chapter 6

Overall assessment

6.1 Introduction

This chapter provides an overall assessment of the quality of the Greater North Sea area (Region II), and the relevant human impacts, based on information from Chapters 2 – 5. It attempts to combine this information to identify impacts of concern and any significant gaps in knowledge. The present QSR addresses the Joint Monitoring and Assessment Programme (JAMP) issues, and answers to the best possible extent the questions that have been raised.

Section 6.2 gives an overview of human pressures resulting from both land-based and sea-based activities. The pressures have been ranked according to their relative impacts on the North Sea using a process of assessment involving structured expert judgement. For each of the different human pressures identified as being of greater concern, the impact and any changes are evaluated, the effectiveness of existing measures is discussed, and recommendations for policy options to be considered by the appropriate authorities are made.

The basis for the assessment is principally formed from the results of joint monitoring activities carried out by the coastal states as well as from national monitoring. However, present monitoring programmes do not systematically cover the entire area (section 4.1). This limits the assessment of its status. Modelling techniques are used to improve our understanding of the present status and developments, and the implications of human activities. Application of assessment tools such as models, 'Ecotoxicological Assessment Criteria' (EACs) and 'Background/Reference Concentrations' (BRCs) requires a certain amount of caution, as uncertainties still exist. Also, the expert judgement process should be seen as a tool and not as a definitive ranking system.

In section 6.3, the main limitations in our knowledge that are relevant for making a quality status assessment are identified. It focuses on the lack of data and of statistical information, on research needs (both in the fields of natural sciences and socio-economics) and on reference values and assessment tools. In addition, problems of comparison between OSPAR regions are addressed. Where appropriate, the precautionary principle should be applied.

The next section (6.4) presents a concise overall assessment of the health of the North Sea, with special attention given to the combined effects of impacts.

The concluding section (6.5) is dedicated to the main conclusions of the assessment, an outlook towards further activities and general recommendations.

6.2 Assessment of human impacts

The North Sea has a long history of multiple use by people from many nations. There is awareness of the need to safeguard the marine ecosystem and to achieve sustainability in respect of human use. Knowledge of the main human pressures and understanding their impact is essential to the development and implementation of effective measures to reach such sustainable use. In order to determine the relative importance of the various human pressures a structured prioritisation method has been applied. A hierarchical scheme of criteria, related to an overall objective of a healthy ecosystem and sustainable use of the North Sea, was used. Thirty-two human pressures were defined and each was evaluated against these criteria, taking into account severity, spatial scale and recovery time. A more extensive description of the assessment process, including its strengths and weaknesses, is given in RA (1998). On the basis of scores and argumentation, the human pressures were ranked into four priority classes ***(Table 6.1)***. The classes are described as: class A: highest impact; class B: upper intermediate impact; class C: lower intermediate impact; class D: lowest impact. It must be underlined that this exercise was performed mainly on a qualitative basis. There is scope to repeat it in the future, using more quantified criteria.

While the division into classes was established as firmly as the process permits, the order within each class was not considered to be significant. The reasons for placing pressures in the higher impact classes, A and B, are described in the following sections. For this description, human pressures within a given class are grouped together according to subject, e.g. fisheries. For information on pressures in classes C and D, the text of chapters 2 – 5 should be consulted. Although the impacts of these pressures are perceived to be less than those in classes A and B for the entire North Sea, they may, however, be of more serious concern in combination with other human pressures.

Initially, in addition to the thirty-two pressures, a thirty-third pressure was defined as 'various human activities contributing to climate change'. However, in view of the very broad scope of its causes and effects, it was considered inappropriate to compare this item directly with the other pressures. Since climate change has, potentially, a very significant influence it is addressed first in the next section.

6.2.1 Climate change

The climate of the North Sea and adjacent areas is, in general, strongly influenced by climatic oscillations originating in the North Atlantic Ocean, whereas in the eastern North Sea ingressions of continental climatic conditions sometimes occur. The North Atlantic oscillations control the variability of water inflow from the North-east Atlantic into the North Sea and the large-scale atmospheric circulation. The North Atlantic Oscillation index is a measure of the intensity and persistence of westerly winds over the North Atlantic. Its impact, which extends to the North Sea, affects cloud cover (precipitation and light), upper ocean turbulence and heat flux and is, therefore, an important factor in the ocean's productivity. Wind speeds showed no significant trend over the last 100-year period, but an increase has been observed since the 1960s.

Sea surface temperature series show a weak upward trend that is in agreement with the global temperature increase of about 0.6 ºC in 100 years. As Atlantic water is the main source of nutrients and supply of plankton for the North Sea, climatic variables have been demonstrated to influence the recruitment and growth of several fish species and the migration of adult fish into the northern North Sea.

It is difficult to determine the possible regional effects of climate change. However, for the North-east Atlantic, a surface air temperature increase of about 1.5 ºC, a sea level rise of about 0.5 m, and a general increase in storminess and rainfall are predicted by the year 2100. Model results suggest an increase in surface temperature and precipitation in Scandinavia, and a decrease in Arctic ice volume leading to unpredictable reactions of the climate system. Problems associated with sea level rise mainly concern the Dutch and Belgian coastal zone, the Wadden Sea, the German Bight, south-eastern England, and the mid-Channel ports in England and France.

The effects of climate change on the marine ecosystem and on some human activities could be enormous, particularly if changes were to occur in global oceanic circulation patterns. The uncertainty about the occurrence and the possible impacts of such events is very large. Consequently, there will be a need to minimise such uncertainty. To this end, long term monitoring of key physical, chemical, and biological variables and further development of models and assessment tools will be important. Ongoing consideration of the possible changes resulting from climate change and the various possible response scenarios of the North Sea riparian states will need to be coupled with such monitoring and modelling efforts in order to inform the debate on how best to address the future challenges in this important area of concern. As climate change is considered to be at least partly caused by human activities, reduction of the input of greenhouse gases, according to the UN Framework Convention on Climate Change, is necessary.

CLASS A: HIGHEST IMPACT

6.2.2 Category fisheries

Changes and evaluation of impact

Effects of fisheries, including industrial fishing and shellfisheries, occur at all levels in the ecosystem (from benthos to mammals). The main impacts of fisheries vary

Table 6.1 Priority classes of human pressures.

Class*	Human pressure	Category
A	Removal of target species by fisheries	fisheries
	Inputs of trace organic contaminants (other than oil and PAHs) from land	trace organic contaminants
	Seabed disturbances by fisheries	fisheries
	Inputs of nutrients from land	nutrients
	Effects of discards and mortality of non-target species by fisheries	fisheries
	Input of TBT and other antifouling substances by shipping	trace organic contaminants
B	Input of oil and PAHs by offshore oil and gas industry	oil and PAHs
	Input of oil and PAHs by shipping	oil and PAHs
	Input of other hazardous substances (other than oil and PAHs) by offshore oil and gas industry	other hazardous substances
	Inputs of heavy metals from land	heavy metals
	Inputs of oil and PAHs from land	oil and PAHs
	Introduction of non-indigenous species by shipping	biological impacts
	Input of other hazardous substances (other than oil, PAHs and antifouling) by shipping	other hazardous substances
	Introduction of cultured specimen, non-indigenous species and diseases by mariculture	biological impacts
	Inputs of microbiological pollution and organic material from land	biological impacts
C	Input of litter specific to fisheries	litter and disturbance I
	Physical disturbance (e.g. seabed, visual, noise, pipelines) by offshore oil and gas industry	litter and disturbance I
	Input of litter by shipping	litter and disturbance I
	Dispersion of substances by dredging and dumping of dredged material	dredging and dumping
	Dumping of (chemical) ammunition by military activities	dredging and dumping
	Constructions in the coastal zone (incl. artificial reefs) by engineering operations	engineering operations
	Input of chemicals (incl. antibiotics) by mariculture	mariculture
	Mineral extraction (e.g. sand, gravel, maërl) by engineering operations	engineering operations
	Input of nutrients and organic material by mariculture	mariculture
	Physical disturbance by dredging and dumping of dredged material	dredging and dumping
	Inputs of radionuclides from land	radionuclides
D	Physical disturbance (e.g. noise, visual) by shipping	litter and disturbance II
	Input of litter by recreation	litter and disturbance II
	Physical disturbance (e.g. seabed, noise, visual) by military activities	litter and disturbance II
	Physical disturbance (e.g. noise, visual) by recreation	litter and disturbance II
	Power cables (electromagnetic disturbances) by engineering operations	litter and disturbance II
	Dumping of inert material (e.g. wrecks, bottles)	litter and disturbance II

* Human pressures are ranked according to their relative impact on the Region II ecosystem, including sustainable use. While the division in the four classes A-D was established firmly, ranking within classes was not considered to be significant. Class A = highest impact; Class B = upper intermediate impact; Class C = lower intermediate impact; Class D = lowest impact.

from one type to another, but in general are: removal and discarding of target species; seabed disturbance; discarding and mortality of non-target species. These impacts are widespread and are ecologically important.

The removal of target species impacts the whole North Sea to varying degrees. At present, 30 – 40% of the biomass of commercially exploited fish species in the North Sea is caught each year. Despite some recovery in recent years, there is concern about the stocks of herring and cod, which are outside Safe Biological Limits. The spawning stock of mackerel has not yet recovered since its collapse in the mid-1960s. Other stocks including haddock, whiting, saithe, plaice and sole are also close to or outside 'Safe Biological Limits'. Catch levels for many fish stocks are almost certainly not sustainable. Stocks of sandeel and Norway pout are probably within safe biological limits. High fishing mortality of sandeels has been documented to interfere with the food requirements of seabirds off the Scottish coast. These complex interactions call for the development of a multi-species approach. Fishing mortality typically leads to a smaller proportion of older and larger individuals in the population, and it can also affect the genetic composition of a population. Fast growing individuals tend to be selectively removed from the population and this may lead to a smaller size and lower age of maturation. There are indications that this happens with North Sea cod and plaice. Target species play an important role in the food chain of the North Sea. Reduction in the stocks of target species leads to a reduction of food availability for some species but will, on the other hand, decrease the predation pressure on other species. Such interactions can alter the composition of the total fish population.

Seabed disturbance is caused by towed demersal gear, notably beam trawls. Demersal fishing occurs throughout the North Sea but its distribution is patchy. Of the total beam trawl effort, 80% is conducted by the Dutch fleet covering about 40% of the area between the Shetland Islands and Hardanger Fjord, and the Strait of Dover. Other investigations show that some areas are visited more than 400 times a year and some not at all. Sediments are turned over each time to a depth of at least 1 – 8 cm. Tracks may persist for a few hours in shallow waters with strong tides, or for years in the deeper areas. Disturbance of the seabed increases the resuspension of sediments and alters the structure of both soft and hard substrates. Disturbance by demersal gear, including in some areas gear used for catching shellfish, affects biogenic structures that provide a habitat for many organisms, e.g. mussel beds, cold water coral and *Sabellaria* reefs and seagrass beds. Changes in habitat structure are followed by changes in species assemblages.

Various effects are associated with discards and with mortality of non-target species by fisheries. Certain fishing practices lead to the discarding of more than half of the weight of all fish species caught and considerable amounts of benthos. In addition, significant amounts of offal from gutting are dumped. Estimates of discarded fish alone (including offal) amount to 0.55 million t, which is quite substantial compared to total annual landings of around 3.47 million t. Several species of scavenging seabirds do profit from these food sources which constitutes one third of their food requirements, and their populations have increased beyond historic levels.

Towed demersal gears kill both infauna and epifauna. The impact is determined by the size and weight of the gear, the type of substrate and the strength of tides and currents. Species composition has changed from larger, more long-lived species to smaller, more opportunistic species. Quantities of prey displaced, damaged or killed by the passage of towed gears are also made available for scavenging fish and other organisms. A number of fish species, mainly slow-growing species with low fecundity (e.g. large ray species) have declined over recent decades and the proportion of large individuals has decreased. Marine mammals and seabirds die as by-catch in gill nets and other fixed nets. More than 7 000 harbour porpoises are thus lost each year which is thought to pose a significant risk to their population.

Effectiveness of measures

Most of the main target fish stocks used for human consumption remain close to or outside safe biological limits. Of these, cod, haddock, whiting, saithe, plaice, herring and mackerel are jointly managed by the EU and Norway. In the North Sea, the main tool for modulating removal rates from these stocks is the Total Allowable Catch (TAC) system with its associated national quotas. However, the TAC system does not restrain the level of actual catches because of discarding, high grading and misreported or unreported landings. This may lead to an overshoot of the TACs and hence to maintenance of removal rates in excess of those required for the sustainable use of the stocks. An additional factor which adds to this problem is the adjustment for socio-economic reasons of some TACs to above the levels advised by ICES. A recent revision of the EU’s Regulations on monitoring and control is expected to enhance the observance of TACs.

No system for limiting fishing effort yet exists in the North Sea, apart from certain conditions included in the EU’s Multi-Annual Guidance Programme (MAGP). The size of the fleet of the EC Member States has been reduced in accordance with the overall target of MAGP III. This overall reduction, however, was only achieved because some states reduced their fleets beyond their obligations, thus compensating the failure of others. However, this has not resulted in reduced fishing effort because of compensatory increases in fishing efficiency. Within MAGP IV, which is currently in progress, a reduction of either fleet size or fishing activity is accepted as a way to achieve the desired decrease in fishing capacity for some sectors.

The selectivity of fishing gears, notably trawls, employed in the North Sea continues to be insufficient. This widespread phenomenon results in undesirable by-catch and discard levels. A new package of technical measures will become applicable in 2000 in Community waters. This, and the previous package, also includes a definition of closed areas and/or seasons for the protection of juvenile plaice (and hence sole), whiting and haddock (via restrictions on fishing for Norway pout), herring (via restrictions on fishing for sprat) and mackerel. Alternative gears and fishing techniques are being developed to reduce kills of non-target benthic fauna in the trawl path and to eliminate by-catch of non-target organisms such as bottom fauna and mammals. In co-operation with the fishing sector, these alternative techniques will be tested further for their effectiveness at reducing adverse effects and for their catching efficiency.

At present, the European Commission is in the process of widespread consultation within EU Member States on possible revisions to its Common Fisheries Policy. The intention is to achieve required and agreed revisions by or before 2002 but this date is not, for most topics, obligatory.

The effect of the Norwegian discard ban or of any real-time closures instituted by Norway is unmeasured. Due to the discard ban, Norwegian vessels have to leave areas where fish of illegal size or protected species are caught in quantities above the legal by-catch level. Therefore, the discard ban and real time area closures will in principle reduce fishing mortality of undersized fish or protected species.

Various national conservation measures have also been introduced. Examples include restriction of the cockle fishery in the Dutch Wadden Sea and permanent closure of a part of the intertidal area. In the UK, a number of nursery areas for bass have been protected. UK national legislation insists upon the use of more selective gear in all Norway lobster fisheries and some whitefish fisheries. In 1996, Germany temporarily closed an area of the German Bight to all fishing activities in order to protect juvenile cod.

Recommendations

The outcome of the present quality status assessment calls for appropriate management actions by the competent authorities and international bodies. In view of the large impact of fisheries on the North Sea ecosystem, the conclusions of the 1997 Intermediate Ministerial Meeting should be included into the EU Common Fisheries Policy and Norwegian fisheries management policy. In particular, further development of the ecosystem approach and implementation of it and the precautionary approach to fisheries management is an important step in sustaining harvests and ecosystem health. One of the most urgent issues in this process is the further integration of environmental objectives and fisheries policy (5NSC, 1997).

For immediate action and to help facilitate the initiation of this new policy, the following management actions should be considered:

- To ensure sustainability of the major fish stocks, further consideration should also be given to the application of a precautionary approach to fisheries management as defined in 1998 by ICES and implemented for the first time for a range of stocks by the EU Council of Ministers when setting TACs for 1999. The implied reduction in the fishing effort for many stocks should ameliorate the current situation with respect to other biota, habitats etc;
- To this end, reduction of fleet capacity and the associated fishing effort should continue to be pursued both in the EU and in Norway. The objective is to attain stock sizes clearly above safe biological limits and to minimise ecological damage;
- Additional closed areas which protect juvenile fish should be identified, implemented effectively, and their effect on improving recruitment to the fishery should be evaluated;
- Closed areas should also be considered for the protection of specific benthic habitats if identified to be of conservation value, and methods for the effective closure of benthic habitats should be further developed;
- Development and application of fishing gears which reduce or eliminate catches of non-target organisms and habitat disturbance should be encouraged;
- Early consideration should be given to the management of North Sea sandeel fisheries;
- In view of the complex effects of fishing activities on target as well as on non-target species, in a longer term perspective efforts should be made to develop a multi-species approach as a first step towards the ecosystem approach;
- To ensure better integration of fisheries management with more general environmental needs the research base which is needed to underpin the present limited knowledge of the marine ecosystem should be increased.

6.2.3 Category trace organic contaminants

Changes and evaluation of impact

The category of trace organic contaminants has two sub-categories: trace organic contaminants from land (excluding oil and PAHs, which are dealt with in section 6.2.5); organotin compounds and other anti-fouling substances used by shipping.

Inputs of trace organic contaminants from land include all pathways, e.g. riverine, direct, atmospheric, sewage and sludge formerly deposited, and the dumping of dredged material. Sources can be within or outside the OSPAR area, since long-range transport via air and water commonly occurs. Dispersion of trace organic contaminants covers the entire North Sea and recovery times can be long, for some of them of the order of a century. Most of the available trends concern concentrations in biota, mainly fish (liver) and mussel tissue.

In relatively contaminated coastal areas, decreasing levels of the pesticides α- and γ-HCH (lindane) have been observed in biota. Recent experiments have suggested that lindane affects grazing by zooplankton, thereby enhancing phytoplankton growth. Concentrations of HCB, which at present mainly originate from industrial processes and municipal waste incineration, and the pesticide DDT have decreased at most locations. Long after banning DDT, elevated levels were still observed in UK surveys of fish livers from the Forth and Humber estuaries. There is advice against human consumption and restrictions on the sale of fish and shellfish from several Norwegian fjords because of high PCB levels. High concentrations of the pesticide toxaphene were measured in dolphin blubber from the central North Sea.

In general, the extent of the adverse effects of many pesticides on the health of organisms is unknown and, given their extensive use, this is an issue of serious concern.

At present, trends in PCB concentrations are either absent or slowly downward in the North Sea. BRCs in fish liver and mussel tissue were exceeded in some coastal areas and fjords. Although the ecological risks of PCB contamination were recognised more than a decade ago, recovery times appear to be longer than anticipated. There is increasing scientific evidence for the negative effects of PCBs on hormone metabolism and reproduction in harbour seals, although links with decreased resistance to diseases are as yet unclear.

In the case of dioxins, which are mainly formed during production and incineration processes, a limited number of downward trends in concentrations in biota have been observed. The presence of dioxins in several seafood species concur with high levels in sediments found at some Norwegian locations.

The presence of the polycyclic musk fragrances AHTN and HHCB was demonstrated in German coastal waters. The levels of AHTN in the water remained constant, although HHCB levels had increased at some stations. A multitude of other organic compounds, e.g. brominated flame retardants, pesticides such as dieldrin, simazine and atrazine, PCT (polychloroterphenyl, its chemical characteristics being comparable to PCB), benzothiazoles and the cleaning agents octylphenol and nonylphenol ethoxylates (with suspected hormone disruptive capacity), have been measured in water, sediment and biota. In the absence of information on trends and ecotoxicological criteria the significance of these concentrations is not yet clear. However, a survey of fish in UK estuaries revealed distinct oestrogenic effects in some of the populations. Further research is being undertaken. It should be stressed here that an increasing number of man-made compounds are being detected in the North Sea for which ecological effects are largely unknown.

The impact of tributyltin (TBT) from shipping is greatest in harbours, marinas and shipyards, and close to shipping routes. EACs for sediments are exceeded by up to 30 million times in some harbours, necessitating special attention in some cases with regard to the removal and disposal of sediments to avoid dispersing the contamination. Away from the sources, concentrations in water and sediments are often below detection limits, which are close to or even above the EACs, although accumulation of TBT in aquatic organisms and seabirds is encountered, even in remote areas. The most prominent ecological effect of this substance is changes in sexual organs, leading to impaired reproduction in several species of marine snails. In addition, shell thickening has been observed in oysters. The grazing capacity of zooplankton is also affected by low TBT concentrations, with problems similar to those mentioned for pesticides. Marina areas still show evidence of historical contamination. Recovery times may well be in the order of decades. Information on other antifouling substances is limited.

Effectiveness of measures

Although the uses of PCBs have been banned, some measures still need to be implemented. At the third North Sea Conference (1990) and in PARCOM Decision 92/3, it was agreed that by 1995, or by the end of 1999 at the latest, measures should be taken to phase out and to destroy in an environmentally safe manner all identifiable PCBs and hazardous PCB substitutes. Similar measures are provided for in Council Directive 96/59/EC. The absence of major improvements in sediment quality is partly due to turbation of previously deposited, contaminated sediments, which can act as a source.

Following reduction measures on industrial sources of dioxins, concentrations in sediments and seafood close to these sources have decreased significantly, but are still high.

In the Forth estuary, concentrations of HCBs in water decreased owing to reduced effluent discharges.

The target set in PARCOM Recommendation 92/8 to phase out the use of nonyphenol ethoxylates (NPEs) for domestic purposes before 1995 has been met. Progress in meeting the target of phasing out NPEs from cleaning agents for industrial purposes by 2000 has not yet been assessed. As there is no systematic monitoring for NPEs in the marine environment, associated improvements cannot be evaluated.

Few trend studies on TBT are available. These show decreased concentrations owing to the reduction in the use of TBT and the development of new antifouling paints, although TBT concentrations still often exceed safe levels. In general, information on the trends of persistent organic contaminants is very scarce.

Recommendations

Both the fourth NSC and the 1998 OSPAR MMC agreed to move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020 starting with the substances mentioned in Annex 2 (OSPAR List of Chemicals for Priority Action) of the OSPAR Strategy for Hazardous Substances. Although the main policy target is well in place, significant effort is required in order to accomplish this goal, especially for diffuse sources. Establishing a lead country for each priority substance is important for the implementation process within the OSPAR framework.

At present, a dynamic mechanism is being developed as in integral part of the OSPAR Strategy with regard to Hazardous Substances, to select the hazardous substances to be given priority in addition to those already mentioned in Annex 2 of this strategy. In view of the enormous number of substances of possible concern for the marine environment it is essential that this mechanism is finalised as soon as possible. Techniques should be developed for detecting the presence of such substances in the marine environment, including biomarker assays, and identifying their sources and pathways. This may involve one-off surveys by competent laboratories and, where appropriate, the application of biological effects monitoring techniques.

Within the IMO, a mechanism for a general ban on the use of organotin compounds in anti-fouling paints has been decided. The target is to prohibit their application from 2003 and to require the removal of TBT from ships' hulls by the year 2008. Given the serious effects of TBT on snail and bivalve populations, effective implementation of this measure is required. Within the EC the control on other TBT applications has been increased after a revision of the Directive 76/769/EEC.

6.2.4 Category nutrients

Changes and evaluation of impact

The anthropogenic input of nutrients from land and changed nutrient ratios primarily affect the coastal zone. Nutrient related problems are widespread in particular estuaries and fjords, the Wadden Sea, the German Bight, the Kattegat and the eastern Skagerrak. Negative impacts include periodic disturbances of the ecosystem such as oxygen depletion and the subsequent mortality of benthic organisms, as well as changes in the abundance and diversity of the different animal and plant communities, e.g. increased phytoplankton blooms including, occasionally, harmful species. As a result of periodic oxygen depletion in the Kattegat bottom water, fishing for Norwegian lobster has almost ceased in this area. In view of the storage of nutrients in the sediments, recovery times can be of the order of decades.

Effectiveness of measures

The second NSC agreed to aim to achieve, between 1985 and 1995, a substantial reduction of the order of 50% in inputs of phosphorous and nitrogen, into areas where these inputs are likely, directly or indirectly, to cause pollution. The 1995 Progress Report for the fourth NSC indicates that for phosphorus an overall reduction of 50% would be achieved by most countries, whilst for nitrogen the overall reduction was only about 25% mainly due to rather little progress in the agricultural sector.

Since 1985 there has been a significant reduction in the total inputs of phosphorus, but no clearly discernible reduction in riverine inputs of nitrogen to the North Sea. This is primarily due to the poor reduction of the input to the aquatic environment from agriculture. Riverine inputs showed big annual differences related to differences in river flow. No trends were detected over the period 1990–6. However, over the same period the direct inputs of nitrogen decreased by about 30% and those of phosphorus by about 20%, which reflects improvement in sewage treatment. No general trends were noted for atmospheric inputs. Within the EC Council Directive 91/271/EEC concerning urban waste water treatment and Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources are applicable. The 1998 implementation reports on these directives illustrated their rather poor implementation.

In general, nutrient concentrations in coastal waters did not show a significant trend over the last decade. However, along the coasts of the south-eastern North Sea phosphorus levels have significantly decreased since 1989, owing to reduced phosphorus loads from sewage and industry. Model calculations suggest that a 50% input reduction of both nitrogen and phosphorus may yield up to 30 – 45% reduction in eutrophication parameters. Coastal regions will benefit more than the central and northern North Sea. The merit of a 50% reduction in inputs has been illustrated in Danish waters where, in a two year period of low rainfall (1996–7), the ecosystem responded positively to low riverine inputs of nitrogen.

A number of areas under the influence of inputs from land-based sources continue to suffer from eutrophication. However, some improvement with respect to nuisance algal blooms, oxygen depletion and benthos/fish kills has been seen in many areas.

Recommendations

In view of the negative impacts of anthropogenic nutrient inputs over extended parts of the North Sea coastal zones, implementation of the OSPAR Strategy to Combat Eutrophication should be pursued vigorously. An important first step is to take the necessary action to achieve the agreed 50% reduction target, in particular with regard to nitrogen. Efforts should be focused on emissions, discharges and losses from agricultural and urban sources, in particular through enforced application and compliance with the EC Directives 91/676/EEC and 91/271/EEC concerning nitrate and urban wastewater treatment. Further measures should aim at reducing mineral surpluses. In support of the Strategy, efforts should be made to complete the development and application of the classification criteria for establishing the eutrophication status and to evaluate the situation that will exist when the 50% reduction in the inputs of nutrients has been achieved.

Research efforts should focus on qualitative and quantitative links between nutrient enrichment and environmental responses. Emphasis should be placed on the environmental effects of oxygen depletion and on changes in the community structure of planktonic as well as benthic algal species.

CLASS B: UPPER INTERMEDIATE IMPACT

6.2.5 Category oil and PAHs

Three major sources of contamination by oil and PAHs have been considered: land based sources; offshore oil and gas industry; and shipping.

Changes and evaluation of impact

The impact of oil in the marine environment is related to its form, dispersion and degradation and to the sensitivity of the areas affected. Despite the efforts made, overall estimates of oil entering the North Sea are not well established, but the 1993 QSR indicated a range of 86 000 – 210 000 t/yr.

Land-based sources of oil are mainly reflected in riverine inputs and loads directly into marine waters via point source discharges. Although the 1993 QSR indicates a total oil input via rivers and land run off in the range 16 000 – 46 000 t/yr, there are difficulties in obtaining more up-to-date estimates. The only recent data is for the Dutch sector where riverine loads were estimated at 3 430 t in 1995. For direct discharges, the 1993 QSR indicated that oil inputs were in the range of 13 000 – 35 000 t/yr. Except for refineries, which discharge oil to rivers and directly to marine waters, there is no recent data on point source loads of oil from land based sources. Although no systematic assessment has been made, legal and illegal discharges of oil from shipping contribute to the contamination of the North Sea and harbours.

An overwhelming majority of refineries had complied with the measures stipulated in PARCOM Recommendation 89/5 by 1997 and the amount of oil discharged has decreased considerably. The total input was reduced by more than 50% between 1993 and 1997, to inputs of less than 1 000 t, and by more than 90% since 1981, when inputs were just over 9 000 t. Data for the Dutch sector of the North Sea indicate decreased riverine inputs of oil.

Total inputs of oil from the offshore oil and gas industry (475 installations) have decreased from 28 000 t in 1985 to just over 10 000 t in 1997. Approximately two thirds of the input was from discharges of produced water in 1995. Produced water quantities have increased progressively during recent years due to the maturation of oil fields. Inputs of oil from cuttings have progressively decreased owing to replacement of oil based drilling muds or, by water-based and organic-phase drilling fluids (OBF). Since 1996 the discharge of oil based cuttings has ceased.

OSPAR has not established an EAC or BRC for oil. Comparison of effect concentrations derived from laboratory tests and oil concentrations near drilling sites predicts persistent effects on benthic communities within 200 m of the source. In field surveys, major changes have been found up to 1000 m from the source. The faunal effects can extend to 3 km or more. Elevated levels of hydrocarbons in sediments can be found up to 8 km from some oil fields. With the present numbers of installations, the area potentially affected may be substantial. No trends in oil concentrations could be established.

The amount of oil discharged into the North Sea from shipping was estimated at 6 750 t in 1995. Oil spills predominantly originate from shipping accidents. Accidents such as that involving the ‘Braer’ (1993, 86 300 t) can occasionally cause large releases of oil. Impacts of accidents such as that involving the ‘Pallas’ (1998) can be significant, due to local (e.g. Wadden Sea) and seasonal (overwintering of seabirds) factors, even though the release of oil is relatively small in quantity. Operational discharges of oil are much more frequent than accidental ones. Cumulatively, they may have a greater impact on the environment. However, there are international standards which, if followed, should prevent such discharges creating oil slicks. Since 1989 the number of oil slicks observed in a year has decreased markedly, although recent data suggest increased frequencies in offshore areas. Many of the spills from shipping may go unnoticed. Each year tens of thousands of seabirds die from oiling. However, the consequences for seabird populations are largely unknown. Relatively constant, high oiling rates are found along the Danish West Coast. In the other observed regions of the North Sea, including the Danish part of the Wadden Sea and along the Dutch coast, bird oiling rates appear to be declining.

Inputs of PAHs are related to sources on land, the offshore industry, and shipping, but respective loads are not known. PAHs are widespread, particularly in sediments, including those in offshore areas. No significant reduction in sediment PAH concentrations in the Dutch coastal and the Wadden Sea areas were found. In some highly contaminated areas, decreasing levels in biota have been observed for PAHs (fluoranthene, pyrene and benzo[*a*]pyrene). The lower limit of the EAC for pyrene in sediment is exceeded at almost all the locations that are reported on in Chapter 4, but the situation is better for the other PAHs. Background values for water and biota are still under discussion. Liver tumours in North Sea flatfish can be correlated to contamination, especially PAHs, but also to persistent chlorinated hydrocarbons.

Effectiveness of measures

Discharges of oil from refineries were reduced by more than 90% over the period 1981–97. Most refineries meet the OSPAR discharge standard of 5 mg/l total oil, including aromatic compounds, in effluent (PARCOM Recommendation 89/5).

The total input of oil from the offshore oil and gas industry has decreased significantly since 1985, but has stabilised since 1993. Discharges of oil based cuttings have ceased in accordance with PARCOM Recommendation 92/2. Measures to improve produced water quality have been effective, with most discharges meeting the standard of 40 mg/l oil in water (PARCOM Recommendation 86/1). However, the total volume of produced water has, for various reasons, increased significantly and consequently the overall input of oil via this source has progressively increased.

From 1 August 1999 the North West European Waters, including the North Sea, have become a Special Area under Annex I of MARPOL. Thus, discharge of any cargo-related oil from tankers is prohibited, and stricter controls on the discharge of processed bilge water from the machinery space of other ships have been introduced.

Inputs of PAHs from the offshore oil and gas industry will have decreased by virtue of the reduction of inputs of oil. In order to reduce the input of PAHs from land-based sources, application of one-component coal tar coatings on inland ships were phased out from the beginning of 1999 (PARCOM Recommendation 96/4). Also, limit values have been agreed for emissions to air from aluminium electrolysis plants, which should be achieved by the year 2007 (OSPAR Recommendation 98/2). The present assessment, however, shows that concentrations of PAHs in sediments do not follow a clear trend.

Recommendations

The following actions should be considered:

- The establishment of better estimates of oil and PAH inputs from all land based sources;
- The expeditious fulfillment of the objectives of the OSPAR Strategy for offshore oil and gas activities.

With regard to shipping, it is considered desirable to strengthen existing measures to ensure the continued decline in illegal discharges of oil, e.g. the provision of waste reception facilities in ports, a matter currently under consideration by the EC, the development of measures to promote the use of such facilities, and simplifying control and enforcement. The further development of tools to determine sources, e.g. fingerprinting and tagging, should be pursued.

Based on available knowledge of sources and pathways of PAHs, further programmes and measures, e.g. for creosoted timber and wood burning stoves, should be considered and developed as necessary. Moreover, reliable information is needed on concentrations and effects of PAHs in the marine environment.

6.2.6 Category heavy metals

Changes and evaluation of impact

Concentrations in water, sediments and biota decrease from the coast to the open sea. They are highest in estuaries, fjords, and near industrialised zones and densely populated areas. Mean concentrations of cadmium and lead in water have decreased in the North Sea, comparing the periods 1982–5 and 1986–90. This reflects the significant reductions in the inputs of all heavy metals in that period. In most areas, levels of cadmium, mercury, lead and copper in sediments and biota decreased or showed no significant trend, depending on the area. The possibility that some early data sets may have been affected by poorer quality data cannot be discounted, however.

Heavy metals are naturally occurring and do not degrade. Anthropogenic contributions may cause serious effects. There is evidence of local effects close to known sources, but no evidence of widespread toxic effects. Effects on biota can be expected in areas where EAC limits (in sediments and water) are exceeded, especially if the observed concentrations are higher than the upper EAC limits. Such areas have been observed for the water and sediment compartments. It must be noted here that only provisional EACs exist for heavy metals in sediments, while EACs for biota are still lacking.

Most reported cadmium levels in seawater are within the EAC range, except for the most contaminated locations in some estuaries, where the EAC upper limit is exceeded or approached. Mercury levels in seawater seldom exceed the EAC lower limit, and lead concentrations are generally below the EAC values.

Reported levels of lead in sediments are within the EAC range or even exceeded the EAC upper limit. For the other metals, the EAC upper limit in sediment is exceeded in some estuaries and in some locations in the Dutch Wadden Sea (cadmium). In addition, concentrations of metals in sediments have been reported to exceed the EAC lower limits in a much larger area, in some locations in the German (cadmium), Dutch (cadmium and copper) and Belgian (cadmium, mercury and copper) coastal zones.

BRCs for cadmium, mercury, lead and copper in biota, i.e. blue mussels, are exceeded in some estuaries, fjords and along the south-eastern coast of the North Sea. For example, the BRC for cadmium in blue mussels is exceeded 95-fold in the Sørfjord and 20-fold in the Hardangerfjord, due to the presence of smelting industries. In the Sørfjord, advice against the consumption of blue mussels, because of high metal concentrations (cadmium and lead), has been issued. The levels of mercury in fish muscle exceed BRCs at some locations along the east coast of the North Sea.

Ecological risks mainly concern the marine life in estuaries and in the coastal zone. Some of these areas where heavy metal concentrations are highest may also be of major ecological importance as habitats, breeding and feeding grounds for numerous species. Cadmium, mercury and lead accumulate in organisms at any trophic level and end up in top predators (fish, birds, sea mammals or even man), while copper can affect the phytoplankton species composition and its productivity.

Recovery times are in the order of decades. Dissolved metals are transported with the water masses and remain for 1 – 3 years in the North Sea. Most of the particulate bound metals, however, are trapped in sedimentation areas where they pose a risk to benthic organisms. Even metals bound to buried sediments may become available by resuspension and mobilisation.

Effectiveness of measures

Policy measures have resulted in important reductions in the atmospheric deposition of cadmium, mercury and lead, in riverine inputs of mercury and in direct inputs of cadmium, mercury, lead and copper. Most countries have reached, or are close to, the reduction target of 50% set for the period 1985–95. In some areas with a high sedimentation rate and in estuaries, fjords and enclosed seas which are more exposed to contamination, these reductions have led to lower levels of cadmium, mercury, lead and copper in sediments. Cadmium and lead concentrations in water, and mercury levels in biota have decreased in most areas of the North Sea. Major reductions at sources and in concentrations have been achieved.

Recommendations

Previous input reduction measures for heavy metals have proven effective to some extent. Despite these achievements, cadmium, mercury and lead should still remain substances for priority action under the OSPAR Strategy with regard to Hazardous Substances. Effective implementation of the recommendation to phase out mercury-based processes of the chlor-alkali industry should be pursued. No OSPAR recommendations have yet been issued for copper. Since this metal mainly comes from diffuse sources and as it is used in anti-fouling substances as an alternative for TBT and tar, consideration of appropriate measures is recommended.

This quality status report shows that specific measures should be developed at the appropriate level to solve regional and local problems.

6.2.7 Category other hazardous substances from sea-based sources

Changes and evaluation of impact

Inputs of hazardous substances, other than oil, PAHs and anti-fouling substances, are considered from two sources: the offshore oil and gas industry and shipping.

The main inputs of hazardous substances from the offshore oil and gas industry arising from produced water (and formerly in oil-based muds) and from flaring operations, comprise benzene, added chemicals, phenols and benzoic acids. Barium and iron are the most dominant elements, but smaller amounts of other metals are also found, especially nickel, lead and zinc. Although concentrations of contaminants in produced water can be estimated, available information is too limited to make an assessment of impacts on environmental quality and ecosystem effects. Increasing oil production and ageing of the oil fields are reasons for growing concern. This is because quantities of produced water will increase and associated discharges of hazardous substances are expected to increase further.

Shipping causes input of hazardous substances through cleaning tanks, burning fuel that contains waste products, discharges of waste and loss of cargo. A variety of substances enter the environment, e.g. phosphorus ore, pesticides, lipophilic substances. Discharges of the latter group of substances are permitted in some cases, but have caused the death of many seabirds along the Dutch coast.

Effectiveness of measures

Between 1996 and 1998 a number of decisions were adopted by OSPAR in order to regulate discharges of waste and chemicals from offshore installations, and in 1999 OSPAR adopted its Strategy on Environmental Goals and Management Mechanisms for Offshore Activities. In 1995, PARCOM adopted a ‘harmonised offshore chemical notification’ format (HOCNS) to facilitate the control of chemicals used and discharged offshore. Additionally, a procedure has been put on trial, which provides a means of assessing chemicals according to their hazard ranking. Together, these procedures have enhanced national control measures and promoted the principle of substitution whereby more hazardous chemicals are replaced by those which are less hazardous.

Within the framework of IMO, several measures have been taken in order to reduce pollution to air and water from ships and to reduce further the risk of shipping accidents, including routeing measures. Furthermore, measures were taken to reduce the number and quantity of illegal discharges more effectively, and to increase the safety of shipping traffic. Within the Bonn Agreement Contracting Parties adopted the FEPO (Facilitating Effective Prosecution of Offenders) Manual as a means to improve and facilitate the effective prosecution of offenders against MARPOL. The second part of the Manual on Oil Pollution containing guidelines on international co-operation was adopted on 1 October 1999. These guidelines are a step forward in the regional implementation and enforcement of the MARPOL regulations.

Recommendations

Although the offshore oil and gas industry and shipping are two of the main activities in the North Sea, the information which is currently reported within OSPAR only allows limited scope for assessment of the impact of hazardous substances mentioned in this section. More information is needed on current and potential inputs, field concentrations, chemical fate and biological effects of such substances. Co-operation and the exchange of all relevant information, in line with the EC Council Directive 90/313/EEC on 'freedom of access to environmental data', is required. Active dissemination of information to the general public through a variety of means (e.g. publication of reports, information to press, web-sites) is of key importance for increasing public awareness and understanding by all stakeholders. To this end, reporting efforts within OSPAR should be reinforced and actions should be considered.

With regard to the offshore industry, effective implementation of the OSPAR Strategy on Environmental Goals and Management Mechanisms for Offshore Activities should be pursued.

With regard to shipping, actions such as the following should be considered:

- Ratification and effective implementation of various international agreements, such as Annex VI to the MARPOL. The EU Directive on Harbour Reception Facilities, which is currently being developed, should be a major step forward in the reduction of waste discharges;
- Measures to recover lost cargo, e.g. tags and transponders, should be promoted in international forums and could be beneficial from both an ecological and an economic point of view;
- International co-operation on control, enforcement, cost claims and sanctioning should be further strengthened;
- Positive economic incentives delivering environmental benefits should be developed.

6.2.8 Category biological impacts

Changes and evaluation of impact

The importance of biological impacts is mainly due to the high potential risks of diseases, changes of species composition, the introduction of toxic algal species and genetic changes in indigenous fish populations.

Non-indigenous species can spread out over large areas and ecosystem recovery may be impossible. Several activities may lead to an introduction of organisms, such as: the introduction of non-indigenous species by shipping; introduction of cultured specimens, non-indigenous species, diseases and parasites by mariculture; and inputs of microbiological pollution from land.

Ballast water is one of the main vectors for the introduction by shipping of non-indigenous species into the North Sea. Alternatively, organisms may be transported while attached to the hull of a ship. Throughout history, several species are known to have been introduced by shipping, e.g. the North American razor clam, and a polychaete (worm) species. Some of the newcomers, e.g. Japanese seaweed, appeared to have deleterious effects in their new environment by outcompeting indigenous species, while in other cases no adverse effects have been demonstrated. However, observed examples (e.g. in the Mediterranean) show that these risks should not be underestimated.

An example of an introduction of non-indigenous species by mariculture is the toxic alga *Fibrocapsa japonica.* This planktonic species has been observed in the entire Dutch coastal zone and in the German Wadden Sea. Its toxin appears to accumulate through the food chain, as fibrocapsine has been demonstrated in dead seals. A growing concern is human consumption of shellfish containing algal toxins, which may affect public health.

Introduction and escape of cultured specimens may cause changes in the genetic composition of wild stocks. The number of escapees may well contribute to a loss of genetic diversity and reduce the ability of wild salmon stocks to adapt to local environmental conditions. The extent of such effects on genetic composition is not well documented.

It has been shown that antibiotic resistance in bacteria evolves near fish farms. However, use of antibiotics has reduced significantly in recent years due to the development of effective vaccines.

Spreading of salmon lice from farmed to wild stocks of salmon is an issue of concern in the northern part of the region (especially in Norway). Heavy infection may cause large mortality and it appears that the problem with salmon lice has increased. The detailed mechanisms for transfer of lice from cultured to wild salmonids is not well documented. Infections, however, have been found to be heavier in regions with dense aggregation of aquaculture plants.

The microbiological quality of bathing water, which mainly depends on inputs of microbiological pollution from land, has improved in recent years due to the wider use and improvement of waste water treatment plants. A significant increase in the number of satisfactory locations was observed. However, bacteriological pollution from insufficiently treated sewage and from various diffuse sources remains an issue of concern along the shorelines of the North Sea.

Samples of shellfish are tested regularly in order to check the extent to which they are contaminated by *E. coli.* This determines whether the shellfish can go directly for human consumption or are required to be treated beforehand (Shellfish Hygiene Directive (91/492/EEC)).

Effectiveness of measures

In order to reduce the risk of introducing non-indigenous species, ballast water may be exchanged in open sea, although this can be hazardous and is not always possible for ships, depending on their design and the prevailing sea conditions. Within regional areas such as the North Sea this measure may not be effective in preventing the introduction of viable new species and would not often be practicable given the short voyage times. The IMO has published guidance on minimising the risk of introducing non-indigenous species, and this is widely available to the shipping industry. The IMO is currently developing draft regulations on ballast water management, although it is likely to be several years before such measures might come into force.

The EC Directive on urban waste water treatment (91/271/EEC) regulates treatment of sewage effluents. This directive must be implemented by 1999 to 2006, depending on the size of the agglomeration. Also, the EC Directive on the quality of shellfish waters (79/923/EEC) plays a significant role in protecting shellfish fisheries from sewage pollution.

Recommendations

The risk of introducing non-indigenous species during transit between continental shelf ports should be taken into account during the development of any regional guidelines for ballast water management. As differences in regulations between neighbouring ports could lead to undesirable economic effects, both the ecological and economic consequences of regional agreements should be considered. OSPAR Contracting Parties should take concerted action within the IMO in order to support and speed up the IMO's ongoing work on regulations for ballast water management. North Sea riparian states should consider the need for special regulations for the North Sea (or the North West European Waters).

As it is often not clear whether species found in ballast water are indigenous or non-indigenous, a comprehensive study is needed to determine the indigenous species for each of the riparian OSPAR states.

There is a need for more research on possible genetic effects of cultured salmon on wild stocks. Information about the spreading of parasites and diseases related to mariculture activities is also very limited and more research is needed.

In order to avoid health risks arising from the consumption of shellfish, continued effective monitoring of algal toxins is required. Monitoring of both water and shellfish flesh is already a requirement of the EC Directive on the quality of shellfish waters in order to prevent shellfish which are affected by toxins from being harvested and sold.

6.3 Limitations in knowledge

The assessment of the marine environment does not only suffer from gaps in knowledge, but also from incomplete understanding of the complexity of nature with synergisms and non-linear impacts. This, coupled with an absence or lack of fully developed assessment tools, often presents difficulties for the assessment of the impact of human activities. In the present section, key limitations in knowledge are listed. Some gaps in information are a consequence of earlier priorities, both in terms of geographical coverage and the range of substances and issues.

Climate change

In order to decrease the uncertainty about the occurrence and impact of climate variability on the marine environment, long term monitoring of key physical, chemical, and biological variables and further development of models and assessment tools is essential.

Contaminants and nutrients

It is recognised that the OSPAR riverine inputs and direct discharges (RID) programme of monitoring and reporting on the annual inputs of heavy metals, nutrients, PCBs and lindane provides a basic set of relevant data. The following points relate, therefore, to those contaminants not covered by the RID programme, or aspects of substances that are not adequately addressed by annual RID estimates alone:

- The lack of data on organic hazardous substances is very apparent. First of all there are analytical difficulties and insufficient commitment to funding the effort needed to establish the required detection limits. Secondly, further intercalibration and harmonisation of procedures is needed in order to generate reliable and comparable data sets. In addition, OSPAR failed to take up some of the proposed one-off surveys for specific compounds, e.g. pesticides. Contracting Parties therefore should take concerted action, for example by means of one-off surveys, to deal with hazardous organic substances which reach the marine environment;
- Consistent information on inputs, environmental concentrations and biological effects of chemicals from some sectors, such as the offshore industry, shipping and agriculture, should have been more easily available for the present assessment;
- The chronic and combined effects that hazardous substances have on organisms are not well known, which seriously hampers the assessment of their environmental risk. Endocrine disruption is one of the issues of emerging concern. More information is needed on the substances that affect the hormone systems of organisms, their effect concentrations and ecological impacts;

- Reliable quantitative information on sources and inputs of nutrients is needed. In addition, our understanding of the interrelationship between nutrient sources and eutrophication, and the influences of seasonal variations should be further improved. This will benefit the development of predictive tools for assessing with less uncertainty and greater reliability the direction and relative magnitude of human impacts;
- Trend monitoring in the OSPAR area is unsatisfactory due to insufficient quality assurance procedures and commitment to monitoring;
- There is a lack of data on inputs and fluxes of substances, which are important for establishing budgets for assessment purposes. Reliable estimates of inputs from the atmosphere and sources such as the seabed, adjacent seas etc. are especially needed. In general, a more holistic approach is required;
- A lot of existing data are either not available or not communicated, which is primarily a problem of accessibility and organisation.

Fisheries

- Detailed information is available for relatively few species impacted by fisheries;
- Additional spatial and seasonal data and improved models on multi-species interactions are needed, with special emphasis on predator-prey relationships among commercially exploited fish species and other vulnerable species;
- More information is needed on the longer-term impacts of demersal fisheries on the physical and biological environment of the sea bed. Alternative techniques for demersal fisheries are being developed, though no information on the extent of reduced impacts on bottom fauna and the seabed is available yet;
- Estimates of the seasonal and spatial variability of discards of target and by-catch species from major fisheries should be generated for use in models on the long-term impacts of fisheries.

Other human activities

- Comparable data is lacking on the economic benefits (and drawbacks in the case of misuse of North Sea resources) associated with the North Sea. Such information could improve the scope of a North Sea assessment;
- Information on tourism from different countries is incomplete and is not harmonised, despite being one of the major human activities in the coastal area of the North Sea. Appropriate assessment indicators on tourism could be developed. For instance, one-day visitors are not counted;
- The effect of genetic and ecological interaction of escaped salmon on wild salmon stocks is not well documented. Knowledge is also limited on the extent to which cultured salmon contribute lice to wild salmon and the risk of diseases spreading from mariculture to wild stocks.

Assessment tools

- OSPAR has applied sets of values to assess environmental concentrations, i.e. BRCs to compare with reference sites and EACs to integrate biological effects and chemical analyses. As these reference values are shown to be important for a correct assessment, the data sets need to be completed and updated, with special emphasis on persistent organic compounds. Furthermore, it would be necessary to improve EACs so that assessments can take into account the problems of chronic and combined effects of chemicals;
- Under the new Annex V of the OSPAR Convention, concerning the protection and conservation of the ecosystems and biological diversity of the maritime area, the Commission will aim to apply an ecosystem approach. In this context, Ecological Quality Objectives (EcoQOs) can play an important role. Work is being done to develop such objectives for the North Sea as a test case, incorporating both scientific knowledge and political deliberation. If this test case is successful it might form the basis for further use of EcoQOs. They could also be considered as an important tool in the classification of the ecological status within the EC Water Framework Directive.

Problems of regional intercomparability

The North Sea can by no means be regarded as a closed system. Its physical, chemical and biological properties are strongly influenced by the variable water exchanges with the neighbouring ocean and seas, the countries in its catchment area, and the atmosphere. As has been pointed out above, knowledge of budgets and fluxes is important for assessing the chemical status of the North Sea. This does not only require harmonisation of the monitoring effort, chemical analyses and data handling within the North Sea area, but also with the other OSPAR regions and the EU. Similar problems apply to the assessment of other human pressures, which are often transboundary in nature, e.g. shipping, fisheries, pipelines and cables. Also, assessment of the migration of organisms, both natural and through transportation by man, can be improved by concerted research and monitoring.

The interdependency of the North Sea and neighbouring OSPAR regions will be given further attention in the QSR 2000.

6.4 Overall Assessment

The aim of this section is to consider progress made in the prevention of pollution and the protection of the

Greater North Sea (OSPAR Region II). To this end, consideration is given to the changes that have occurred, building on the information given in the 1993 QSR. Transportation on the North Sea and the exploitation of living and non-living resources are increasing, and some areas, in particular the Norwegian Trench, continue to function as a sink for contaminants. Consequently, the ecosystems continue to suffer from a number of old problems, sometimes showing some signs of amelioration, but also new problems have arisen. The effects of hazardous substances, eutrophication, and the direct as well as indirect impacts of fisheries comprise the most important issues.

Riverine and atmospheric pollution originates mainly from those areas around the North Sea which are densely populated. Parts of the catchment area are heavily industrialised and intensively used for agriculture. The number of people living in this area is large (see *Table 3.1*) and has increased by about 10% compared to the early 1990s.

There is the potential for substantial effects to occur as a result of climatic changes. While both coastal zone ecosystems and human activities may be at risk due to sea level rise and increases in numbers and force of storms, unmanageable effects could occur if large-scale oceanic circulation patterns were to change. This would affect both the marine and terrestrial ecosystems and, obviously, interfere with man's activities. Although indications for this prospect exist, at present science does not allow for an accurate estimation of this risk.

Trends in human impacts

For many issues there have been improvements in environmental status since the 1993 QSR. Inputs of cadmium, mercury and lead have decreased. Estuaries, coastal zones and a very few locations in the sea near some well-known point sources show significant downward trends in concentrations in sediments and organisms. There seem to be generally decreasing trends in concentrations of PAHs and some organochlorines in organisms. There have been major reductions in oil discharges from refineries. Offshore, the discharge of oil from cuttings has ceased. Together, these account for a reduction of the order of 30 000 t/yr of oil entering the rivers and the sea. With respect to nutrients, there have been overall reductions in the inputs of phosphorus (of the order of 50% since 1985). There has been a reduction in the direct inputs of nitrogen (of the order of 30% since 1990) although this represents only a small proportion of the total input. The impact of the huge quantities of dredged material disposed of has decreased due to lower contamination of that material. However, increased capital dredging, needed for accommodating ships with a greater draft, will increase pressures from this activity. Some of this pressure may be mitigated by use of the best available dredging techniques and making use of the dredged material for engineering purposes within the estuary of its origin. Other contributions to the reduction of human pressures since 1993 were the cessation of the dumping of sewage sludge at the end of 1998 (the dumping of other industrial wastes was phased out in 1992) and the reductions in a number of the chemicals used in mariculture.

With respect to some other major human pressures, no general improvement can be reported. Inputs of produced water by the offshore oil and gas industry have increased. Overall inputs of nitrogen have not changed significantly. A number of areas still suffer from eutrophication. However, some improvements have been noted. Fishing continues to have a major impact on the North Sea ecosystems through the removal and discarding of target species, mortality of non-target species and the physical disturbance of benthic habitats. Many target fish stocks are outside Safe Biological Limits. Concentrations of the anti-fouling agent TBT still exceed safe levels in marina areas. 'Imposex' caused by TBT in a number of benthic organisms, is still a common phenomenon in the North Sea, although measures have improved the situation locally.

Coastal zone

In general, human pressures are greatest in the coastal zone as it is the area most immediately affected by waterborne contaminants, nutrients and many human activities. Human impacts in estuaries situated in industrialised and highly populated areas, such as the Seine, Western Scheldt, Rhine/Meuse mouth, Ems, Weser, Elbe, Forth, Humber and Thames, can include health problems for organisms, eutrophication and physical disturbance by dredging. In some Norwegian fjords, which are relatively sensitive to human pressures due to limited water exchange, and at some locations along the Scottish coast, mariculture can be a significant source of contamination. It also introduces diseases, non-indigenous species and escaped cultured fish. At the same time, mariculture is sensitive to contamination and to eutrophication effects, such as oxygen depletion and toxic algae. In many areas which are important as nursery grounds for young fish and sea mammals and as feeding grounds for birds, e.g. the Wadden Sea, fishing and shellfish harvesting conflict with these ecological functions.

Many sensitive coastal habitats in the southern part of the Greater North Sea, such as freshwater/saltwater transition areas, intertidal areas, wetlands and salt marshes, vanish due to draining, erosion or the construction of coastal defence structures or other installations. These coastal zones, in particular the sandy coasts, also tend to be severely disturbed by recreational activities. In addition, pollution of the coast by litter occurs on a large scale.

Although most areas in the coastal zone are relatively well-studied, information on the combined effects of human activities on the ecosystem and on conflicts between human activities is very limited.

Open sea
In the open sea, three main impacts of human activities occur.

Fisheries heavily affect the ecosystem by the regular removal of a large part of the total fish biomass. This activity not only removes food from the system, but also causes substantial mortality to non-target species. Benthic organisms, but also non-commercial fish species, birds and marine mammals are affected.

Inputs of contaminants occur in the open sea from the offshore oil and gas industry, for an important and increasing part through the discharges of produced water. Oil (including PAHs), but also phenolic compounds, possible endocrine disruptors, and chemicals used in the production process are discharged.

Some persistent contaminants also reach high levels in the open sea at the places where they are concentrated, such as sedimentation areas (in particular the Skagerrak and Norwegian Trench), and, in the case of lipophilic trace organic contaminants, in the fatty tissues of living organisms.

Finally, the intensive, sometimes conflicting, use of the North Sea causes a number of problems in relation to a healthy ecosystem and sustainable use.

6.5 Conclusions, outlook and recommendations

"There is hope because of the progress made, but concern because this progress is sometimes slow." (Former chairman of ASMO).

Conclusions
1. Generally, significant improvements can be reported in connection with the inputs of heavy metals, oil and the nutrient phosphorus. These improvements are predominantly reflected in the reduced pressure on the marine environment at a local or regional level. At the same time, an increasing number of man-made compounds are being detected in the North Sea for which the ecological effects are largely unknown.

2. Some improvements have been made with respect to TBT but existing levels are still a matter of concern. The situation will become more satisfactory once less hazardous anti-fouling coatings are introduced on a much larger scale than at present.

3. The inputs of some persistent organic substances have been reduced, but corresponding reductions in concentrations are not often observed in the marine environment. Further improvements are required. In general, the extent of the impact of many hazardous substances is unknown and, where there is significant use and pathways to the marine environment, such substances are of serious concern.

4. Certain activities give cause for concern because of their continued widespread impact or increasing trend. These include:

- impacts of fisheries by the removal and discarding of target species, seabed disturbance, and discards and mortality of non-target species;
- inputs of nitrogen from land-based sources;
inputs of oil and production chemicals to the marine environment from offshore oil and gas exploitation.

5. Dredging impacts have diminished because of the reduced contaminant load in the large quantities of material which are disturbed. Accommodating larger vessels will increase the quantity of dredged material and thus this human pressure.

6. The tools available for assessment are limited in their development and range of application. There is a need to improve the means of assessment and, to this end, to optimise and integrate the biological effects and chemical analysis approaches to monitoring and assessment.

7. There are (inevitably) gaps in knowledge. These relate both to the systematic spatial coverage of conditions in the Greater North Sea and to temporal trends. It should be noted however, that the complexity of natural systems with synergisms and non-linear impacts will always interfere with interpretation and assessment of data.

Outlook
1. The general improvements that have been made until now are reassuring and the five OSPAR strategies provide a framework for continuing these improvements. However, there is an urgent need to develop the measures necessary for their implementation, in order to meet their objectives and time scales.

2. Pressures associated with fisheries will, if the activity is not limited, assume a greater (relative) importance in terms of adverse impact.

3. Whilst some aspects of offshore oil and gas activity have improved considerably, there is likely to be an increase in the quantities of produced water discharged containing oil and production chemicals. This is due to the progressively maturing oil fields and the increasing production of oil and gas.

4. The significant increase anticipated in the size of cargo vessels using North Sea ports will result in additional physical disturbance with increased capital dredging in the short term.

5. With increasing space requirements in densely populated coastal areas and improving technical knowledge, more intensive use of the marine area can be expected. Spatial planning and integrated management, e.g. for artificial islands and offshore windmill parks, will become increasingly important in order to prevent conflicts between new and existing human activities and to protect marine and coastal habitats.

6. The major changes and impacts which could arise through rising sea levels and the increased severity of storms associated with global warming could cause effects far exceeding those caused by other human pressures, but they would be on a longer time scale. Should sea levels rise as predicted, the resulting coastal protection measures and possible land retreat will have significant impacts in the medium to long-term.

Recommendations

These recommendations complement the more detailed recommendations made in section 6.2. By their nature they are more general, or relate to matters common to several aspects of this QSR. The following actions and those described in section 6.2 should be considered by the appropriate authorities:

1. The OSPAR Strategies should be implemented, in line with their respective time scales for action, in order to ensure continuing improvements. To this end, adequate resources should be made available.

2. Future assessments of the quality status of the North Sea could benefit from improved co-operation with other fora on a European and even global scale, especially with regard to harmonised monitoring effort, data exchange and development of compatible assessment tools.

3. An overview of existing information and literature should be established in particular regarding the occurrence and effects of hazardous substances in the marine environment. Steps should be taken to close the gaps in knowledge and there is a need to concentrate effort on particular issues of concern. In respect of temporal trends and spatial surveys, monitoring efforts should be optimised within the JAMP.

4. Effort should be invested in developing tools for the assessment of substances and effects of concern, taking into account the merits of integrating biological effects and chemical monitoring approaches. Further development of biomarker techniques and more efficient data gathering is crucial, e.g. by one-off surveys by a pilot laboratory.

5. Given that some human pressures, or aspects of them, are likely to increase in the short term or are unlikely to diminish (cf. Outlook), the need for consideration of their impact should be reviewed in the short term and action taken accordingly.

6. On the basis that the possible changes associated with global warming will increasingly assume greater importance in the medium to long-term, the implications on the North Sea environment of those changes should be evaluated.

7. The ecosystem approach, which has been a major recommendation of the 1997 IMM, needs further development and application according to OSPAR's Annex V. An important aspect of this approach is improved integration between the different sectors operating on the sea, but also between scientists, policy makers and other stakeholders. Through concerted action these parties should progress towards effective protection and conservation of the ecosystems and biological diversity of the maritime area.

8. In order to increase understanding by all the stakeholders and by the general public of the human influence on the marine environment and the related policies, dissemination of information should be actively pursued by a variety of means (e.g. publication of reports, information to the press and web-sites).