons	Pb tons	Zn tons	g-HCH kg	PCBs kg	NH4-N kt	NO3-N kt	PO4-P kt	Total N kt	Total P kt	SPM kt
Belgium	3	0.3	46	42	249	32	77	3.9	30	1.4	42	3.1	323
France	-	-	-	-	-	-	-	15.5	63	2.2	0	2.5	217
Germany	5.4	2.7	227	137	1061	23	32	8.9	146	2.4	189	9	1701
Ireland	4.88	7.03	94	65	372	-	-	1.76	83	2.14	124	5.8	746
Netherlands	5.4	1.4	205	109	825	82	-	7	176	5.1	240	10	1192
Norway	2.74	0.48	461	37.5	629	0	-	33	37	5.4	100	8.7	1291
Spain	82	5	162	187	521	76	238	18	32	4.1	66	5.1	789
Sweden	0.62	0.07	44.9	12.6	161.5	-	-	2.49	14.4	0.31	29.1	0.87	*
UK	8	1.4	397	304	1639	162	157	48	211	20	290	24	2249

* not determined

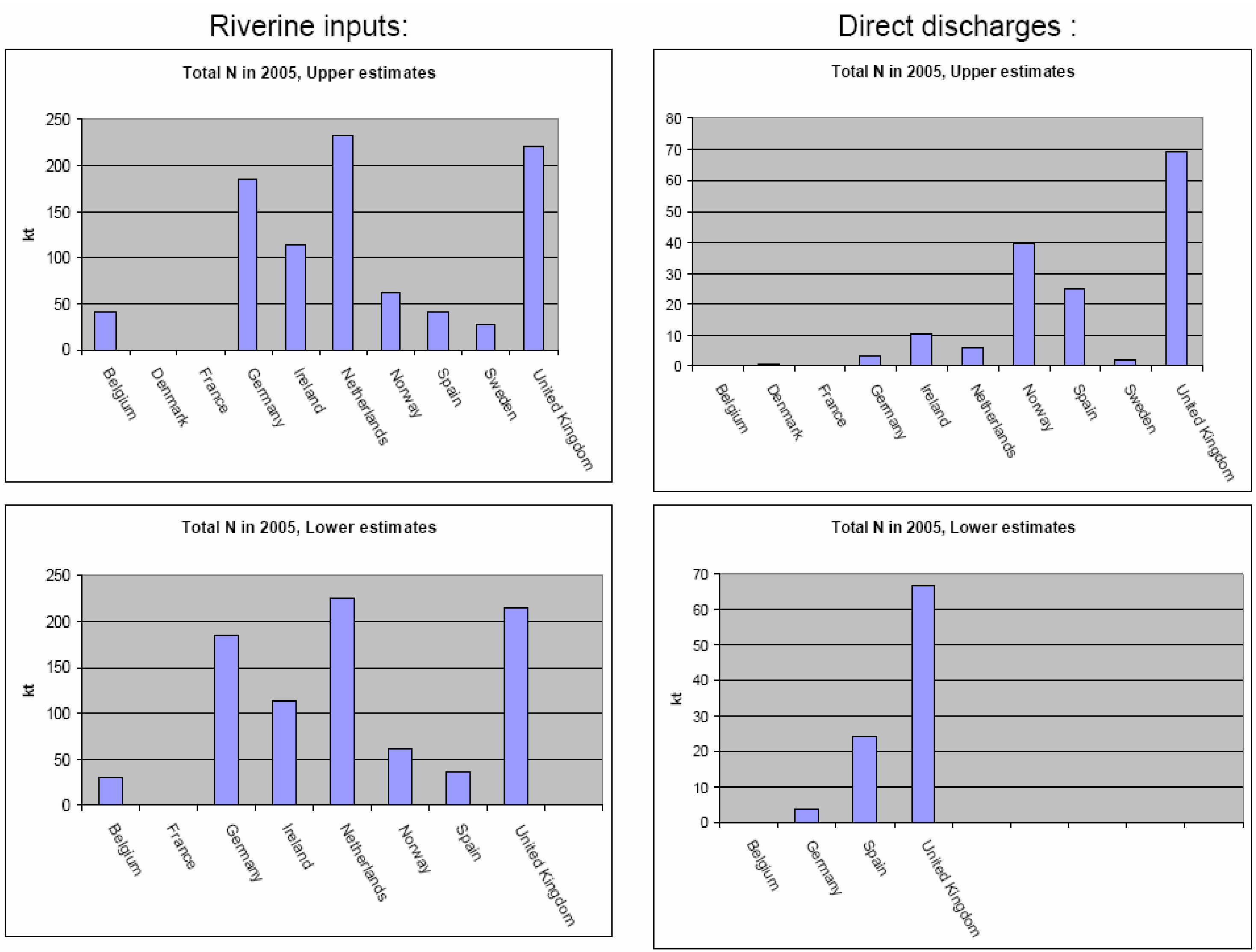

Riverine inputs:
Direct discharges :
Total N in 2005, Upper estimates
kt
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Spain
Sweden
United Kingdom
Total N in 2005, Lower estimates

Figure 5-1 (a)

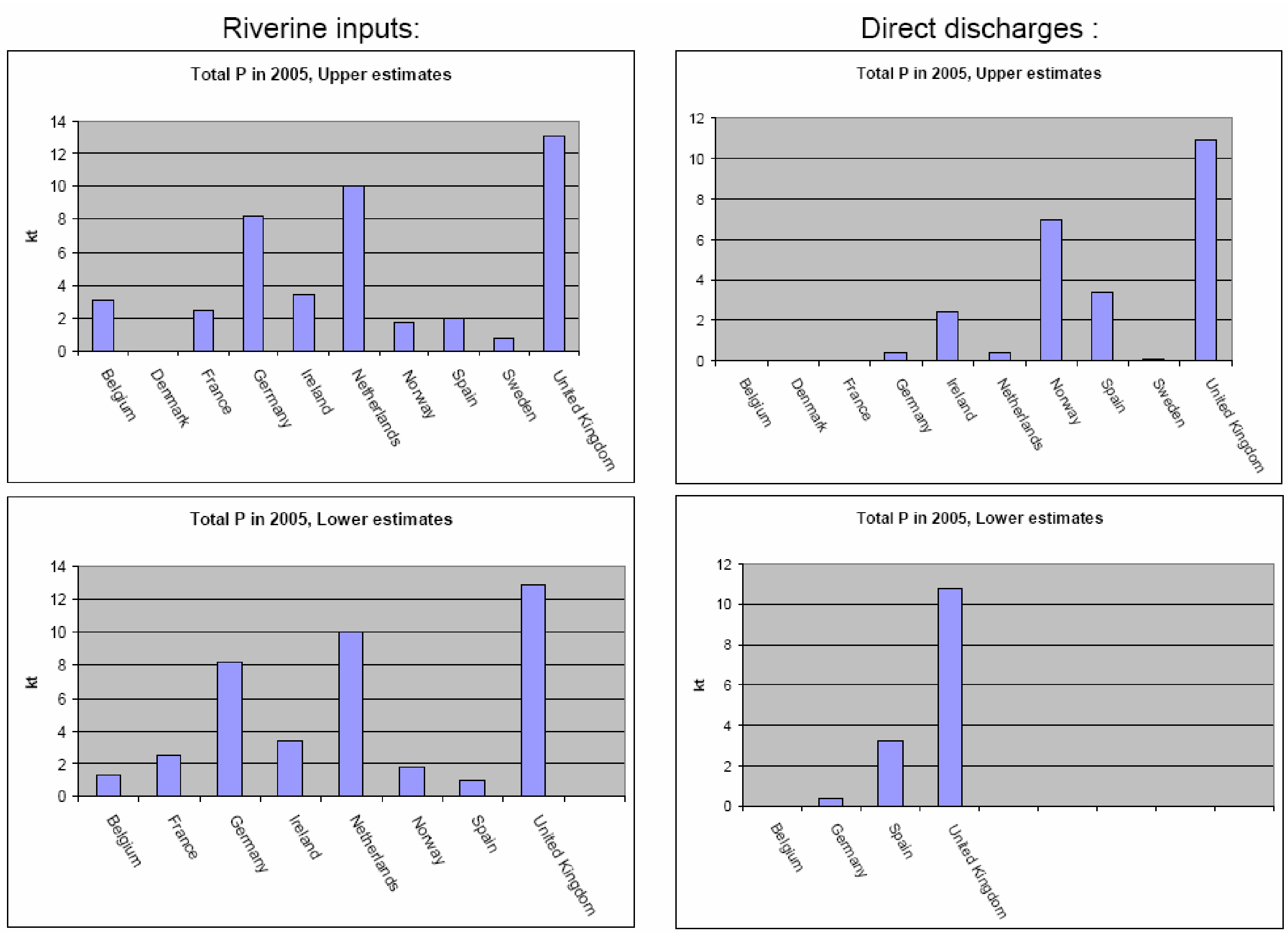


Figure 5-1 (b)

Figure 5-1. Illustration of riverine inputs (in tons) and direct discharges (in tons) of (a) total nitrogen and (b) total phosphorus. For nitrogen (a) no data are reported by France and Portugal, and direct discharges are not applicable for Belgium. Riverine inputs of nitrogen reported by Denmark are too small to show in the chart. For phosphorus (b) no data are reported by Portugal, no direct discharges are reported by France, and direct discharges are not applicable for Belgium. Data on phosphorus reported by Denmark are too small to show in the chart. Copied from OSPAR (2007a).

There are a number of factors that can influence the accuracy, reliability and comparability of RID data reported. Two major issues identified as requiring further attention are (a) quality assurance procedures; and (b) transparency in the use of data by delivering of limits of detection (LoDs) and limits of quantification (LoQs), and the way estimates are reported in cases where measurements are below those limits.

5.2 Oil and Gas

Discharges in the North Sea originate from operations on Norwegian, British, Danish and Dutch Shelves, in addition to Spanish and Irish activities. The number of installations with emissions and discharges in 2005 covered by OSPAR is given in Table 5-2. Total discharges and spillage of dispersed oil in tonnes 1984-2005 is given in Table 5-3. Quantities of oil and organic-phase fluids discharged via cutting are presented in Fig. 5-2. Discharges from oil and gas activities were also discussed in chapter 4.2.4, focusing on Norwegian areas. Discussions about the effects of pollution from the oil and gas activity are presented in chapter 7.

Table 5-2. Number of installations with emissions and discharges covered by OSPAR measures [A] (OSPAR 2007b)

Country	Production [B]		Sub sea [E]	Drilling [F]	Other [G]	Total
	Oil [C]	Gas [D]				
Denmark	12	0	1	3,8	0	16,8
Germany	1	2	0	0,548	0	3,548
Ireland	0	2	3	0	1	6
Netherlands	8	102	9	10	0	129
Norway (1), (2), (3)	47	6	33	13,6	8	107,6
Spain (4), (5)	0	0	0	0	1	1
United Kingdom	80	145	138	43	1	407
Total	148	257	184	71	11	671

A. Platforms are reported separately, even when they are joined by walkways or bridges.
B. Installations are reported as "Production" when production has started, even if drilling is still undergoing. Storage installations are considered as "Production".
C. Installations which produce oil and gas are considered as "oil installations".
D. Installations which produce gas and condensate are considered as "gas installations".
E. One installation per cluster of well heads.
F. Exploration & development drilling rigs with no simultaneous production only. The number is expressed in years-equivalent of activity.
G. Example: offshore underground storage.
(1) Norway: this includes 1 storage ship, 1 riser platform and 6 loading buoys
(2) Norway: there is one new sub sea field on stream in 2005
(3) Spain: drilling: no drilling activities in 2005 in the OSPAR area
(4) Spain: other: underground storage; Gaviota field
(5) Spain: sub sea: no discharges from the 4 sub sea installations in the OSPAR area

Table 5-3. Total discharges and spillage of dispersed oil in tonnes 1984-2005 (Copied from OSPAR 2007b)

Country	1984	1990	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Denmark	763	543	81	178	196	172	173	185	201	679	305	322	377	487	452
Germany	0	NI	NI	NI	NI	NI	0	0	0	3	0	0	0	0	0
Ireland	0	NI	NI	NI	NI	NI	0	1	0,042	0,245	0	0	NI	0	0
Netherlands	1 153	546	285	275	232	288	284	205	169	190	256	149	114	121	108
Norway	3 900	1 096	1 491	1 064	1 519	1 813	2 440	2 648	2 887	3 081	3 210	2 921	3 505	2 946	3 306
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom [1]	21 360	15 499	12 335	9 371	9 835	9 876	13 856	10 832	10 387	5 473	6 010	5 817	5 345	5 355	5 047
Total	27 176	17 684	14 192	10 888	11 783	12 150	16 752	13 872	13 643	9 426	9 782	9 209	9 341	8 909	8 913

Notes :Spillages are not taken into account for 1990.
From 1997-1999, UK data include OPF.

[1] Revised data for 2001: Pipeline leak investigated in 2001 resulted in operator being fined for a discharge of 450 tonnes of crude oil

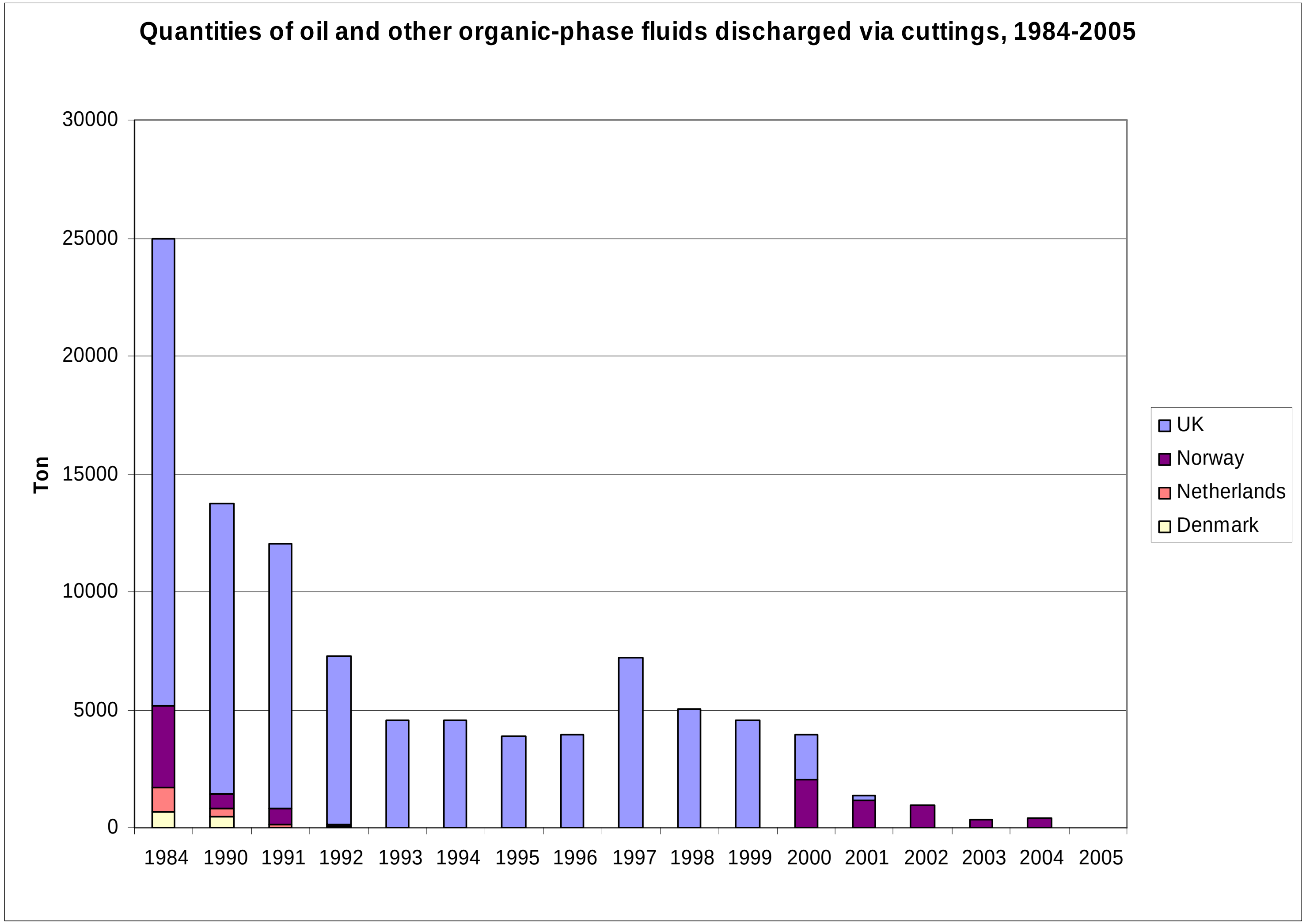


Figure 5-2. Discharges of oil based drilling mud and oil based drill cuttings 1984-2004 (OSPAR 2006a).

5.3 Atmospheric deposition

The status of the atmospheric deposition of pollutants to the sea can be estimated based on observations and computer modelling. For most of the pollutants the focal point of modelling was the impact on terrestrial environment. Estimates based on observations have certain weaknesses, e.g. the reliability is highest near the observation site. The number of stations used for the observation of pollutant deposition is currently limited to a small number of on-shore coastal monitoring stations. By using the efforts undertaken within the OSPAR Comprehensive Atmospheric Monitoring Programme (CAMP) (OSPAR 2007c) one can obtain the current status of knowledge concerning the pollutant deposition to the sea. Hereby data from a number of observational sites are combined aiming for an estimate of atmospheric deposition within the North Sea region. An overview of the geographical distribution of monitoring sites for the CAMP programme is displayed in Figure 5-4. Regular observations of deposition in precipitation are undertaken for OSPAR's CAMP for the parameters summarised in Table 5.4.

Table 5.4 Observations of air pollutants available through OSPAR

Components for Mandatory observation	Metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Organics: γ-HCH, Nitrogen: NH_4^+, NO_3^-
Components for Voluntary observation	PCB 28,52,101,118,138,153,180 PAHs: Phenanthrene, anthracene, flouranthene, pyrene, benzo(*a*)anthracene, chrysene, benzo(*a*)pyrene, benzo(*ghi*)perylene, indeno(*1,2,3-cd*)pyrene

Modelling approaches is a tool to overcome the monitoring limitations which are mostly concentrated in the coastal zone. These coastal zones are transition zones in the physical environment, so that the simple extrapolation to the sea area often leads to unrealistic estimations and modelling is needed to obtain reliable information on the distribution of pollutant deposition. Over the past decades, modelling initiatives for deposition estimates within Europe concerning the North Sea region, have been set up and their central programme is within the European Monitoring and Evaluation Programme (EMEP) which is part of the Convention on Long Range Transboundary Air Pollution (CLRTAP). Two main modelling units within EMEP focus either on modelling sulphur, nitrogen, ozone and, more recently particulate matter or modelling heavy metals and organic compounds. A third unit within EMEP manages the observation programme associated with this modelling.

Supporting international protocols towards a reduction in emissions of air pollutants, these models estimate the transfer of pollutants between regions through the atmosphere. Methodologies for the modelling are based on scaling factors obtained within the 1990s based on observations carried out during that time. The upgraded method, now known as the 'Method3a' has become OSPARs preferred tool for deposition estimates. The advantage of using this method is that it is largely driven by observations. Disadvantages include the limited number of observational sites that are available. The availability of stations used for the development of scaling factors has been changed while these relationship factors have not been revisited since the 1990s.

Since pollutant deposition within marine areas are not central within these initiatives, model estimates have only rarely been validated with observations and their validity is therefore uncertain. Model evaluations carried out in the late 1990s found similar distributions of pollution deposition but a regular and unexplained underestimate. The combination of methods is therefore needed to become a more reliable estimate of the total pollutant deposition into the North Sea marine area.

An overview of the mean annual depositions in 2005 for the different observational sites is given in Table 5-5. Estimates provided by CAMP show marginal changes in deposition between 2004 and 2005 (Table 5-6). However, notable decreases in deposition of most contaminants under study can be observed from 2000 to 2005 (Fig. 5-5). Information on limits of detection (LoDs) or limits of quantification (LoQs) in the CAMP and ranges of reported LoDs/LoQs per component and delivering institute is not uniform. Methodologies by which these are derived are largely unknown. This Method3a approach has recently been used to give an estimate of air emissions of pollutants to the surface of the Norwegian part of the North Sea (Table 5-7) (Molvær et al., 2008). Compared with other sources of contaminant transport into the marine areas the depositions from air were often in the same order of magnitude or even larger, which underlines the importance of the inclusion of deposition of airborne pollutants within marine budget estimates.

Similar to what was mentioned for riverine input and direct discharges (chapter 5.1) there are a number of factors that potentially influence the accuracy, reliability and comparability of CAMP data reported. The two major issues identified requiring further attention are (a) quality assurance procedures; and (b) transparency in the use of data by delivering of limits of detection (LoDs) and limits of quantification (LoQs), and the way estimates are reported in cases where measurements are below those limits.

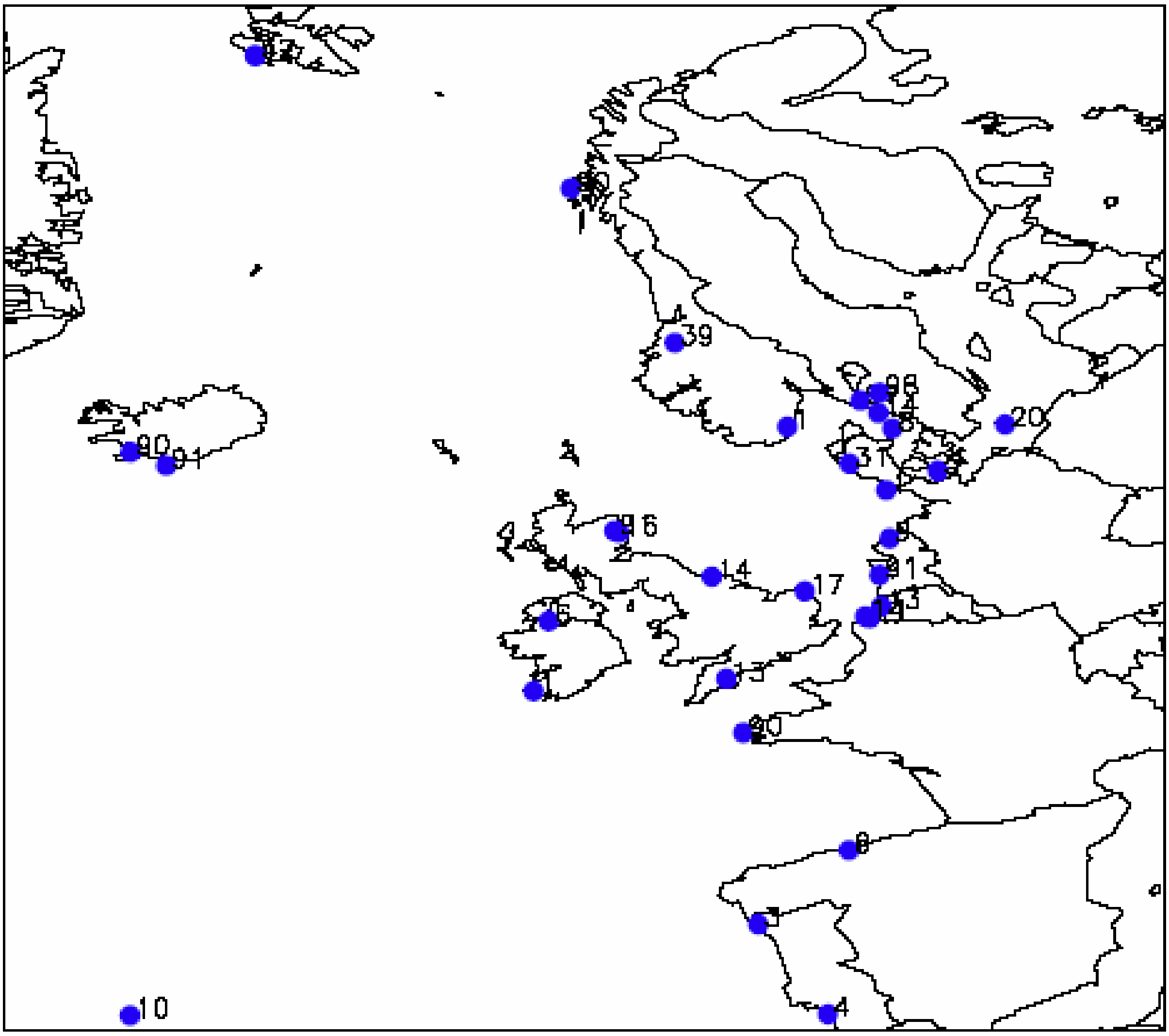


Figure 5-4. Monitoring sites reporting to the OSPAR CAMP programme in 2005 (OSPAR 2007c)

Table 5-5. Reported mean annual depositions of heavy metals in precipitation (mg m^{-2} year^{-1}) for 2005 (OSPAR 2007c)

		arsenic µg/l	cadmium µg/l	chromium µg/l	copper µg/l	lead µg/l	nickel µg/l	zinc µg/l	*precipitation mm*
Belgium	*BE0014R*	0,27	0,06	0,33	2,97	1,90	0,48	8,77	*1088,01*
Denmark	*DK0008R*	0,19	0,03	0,18	1,38	1,01	0,32	12,52	*522,21*
	DK0020R	0,15	0,05	0,17	1,45	1,62	0,38	16,09	*408,54*
	DK0031R	0,09	0,03	0,11	0,95	0,85	0,29	8,78	*681,82*
France	*FR0090R*	0,16	0,03	0,15	0,74	0,85	0,39	2,02	*899,04*
Germany	*DE0001R*	0,12	0,03	0,16	1,07	0,94	0,35	7,59	*584,61*
Iceland	*IS0090R*	0,20	0,01	0,40	3,87	0,37	0,97	7,62	*731,73*
	IS0091R	0,07	0,05	1,28	1,84	1,99	2,84	12,42	*1485,90*
Ireland	*IE0001R*	0,50	0,07	0,50	8,95	0,75	0,66	13,38	*1496,15*
Netherlands	*NL0009R*	0,37	0,07	0,39	1,89	2,13	0,46	9,24	*612,49*
	NL0091R	0,09	0,05	0,28	1,10	2,19	0,36	4,95	*962,48*
Norway	*NO0001R*	0,26	0,04	0,30	0,76	1,17	0,47	5,35	*1407,39*
Portugal	*PT0003R*		0,43		1,17	0,75	0,78	13,09	*914,35*
	PT0004R		0,43		0,45	0,65	0,78	5,24	*426,60*
	PT0010R		0,43		27,74	0,65	38,30	59,00	*1429,13*
Spain	*ES0008R*	0,38	0,15	59,91	27,79	9,28	48,48	84,29	*606,60*
Sweden	*SE0097R*	0,21	0,05	0,20	0,99	1,23	0,39	6,61	*727,86*
United Kingdom	*GB0006R*	0,15	0,02	0,04		0,12	0,08	1,01	*1521,58*
	GB0013R	0,54	0,05			0,78	0,43	5,15	*1030,13*
	GB0017R	0,15	0,03	0,10	1,00	1,42	0,34	6,45	*460,019*
	GB0091R	0,09	0,04	0,06		0,52	0,29	4,59	*803,07*

highest concentrations (red) — second highest concentrations (yellow) — lowest concentrations (cyan)

Table 5-6. Estimated total annual depositions to the North Sea in 2004 and 2005 derived from the observations in CAMP. Metals are given as tonnes per year, nitrogen compounds as kilo tonnes per year. From OSPAR (2007c).

	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Nitrate	Ammonium
2004	39	16	44	236	289	92	1552	117	142
2005	45	11	49	271	333	96	1575	119	141

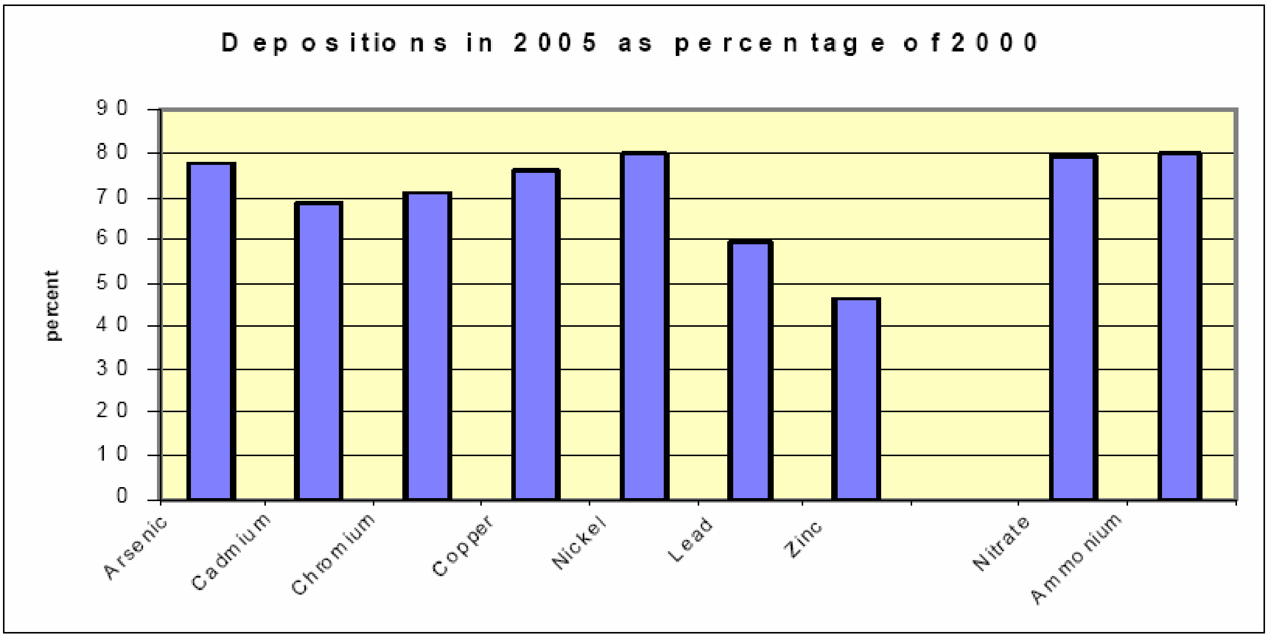


Figure 5-5. Estimated deposition changes derived from measurements in the CAMP area. Copied from OSPAR (2007c).

Table 5-7: Model estimates of air emission of hazardous substances within three sub-regions of the Norwegian part of the North Sea (Molvær et al, 2008). The sub-regions are: Region 1 - Skagerrak (east of 8ºE), Region 2 - the Norwegian Coastal Current (NCC, south of 62ºN), and Region 3 - the remaining part of the Norwegian territory within the North Sea. Units are kg/year.

	Region 1	Region 2	Region 3
Arsenic		13800	11360
Cadmium		3450	2840
Chromium		14490	12780
Mercury	759	690	497
Lead	82800	100740	84490
PAH	0,3	1,0	1,1

5.4 Transport of pollutants within the North Sea

Pollutants within the North Sea area are transported with the prevailing oceanic circulation. Measurements aiming to observe oceanic transport are scarce within the North Sea region. Within NOOS (North West Shelf Operational Oceanography System, regional alliance of EUROGOOS) an initiative for a new monitoring strategy aiming to address this gap is under development. The preliminary structure of such a monitoring strategy is displayed in Figure 5.8

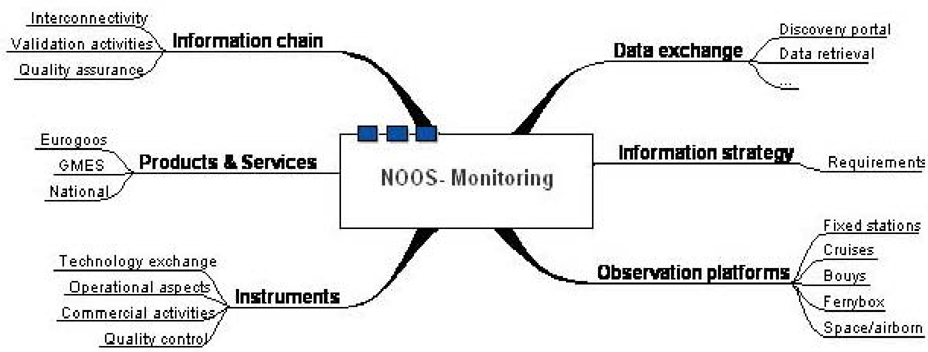


Figure 5.8: Preliminary structure of NOOS-Monitoring strategy

Experiences from the SeaNet initiative led to the installation of operational data exchange routines through the FTP-box, based on the need for improved forecasts of storm surge for the coasts of the North Sea. This has been extended in the framework of the Seprise-project. Good examples of information strategy and information integration are the EU FP5 supported project ODON (monitoring optimisation for modelling) and recently initiated EMECO (European Marine Ecosystem Observatory). EMECO appears to be a good platform to reach a North Sea corporate level for ecological monitoring and modelling.

A number of important efforts currently taking place at the European level will impact internationally on the sustainable management and exploitation of the North Sea. Namely the Water Framework Directive for river basins and the coast, the proposed infrastructure for Spatial Information Directive (INSPIRE) in view of the exchange of geo-marine-data and information, the development of the Global Monitoring for Environment and Security (GMES), the proposed Marine Strategy Directive, the Green Book on a European Maritime Policy and its EU-wide stakeholders consultation, and the role of EuroGOOS in these developments.

GMES is the main European contribution to the objectives of global monitoring of the Earth System, providing links between national monitoring and global aspects of the problems involved, such as climate change and non-sustainable use of the resources of the marine domain. From an operational perspective, EuroGOOS and the International Council for the Exploration of the Sea (ICES) are jointly developing quarterly analyses of the ecological trends as well as the status of the North Sea. This effort makes it possible to bridge in a pragmatic way the gap between real-time oceanography and OSPAR’s quality status reports.

Transport estimates for the North Sea region on an operational basis can be obtained regionally from the national hydrographic services as well as taking the whole North Sea region into account via initiatives like the NOOS services (e.g. www.noos.cc). The improvement in the availability of operational observations and modelling data is the main aim of integrated projects supported by the European commission like ECOOP (European Coastal shelf Operational monitoring and forecasting system) and the upcoming MyOcean (Development and pre-operational validation of upgraded GMES Marine Core Services and Capabilities)

5.5 Knowledge gaps

A summary of the main knowledge gaps reported in this chapter is presented in Table 5-8. Data sources and R&D projects providing relevant information on input of nutrients and pollutants within the North Sea are listed in Table A.4 (Appendix).

Table 5-8. Summary of knowledge status on input of nutrients and pollution to the North Sea from non-Norwegian sources and from transboundary transport.

Topic	**Knowledge status/ gaps**	**Proposed actions to fill the gaps**
Riverine Input	By far not all riverine sources are monitored regularly. Processes that are important for the transport into the North Sea are mostly not considered in the estimates (i.e. retention within the rivers/Fjords)	Development of comprehensive integrated monitoring program
Direct Discharges	Some common activities in Europe are undertaken. However these activities are missing strongly on common methodologies and common quality control procedures.	Integration of European wide efforts.
Atmospheric deposition	The available data sources are too scarcely distributed to receive realistic deposition rates. A common data quality control procedure is missing	Integration of European wide efforts
Transport within the North Sea	Lack of knowledge regarding estimations of circulation patterns in the North Sea region. Validation of model system is not satisfactorily conducted for all models	Improvement of models Establish better model validation procedures

6. Land –Coast –Ocean interaction

6.1 Retention of pollutants in fjords and coastal waters

Typically 80-95% of organic micro pollutants and metal are associated with particles and, to a lesser degree, nutrients (large variations between summer and winter according to phytoplankton biomass). This means that sedimentation is an important process as exemplified by highly polluted sediments often found in harbours and fjords. A significant part of a discharge therefore usually remains in the fjord. In budgets and EIAs it is practical to distinguish between two fractions:

1. One buried in sediments and remaining in the fjord
2. One leaving the fjord through water exchange

This is illustrated in Fig. 6-1. A number of factors and processes are important in the retention process, e.g. the type of substance, the amount and type of particles in the water mass, fjord topography and the water exchange. As an example: one may safely assume that the retention is very high for a discharge of PAH to the inner part of Årdalsfjord more than 180 km from the coastal water.

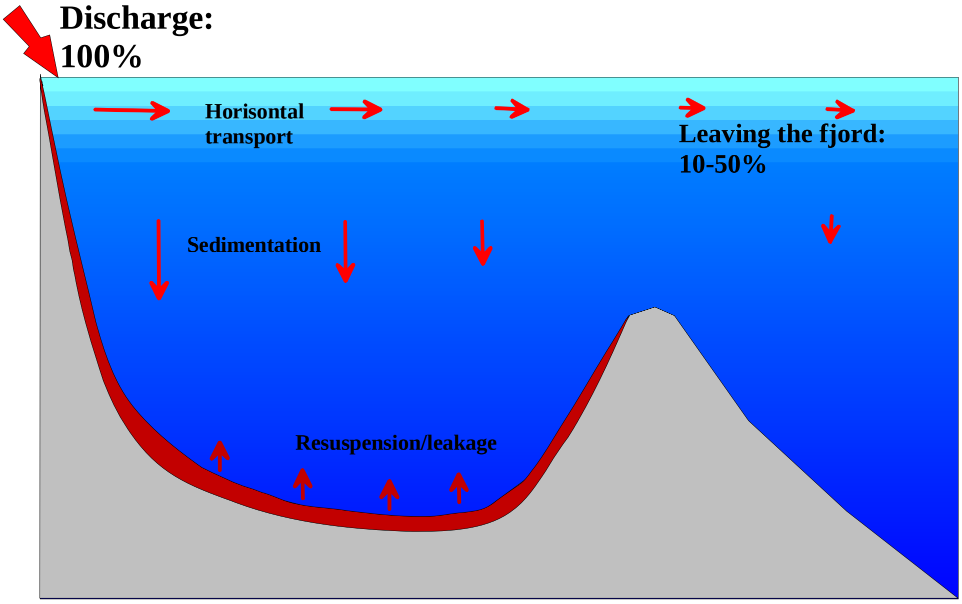


Figure 6-1. General description of retention in a fjord.

In the context of the implementation of the Water Framework Directive, Fraction 1 is e.g. important for environmental effects in fjord systems and the coastal zone, with accumulation of toxic substances in the soft bottom fauna living in polluted sediments or high oxygen consumption in fjord basins due to sedimentation of organic material. On the other hand, Fraction 2 should be considered for effects in the coastal water and offshore areas as in the management plans for the North Sea.

The retention process and its importance are addressed in an ongoing SFT-project dealing with "Discharges of oil and toxic substances to Norwegian marine areas" (Molvær et al., 2008). As preliminary basis for a more general evaluation, 50-90 % retention of dioxins and PAH in two fjord systems were calculated. For nitrogen and phosphorus studies in estuaries indicates a significantly smaller retention, of the order of 10-30% and 10-40% of nitrogen and phosphorus, respectively (Nowicki and Oviatt, 1990; Eyre, 1998; Stigebrandt and Aure, 1988). In previous chapters, discharges to the North Sea may therefore be significantly overestimated as they exclude retention.

From the Norwegian Skagerrak coast in the south to Troms and Finnmark the tidal amplitude increases by a factor 10, and in general this creates a higher water exchange through the coastal zone. One may therefore assume that retention is more important on the Norwegian North Sea coast that for the Norwegian Sea and Barents Sea coasts.

Except for the estimates show above, there are few facts and data describing the extent of retention of polluting substances in the Norwegian coastal zone. It should therefore be listed as an important knowledge gap.

6.2 Land – ocean interaction and the Water Framework Directive

In the context of the Water Framework Directive (WFD), the amount of discharges buried in sediments and remaining in the fjord is important in terms of environmental effects in fjord systems and the coastal zone. This starts with the accumulation in the soft bottom fauna living in polluted sediments. Additionally, fluxes of substances leaving the fjord should be considered for effects in the coastal water and offshore areas within management plans for the North Sea. Sediments in a fjord system can act as a source of pollutants for a long period of time following after discharge discontinuation.

Norway will implement the WFD as a part of the EEA agreement. However, only 20 % of Norwegian river basin district areas will follow the EU implementation timeframe for management plans. The remaining 80% will be implemented with a six year delay as a consequence of the long negotiation process with the EEA-countries. For the Norwegian areas that follows the EU implementation timeframe, data on input from land to fjord and coast would be expected and the ecological status for these areas is to be reported. In order to achieve this, a wide range of chemical and biological parameters have to be monitored and reported (Table 6-1 and Chapter 7.4.2.).

Regarding status and data collection including marine areas, three river basin districts will be included in the first planning period for the North Sea area. For these limited areas, the management plan is expected to make available sufficient data and information needed as an input to a future North Sea management plan. However, the marine coverage in this first planning period is very limited. A full map including all riverbasins can be found on www.vannportalen.no

The river basins that also include marine areas are:

- Nordås lake with adjacent fjords
- Figgjo river basin with adjacent coast
- Otra river basin with adjacent coast

Table 6-1. Knowledge gaps on land-ocean interaction and WFD

Knowledge gaps	Proposed actions to fill the gaps
There are few facts and data describing the extent of the retention of nutrients and polluting substances in the Norwegian coastal zone.	Research and monitoring programs.
Data for river basin planning for the North Sea except Nordås, Figgjo and Otra.	Include all river basin districts to cover land, fjord and coastal areas.

7. Effects from pollution and other environmental factors

7.1 The ecosystem, human pressures and quality assessments

7.1.1 Human pressures and assessments of ecosystem changes

There have been several general assessments of the ecological status of the North Sea during the last decades. The most comprehensive of these is the OSPAR Quality Status Report (QSR) of 2000 (OSPAR 2000) (see below). This was preceded by a quality status report in 1993 prepared by OSPAR and ICES under the common effort "North Sea Task Force" (NSTF 1993). After the QSR 2000, several broad summary reports for the European seas have been prepared (ICES 2003, 2005). Integrated with the work on the quality status assessments, a series of conferences on the North Sea environment have been held, starting in 1987 (Bremen 1987, London 1988, den Haag 1990, Esbjerg 1995, Bergen 2002). The fifth and presently last of the conferences focussed on the development of indicators of ecosystem status. Scientific work on integrated assessments continues as part of activities by ICES and other international bodies (see below).

To a large degree, the work on compiling basic data and information for status reports, and the evaluation of the data for system components, has been carried out by ICES. ICES has also been instrumental in developing methodological guidelines and organising international workshops to improve standardisation and co-operation. Monitoring and data acquisition has been the responsibility of each country, however for at least some components, activities have been regulated by international agreements (e.g. OSPAR JAMP/CEMP programme on contaminants).

Several regional assessments have been carried out through EU-funded activities. In particular, the Interreg project Forum Skagerrak performed a general assessment of the Skagerrak in 2001 (Karlson et al. 2001), and later, several studies on various topics. The EU Water Framework Directive (WFD), which was adopted by the EU council in 2000, is still in an early implementation phase, but will, when the monitoring system is implemented; provide a common framework for monitoring and assessment of ecological status in coastal waters (1 nm outside base line) around the North Sea.

A major assessment to be undertaken is a new OSPAR QSR due to be launched in 2010. Preparatory work for the status report is in progress. The EU "Marine Strategy Directive" has been adopted by the EU member countries (December 2007) and will form a framework for marine monitoring activities, environmental quality evaluations and management from the WFD seaward line to the territorial border.

From the first North Sea conferences in 1987 and the QSR 1993 until now there has been a gradual shift in focus from documenting effects on species and habitats to effects on the ecosystem as a whole. This shift in attitude is based on the general observation that natural systems all over the world are in a state of degradation due to overexploitation of resources and impact from pollution. These systems are complex entities and, hence, it is recognised that mitigation measures must take the whole systems into account and not only separate parts of them (Misund & Skjoldal 2005, Rosenberg & McLeod 2005). Initiated more than 30 years ago, this so-called "ecosystem approach" has gradually been developed as a basic principle for environmental management. The ecosystem approach, as presently apprehended, shall form the basis for the assessments in the coming OSPAR QSR 2010 and the EU Marine Strategy Directive.

The ecosystem approach
A technical definition of the "ecosystem approach" is presently formulated as (ICES 2005, Misund and Skjoldal 2005):

"The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, on order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity".

It is worth stressing the emphasis on integrated management of human activities which means that different sectors need to work closely together for an effective approach to management, for instance by close co-operation between fisheries and environmental conservation (Misund and Skjoldal 2005).

7.1.2 Multinational assessments of quality status in the North Sea area

OSPAR Quality Status Report 2000 (QSR 2000)
The OSPAR Quality Status Report of 2000 for the North Sea is one of five regional quality status reports for the NW Atlantic produced by the OSPAR Commission as part of its commitment to undertake and publish at regular intervals joint assessments of the status of the marine environment. The report covers the area known as the Greater North Sea (see Chapter 3) assessing information collected until 1999 and focusing on the status and temporal changes in the North Sea that have been observed, building on the 1993 NSTF QSR.

The report clearly expresses that the intensive, and sometimes conflicting, use of the North Sea causes a number of problems in relation to a healthy ecosystem and sustainable use. Many old problems continue to affect the ecosystems, but general improvements have been made following measures to reduce inputs of heavy metals, oil components, phosphorus and sewage sludge. However, continued concern is expressed about increased impact of fisheries, inputs of nitrogen, chemicals from produced water in offshore oil and gas industry, antifouling paints, and synthetic compounds. It is pointed out that the human impacts are greatest in the coastal zone.

On an overall basis, human pressures have been classified in priority classes according to concern of impact. As the most important issues (first priority class) the assessments point out impact of fisheries (direct and indirect), trace organic contaminants and nutrient enrichment. The main impacts of fisheries result from the removal of target species, discarding and mortality of non-target species and seabed disturbance from towed demersal gears. Trace organic contaminants include several persistent compounds for which recovery times may be very long. Nutrient enrichment leads to increased phytoplankton growth and oxygen depletion which causes particular problems in estuaries and fjords, the southern North Sea, Kattegat and Skagerrak. The enrichment is specifically related to inputs of nitrogen, of which there has been no discernible reduction.

The second priority class comprises oil and PAHs, heavy metals, other hazardous substances, and biological impacts from non-indigenous species.

EU Interreg Forum Skagerrak

The assessment report for Skagerrak in 2001 (Karlson et al. 2001) stated that eutrophication and toxic contaminants cause severe coastal problems in Norway and Sweden due to local loading and restricted water exchange. Eutrophication contributes to toxic algal blooms and oxygen deficits, whereas several contaminants (PAHs, PCBs, organochlorine compounds, organotin compounds) may be found in elevated levels in organisms in harbours and estuaries. Problems are less in the open Skagerrak. Fish resources appeared to be over fished and stocks of cod, herring and plaice were considered to be poor, though stable.

In follow-up work during Forum Skagerrak II several projects with various key themes were carried out (Olsson 2007). Studies regarding effects incorporated nutrients, organotin compounds, and oil spills from shipwrecks. The studies maintained that eutrophication and toxic contaminants causes some of the most serious problems in Skagerrak coastal areas.

ICES work

Two ICES projects on integrated assessments for the North Sea have recently been reported. The most comprehensive of these, performed by the "Regional ecosystem study group for the North Sea" (REGNS), drew together different types of data relating to changes in pressure and state over several decades from monitoring programmes with a wide spatial coverage (Kenny et al. 2006). In total more than 110 variables representing hydrophysics, nutrient concentrations, nutrient input, oxygen, plankton, fish abundance, fish landings, seabirds and mammal populations were used and spatially resolved for ICES statistical rectangles. The assessment has provided insight into some of the major ecosystem relationships in the North Sea. For instance, plankton communities and fish landings revealed gradients of response to major riverine inputs of nutrients in south-east and sources of nutrients from the Atlantic in north-west (Fig. 7.1). The spatial differences observed suggest that the identification of sub-regions should form the basis for ecosystem management units for the North Sea. Further, decreasing the nutrient inputs from land sources may be questionable in terms of affecting the entire North Sea, whereas it may be expected to have clear impact on more local scales (Kenny et al. 2006). On a time scale, these assessments revealed two relatively stable ecosystem states, one pre-1983 and one post-1997, with intervening years with high ecosystem variability (Fig. 7.2). Whereas some variables appear to have changed rather abruptly, the ecosystem as a whole appeared to have changed more gradually and with some spatial variation. Ecosystem changes and variations among sub-regions, presents several challenges to the management of the system as a whole.

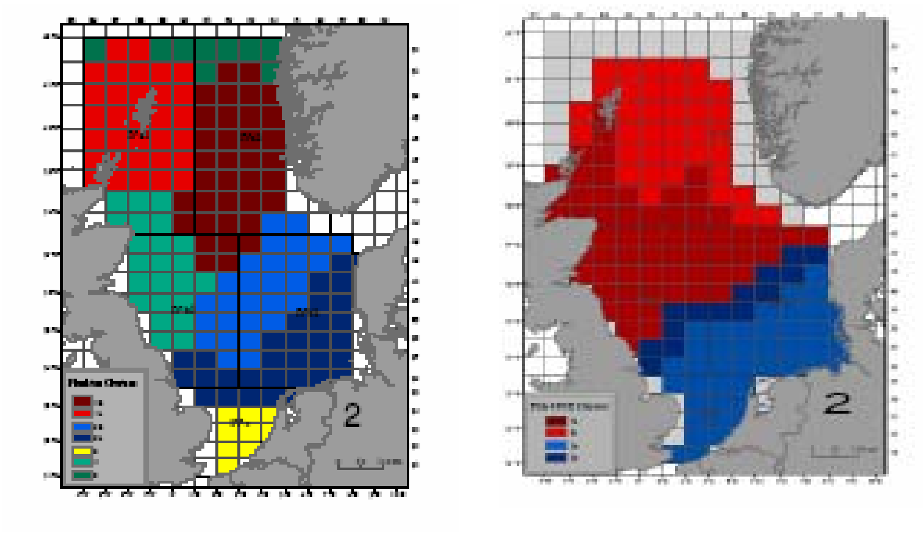


Figure 7-1. Distribution of plankton species assemblages (left) and fish assemblages (right) in the North Sea. Data for fish assemblages are recorded as 'catch per unit effort'. The data are spatially resolved according to ICES statistical rectangles. From Kenny et al. (2006).

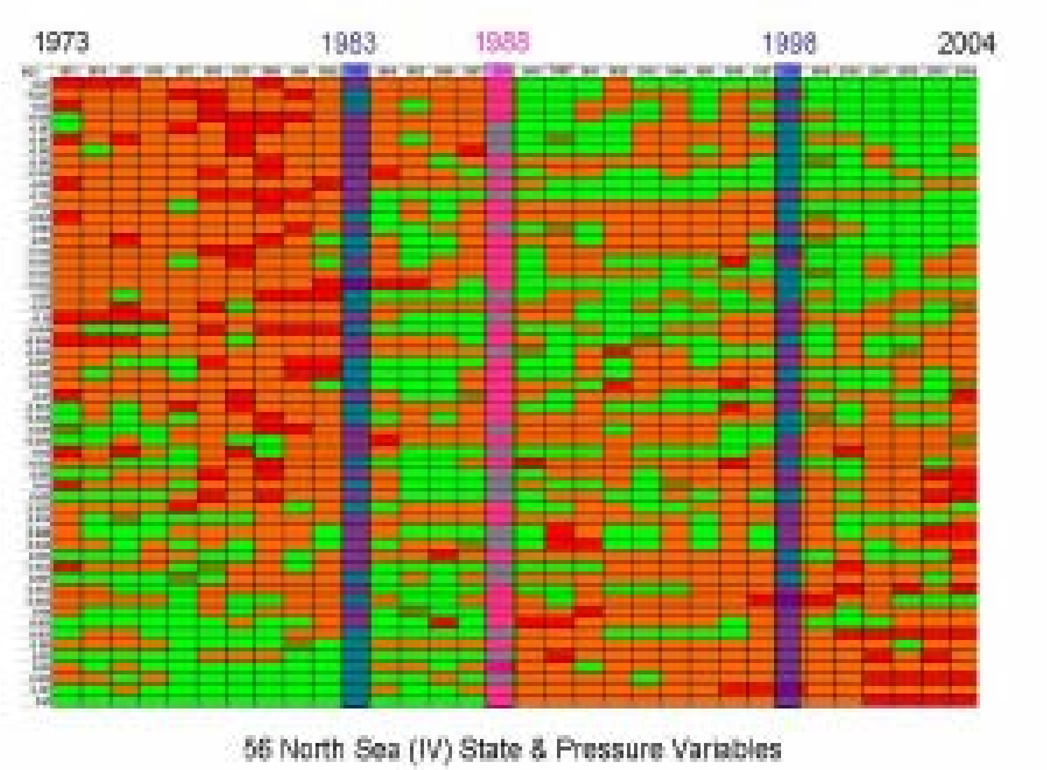


Figure 7-2. Shade diagram for time-trends including 56 variables representing nutrient, plankton communities and fish abundances in the North Sea from 1973 to 2004. Major changes are indicated with bars for the years 1983 and 1998. From Kenny et al. (2006).

The REGNS assessment did not have a full coverage of all North Sea areas. Skagerrak, for instance, was not included (Table 7-1). The assessment is also somewhat limited with regard to being a basis for integrated management as several key ecosystem components were not taken into account, for instance macrophytes and benthic fauna. This is mostly due to insufficient spatial coverage of data, lack of monitoring series, or simply lack of data. Overall, the REGNS assessments have provided some important conclusions regarding the synthesis of large amounts of data from different contributors, revealed knowledge gaps, and evaluated a large amount of data for the purpose of providing a scientific basis for management actions. One issue that was clearly stressed is the importance of increased coverage of ecosystem components that are presently not well reported (Kenny et al. 2006).

The second ICES project performed by the "Study Group on the North Sea Benthos Project 2000" made an integrated assessment of soft bottom macrofaunal data from the year 2000 and compared to a similar study in 1986 (Rees et al. 2007). Most data were collected during a co-operative sampling effort from a spatial grid of locations in the southern North Sea, but data from other sources were included to provide coverage of other areas as well. In northern North Sea and Skagerrak, Norwegian data from the offshore petroleum monitoring and the SFT coastal monitoring programme were supplied. Figure 7.3 illustrates distribution of different species assemblages. Although the data from external sources gave additional information from the study, the importance of harmonising survey and sampling methodology was clearly stressed in order to address issues such as global warming or other large-scale trends for the area (Rees et al. 2007).

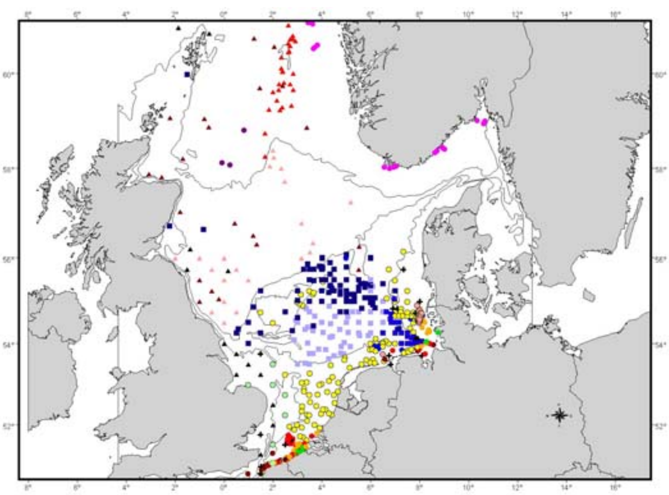


Figure 7-3. Distribution of species assemblages of soft bottom macrofauna. Different species assemblages are indicated by colour coding (From Rees et al. 2007).

7.1.3 Ongoing work on quality status and monitoring

OSPAR QSR 2010

Following provisions of the OSPAR convention, OSPAR will undertake and publish a new Quality Status Report in 2010. The report will build on and update the assessments provided by the QSR 2000 (OSPAR 2006b). The QSR 2010 will focus on the ecosystem approach and the issues addressed in the OSPAR thematic strategies rather than separate the issues according to scientific disciplines. The thematic strategies are: B biodiversity, E eutrophication, H hazardous substances, O offshore oil and gas, and R (radioactive substances). In addition, the QSR will include similar reviews of other fields of human activities, especially fishing and shipping, in order to evaluate the ecosystem approach and give an overall assessment of the marine environment (OSPAR 2006b).

The work on the QSR 2010 started in 2006 with preparatory work and is presently in the development phase where thematic contributions are produced in OSPAR thematic committees. The QSR compilation and drafting will take place in 2009, with final editing in the beginning of 2010. Details on objectives, structure and timetable for the work are given by OSPAR (2006b).

EU Marine Strategy Directive and Habitat directive

See chapter 8.

Global Ocean Observation System (GOOS)

ICES and EuroGOOS are running a project entitled "North Sea Pilot Project" (NORSEPP) focusing on oceanography and fish stocks. The aim of NORSEPP is to promote the use of operational oceanography for biological applications such as fish stock assessments. NORSEPP provides quarterly reports. The latest report is from 2nd quarter 2007.

Table 7-1. Knowledge gaps related to the ecosystem, human pressures and quality assessments.

Knowledge gaps	**Proposed actions to fill the gaps**
The REGNS assessment did not have a full coverage for all North Sea areas. Skagerrak, for instance, was not included. The assessment is also somewhat limited with regard to being a basis for integrated management as several key ecosystem components were not taken into account, for instance macrophytes and benthic fauna. This is mostly due to insufficient spatial coverage of data, lack of monitoring series, or simply lack of data.	Improved monitoring of biology and especially benthic organisms offshore in the Skagerrak.
The OSPAR QSR 2000 indicated limitations in knowledge on several issues with regard to the evaluations of the importance of human impacts. In short, these comprise issues such as consequences of climate change, lack of data on inputs and biological effects of chemicals and organic hazardous substances, lack of reliable quantitative information on sources and inputs of nutrients, budgets and fluxes of substances both within the North Sea and between the North Sea and adjacent waters, longer-term impacts of fisheries, and trend monitoring.	Improved monitoring of biology and especially longer-term impacts of fisheries, and trend monitoring.

7.2 Quality of the marine environment

7.2.1 Structure of the quality assessments

The OSPAR Quality Status Report 2010 will focus on the ecosystem approach and the issues addressed in the OSPAR thematic strategies (biodiversity, eutrophication, hazardous substances, offshore oil and gas industry, radioactive substances) with addition issues of fishing and shipping. It is here considered purposive to use the same main issues as a basis for the summary of studies of human-related effects on the ecosystem, hence ensuring compatibility of the basis for the management plan and the QSR 2010. Within this frame, effects in coastal and inshore Norwegian waters will probably mostly be directed towards the management plan, which will be expected to be more detailed with regard to Norwegian conditions than the QSR 2010.

7.2.2 Biodiversity

Traditionally, monitoring of environmental quality has included studies of benthic species assemblages. In Norwegian coastal waters a number of studies have been carried out since the 1970s, most of them in polluted fjords and coastal areas affected by human activities, but also in less influenced areas. Most studies have been performed separately and on short term basis, but more or less long-term programmes with repeated studies have been established in the Oslofjord, Frierfjord and Grenland area, Kristiansandsfjord, Hardangerfjord/Sørfjord, Bergen area and Sognefjord/Årdalsfjord.

Altogether, these studies have provided a wealth of data on benthic species assemblages in coastal waters. A summary of data from areas with little or no influence from pollution focussing on regional gradients in diversity and temporal changes was presented by Moy et al. (1996). Updated maps showing sampling sites are given by Moy et al. (2003). Offshore, soft-bottom fauna forms an important part of a large-scale monitoring program for the Norwegian petroleum industry. This programme covers all Norwegian oil fields in the central North Sea (see below).

Studies of plankton, commercial species, fish and vertebrates are in general organised in more permanent programs, however, very often being restricted to selected species or species groups (see below). Short overviews of permanent programmes are presented by NFR (2004), Oug & Olsgard (2005) and Oug & Naustvoll (2008).

A national program for mapping of coastal marine habitats with particular relevance to biodiversity was initiated in 2003 (see below). Presently kelp forests, seagrass beds, mud-flats and several other habitats have been mapped in the counties Aust-Agder and Hordaland. Maps will become particularly important for management purposes and planning of use of coastal areas, but will also form a basis for future biodiversity monitoring.

Trend monitoring

The coastal monitoring program

The Norwegian Coastal Monitoring Programme with focus on the North Sea and especially Skagerrak, was established by the Norwegian State Pollution Authorities (SFT) in 1989, and has been running continually since 1990. This programme aims to assess the environmental quality in the outer coastal waters in relation to long-transported and regional nutrients, by conducting yearly monitoring of plankton, hard-bottom and soft-bottom species assemblages. Planktonic and soft-bottom monitoring is concentrated in Skagerrak, whereas hard-bottom monitoring also covers western Norwegian areas north to the vicinity of Bergen. Recently there has been a northward extension of the soft-bottom part. The programme has shown that species communities are generally diverse and hence indicate good ecological status, except in the most easterly parts (outer Oslofjord) where the hard-bottom studies suggest a somewhat reduced status (Moy et al. 2002). Generally the programme provides a good overall picture of patterns in nutrient concentrations, water mass circulations and trends in the species communities in coastal currents and outer coastal areas. Areas of improvements include survey parameters linking more closely water masses and the seabed, extending northwards and with the inclusion of fjords and sheltered coastline.

Coastal shallow-water fish
The Institute of Marine Research (IMR) has since 1919 run a programme with beach seines samples for shallow-water fish in coastal areas of Skagerrak. The programme mainly focuses on juveniles of cod and other commercial species, but also gives information on non-commercial species and some data for bottom vegetation. Results show that dramatic reductions in the recruitment of cod and other species took place in the 1930s and the 1970s (Johannessen & Sollie 1994, Moy et al. 1996).

Offshore benthic organisms
Macroinfauna in soft sediments is well-studied in the western part of the Norwegian sector as part of the Norwegian monitoring program for the petroleum industry. Sampling and analytical methodologies are well established and carried out according to internationally-recognised quality assurance and accreditation schemes. Up to 1996, the environmental conditions of the seabed around oil-producing installations were monitored individually on an installation-by-installation approach. In 1996, the increasing number of production installations called for a regional approach, in which the combined activity within a defined region was monitored. This has contributed to a wealth of samples being collected and analysed every year and a unique amount of data stored in a database owned by the oil industry association (OLF). A recent summary report is published by OLF (Renaud et al 2008). There is no comparable programme for macrobenthic sampling in offshore areas in Skagerrak and parts of the Norwegian Trench.

Compared with the studies of almost a century ago, today's benthos appears to be represented by smaller individuals, most likely with a shorter life-span. There appears to have been a reduction in the abundance of large, long-lived animals such as bivalves, possibly in connection with bottom disturbance from activities such as trawling.

Other benthic faunal components such as meiofauna (for practical purposes, defined as the fauna smaller than the macrofauna) and the megafauna, the large animals generally moving around on top of sediments, are little or not investigated on a large scale in the Norwegian sector. Studies of megafauna were included in the EU project MAFCONS (Iversen et al. 2006) which was ended in 2005.

Plankton
Samples for phytoplankton and zooplankton are collected regularly across several permanent transects running across the Skagerrak and the North Sea, viz. Torungen (Arendal) – Hirtshals, Hanstholm – Aberdeen and Utsira west (NFR 2004, Oug & Naustvoll 2008, Gjøsæter et al. 2008). In addition phytoplankton is monitored on commercial shipping routes by a system called 'ships of opportunity'. The latter is mainly targeted on blooms and other events, but there are facilities for sample collection. In the case of zooplankton, monitoring

has shown that more southern species have gradually increased during the last decades. In particular, the cold-water copepod *Calanus finmarchicus* is in retreat and is partly replaced by the more southern *C. helgolandicus*. This may have implications for higher trophic levels as the food value and time of maximum plankton density may change.

Commercial fish and marine mammals
The Institute of Marine Research (IMR) is responsible for the monitoring of stock abundances of commercial fish and marine mammals. In offshore areas permanent surveys and cruises are carried out and sampling methods are as standardised as possible. Several cruises are coordinated by ICES and carried out through cooperation with other North Sea countries (see e.g. NFR 2004, Oug & Naustvoll 2008). The main species surveyed are cod, haddock, herring, mackerel and sandeel. Data is reported to ICES which is responsible for providing advice on fish quotas and total catches which should be allowed. Summaries of the main results and trends are given in yearly status reports from IMR, with the latest published in 2008 (Gjøsæter et al. 2008).

Other monitoring programmes

Harmful and toxic algae
In coastal waters harmful and toxic algae are monitored on behalf of the aquaculture industry and the Norwegian Food Safety Authority (NFSA). The main aims are to warn against blooms of species which may harm fish and give advice on consumption of shellfish that may potentially be contaminated with algal toxins. During the growth season, samples are collected with a high frequency at fixed stations. The data illustrate the occurrence and abundance of selected species in coastal waters.

Sugar kelp along the coast of southern Norway
The sugar kelp (*Saccharina latissima*) has declined dramatically along the southern coast of Norway during the last decade. Losses are estimated to 90 % in the Skagerrak area and in the order of 50 % in western Norway south of Stad. The kelp has been replaced by a silty turf community dominated by filamentous algae (Moy et al. 2008). A sugar kelp mapping and monitoring project (2004-2008) have surveyed more than 200 sites from Østfold to Romsdal. Based on this and experimental studies it is suggested that the shift in vegetation is a result of long-time eutrophication combined with increased sea temperatures (Moy et al. 2008). It is assumed that these changes may have severe ecological consequences as kelp-dominated areas are highly diverse and productive systems providing food and shelter for juvenile fish. However, the direct effects of eutrophication on macroalgae systems like those in Skagerrak are so far poorly understood because of complex interactions between biotic and abiotic compartments and the variability of the biological response to abiotic forcing (physical or chemical pressures). There appears to be, at present, a need for a continued programme monitoring the development of the future ecological status in the affected areas as well as in fjords and sheltered coastal areas.

Commercial crustaceans and molluscs
Stocks of several commercial invertebrates such as prawns, Norway lobsters, lobsters, oysters and giant scallops are surveyed more or less regularly. Prawns and Norway lobsters are included in offshore programmes, whereas the other species are surveyed as part of coastal activities.

Alien species

For Norwegian waters, information on non-indigenous (alien) organisms is assembled and systematised by the Norwegian Biodiversity Information Centre (Artsdatabanken). A complete and updated review of the species including an analysis of the risk of ecological effects is provided in the 2007 Norwegian Black List (Gederaas et al 2007). In addition, supplementary information is accessible in an open searchable database. In total, there are 46 marine species on the list, of which the most important groups are planktonic microalgae, benthic macroalgae and invertebrates. Twenty eight of these species are considered to have a high risk of negative effects on native organisms. Alien species may reach Norway through transport, tourism, aquaculture, and by secondary introduction from neighbouring countries. The most important route to Norway for marine organisms appears to be by secondary introduction. A majority of reports of alien marine species are from southern Norwegian coastal waters, especially from the Skagerrak area. This is largely due to secondary introductions from southern North Sea and the Baltic.

Ocean and coastal water monitoring by ships of opportunity

Ships of opportunity have been used for many years to observe the ocean and coastal seas and to complement monitoring capabilities of the marine environment. In recent years a rapid improvement of ocean observing systems has taken place, in which observations from existing commercial ships such as ferries and cargo ships have raised increased interest. Instrument packages onboard of these vessels are nowadays also referred to as Ferryboxes (Colijn, 2006). The most advanced Ferryboxes integrate both measurements of physical, chemical and biological parameters (e.g. chlorophyll-a fluorescence, turbidity, temperature, salinity and oxygen) of the marine environment, and observations of optical properties of ocean and atmosphere.

A network of Ferryboxes has been established within the North Sea region, including trans-national collaborative efforts for managing and harmonising the systems. The network provides continuous, high-frequency and cost-efficient observations along repeated transects (ship lines), which form a unique and highly valuable dataset for apprehending short-term to longer-term responses of pelagic ecosystem to environmental variations. Some systems are capable of taking water samples at specified positions for later laboratory analyses of nutrient concentrations, organic pollutants, algae taxonomy and toxicity etc.

The Ferrybox systems operated by NIVA delivers data on nutrients, turbidity and phytoplankton abundance and taxonomy to the coastal monitoring programme, and to monitoring programs in inner and outer Oslofjord. Real-time data is also disseminated on internet (www.ferrybox.no) and is part of a pan-European network of services within the Global Monitoring for Environment and Security (GMES) program. This system enables early detection of potential harmful algal blooms, and the ferrybox system was showed to detect algal blooms in the Inner Oslofjord that regular monitoring programs were unable to detect (Magnusson et al. 2007). NIVA's system provides a combination of ferrybox and satellite remote sensing data with daily coverage of the North Sea region. This combination strongly increases the horizontal coverage of the monitoring area as compared to ferrybox data alone and acts at the same time as quality assessments of the satellite products.

Future efforts on monitoring of the marine environment should focus on further utilisation and implementation of new technology like Ferrybox and satellite remote sensing within the monitoring programs (Table 7-1).

Knowledge gaps and proposed actions

Presently no monitoring programmes exist to provide a broad representation of biodiversity and ecological quality of Norwegian parts of the Skagerrak and the North Sea. Existing programmes are either regional, e.g. the coastal monitoring programme which is incomplete for western Norway, or directed at particular species groups and system components, such as the monitoring of toxic algae and commercial fish. No programme focuses particularly on inshore coastal waters or freshwater-sea transitional areas.

Early attempts to establish broad-based monitoring programmes for biodiversity were made in the 1990s by the Norwegian Directorate for Nature Management, when a strategy for an overall national programme was prepared (see e.g. DN 1995, 1998). The work was continued in 2002 when the directorate appointed a working group on marine biodiversity to provide technical advices and concrete plans on how to map and monitor marine biological diversity. In 2005 the group published a plan on how to monitor biological diversity in Norwegian costal water (Oug & Olsgard 2005). A second report by the working group proposes elements to be given priority for monitoring of biodiversity in the ocean and Arctic (Oug & Naustvoll 2008). Both reports present monitoring schemes which covers a broad range of organisms and build as far as possible on existing activities. Suggestions for supplements and additions are given with the aim of obtaining holistic programmes where causes to changes in biodiversity may be revealed. Together, the two reports give advice on monitoring of biological diversity in all sea areas included in Norwegian national jurisdiction.

With regard to alien species there are gaps in knowledge related to their effects and ecological consequences. The methodology presently used for risk analyses needs to be further developed and improved. Further, it is important to draw up good routines for reporting and documenting new discoveries of alien species. Essentially, the most efficient measures will be to prevent introductions. Such an approach will require more information and knowledge that exists today. In particular, knowledge of alien species in neighbouring countries which have not been found in Norway, so-called “door-knocker”, and their possible routes of dispersal may be crucial to prevent their establishment. The main knowledge gaps presented above are summarised in Table 7-2.

Table 7-2. Examples of knowledge gaps for organisms groups and habitats.

Organism group or habitat	**Knowledge gaps**	**Proposed actions**
Coastal pelagic systems	Species composition (other than toxic algae), dynamics	Standardised monitoring and research. Research projects.
Intertidal soft sediments	Poor and very little information on species composition, production, and ecological importance (bird feeding, nursery grounds for juvenile fish). Generally threatened by human activities	Standardised monitoring and research. Research projects.
Offshore soft sediments	No monitoring in Norwegian Trench (between coastal waters and offshore monitoring for petroleum industry) and Skagerrak deep water.	Extend geographical range of present monitoring programmes
Offshore hard-bottom	Poor or little knowledge on species and habitats. Possible occurrences of coral reefs, soft corals and sponges in Skagerrak and Norwegian Trench largely unknown	Seabed mapping
Fish	Non-commercial species not recorded.	Complete work-up of fish samples
Pelagic (water surface)	Low temporal and spatial resolution of water quality monitoring in coastal and oceanic areas.	New technology like ferrybox systems and satellite remote sensing provides cost-efficient data collection and should be further utilized and implemented in monitoring programs.

7.2.3 Eutrophication

The eutrophication status of the entire Norwegian North Sea coast has recently been classified (Molvær et al 2007b, c) using the OSPAR Common Procedure for Identification of Eutrophication Status of Maritime Areas. Compared with the previous assessment undertaken in 2002, this classification was based on new data on nutrient load, oxygen conditions, hardbottom fauna and flora (especially sugar kelp), harmful planktonic algae, as well as other data from a number of recipient studies.

Along the Skagerrak coast (from the Swedish border to Lindesnes), 14 areas were studied and classified. Despite a variable quality of the data, the overall classification of the coastline was

Problem Area (Fig. 7-4). One should note that this classification assumes that the decline of sugar kelp on the Norwegian Skagerrak coast to some extent is caused by eutrophication. For some areas this assumption is crucial for the classification. If future studies of the kelp disappearance prove otherwise, this classification should be revised.

Twenty one areas were classified between Lindesnes and Stad,. The two most striking features were an overall increased anthropogenic nutrient load and lack of monitoring data. Four Problem Areas, 14 Potential Problem Areas and three Non Problem Areas were identified (Fig. 7-5). The high number of Potential Problem Areas is caused by the combination of increased anthropogenic nutrient load and insufficient data for assessment of effects. Table 7-3 summarises the main knowledge gaps identified through the work described above.

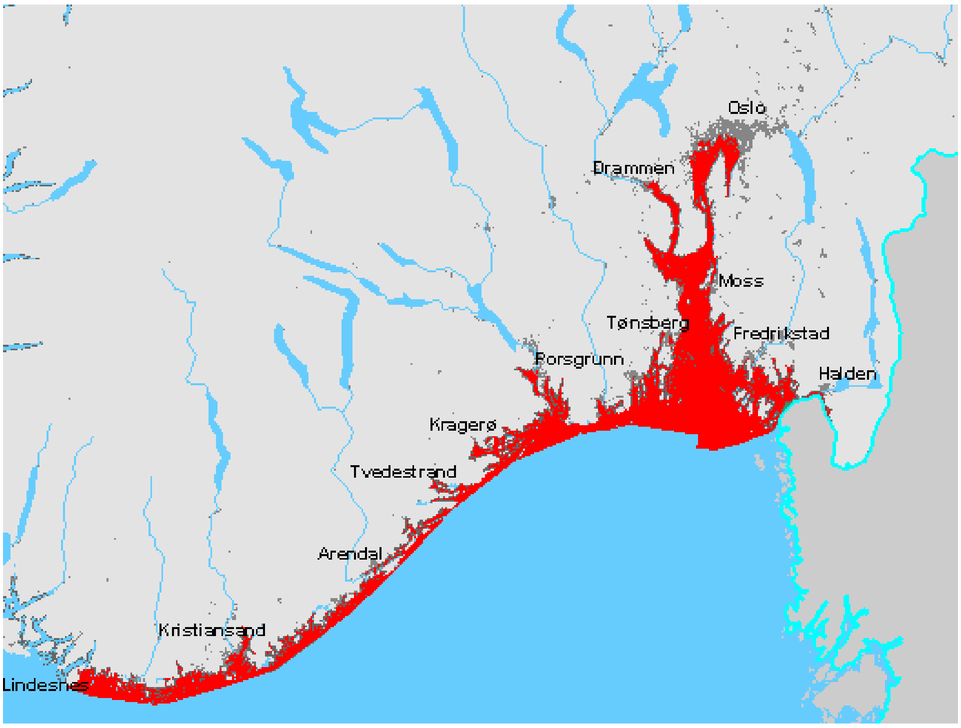


Figure 7-4. Classification of the Norwegian Skagerrak coast as Problem Area (marked red). From Molvær et al. (2007b).

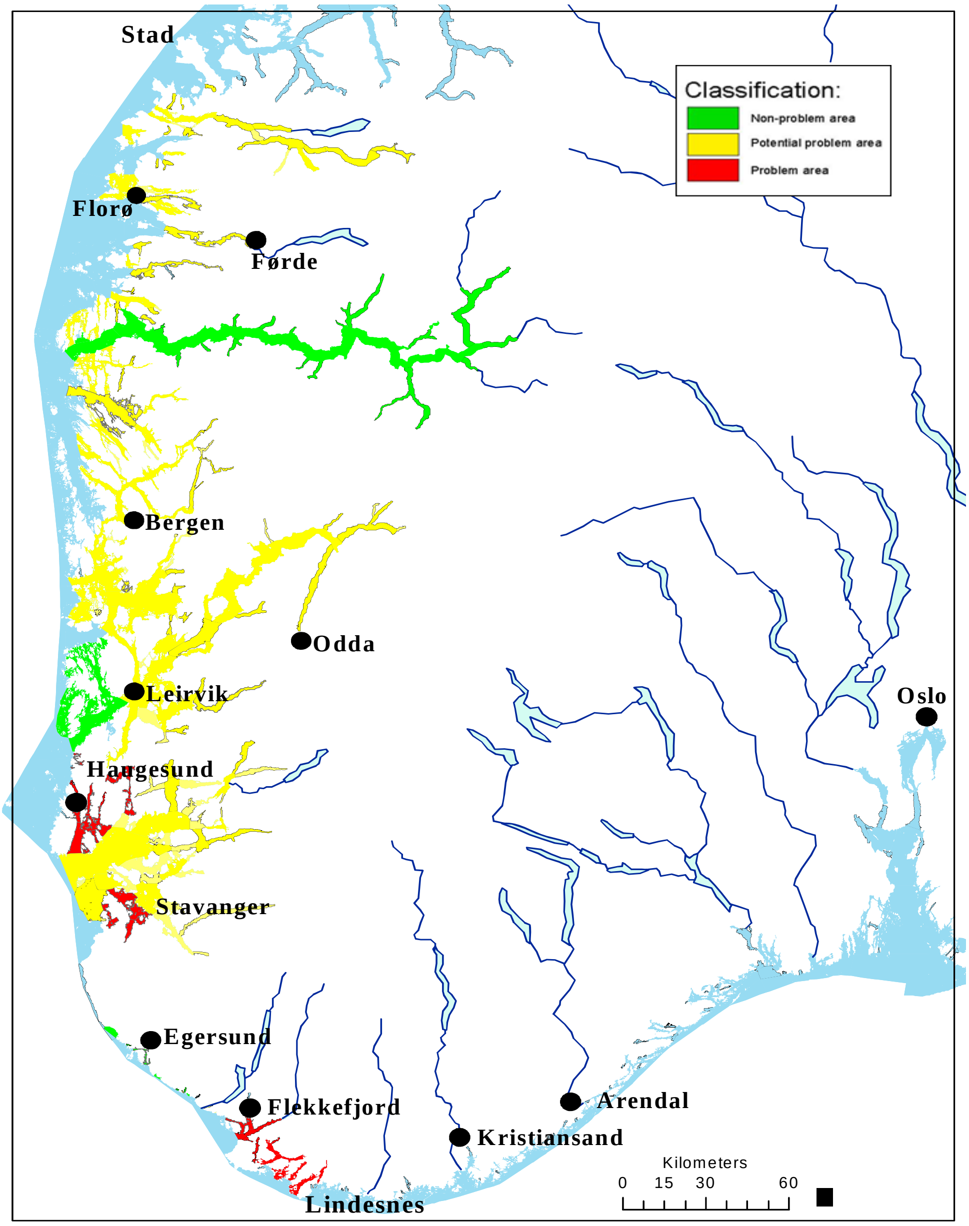


Figure 7-5. Overall classification of the Norwegian West Coast from Lindesnes to Stad. Note that every area has one classification, even though it may contain minor parts that deviate. From Molvær et al. (2007c).

Table 7-3: Summary of knowledge status on eutrophication in Norwegian coastal areas.

Knowledge gaps	Proposed actions to fill the gaps
Varying data quality and lack of monitoring data	There is a definite need for systematic monitoring with a long perspective, especially of Category II-III effects, and with focus on selected Potential Problem Areas.
If future studies prove that the disappearance of sugar kelp is not caused by eutrophication, the classification should be revised. Multiple effects related to eutrophication and climate change needs to be studied further.	Assumption that decline in sugar kelp is related to eutrophication should be further investigated.

7.2.4 Hazardous substances

Hazardous substances are found in chemicals, products and in various industrial processes. Some of the hazardous substances are no longer in use in countries along the shores of the North Sea, but they are transported via pathways such as the atmosphere or ocean currents from other parts of the world. Examples are persistent organic pollutants (POPs) such as poly chlorinated biphenyls (PCBs), dioxins, various pesticides, detergents, flame retardants in addition to offshore chemicals and heavy metals among others. Other hazardous substances are released from sources either on- or offshore in the North Sea area. Land-based dumping sites may leak contaminants such as PCBs and brominated flame retardants. Rivers carry contaminants over large distances, originating from among other industrial discharges, dump sites and contaminated soil. Along the coast tributyltin (TBT) used in antifouling of boats causes severe irreversible effects on marine gastropods, such as imposex (Mensink et al. 1996). Knowledge of impact from TBT is described in the section on shipping and impact from oil and gas industry in the section on oil and gas.

Regulation

Hazardous substances are regulated globally, regionally and nationally. Registers and lists of substances are regularly updated as the potential environmental hazard of "new" chemicals or substances is identified. Registers are all available on internet.

<u>The Stockholm Convention on Persistent Organic Pollutants (POPs)</u>

The Stockholm Convention is a global treaty in which the parties have agreed to phase out 12 of the most hazardous pops. These are:

- Aldrin
- Chlordane
- DDT
- Dieldrin
- Dioxins
- Endrin
- Furans
- Heptachlor

- Hexachlorobenzene (HCB)
- Mirex
- Polychlorinated Biphenyls (PCBs)
- Toxaphene

UNECE

Hazardous substances in Europe are regulated by United Nations Economic Commission for Europe (UNECE).The major aim of UNECE is to promote pan-European economic integration. To do so, it brings together 56 countries located in the European Union, non-EU Western and Eastern Europe, South-East Europe and Commonwealth of Independent States (CIS) and North America. All these countries dialogue and cooperate under the aegis of the UNECE on economic and sectoral issues. Since 1979 the Convention on Long-range Transboundary Air Pollution has addressed some of the major environmental problems of the UNECE region through scientific collaboration and policy negotiation. The Convention has been extended by seven protocols that identify specific measures to be taken by Parties to cut their emissions of air pollutants:

- The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 24 Parties.
- The 1998 Protocol on Persistent Organic Pollutants (POPs); 29 Parties.
- The 1998 Protocol on Heavy Metals; 29 Parties.
- The 1994 Protocol on Further Reduction of Sulphur Emissions; 27 Parties.
- The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes; 22 Parties.
- The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes; 31 Parties.
- The 1985 Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent; 23 Parties.

Oslo-Paris Convention (OSPAR)

OSPAR publishes a list of substances of possible concern. The OSPAR Commission is publishing this List of Substances of Possible Concern in order to enable the transparency of its decisions on which substances to classify as chemicals for priority action, and to provide an opportunity for any errors or omissions in the data on which those decisions were based to be put right.

Regulation of chemicals

Chemicals in general are regulated through the European system REACH. REACH is the new EU directive on the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals. Main aims of REACH are to improve the protection of human health and the environment from the risks that can be posed by chemicals, the promotion of alternative test methods, the free circulation of substances on the internal market and enhancing competitiveness and innovation. REACH makes industry responsible for assessing and managing the risks posed by chemicals and providing appropriate safety information to their users. In parallel, the European Union can take additional measures on highly dangerous substances, where there is a need for complementing action at EU level. In Norway, SFT is responsible for managing the system. The register itself, the European Chemicals Agency, is located in Helsinki, Finland.

The offshore industry in Norway is obliged to perform toxicity tests on substance level for all chemicals in use. They must assess the environmental hazard related to use of each chemical. The data are submitted to the database CHEMS, run by NOVATEC. National authorities have access to the database through SFT.

Monitoring

CLRTAP: Parties report emissions to air

CLRTAP: EMEP monitors concentrations of HM, POPs, and N-compounds in air and precipitation. Modelling of transport and deposition is carried out, based on emission and monitoring data. Data are available to public.

Under OSPAR, the Comprehensive Monitoring Atmospheric Programme (CAMP) monitors concentrations of heavy metals, organic compounds and nutrients in precipitations in air, and their depositions. The results are reported to OSPAR. All data are available to the public.

Joint Assessment and Monitoring Programme (JAMP) is an international coastal monitoring programme, in which 12 countries participate and report to OSPAR. Sediment and fish/gastropods are sampled from many stations along the Norwegian coast, and analysed for heavy metals and POPs. Results are submitted to SFT on a yearly basis, and SFT submits these results to OSPAR. All data are available to the public.

Knowledge gaps

Focus in monitoring effects and levels are on the substances regulated by these protocols and conventions. Knowledge on other substances is scarce, and there is reason to believe that a variety of substances not yet regulated or listed in these protocols and conventions affect the environment at present. This must be considered a gap in knowledge.

The actual effect on an organism at a measured level of a certain contaminant is mostly unknown. Research of actual effects is only done for a few substances. Synergistic effects of exposure to multiple contaminants are also mostly unknown.

In general there seems to be a lot of research and mapping of contaminants in the southern parts of the North Sea, whereas the focus in the Norwegian part is on the effects of the petroleum industry. As a result, there is a need to first map, then monitor contaminant body burden in species in various habitats in the North Sea, such as the deep trench close to the Norwegian coast, and also the shelf. The mapping and subsequent monitoring should focus on both commercial and non-commercial species.

Data are not gathered in a common database, but data on the quality status of the North Sea is published in the quality status reports issued by OSPAR. Otherwise, data needs to be sought out from the literature, as the examples in the Table 7-4 shows.

Table 7-4. Examples of knowledge status and gaps of knowledge on effects from exposure to hazardous substances in organisms in the North Sea. Ww= wet weight BRF- brominated flame retardants. More details are shown in Table A.5 (Appendix).

Organism group	Knowledge gaps	Proposed actions
Birds	Levels in other birds, at different life stages). Effects on population. Synergies with other contaminants.	Data must be sought out from various sources and compilated. OSPAR and ICES have some data. Standardised monitoring and research. Research projects.
Sea mammals	Levels in other sea mammals, other lifestages, food items.	Data must be sought out from various sources and compilated. OSPAR and ICES have some data. If lack of data – standardised monitoring.

7.2.5 Oil and gas

Oil and gas industry in the North Sea have discharges of chemicals and produced water with oil compounds and other substances. The industry is regulated by, among others, the Norwegian Pollution Control Authority, SFT. All discharges are reported yearly and the industry must carry out monitoring of the effects of the discharges on sediments and the water column. The sediment offshore monitoring in the North Sea started in the early 80s, and since 1996 the sediments has been monitored in 11 regions every third year along the Norwegian shelf. The water column monitoring started in 1999 and is divided into the condition monitoring of condition every third year and the monitoring of effects on a yearly basis.

Sediment monitoring

The results so far show that the sediments in the vicinity of older installations, such as at the Ekofisk-field, Statfjord-field and Gullfaks-field, are contaminated with THC and PAH. However, the contaminated area is decreasing. Newer oilfields, set up after the ban of discharge of drill cuttings with oil based muds in 1993, are generally not contaminated. The benthos is primarily affected to some extent close to the installations (Renaud et al. 2008).

Monitoring data is gathered in a database, the monitoring offshore database (MOD), owned by the Norwegian Oil Industry Association (OLF) and managed by Det Norske Veritas (DNV). The data is publicly available as it is submitted to SFT every year, and reports are available on www.sft.no.

Water column monitoring

Results from the monitoring of effects in 2006 (Sundt et al. 2007) at the Ekofisk field showed that caged organisms were been exposed to moderate levels of produced water components. Mussels accumulated PAHs, with levels following the expected gradient with distance from the source of discharge. Concentrations of PAH and AP-metabolites in the bile of caged cod were elevated suggesting moderate exposure levels. Biological responses that can be interpreted as moderate negative were observed in organisms caged close to points of discharge.

The monitoring of condition in 2005 (Grøsvik et al. 2007) showed that:

- Di- and polyaromatic hydrocarbons (NPD/PAH) were below levels of quantification (LoQ) for fish (cod/haddock) sampled in all regions (North Sea Ling bank/Egersund bank, reference station, and Tampen in addition to the Barents Sea.
- Only haddock showed higher level of PAH metabolites at Tampen
- Only haddock showed higher levels of DNA adducts at both Tampen and reference sites, much higher at Tampen
- Analysis of alkylphenols in cod liver, haddock liver and herring muscle were all below LoQ.

Water column monitoring data is regarded as public information as they are submitted to SFT, however no database for gathering all the data exist.

Knowledge gaps

Gaps in knowledge and uncertainties in the sediment offshore monitoring regarding the effects are related to transport of contaminated sediments, especially from old cutting piles containing oil-based mud. These cuttings piles diminish little by little each year in exposed, shallow regions such as Ekofisk, as the heavily oil contaminated sediments are weathered down by the sea. Actual resulting levels of contamination and significance of this transport is not known.

Gaps in knowledge (Table 7-5) in general include a better link between biomarker monitoring and risk assessment (OLF 2005). Furthermore, fieldwork has been observed to suffer from methodological problems, and difficulties actually finding the produced water plume emerging from installations with produced water emissions due to dilution and shifting currents. There is a continuous need to focus on developing methods with appropriate sensitivity. However, these methods should be able to distinguish between actual effects on biota and mere exposure.

Table 7-5. Overview of relevant levels and effects, in addition to data sourced. More details are shown in Table A.6 (Appendix).

Part of ecosystem or organism group	**Knowledge gaps**	**Proposed actions**
Fish	Actual consequences of measured levels in the organisms. Antagonistic effects of exposure to multiple contaminators.	Research and development
Mussels	Actual consequences of measured levels in the organisms.	Research and development
Sediment	Actual consequences of measured levels on the ecosystem.	Research and development

7.2.6 Radioactive substances

The Institute of Marine Research monitors yearly levels of ^{137}Cs and ^{99}Tc in water, sediments and organisms. ^{137}Cs is detected in all analysed samples, but levels are generally low (Iversen et al. 2006). In bottom sediments, highest levels are found in Skagerrak, which may be related to transport from the Baltic Sea. Levels are also low in organisms.

7.2.7 Fishing

Fishery activities affect the ecosystems in various ways. The most important are removal of biomass and reduction of fish stocks, physical impacts of benthic habitats from use of trawls and other bottom gears, and effects of operational and accidental discharges. Biomass removal affects fish stocks being exploited, but also several non-target fish species and a variety of organisms taken as bycatch and eventually ending up as discard are influenced. The physical impact of benthic habitats from bottom trawl equipment can be substantial and is likely to disturb the natural environment for fish and several other organisms. Operational discharges comprises slop water, oil and fuel residues, garbage and amounts of fish processing waste and other organic matter. An overview of data sources for effects of fisheries on the North Sea ecosystem is given in Table 7-6.

Table 7-6. Overview of data sources to be considered for the assessment of the fisheries impact to the North Sea Ecosystem.

Type of sources	Types of data	Reports
National sources		
Norwegian Fishery Directorate	Information about catches in different regions from different months, species, fishing gear etc.	No reports. Data from databases has to be compiled.
NCA (Norwegian Coastal Administration)	Accidental discharges	
IMR (Institute of Marine Research)	Biological resource data (fish stocks)	Yearly updated reports. Fisken og Havet, special editions.
StatoilHydro	Regional EIA of the North Sea	Birkely et al. (2006)
International sources		
ICES (International Council for the Exploration of the Seas)	Biological resource data (fish stocks) from all countries. Data on contamination status. Data on fish catches	
NCM (Nordic Council of Ministers)	General data on discharges obtained through targeted projects	Various reports

The most important commercial fish species are herring, sand-eel, mackerel, cod, haddock and saithe. Commercial fish stocks are currently fully exploited (haddock) overexploited (cod) or recovering from previous over-exploitation (herring) (ICES advice series available at www.ICES.dk). All landings of fish are recorded based on geographic position (area and location) of the catch according to the ICES statistical rectangles (see Chapter 3). The latest update is from 2006 (Birkely et al 2006), containing landing statistics for the years 2000, 2002 and 2004 from Norwegian, British and Danish fishery in the Norwegian sector. Detailed and long-term data series are available for commercially important fish species. Regular updates on the status for fish stocks are published by The Institute of Marine Research, e.g. Iversen et al. (2006).

Indirect effects of fisheries can be substantial. Table 7-7 gives an overview for different fishing gears with regard to selectivity of targeted species and effects on habitats and other organisms. Passive gears like gillnets can also catch marine birds and mammals, and in this way negatively impact other groups than fish. Lost gillnets are non degradable and continue to fish for long periods (ghost fishing). Ghost fishing is an unwanted taxation of the stock, which is hard to document.

Table 7-7. Overview of different types of fishing gear and environmental impact.

Bottom trawl and Danish seine	**Pelagic trawl and purse seine**	**Gillnets, longlines, podnet, and fish traps**
Low species selectivity Affects benthic habitats Bycatch of benthic invertebrates	High species selectivity No or very limited contact with the seabed, and thereby limited impact to benthic habitats	Low species selectivity Limited impact to benthic habitats Gill- and podnet ghost fishing

Bottom trawls both have low species selectivity, thus catching many non-target species, and affect benthic habitats. In the EU project "managing fisheries to conserve groundfish and benthic species diversity" (Mafcons), the effects of fishery activities on benthic productivity and diversity in the North Sea ecosystems have been investigated (www.mafcons.org). The project aimed to increase the understanding of structuring processes of fish and invertebrate communities and the mechanisms through which fishing affects these. In this project, production and biomass of demersal fish and benthic organisms were determined, data for fish catch and landings were assembled, and models to estimate impacts were developed. The project partly covered the Norwegian sector in the North Sea, but Skagerrak was excluded. Fig. 7-6 shows the results from models to estimate the impact of otter trawling for demersal fish on invertebrates rates.

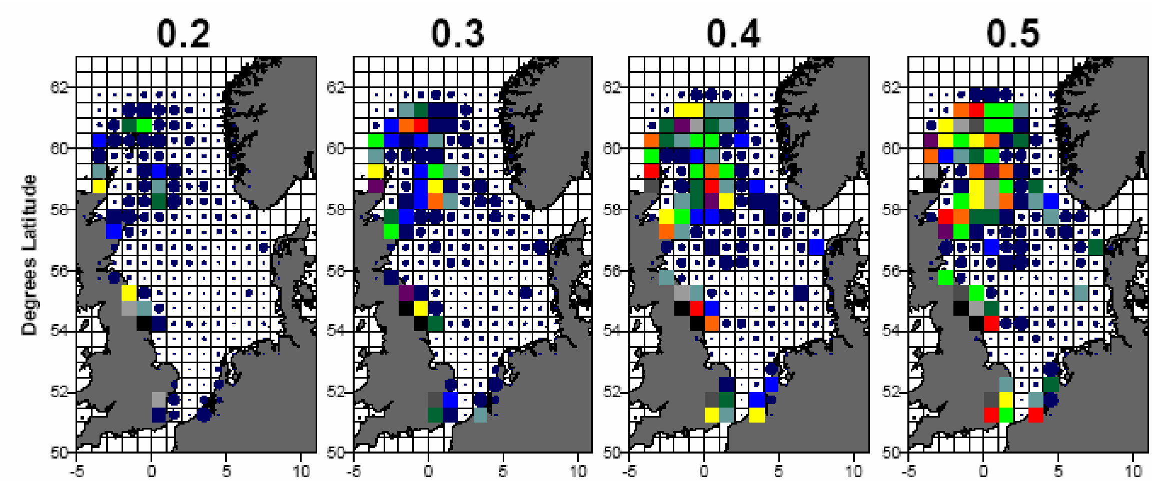


Figure 7-6. Modelled impact of otter trawling on benthic invertebrates showing annual mortality given present distribution of otter trawl fishing activity and different "per fishing event" mortality rates (0.2-0.5). All data are spatially resolved according to ICES statistical rectangles. From Mafcons project report: www.mafcons.org.

7.2.8 Shipping

OSPAR QSR 2000 indicated that the most important impacts related to shipping are introductions of non-indigenous species, effects of antifouling substances, and spills and discharges of oil and other substances. For Norwegian waters, information on non-indigenous species is assembled and systematised by the Norwegian Biodiversity Information Centre (Artsdatabanken). Information on effects of antifouling substances is regularly monitored as part of the OSPAR JAMP/CEMPs monitoring for coastal areas, as well as in separate studies in harbours and along ship routes. Regarding environmental effects from larger oil spills and ship accidents, the Norwegian Coastal Administration (Kystverket) is responsible for preparing contingency plans and carrying out actions to combat acute effects in co-operation with SFT and DN. These bodies are also responsible for environmental investigations after acute pollution.

Non-indigenous species

The data compiled on the Norwegian 2007 Black List indicate that there are very few, if any, alien species which have been transferred to Norwegian waters by shipping (Gederaas et al. 2007). However, there are several species, e.g. among planktonic microalgae, for which dispersal routes are not known and where shipping may have been involved. Also, several species which have been introduced to neighbouring countries by shipping have later reached Norwegian waters by natural dispersal (secondary introductions).

Transfer of micro-organisms, plankton and larvae of benthic organisms in ballast water is of most concern. Although the ecology of Norwegian waters appears relatively pristine, the risk of invasion of non-indigenous species is increasing, due to the increasing shipping trade to Norwegian waters. Norway has been active in developing the IMO ballast water convention. Measures should be taken to monitor the situation and reduce the risk until implementation of the IMO ballast water convention.

Antifouling substances

Tributyltin (TBT) has been widely used for about 50 years as a highly effective antifouling agent in ship paints to prevent growth of attached algae and invertebrates on ship hulls. Negative effects on non-target organisms were recognised in the 1980's, especially in molluscs. The most severe effects are observed in shell-bearing snails such as dog whelk and redconc, where deformation of female sexual organs (imposex) and eventually sterility follows from TBT exposure. For the Skagerrak area an overall assessment of occurrence, levels in organisms and effects has been given by Strand et al. (2006). In the report, a five-class scheme of assessment criteria for effects were developed based on the WFD classification system, and used to present detailed maps of levels and effects. The study shows that all areas in Skagerrak are affected, but that the risk of chronic adverse effects is substantial in costal waters and in the proximity of harbours and marinas. A ban on the use of TBT on leisure vessels was introduced in 1989, whereas the use on larger vessels is to be terminated during the course of 2008. Following the ban a reduction in imposex has been observed in outer Oslofjord and Haugesund area, starting in 2002. There has also been a decrease in levels in blue mussels (Green et al. 2007).

Norwegian data on TBT effects are almost exclusively from the dogwhelk, organisms living in the intertidal zone. Little or no information on effects in subtidal areas exist. In the Norwegian part of the North Sea outside Skagerrak there is no information on effects.

Oil spills and legal operational discharges

For Norwegian waters an approach for prioritising environmental resources with regard to oil spills ('MOB-model') has been developed and implemented by the Norwegian Pollution Control Authority (SFT) and Directorate for nature management (DN) (SFT & DN 1996). The approach considers natural occurrence, protection value and vulnerability to oil as important criteria for evaluation of the resources. The system is presently developed in some detail with respect to sea birds, mammals, fish and supra-littoral meadows (terrestrial habitats). Data is entered into a database MRDB – marine resource database – which is owned by several directorates and oil companies (www.mrdb.no). The MOB-model is used in current contingency plans in the municipalities, in national contingency plans operated by the Norwegian Coastal Administration, and by the oil companies (http://planverk.nofo.no/MOBkart/). It has also been the basis for several evaluation reports on potential effects from large-scale oil spills (e.g. Brude 2005).

The environmental risks related to shipping trade in Norwegian coastal waters have been evaluated by Dragsund et al. (2004). The study uses data from the MRDB-database for the evaluations based on estimated frequency of accidents and consequences of damage. Risks are considered to be highest in Sogn, Rogaland and outer Oslofjord. There is also a study on risks of acute pollution of chemicals related ships in Norwegian waters (Lenes et al. 2004). The study concludes that the most transported chemicals are easily degradable and do not represent severe threats to marine organisms. The risk of acute pollution is generally considered to be low, but in some industrialised areas (e.g. Oslofjorden, Grenland, Kårstø, Sture, Mongstad) particular emergency readiness measures for acute pollution should be considered.

Environmental consequences of oil spill accidents in Norwegian waters have been assessed in several studies. The most recent are the "Server" and "Rocknes" shipwreck on the west-coast near Bergen.

A present weakness in the contingency plans is that the MOB-model used for assessing vulnerability is based on some selected system components only. It is therefore a knowledge gap with regard to the possibility of assessing vulnerability for the ecosystems on the whole, and, consequently, with regard to the time taken for recovery from damage. For instance, shallow-water marine habitats, macroalgal communities and invertebrate species assemblages are not taken into account. Effects in open sea are also insufficiently covered.

Information on effects of discharges such as oily bilge water, grey water and garbage is poor.

A summary of knowledge status presented above is given in Table 7-8.

Table 7-8. Summary of knowledge status on effects from shipping to Norwegian coastal and offshore areas. More details are included in Table A.7 (Appendix).

Part of ecosystem or organism group	**Knowledge gaps**	**Proposed Actions**
Introduction of alien species	Verify introduction by shipping	Establish a 'warning list' of potentially new introductions; develop methods to treat ballast water Monitor the situation and reduce the risk until implementation of the measures of the IMO ballast water convention
Shell-bearing snails	Poor or no information on effects of TBT in subtidal and offshore areas outside Skagerrak. Extent of influence/ recovery today.	Include these areas in national monitoring programs.
Shore and shallow water systems.	Duration and extent of effects from oil spills on resident flora and fauna, risks of chronic long-term effects	Assess acute and long-term effects on resident benthic species assemblages, map particularly vulnerable habitats and ecosystems to be included in contingency plans.

7.3 Knowledge on habitats and threatened species

7.3.1 Habitat mapping

National program for mapping of vulnerable coastal marine habitats

A national program for mapping of coastal marine habitats was initiated by an interdepartmental group in 2003. The main contributors to the program are three ministries: Fisheries and Coast, Environment and Defence. In the program habitats have been selected which are of special interest to marine biodiversity, e.g. kelp forests, seagrass beds, carbonate sand and calcareous algae beds. Intertidal mud-flats, deep fjords, shallow-threshold fjords (‘polls’) and strong current areas are also included. Presently the mapping has been carried out fairly extensively in the counties of Aust-Agder and Hordaland. Until 2010 approximately 35 % of the selected habitats will be mapped and the information will be made available on web through the Norwegian Directorate for Nature conservation. Major contributors are NIVA, IMR and NGU. Occurrences of carbonate sand have been particularly mapped by NGU (Ottesen et al. 1995). The data and information will be valuable in a future management plans for the North Sea.

MESH

Development of habitat maps for the North Sea (searchmesh.net). *MESH:* International marine habitat mapping programme entitled 'Development of a framework for **M**apping **E**uropean **S**eabed **H**abitats, or **MESH** for short, which started in spring 2004 and finished in January 2008. A consortium of 12 partners across the UK, Ireland, the Netherlands, Belgium and France gained financial support from the EU INTERREG IIIB fund for an international marine habitat mapping programme. The MESH partnership covered all five countries in the INTERREG (IIIb) north-west Europe area, drawing together scientific and technical habitat mapping skills, national data collation and management expertise, and experience in the use of habitat mapping in management and regulatory frameworks. Habitat maps relevant to the future management plans for the North Sea are available through the web.

7.3.2 Marine protected areas

Natura 2000

The Habitats Directive (92/43/EEC) was adopted in 1992 by European Union governments as a means of protecting the most seriously endangered species and habitats to be found in Europe. The Habitats Directive (HD) complements the Birds Directive of 1979, and the designated areas under both of these directives form a network of protected sites known as Natura 2000. Maps will be available through the web.

Suggested MPAs for the Norwegian sector of the North Sea

A proposal for protected marine areas along the Norwegian coast was launched in 2004 by an expert committee appointed by the Directorate for nature management (Rådgivende utvalg 2004). This is expected to be adopted in 2008. Maps and information will be made available on the web. Most proposed MPAs are located in the coastal zone and inshore waters, but three areas, two in Skagerrak and one near Bergen, reach outside Norwegian inshore waters. The seabed and associated plants and animals are the main objects of protection there. Selected areas are generally not significantly influenced by human activities and will serve as reference areas and preferred sites for biodiversity research. Fishery with non-disturbing gears will be allowed.

7.3.3 Threatened species

A new official Norwegian Red List of threatened and near threatened species was launched in December 2006 (Kålås et al. 2006). The Red List has been drawn up in accordance with the international guidelines issued by the World Conservations Union (IUCN 2003) and is essentially an evaluation of the risk of species becoming extinct in Norway. The marine organisms considered belong to benthic macroalgae, invertebrates, fish, birds and mammals. The area covered comprises the coastal zone around the Norwegian mainland, the Norwegian economic zone, and for some groups the fishery zone around Spitzbergen. Evaluations have been performed for the area as a whole, with the understanding that separate evaluations for regions or sub-areas, e.g. the Norwegian part of the North Sea, have not been performed.

More than 2000 marine species were evaluated. Of these, the number of threatened and near threatened species in the main groups is, respectively, macroalgae 31, invertebrates 59, fish 34, birds 7, and mammals 11. The species have been assessed based on changes in populations or distributions, which have been related to threats from impact factors such as habitat loss and disturbance, pollution, exploitation and climate changes. The list does not give summary information about how many of the red-listed species are found in the North Sea area and what are their main threats, but this information can be compiled from primary data on each species, which largely are entered in a searchable database (www.artsdatabanken.no/ "rødlistebasen"). It may seem, however, that the most important threats for the marine red-listed species are habitat loss, contaminants and exploitation.

The Norwegian Red List is compatible with a Swedish Red List (Gärdenfors 2005), covering Swedish waters in inner Skagerrak and Kattegat, which was also based on the IUCN criteria. For the North Sea itself, there is a red lists for German waters which, however, uses somewhat different criteria and may not be directly comparable. OSPAR has made a list of threatened and declining species which seems largely to be based on expert judgements (OSPAR 2004). The OSPAR list identifies 19 species as threatened for the North sea, of which only 6 species also are entered on the Norwegian Red List (flat oyster, common skate, spotted ray, cod populations, blue whale, northern right whale).

7.3.4 Threatened habitats

OSPAR has provided a list of threatened and declining habitats as part of the strategy of protection and conservation of the ecosystems and biological diversity (OSPAR 2004). For the North Sea area, nine habitats or community types are identified to be under threat or in decline. Of these, seven habitats are also found in Norwegian waters, viz. intertidal mudflats, deep water coral reefs, horse mussel beds, intertidal blue mussel beds on soft sediments, oyster beds, burrowing megafauna communities and sea-grass (Zostera) beds.

Only deep water coral reefs are presently monitored in Norway, but the monitoring is concentrated on reefs found north of the North Sea area. There is no monitoring of the other habitat types, but intertidal mudflats, oyster beds and sea-grass beds are presently being mapped during the national project for mapping of marine habitats.

There is presently no work in Norway trying to identify declining habitats or habitats being at risk of extinction. It is intended that a red list of habitats should be developed by the Norwegian Biodiversity Information Centre (Artsdatabanken).

Norwegian MPAs
In the proposal for Norwegian marine protected areas, aspects such as representativeness, distinctive characteristics, low human influence, and suitability for research and monitoring have been taken into account (Rådgivende utvalg 2004). In total, 10 areas and water bodies from the Swedish border to Stad have been proposed. Most areas are located in the coastal zone, but three areas in Østfold county, near Arendal and in the Korsfjord at Bergen reach out into open sea. In most cases it is the sea-bottom and the associated plants and animals which constitute the objects for protection. It is intended that sustainable use of the areas should be allowed, including fishing with light gears that do not disturb the seabed. Maps showing the areas are given by Rådgivende utvalg (2004) and may also be found in Oug & Olsgard (2005) and Oug & Naustvoll (2008).

7.4 Ecosystem health indicators on a broad scale

7.4.1 OSPAR ecological quality indicators for the North Sea

Following the fifth North Sea Conference in 2002, OSPAR has adopted a system of Ecological Quality Objectives (EcoQOs) as a means of applying an ecosystem approach to the management of human activities. The system has been gradually developed over the years, but the conceptual basis and the particular elements were specifically developed for the North Sea in a pilot project following the conference (OSPAR 2006b). Within the overall concept, ten fields, or Ecological Quality Issues, have been selected in which it is attempted to measure aspects of the general ecological quality. Under each issue there are one or more elements to be measure and the desired level of ecological quality is set as the quality objective (EcoQO). Table 7-9 presents the issues and quality elements for the North Sea.

The quality objectives are either in the form of targets (achieve certain conditions), limits (avoid certain conditions), or indicators (show what is happening). For targets and limits the levels of the quality objective may be set in relation to a reference or background level where anthropogenic influence on the system is minimal. The system is still under development in order to make it complete with regard to all system compartments and the different human pressures. In further development the DPSIR (driving force – pressure – state – impact – response) framework offers a structured approach in selecting a balance between objectives set for ecosystem states versus objectives for pressures, impacts and responses (OSPAR 2006b).

Table 7-9. OSPAR Ecological Quality objectives (EcoQOs) for the North Sea

Ecological Quality Issue	Quality elements
Commercial fish species	a) Spawning stock biomass
Threatened and declining species	b) Presence and extent of threatened and declining species
Sea mammals	c) Population trend d) Utilisation of breeding sites e) By-catch of harbour porpoises
Seabirds	f) Proportion of oiled common guillemots on beaches g) Mercury concentrations in seabird eggs h) Organochlorine concentrations in seabird eggs i) plastic particles in stomachs of seabirds j) Sand-eel availability to black-legged kittiwakes k) Seabird populations trends
Fish communities	l) Changes in proportion of large fish
Benthic communities	m) Changes in zoobenthos in relation to eutrophication n) imposex in dog whelks o) density of sensitive species p) density of opportunistic species
Plankton communities	q) Phytoplankton chlorophyll a r) phytoplankton indicator species for eutrophication
Habitats	s) Restore/maintain habitat quality
Nutrient budgets	t) Winter nutrient (DIN and DIP) concentrations
Oxygen consumption	u) Oxygen

7.4.2 Water Framework Directive - water quality status indicators

Quality indicators – main groups, environmental factors

Relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according to the normative definitions in Annex V 1.2 in the Directive.

Annex V 1.1.3. Transitional Waters	Annex V 1.1.4. Coastal Waters
Biological elements	
• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna* • *Composition and abundance of fish fauna*	• *Composition, abundance and biomass of phytoplankton* • *Composition and abundance of other aquatic flora* • *Composition and abundance of benthic invertebrate fauna*
Hydromorphological elements supporting the biological elements:	
Morphological conditions: • *depth variation* • *quantity, structure and substrate of the bed* • *structure of the inter-tidal zone* *Tidal regime:* • *freshwater flow* • *wave exposure*	*Morphological conditions:* • *depth variation* • *structure and substrate of the coastal bed* • *structure of the inter-tidal zone* *Tidal regime:* • *direction of dominant currents* • *wave exposure*
Chemical and physio-chemical elements supporting the biological elements:	
General: • *Transparency* • *Thermal conditions* • *Salinity* • *Oxygenation conditions* • *Nutrient conditions* *Specific Pollutants:* • *Pollution by all priority substances identified as being discharged into the body of water* • *Pollution of other substances identified as being discharged in significant quantities into the body of water.*	*General:* • *Transparency* • *Thermal conditions* • *Salinity* • *Oxygenation conditions* • *Nutrient conditions* *Specific Pollutants:* • *Pollution by all priority substances identified as being discharged into the body of water* • *Pollution of other substances identified as being discharged in significant quantities into the body of water.*

Classification systems

The normative definitions of ecological status according to WFD:

> **Annex V Table 1.2. General definition for rivers, lakes, transitional waters and coastal waters**
> High status
> *"There are no, or only very minor, anthropogenic alterations to the values of the physicochemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.*
> *The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion. These are the type specific conditions and communities."*
> Good status
> *"The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions."*
>
> Moderate status
> *"The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status."*
> Poor status
> *"Water showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor."*
> Bad status
> *"Water showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad."*

The observed results from the monitoring of the biological quality elements should be compared against the reference conditions for that type and expressed as an Ecological Quality Ratio:

> **Annex V, 1.4.1 (ii)**
> *"In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero."*

Reference conditions
The reference condition is a description of the biological quality elements that exist, or would exist, at high status, that is, with no, or very minor disturbance from human activities. The objective of setting reference condition standards is to enable the assessment of ecological quality against these standards.

In defining biological reference conditions, criteria for the physico-chemical and hydromorphological quality elements at high status must also be established. The reference condition is a description of the **biological** quality elements only. High **ecological status** incorporates the biological, physico-chemical and hydromorphological elements.

Reference conditions must summarise the range of possibilities and values for the biological quality elements over periods of time and across the geographical extent of the type. The reference conditions represent part of nature's continuum and must reflect natural variability.

Because reference conditions must incorporate natural variability, in most instances they will be expressed as ranges. Reference conditions should be derived with a view to distinguishing between very minor, slight, and moderate disturbance. 'Very minor' disturbance could be defined as just detectable in the sense that the disturbance is more likely to be anthropogenic than not. Slight disturbance could be defined as anthropogenic at a prescribed level of confidence.

7.4.3 Other ecological quality indicators

Advices on consumption of marine organisms in view of contaminants
The legislation for safe food, healthy plants, fish and animals is supervised by the Norwegian Food Safety Authority (NFSA) which in turn participates in an international cooperation on food safety through the European Food Safety Authority (EFSA). NFSA is responsible for giving advices on consumption of seafood based on monitoring of contaminants in selected organisms. Basic data is obtained as part of several programs such as the OSPAR JAMP monitoring program (e.g. Green et al. 2007), surveillance research programmes of fish from fisheries and farming administered by the National Institute of Nutrition and Seafood Research (NIFES), and separate studies in contaminated fjords and harbours.

An overview of monitoring results and advice on consumption for Norwegian coastal waters has recently been presented by Økland (2005). In most cases, contaminants were the reason for most of the advices and these were lead, cadmium, mercury, dioxins, PCBs and PAHs. In the Skagerrak and North Sea regions, advices are given for fjords polluted from smelter industry and most major cities from the Oslofjord to Årdal in Sogn (Økland 2005). The potentially highest risk for contaminants and other undesirable substances in fish and other seafood is posed by dioxins and dioxin-like PCB and by methyl mercury (Knutsen and Alexander 2004).

The surveillance program at NIFES, which started in 1994, comprises the economically most important fish species for Norwegian export. The program covers open sea areas, but at present data cannot be presented explicitly for the North Sea. However, North Sea herring, mackerel and Norway pout are species mainly distributed in the North Sea. In these species, levels of contaminants are generally low and below critical values stated by EU. The monitored contaminants comprise cadmium, dioxin-like PCBs, dioxins, lead, mercury, and polybrominated di-phenyl ethers (data from NIFES database, www.nifes.no). As regards "new" organic pollutants (e.g. PFAS), there is not yet adequate documentation available to be able to determine the degree to which these constitute, or may come to constitute, a problem for food safety.

Environmental Impact Factor (EIF)

The environmental impact factor (EIF) is developed as a management tool and used by the oil industry to identify the potential most environmentally harmful discharges from produced water. EIF is based on environmental risk and hazard assessments. EIF is intended to quantify the environmental benefit of different actions to reduce harmful discharges (Johnsen et al. 2000). There is also under development and EIF model for risk assessment of acute oil spills. In EIF acute, risk assessments are performed in three different environmental compartments; water masses, sea surface and shoreline. The probability of presence of a vulnerable resource is also incorporated in the model.

The method takes into account both composition and amount of the discharge and is linked to environmental impact assessments in the area of interest, and the water column monitoring which was initiated in 1999. Information about EIF may be found in e.g. Spikkerud et al. (2006).

8. Framework conditions on management in the North Sea region

8.1 Some relevant EU directives for future planning for the North Sea

There are several directives that are mandatory for the EU member states including the states around the North Sea. Norway is an exception where adoptions of directives are negotiated under the EEA agreement. Three major directives are developed to stop further deterioration of the environment including coastal and marine areas is shortly presented below. Of these three only the WFD is a part of the EEA agreement so far. The degree of success of these three directives will depend on the MS ability to develop a trans-national and transparent implementation process. An intercalibration process is ongoing as a part of the implementation of the WFD, but no such process is planned yet for the other two.

8.1.1 Water Framework Directive

The MSD deadlines are meant to be consistent with those of the EU Water Framework Directive (2000/60/EC), which requires the achievement of good ecological status of surface freshwater and groundwater bodies by 2015 and the first review of River Basin Management Plans developed under the Water Framework Directive (WFD) in 2021. The combined implementation of these two directives is intended to fill the gap between environmental protection of inland waters and the open seas. The preamble of the WFD indicates that common definitions of water quality and quantity should be developed but that local variations should also be taken into account. The Directive’s main principles illustrate its integrated approach to water management.

The WFD aims to:

- Manage water as a whole on a river basin basis reflecting the situation in the natural environment;
- Use a combined approach for the control of pollution, setting emission limit values and water quality objectives;
- Ensure that the user bears the costs of providing and using water reflecting its true costs;
- Involve the public in making decisions on water management.

The WFD applies to all inland surface waters, ground waters, transitional water (including estuaries and coastal lagoons) and coastal waters out to at least one nautical mile from the baseline. It is the coastal waters under the WFD which are relevant for the present geographic overlap analysis.

The European Commission defines coastal water as: Surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.

8.1.2 Marine Strategy

It is not yet clear how Norway will approach the EU Marine Strategy Directive (MSD). The directive aims to achieve good environmental status of the marine environment by 2021 and to ensure the continued protection, preservation and prevention of deterioration of the environment. Adopted by the European Commission in 2005 and amended by the European Parliament and Council in 2006, it establishes four marine regions and identifies eight potential sub-regions. The strategy proposal is based on the concept of regional seas and sets out common objectives and methods. Member States sharing an area are required to develop strategies on how to achieve good environmental status, including detailed assessment of the state of the environment, a definition of good environmental status for the regional context and the establishment of clear targets and monitoring programs. The first programs of measures should be developed by no later than 2016 and made operational within two years of their establishment.

The Marine strategy will be implemented at many levels, ranging from local to pan-European. This leads to the need to identify individual regional areas for which ecological objectives are to be defined. Ecosystem boundaries are typically based on biological and physical processes. The boundaries of these eco-regions should therefore be based on biogeographic and oceanographic features, taking account of existing political, social, economic and management divisions. By doing so, eco-regions should be characterised by greater similarity in biogeographic and oceanographic characteristics among sites within the same eco-regions. It is envisaged that the eco-regions could be subdivided in sub regions as appropriate.

In response and on the basis of the criteria named in the request, ICES submitted a proposal for thirteen ecoregions, including the Baltic Sea and the Black Sea. The North Sea represents ICES ecoregion F.

8.1.3 The Habitats Directive (Natura 2000)

The Habitats Directive (92/43/EEC) is not relevant for Norway but is an important directive for the rest of the North Sea countries. The directive was adopted in 1992 by European Union governments as a means of protecting the most seriously endangered species and habitats to be found in Europe. The Habitats Directive (HD) complements the Birds Directive of 1979, and the designated areas under both of these directives form a network of protected sites known as Natura 2000. All EU member states are required to take steps to ensure that natural habitats and species in the network receive "favourable conservation status", with the aim of guaranteeing their long-term survival. The Member States themselves contribute to the network, which is made up of Special Protection Areas (SPAs) for birds and Special Areas of Conservation (SACs) designated for other species and for habitats. SACs are classified under the HD and provide increased protection and management for rare and vulnerable animals, plants and habitats. Natura 2000 sites can be designated on both land and water. While there has been a lack of clarity about how far out HD marine sites may be designated by a given Member State, some legal decisions have helped to define the limits. A UK High Court decision ruled in 1999 that the Habitats Directive applies “to the superajacent waters up to a limit of 200 nautical miles from the baseline from which the territorial sea is measured”. Marine Natura 2000 areas are protected by conservation measures to ensure they are not over-fished, or affected by pollutants from sewage or shipping traffic. The HD marine sites are those that are included in the present analysis.

8.1.4 Other relevant directives

There exist many directives that are relevant for the North Sea environment. E.g., the EC Nitrates Directive (91/676/EC), the Urban Waste Water treatment Directive (91/676/EC) and the REACH directive. REACH is a new European Community Regulation on chemicals and their safe use (Registration, Evaluation, Authorisation and Restriction of Chemical substances (EC 1907/2006).

8.2 International bodies and conventions relevant for the North Sea area

Several conventions and agencies are involved both in the implementation of EU directives and to work for an improved environmental status for the North Sea. All of these may contribute to a future management plan for the North Sea.

8.2.1 ICES - the International Council for the Exploration of the Sea

ICES is the organisation that coordinates and promotes marine research in the North Atlantic. This includes adjacent seas such as the Baltic Sea and North Sea. The convention acts as a meeting point for a community of more than 1600 marine scientists from 20 countries around the North Atlantic. Scientists working through ICES gather information about the marine ecosystem. As well as filling gaps in existing knowledge, this information is also developed into unbiased, non-political advice. Our advice is then used by the 20 member countries, which fund and support ICES, to help them manage the North Atlantic Ocean and adjacent seas.

ICES plans and coordinates marine research through a system of committees, more than 100 working groups, symposia, and an Annual Science Conference. Most meetings take place either at the ICES Headquarters in Copenhagen, Denmark, or in the member countries.

ICES is the prime source of advice on the marine ecosystem to governments and international regulatory bodies that manage the North Atlantic Ocean and adjacent seas.

The 20 member countries of ICES are: Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, the United Kingdom and the United States of America.

The affiliates are: Australia, Chile, Greece, New Zealand, Peru and South Africa.
Non governmental organisations with formal observer status are: Worldwide Fund for Nature and BirdLife International.

8.2.2 OSPAR

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. The Convention has been signed and ratified by all of the Contracting Parties to the original Oslo or Paris Conventions (Belgium, Denmark, the European Community, Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland) and by Luxembourg and Switzerland.

The first Ministerial Meeting of the OSPAR Commission at Sintra, Portugal, in 1998 adopted Annex V to the Convention, to extend the cooperation of the Contracting Parties to cover all human activities that might adversely affect the marine environment of the North East Atlantic. Nevertheless, programmes and measures cannot be adopted under the Convention on questions relating to fisheries management.

In 2000, to fulfil obligations under Annex IV to the OSPAR Convention, the OSPAR Commission published the first comprehensive Quality Status Report on the quality of the marine environment of the North-East Atlantic. This was supported by five reports on the different parts of the OSPAR maritime area – the Arctic, the Greater North Sea, the Celtic Seas, the Bay of Biscay/Golfe de Gascogne and Iberian waters, and the Wider Atlantic.

OSPAR coordinates several activities relevant for the North Sea e.g. the EMMA group (monitoring, relevant for WFD, HD and MSD) and common procedure, ongoing classification of eutrophication status.

8.2.3 EEA – European Environment Agency

The European Environment Agency is the EU body dedicated to providing sound, independent information on the environment. They are a main information source for those involved in developing, adopting, implementing and evaluating environmental policy, and also the general public. The main clients are the European Commission, the European Parliament, the Council and the member countries.

The EEA mandate is to help the community and member countries make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability. They also coordinate the European environment information and observation network (EIONET). Their role is to be an independent information provider, an analyst and assessor, building bridges between science and policy and to develop strong networks to carry out its work.

EEA has currently 32 member countries:
27 European Union Member States - Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden, Spain and The United Kingdom. EU candidate country Turkey. Iceland, Liechtenstein and Norway (European Economic Area countries). Switzerland.
EEA cooperating countries:
The West Balkan countries - Albania, Bosnia and Herzegovina, Croatia, Montenegro, Serbia and the former Yugoslav Republic of Macedonia.

EEA produce environmental reports concerning the North Sea countries and collects environmental data through the **EIONET** from member countries and collaborating countries on a yearly basis. EEA could be invited to contribute to a future management plan for the North Sea.

8.3 North Sea relevant collaborations activities involving both conventions and agencies - examples

There are many relevant working groups and projects that could be listed here. Two examples related to the WFD and the MSD are presented here.

Under the **Common Implementation Strategy** for the Water Framework Directive (CIS-strategy) several work groups are established around Europe covering both freshwater and coast. A marine group under CIS called COAST has three sub groups called geographic intercalibration groups (GIG). The one covering the North Sea is called NEA-GIG (North

East Atlantic GIG) and could contribute to a future planning for the North Sea. The work groups participating in the CIS is familiar with both freshwater and marine issues.

The **European Marine Monitoring** and **Assessment** (EMMA) Working Group are expected to play a role in the implementation of the MSD and could contribute to a future management plan for the North Sea. This group has representatives from OSPAR, ICES, EEA and CIS.

8.4 EU Framework programmes and Interreg

A large number of projects exist that are relevant to the generation of new data and tools useful for developing a future management plan for the North Sea. Some are already presented in chapter 7. Below a few examples are presented. These are initiatives based on newly finished projects and programmes of which the networks are developing new projects that could contribute to a future management plan for the North Sea.

A few relevant examples:
EU Framework programme and Interreg
Interreg is an important tool for developing regional management collaboration in Europe. Tools and networks developed in several projects can contribute to future management plan for the North Sea. **BALANCE** (web: balance-eu.org) is a good example and a similar project for the North Sea are being developed and is called PLANOR (Norwegian partners: NIVA, IMR, NGU). If successful this will start in 2009.

BALANCE – or in full "Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning" – is an INTERREG III B co-funded project aimed towards development of informed marine management tools for the Baltic Sea based on spatial planning and cross-sectoral and transnational co-operation. It started in July 2005 and ended in December 2007. Main topics have been to Identify and collate relevant and available marine data in the Baltic Sea, Kattegat and Skagerrak area. Define Baltic Sea marine landscapes and develop habitat maps, the latter in 4 pilot areas. Assess the existing Baltic Sea Marine Protected Areas network and develop a “blue corridor” concept. Develop Baltic marine zoning plans in 2 pilot areas (pilot area 2 and 3). Communicate with stakeholders and disseminate the results to partners, stakeholders and the public.

MESH, web address: at: searchmesh.net. This is developed further in a new project proposal called MESMA (Norwegian partners: NIVA, IMR, NGU) under the EU 7 Framework programme and will start in 2009 if successful.

MESH is an international marine habitat mapping programme entitled 'Development of a framework for **M**apping **E**uropean **S**eabed **H**abitats which started in spring 2004 and finished in January 2008. A consortium of 12 partners across the UK, Ireland, the Netherlands, Belgium and France gained financial support from the EU INTERREG IIIB fund for an international marine habitat mapping programme. The MESH partnership covered all five countries in the INTERREG (IIIb) north-west Europe area, drawing together scientific and technical habitat mapping skills, national data collation and management expertise, and experience in the use of habitat mapping in management and regulatory frameworks. The project has generated tools and data relevant for a future management plan for the North Sea. This information is available through the web.

9. Climate change

In this study we have looked for relevant and specific reports at OSPAR, EEA as well as NVE, RegClim and NorClim. There are yet few facts about impacts of future climate changes on the North Sea environment. Changes in freshwater runoff from the Norwegian mainland are described in a recent NVE-report (Roald et al., 2006):

- Moderate changes in the annual flow, with a moderate reduction in Eastern Norway and increase in Western Norway.
- Significant changes in the seasonal distribution. The runoff during winter will increase while the annual spring flood is expected to decrease and occur earlier. Correspondingly a decrease in summer runoff is expected.

If the future hydroelectric power production increases, that will also contribute to a shift towards increased winter runoff to specific fjord systems.

The projected increase in air temperature will lead to an overall increase in sea temperature, where the most important feature may be higher maximum temperature during summer. Species which today already experience temperatures at their maximum tolerance level – or above this, e.g. the sugar kelp - may be damaged. Other species adjusted or able to adjust to warmer water – and this includes exotic species – may be moving northwards along the coast.

Changes in annual and seasonal runoff are expected to create corresponding changes in the flux of nitrogen from river basins to the marine areas (Kaste et al. 2006, Wright et al, 2008). Relatively more nitrogen will be delivered in winter and less in spring, and this may have an effect on the spring algal blooms in the coastal water. Even more so if the nutrient transport into the Skagerrak with the Jutland current and the Baltic current experience a similar shift in time.

There is reason to believe that a shift towards higher temperature and more freshwater in the coastal water may change – and most probably reduce - the renewal of basin water of fjord along the Norwegian Skagerrak coast. If that happens these basins may experience a change towards lower oxygen concentrations and deteriorating conditions for marine life

A summary of climate changes scenarios applied to the North Sea countries was published by Alkyon in 2005 and updated in 2007 (Alkyon, 2007). The scenarios are shown in Table 9-1. Most of these climate change scenarios focus on the absolute and relative sea level rise. Not much attention is given to other important parameters such as the increase in storm surges, wave height, etc. This is mostly due to the fact that predictions of changes in future occurrence of storms, extreme wind and wave conditions are not considered to be very reliable. In scientific climate change estimates most attention is given to absolute sea level rise scenarios. This is due to the fact that most climate change research is carried out on a global scale. Some countries (The Netherlands, Denmark and the United Kingdom) pay attention to the impact of tectonic movements on the relative sea level rise.

Finally one may note that there is a possibility that future climate changes will induce severe changes in the Gulf Stream. If that happens, one may expect changes in the meteorological and hydrological, hydro-physical and biological conditions that are quite different from the scenarios that are described above.

In a long time perspective one may also add ocean acidification due to increasing atmospheric carbon dioxide. The overall decreasing pH may be may be outside the present natural variability by the year 2100 (Anon, 2005). Reviews of trends and possible effects for the Norwegian Sea are given in Golmen et al. (2008).

Knowledge Gaps

So far there has been a focus on meteorological and hydrological changes such as temperature and runoff and scenarios for sea level changes and wave height, but far less on ecological consequences in the marine areas. Among others, the following factors need further investigation:

1. Changing runoff of nutrients and pollutants
2. Changes in the current systems: overall and especially seasonal
3. Changes in transport of nutrients: water quality, including temperature
4. Biological effects from the above parameters

Table 9-1. Summary of climate scenarios applied in North Sea countries. Available climate change scenarios for 2050 in available policy documents (from Alkyon 2007).

	Parameter	The Netherlands	Belgium	Denmark	Germany		United Kingdom (*)
					Schleswig-Holstein	Niedersachsen	
Low estimate	Absolute sea level rise (m)	-	-	-	-	-	-
	Absolute rise high tide (m)	-	-	-	-	-	-
	Absolute rise low tide (m)	-	-	-	-	-	-
	Relative sea level rise (m)	0.10	-	-	-	-	-
	Relative rise high tide (m)	-	-	-	-	-	-
	Relative rise low tide (m)	-	-	-	-	-	-
	Wind speed and gales (%)	-	-	-	-	-	-
	Storm surge increase (m)	-	-	-	-	-	-
	Wave height increase (%)	-	-	-	-	-	-
	Tectonic movement (m/50years)	-	-	-	-	-	-
	Rise of coastal cross-section (m)	0.10	-	-	-	-	-
Medium estimate	Absolute sea level rise (m)	-	-	-	-	0.30[b]	0.21[c]
	Absolute rise high tide (m)	-	-	-	-	-	-
	Absolute rise low tide (m)	-	-	-	-	-	-
	Relative sea level rise (m)	0.30	0.25[f]	-	0.25[a]	-	0.20 - 0.30[d] **(0.35-0.425)**[g]
	Relative rise high tide (m)	-	0.30[f]	-	-	-	-
	Relative rise low tide (m)	-	-	-	-	-	-
	Wind speed and gales (%)	-	-	-	-	-	**- (+10%)**
	Storm surge increase (m)	-	-	-	-	-	-
	Wave height increase (%)	-	-	-	-	-	H: +10%; T:+5%[e]
	Tectonic movement (m/50years)	-	-	-	-	-0.03 - -0.05[b]	-
	Rise of coastal cross-section (m)	0.30	-	-	-	-	-
High estimate	Absolute sea level rise (m)	-	-	-	-	-	-
	Absolute rise high tide (m)	-	-	-	-	-	-
	Absolute rise low tide (m)	-	-	-	-	-	-
	Relative sea level rise (m)	0.45	-	-	-	-	-
	Relative rise high tide (m)	-	-	-	-	-	-
	Relative rise low tide (m)	-	-	-	-	-	-
	Wind speed and gales (%)	10	-	-	-	-	-
	Storm surge increase (m)	-	-	-	-	-	-
	Wave height increase (%)	5	-	-	-	-	-
	Tectonic movement (m/50years)	-	-	-	-	-	-
	Rise of coastal cross-section (m)	0.45	-	-	-	-	-

* **Update March 6, 2007:** Flood and Coastal Defence Appraisal Guidance, Supplementary note to Operating Authorities - Climate Change Impacts, DEFRA, October 2006

[a] 50% of the value presented for 2100.

[b] 50% of the value in m/century.

[c] Based on ODM (2001).

[d] Based on 4 - 6 mm/yr relative sea level rise (DEFRA, 2003).

[e] Presented by Defra (2003) for 2080. H is wave height, T is wave period.

[f] Presented in m per 50 years (for the period 2005 to 2055)

[g] Based on 7 – 8.5 mm/yr relative sea level rise (DEFRA, 2006)

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11. Appendix – Relevant data bases and R&D projects

Table A.1. Specifications of databases, projects and reports relevant for the information on discharges of nutrients and pollutants from Norwegian sources. Additional references and information can be found in Chapter 4.

<table>
<tr><th colspan="2">Agriculture</th></tr>
<tr><td>Databases:</td><td>• The Norwegian Agricultural Environmental Monitoring Programme (JOVA) (observed losses in small agricultural catchments)
• Norwegian Meteorological Institute (Met.no) (precipitation and temperature at about 50 monitoring stations)
• Norwegian Water Resources and Energy Directorate (NVE) (runoff maps for Norway, 1961-1990)
• Norwegian Institute for Air Research (NILU) (wet and dry nitrogen deposition)
• The Norwegian Forest and Landscape Institute (soil properties and topography)
• Norwegian Institute for Agricultural and Environmental Research (Bioforsk) (soil chemical database collected over the last 13 years)
• Statistics Norway (SSB) (agricultural statistics, including crop distribution, application of commercial fertiliser / animal manure, and tillage)
• Norwegian Agricultural Authority (Statens Landbruksforvaltning) (approved applications for state subsidies to reduce tillage)
• Norwegian Grain (Unikorn AS) (cereal crops)</td></tr>
<tr><td>R&D projects and programmes</td><td>• RegClim project
• The Norwegian Agricultural Environmental Monitoring Programme (JOVA) (Pengerud et al. 2007)
• TEOTIL program (Selvik et al. 2007)
• Riverine inputs and direct discharges to Norwegian coastal waters (RID) (Skarbøvik et al. 2007).
• The Norwegian air- and precipitation chemistry monitoring network (Aas et al. 2007)
• Inputs of hydrocarbons and chemical compounds to Norwegian oceanic and coastal areas (Molvær et al. 2007a)</td></tr>
<tr><th colspan="2">Aquaculture</th></tr>
<tr><td>Databases:</td><td>KOSTRA (SSB),
ALTINN (Norwegian Directorate of Fisheries)</td></tr>
</table>

Table A.1 continued

Fisheries	
Databases and reports	*National sources* • SFT (State Pollution Control authority): Emissions to air and sea, regular monitoring data (sediment and water column). Numerous reports. • Statistics Norway (Statistisk Sentralbyrå): Emissions to air Numerous reports updated • Norwegian Directorate of Fisheries: Information about catches in different regions from different months, species, fishing gear etc. Data from databases has to be compiled. • NCA (Norwegian Coastal Administration): Accidental discharges • IMR (Institute of Marine Research): Biological resource data (fish stocks) Yearly updated reports. Fisken og Havet, special editions. • StatoilHydro: Regional EIA of the North Sea (Birkely et al 2006). *International sources* • ICES (International Council for the Exploration of the Seas): Biological resource data (fish stocks) from all countries. Data on contamination status. Data on fish catches • OSPAR (Oslo Paris Convention): Contaminant status data • NCM (Nordic Council of Ministers): General data on discharges obtained through targeted projects Various reports
Oil and gas	
Databases	INKOSYS (SFT) KOSTRA (SSB) MOD database
Reports	Yearly discharge reports to SF T (OLF)
Transport	
Databases	FORURENSNING (SFT) KOSTRA (SSB)
Population	
Databases	FORURENSNING (SFT) KOSTRA (SSB)

Table A.2. List of chemicals of which the use is prioritized by the Norwegian government to be ended or strongly reduced by 2005 or 2010 (Stortingsmelding 58, 1996-1997; Stortingsmelding 21, 2004-2005). The priority list is published at http://www.miljostatus.no/

End of discharge by 2005	**Strongly reduced by 2010**	
	Specified substances	*Other substances*
Short Chained Chlorinated Paraffins (SCCA) PCB Pentachlorophenol (PCP) Nonylphenols and nonylphenol ethoxylates Octylphenols and octylphenol ethoxylates Tensides (DTDMAC, DSDMAC, DHTMAC)	Brominated flame retardants Diethylhexylphthalate (DEHP) 1,2 Dichloroethane (EDC) Dioxines og furans PFOS-related compounds Hexachlorobenzene Medium chained chlorinated paraffins Chlorinated alkylbenzene Muskxylene Tetra-chlor-ethylene Tri-chloro-benzene Tri-chloro-ethylene Polycyclic Aromatic Hydrocarbons (PAH) Tri-butyltin (TBT) compounds Tri-phenyltin (TFT) compounds Lead (Pb) Arsenic (As) Cadmium (Cd) Copper (Cu) Mercury (Hg) Chromium (Cr) Perfluorooctanoic Acid (PFOA) 2,4,6 Tri-tert-butylphenols Dodecyl phenols w. isomers Bisphenol A Decametylcyclopentasiloxan (D5)	Substances that fulfil one of the following criteria: 1. Little degradable compounds that accumulate in living organisms and that a. bring serious long term health effects, or b. are very toxic in the environment 2. Little degradable compounds that accumulates very easily in living compounds (without requirement for known toxic effects) 3. Compounds that are retrieved in the food chain at levels that represent risk to health or environment 4. Other substances, like hormone-disturbing substances and heavy metals that represent risk to health or environment

Table A.3. Main pollutants from different sectors as identified and presented in Chapter 4.

Agriculture	Nutrients, suspended particulate matter, pesticides
Aquaculture	nutrients, organic matter, copper
Fisheries	To air: CO_2, CH_4, N_2O, SO_2, NO_x, NH_3, NMVOC, CO and particles. To water: Grease, hydraulic fluids, slopwater, anti fouling paint. Fish processing: Organic discharges from land based fishing plants, discharge of fish processing waste (particulate organic matter). Waste and trash
Oil and gas	Acute oil spills, dispersed oil, Pb, Cd, Hg, PAH
Shipping	oil (THC), tributyltinn (TBT), trifenylltinn (TFT), As, Pb, HCB, Cd, Cu, Cr, Hg, PCB, PAH, TCB
Industry	As, Cd, Cr , Cu, , DEHP, Dioksiner, EDC, HCB, Hg, PAH, Pb, PCB, Oil (THC)
Population	Nutrients, Organic Matter

Table A.4. Data sources and R&D projects providing relevant information on input of nutrients and pollutants within the North Sea (Chapter 5).

Topic	**Data sources**	**Relevant R&D projects (ongoing or planned)**
Riverine Input	QSR 2000, OSPAR QSR 2010, OSPAR ECOOP Deliverable, D-2.5.1.1 Global Runoff Data Centre (GRDC) developing European Terrestrial Network for River Discharge (ETN-R)	NOOS FP6 Integrated project ECOOP
Direct Discharges	QSR 2000, OSPAR QSR 2010, OSPAR Meeresumweltdatenbank MUDAB (http://www1.bsh.de/meereskunde/DOD) MURSYS (http://www.bsh.de/meeresumweltschutz/mursys) ICES Environmental data centre (http://www.ices.dk/env/) British Oceanographic Data Centre BODC (http://www.pol.ac.uk/bodc) United Kingdom Marine Environmental Data Network UKMED (http://www.bodc.ac.uk/ukmed/) European Directory of Marine Environmental Data EDMED (http://www.pol.ac.uk/bodc/edmed.html) Sites of the respective Belgian, Dutch and Norwegian authorities (without results) Data unit of the Trilateral Monitoring and Assessment Programme TMAP (http://cwss.www.de)(under construction)	NOOS, MyOcean Marine Core Service
Atmospheric deposition	OSPAR CAMP (Comprehensive Atmospheric monitoring Programme, OSPAR 2007c).	
Transport within the North Sea	NCOF FOAM operational modelling system BSH operational model Mumm operational model NOOS modelling systems Scientifically used model application	MyOcean, ECOOP

Table A.5. Examples of knowledge status and gaps of knowledge on effects from exposure to hazardous substances in organisms in the North Sea. Ww= wet weight BRF- brominated flame retardants.

Part of ecosystem or organism group	**Data sources for levels - (and of what)**	**Knowledge gaps**	**Comments**
Birds	Lesser black-backed gull (*Larus fuscus*): Egg/blood samples: HCB: 14,7 ppb ww PCB: 1239,5 ppb ww DDE: 292,6 ppb ww (Bustnes et al. 2006). Fish-hawk eggs (*Pandion haliaetus*): BFR 103 ng/g (from Botisov 2006)	Levels in other birds, at different life stages) Effects on population. Synergies with other contaminants	Data are not assembled in on database. Data must be sought out from various sources. OSPAR and ICES have some data.
Sea mammals	Grey seal age 0-1 years (*Halichorus grypus*): ΣPCB: 4600 ng/g lip ΣPBDE: 290 ng/g lip DDE: 890 ng/g lip DDT: 120 ng/g lip (Kalantzi et al. 2005). Nise (*Phocoena phocoena*): BFR: 180 ng/g (fra Boitsov 2006)	Levels in other sea mammals, other lifestages, food items.	Data are not assembled in on database. Data must be sought out from various sources. OSPAR and ICES have some data.

Table A-6. Detailed overview of relevant levels and effects, in addition to data sourced. (LOQ- level of quantification).

Part of ecosystem or organism group	**Data sources for levels - (and of what)**	**Data sources for effects**	**Knowledge gaps**	**Relevant R&D**	**Comments**
Fish	Cod and haddock: NPD/PAH below LOQ Grøsvik et al. (2007)	Haddock: Increased level of PAH metabolites and DNA adducts Grøsvik et al (2007) Cod: Increased level of PAH- and AP- metabolite (Sundt et al. 2007)	Actual consequences of measured levels in the organisms. Antagonistic effects of exposure to multiple contaminators.	Ongoing watercolumn monitoring. Industry funded research at APN and IRIS on various organisms, not necessarily boreal.	Methodological problems in effect monitoring.
Mussels	Accumulated PAH (Sundt et al. 2007)		Actual consequences of measured levels in the organisms.	Ongoing watercolumn monitoring. Industry funded research at APN and IRIS on various organisms, not necessarily boreal.	Methodological problems in effect monitoring.
Sediment	Offshore monitoring. Levels vary depending on site.	www.sft.no	Actual consequences of measured levels on the ecosystem.	Ongoing sediment monitoring. Industry and NFR funded research at APN, NGU and IMR.	
Biodiversity in benthos	Offshore monitoring. Impact varies depending on site.	www.sft.no		Ongoing sediment monitoring. Industry funded research at APN and IMR.	

Table A.7. Summary of knowledge status on effects from shipping to Norwegian coastal and offshore areas

Part of ecosystem or organism group	**Data sources for levels - (and of what)**	**Data sources for effects**	**Knowledge gaps**	**Relevant R&D**	**Comments**
Introduction of alien species		Norwegian Black List 2007 (Gederaas et al 2007)	Verify introduction by shipping	Establish a ‘warning list’ of potentially new introductions; develop methods to treat ballast water	
Shell-bearing snails	TBT and related compounds in *Nucella, Hinia, Buccinum* etc (Strand et al. 2006); *Nucella* (Green et al. 2007)	Imposex, same species as for levels (Strand et al. 2006; Green et al 2007). Imposex in *Buccinum undatum (*Mensink et al. 1996).	Poor or no information on effects in subtidal and offshore areas outside Skagerrak. Extent of influence/ recovery today.		Dog whelk recovery along the coasts of Norway, Britain and France (Evans et al. 2000).

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Title:
Knowledge status and gaps for the North Sea – focusing on discharges.
Kunnskapsstatus og kunnskapsbehov – hovedfokus på tilførsler

Subtitle:
A pilot study of knowledge gaps and availability of data for the North Sea – focus on discharges.
En pilotstudie om kunnskapsstatus og tilgjengelige data for Nordsjøen – fokus på tilførsler.

Summary: The Norwegian government will develop a management plan for the Norwegian sector of the North Sea. Mapping of the data requirement related to the interaction between land, coast and ocean and identification of specially vulnerable and valuable areas are included. The project focuses on discharges and their impact on the environment in the Norwegian part of the North Sea (part of OSPAR's Region II, Greater North Sea), however information from other countries and regions within the North Sea is also included.

OSPAR is developing a Quality Status Report for the North Sea area entitled the QSR 2010. QSR 2010 is based on regional assessments while this report is a pilot project aiming to identify additional data required for an upcoming management plan for the North Sea. OSPAR QSR 2010 will develop an assessment for the North Sea, however this will probably not be area specific enough to fulfil the needs for a management plan. In addition to the QSR 2010 there will be a need to develop regional plans based on collaboration between the NS countries. EUs directives, conventions and agencies supply a network of laws, directives and agreements relevant for a future management plan for the North Sea.

Relevant sources of data and overall estimates of the amounts of nutrients and pollutants discharged from Norwegian sources into the North Sea are presented. An assessment of the knowledge status is given for individual sectors, with a particular focus on areas where present knowledge or data availability is considered insufficient. Effects of discharges on vulnerable and valuable areas are discussed in the context available data from monitoring and future needs to fill the gaps.

Norwegian key words	Key words
Nordsjøen	North Sea
Kunnskapsstatus	Knowledge status
Kunnskapsbehov	Knowledge gaps
Forvaltningsplaner	Management plans

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