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CONFERENCE
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1990 INTERIM REPORT ON THE QUALITY STATUS OF THE NORTH SEA

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February 1990

SUMMARY

1. The previous Quality Status Report on the North Sea (QSR), published in 1987, contained an overview of the information available on the quantity of contaminants being input to the North Sea, their concentrations in the North Sea, the resulting ecological effects and the evidence for trends. A complete update of this report will be carried out by the North Sea Task Force and is due to be finalized by 1993.

2. This report serves to fill the gap between both comprehensive reports on the Quality Status of the North Sea. It contains scientific information submitted by the North Sea Task Force on recent occurrences of exceptional algal blooms and the 1988 seal epidemic. The Task Force recognizes the existence of two types of sensitive issue: those of which the public is already aware of and those which the scientific community considers deserve special attention because of recent developments in scientific knowledge and understanding. The North Sea Task Force identified four sensitive issues of the latter kind. On the basis of this information the North Sea Task Force has made recommendations to address the gaps in knowledge and the sensitive issues in the 1993 Quality Status Report.

3. This report also presents data on the inputs of contaminants to the North Sea for the year 1988. In some cases data from earlier years had to be used. Except for the figures on shipping, the input data have been collected within the framework of the Oslo and Paris Commissions and have been presented by the Conference Secretariat with the approval of the states participating in the Third International Conference on the Protection of the North Sea. It should be noted that the 1988 data are preliminary due to the fact that they have not yet been examined and approved by the Oslo and Paris Commissions.

4. An assessment of the progress in the implementation of the agreements of the Second International Conference on the Protection of the North Sea can be found in the report "The implementation of the Ministerial Declaration of the Second International Conference on the Protection of the North Sea" (english only) and its "Executive Summary" (english, french and german).

Algal blooms

5. The precise events leading up to an exceptional algal bloom and the nature and effects of individual incidents differ. The *Chrysochromulina polylepis* bloom in the Skagerrak and Kattegat in May-June 1988, after its toxic nature became apparent, was typical of an exceptional algal bloom. The distribution of exceptional algal blooms recorded in 1988 and 1989 is a reflection of hydrographic divisions of the North Sea and areas which experience enhanced nutrient inputs. Exceptional algal blooms have previously caused problems for fisheries, aquaculture, tourism and recreational interests, but recently these effects appear to have been more frequent and serious.

6. The North Sea Task Force therefore recommends that:
- further research should be carried out into the occurrence of algal blooms, and their implications for the dynamics of coastal ecosystems;
- research should be initiated about the life cycle of toxic algae, and more particularly about the resting stage (cysts);
- research should be conducted into the possible association between the presence of fish farms and localized exceptional algal blooms; and
- monitoring of the proliferation of macroalgae should continue and research into exceptional occurrences should be carried out.

Seal stocks

7. The 1987 QSR contained an observation that seal populations had increased on the majority of North Sea coasts since the beginning of the century. In April 1988 an epidemic seal disease broke out which has had a significant impact on many seal populations in the North Sea. The total mortality among harbour seals up to December 1988 was approximately 18,000; in many eastern North Sea areas the mortality was about 60% of the 1988 population. The primary cause was a morbillivirus named Phocine Distemper Virus, which results in symptoms similar to those of the Canine Distemper Virus. An extensive array of research projects has been started in the wake of the epidemic, especially to assess the role, if any, of pollutants.

8. The North Sea Task Force recommends that:
- research should continue to establish the source and full characteristics of the 1988 seal epidemic;
- research should be conducted into the immune response of seals to the Phocine Distemper Virus and research on the role of contaminants should continue, in particular to establish the role played by contaminants in the 1988 seal epidemic; and
- in order to permit future studies of pathogens and contaminants in seal tissues, a blood and tissue bank should be established.

New sensitive issues

9. The North Sea Task Force has identified four new sensitive issues concerning the North Sea environment. These are:
- the impact of the fishing industry on the North Sea ecosystem;
- surveillance for chemicals not usually covered in routine monitoring programmes;
- the environmental impact of persistent chemicals; and
- the role of atmospheric input as a source of contaminants to the North Sea.

Inputs of contaminants to the North Sea in 1988

10. The estimated inputs via rivers and the atmosphere are both subject to considerable uncertainties. Therefore, no historical trends can be distinguished on the basis of the data presented. The order of magnitude of the inputs from both sources is comparable. In comparison with the other sources of inputs to the North Sea, riverine and atmospheric pollution can be considered as major sources.
From 1990 onwards, an improved data base on river inputs will become available within the framework of the Paris Commission as a result of mandatory monitoring using agreed methods. The Paris Commission Comprehensive Atmospheric Monitoring Programme and other efforts of the Contracting Parties may result in more reliable estimates of atmospheric inputs into the North Sea in future years.

11. The amounts of waste incinerated at sea show a tendency to decline since 1986. During 1988 approximately 96,000 tonnes of waste were delivered to be incinerated at the North Sea common incineration site; a decrease of 18% compared with 1986.

12. The United Kingdom is the only country which dumps sewage sludge from vessels in the North Sea. The amounts dumped in 1987 are comparable to those dumped in 1985, which is also the case for the quantities of most heavy metals and organohalogens which were contained in the sludge.

13. The extent of the dumping of dredged materials varies from year to year due to various conditions which influence the extent of dredging operations. In 1988 the quantities of contaminants contained in the dredged

materials dumped in the North Sea were of the same order of magnitude as the river inputs. However,
- the amounts of contaminants actually released from dredged material into the marine environment is unknown; and
- certain dumping operations do not result in an additional load of contaminants to the environment but in a relocation of contaminants.

14. During 1988, 1.7 million tonnes of liquid industrial waste were dumped in the North Sea, mainly originating from the titanium dioxide industry. Between 1985 and 1988 the amounts being dumped decreased by 21%, and the input of contaminants shows a proportionately greater decrease. In 1988, 2 million tonnes of solid industrial waste (largely colliery waste) was dumped in the North Sea; a level similar to previous years (allowing for the effects of industrial action), and a similar input of contaminants.

15. As regards the operational discharges of chemicals from ships, it is estimated that approximately 2,800 tonnes of harmful chemicals were discharged in 1988. No information has become available to improve the 1987 QSR estimates on oil discharges from ships (1,000-1,500 tonnes legal discharges and 1,100-60,000 tonnes illegal discharges). On the basis of information provided by North Sea states, no clear significant trend in observed oil slicks can be discerned since 1987.

16. The total amount of oil discharged from offshore platforms is estimated at approximately 29,700 tonnes in 1988, being equal to the amounts discharged in 1985 and an increase of approximately 9,000 tonnes compared with the discharges in 1987. This increase is mainly the result of a 50% increase in the number of wells drilled with oil based muds on the UK sector of the continental shelf. Oil discharged with production water is subject to an upward trend.

17. In spite of the increase in installed capacity of nuclear installations, discharges of radioactive substances into rivers entering the North Sea have been reduced by 75% between 1985 and 1987/8 as a consequence of measures taken to considerably reduce discharges.
This is not the case for tritium. Between 1985 and 1987/8, the total input of tritium to rivers entering the North Sea increased by approximately 70%, mainly due to the increased capacity of nuclear power plants along the rivers Rhine, Meuse, Scheldt and Elbe.

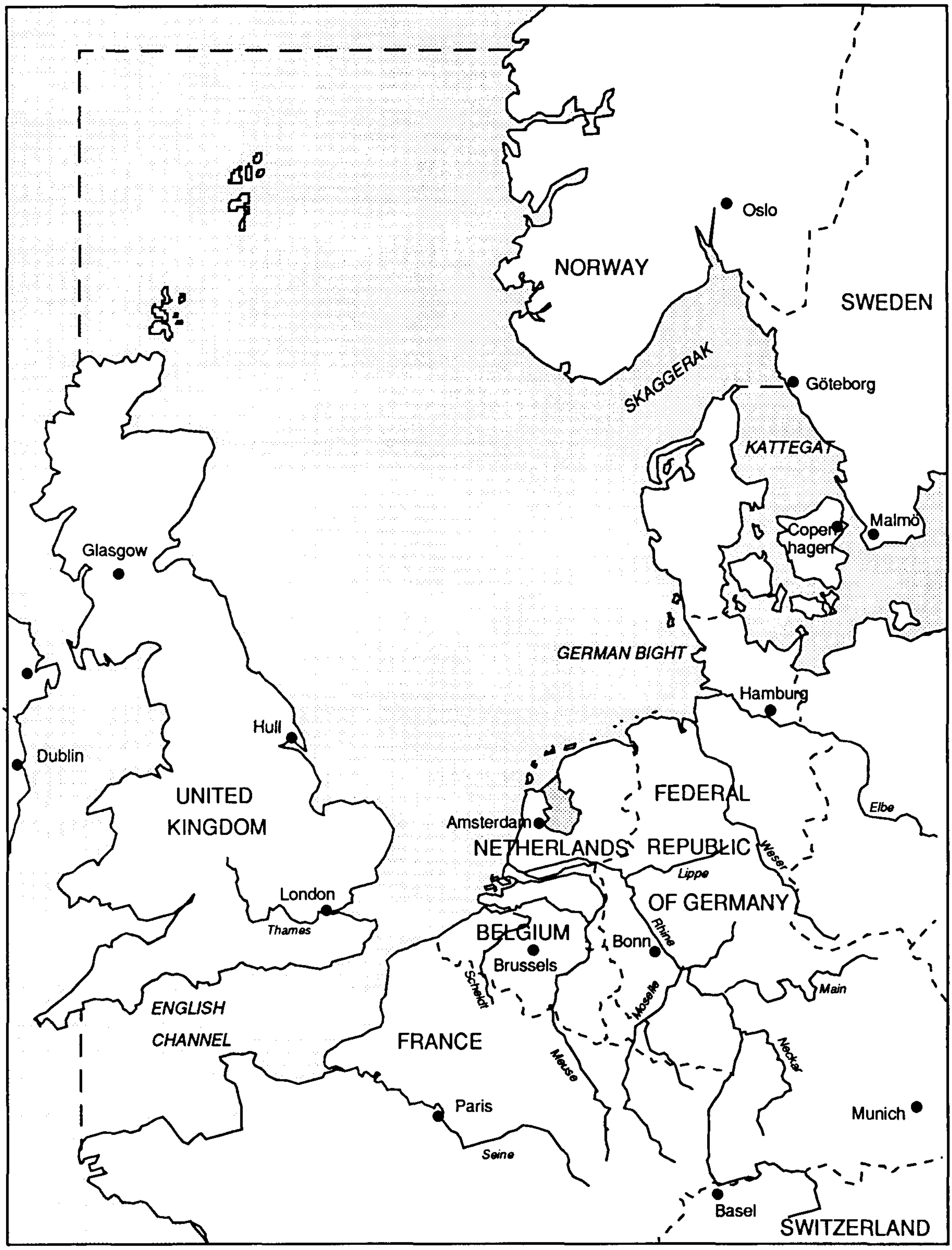

Figure 1 The North Sea

1. INTRODUCTION

1.1 The North Sea Quality Status Report (QSR) 1987, which was prepared for the Second International Conference on the Protection of the North Sea, contained an overview of the information available on the quantity of contaminants being input to the North Sea, their concentrations in the North Sea, the resulting ecological effects and the evidence for trends. Based on this information, the 1987 QSR also assessed the quality status of the North Sea.

1.2 The Second International Conference on the Protection of the North Sea used the 1987 QSR as a scientific basis for its decisions. Due to the fact that it takes several years for improvements in emissions to be evident in the marine environment, it was decided not to produce a new Quality Status Report for consideration at the Third International Conference on the Protection of the North Sea. A complete update of the 1987 QSR will be carried out by the North Sea Task Force and is due to be finalized by 1993.

1.3 The North Sea Task Force undertook to report to the Third North Sea Conference the results of scientific research on two major ecological incidents in the North Sea which have occurred since the Second International Conference on the Protection of the North Sea: the exceptional algal blooms and the seals epidemic. The North Sea Task Force has also reported on several "sensitive issues" which require special attention in preparing the 1993 QSR. These recent scientific findings are presented in this report.

1.4 In addition, it was deemed necessary to have more up to date information on inputs of contaminants to the North Sea available at the Third International Conference on the Protection of the North Sea. The input figures of the 1987 QSR, which were mainly based on the years 1984 and 1985, have therefore been updated. An important basis for this update was the data-set collected within the framework of the Oslo and Paris Commissions. The data presented in this report mainly cover 1988; in some cases 1988 data were not available and use was made of data from previous years. According to the procedures of the Oslo and Paris Commissions, the 1988 data are subject to confirmation in mid-1990.

1.5 For the purpose of the International Conferences on the Protection of the North Sea, the North Sea area is formally defined as:
- the North Sea southwards of latitude 62°N;
- the Skagerrak, the southern limit of which is determined east of the Skaw by latitude 57°44, 8 N;
- the English Channel and its approaches eastwards of longitude 5°W.

A map showing the area defined above is shown in Figure 1.

2. RECENT SCIENTIFIC FINDINGS

2.1 The ecological effects of algal blooms in the North Sea

2.1.1 One of the issues of concern highlighted in the 1987 QSR was the effects of pollution on plankton populations in the North Sea. It was noted that there have been marked changes in plankton populations in the North Sea in recent years; in particular, there has been an increase in the level of chlorophyll production in some coastal areas of the eastern North Sea and Kattegat. Although the exact cause of this phenomenon could not be established with certainty, some of the changes did appear to be linked to nutrient inputs, particularly along the eastern coastal zone. For example, in the German Bight off Helgoland, plankton biomass increased by a factor of four between 1962 and 1985, which was found to correlate well with known increases in nutrient inputs. The increased occurrence of extensive plankton blooms often leads to severe damage to marine communities. The occurrence of a bloom of *Ceratium furca* in the eastern North Sea in September 1981 is an example where severe oxygen depletion in the water column led to high mortalities among benthic communities over an area extending from the German Bight to the coast of Jutland. Nutrient inputs, particularly of nitrate and in some cases phosphate, have increased and in some shallow coastal areas there has been an increase in phytoplankton production and in the frequency and scale of undesirable plankton blooms. However, the 1987 QSR stressed that the relationship between nutrient concentrations and levels of phytoplankton is not a straightforward one and that other factors, such as changes in meteorological and hydrographic conditions, may also play important roles.

2.1.2 The North Sea Task Force agreed that research effort into the phenomenon of nutrient enrichment should be promoted and focused on:
- improved understanding of the input of nutrients to the North Sea;
- improving the understanding of nutrient dynamics, in particular, their relation to the occurrence of exceptional algal blooms in the North Sea;
- an assessment of the critical load of nutrients in the North Sea.

Exceptional algal blooms

2.1.3 The term "bloom" is used to refer to an outburst of growth in the plankton, resulting in a high biomass. It is usually applied to the spring and autumn outbursts of growth which are a normal feature of many sea areas. "Exceptional" blooms are those which are noticeable, particularly to the public, through their effects, such as visible discoloration of the water, foam production, fish or invertebrate mortality or toxicity to humans. Algal blooms are natural events, essential to productivity of the sea, and most types of exceptional blooms are not new occurrences. Nevertheless, there is evidence of recent, more frequent occurrences of algal blooms. This may be due partly to the collection of a larger number of observations owing to greater public awareness. It may also be due partly to the fact that mariculture operations in areas not previously used for fish farming are detecting effects of blooms that may otherwise have gone unnoticed.

2.1.4 The records of the Continuous Plankton Recorder Survey, covering several decades, clearly show that changes in plankton composition are occurring over the entire Northeast Atlantic Ocean; these are not attributed to man's activities, but appear to reflect some form of natural, possibly cyclical, change. However, as acknowledged by the GESAMP Report on Nutrients and Eutrophication in the Marine Environment, there is clear evidence of an association between increases in nutrient inputs and/or changes in nutrient balance and enhanced frequency and/or persistence of troublesome algal blooms in waters with restricted circulation and exchange. Such areas are encountered under certain hydrographic and climatological conditions along the coast of mainland Europe and in the Kattegat and inner Skagerrak.

2.1.5 An update of the present situation with regard to the occurrence of exceptional algal blooms in North Sea states is provided in Table 1.

Table 1 Recent Exceptional Algal Blooms in the North Sea

Year/Season	Species	Location
May 1988	*Phaeocystis pouchetii*	Boulogne (southern North Sea)
May-June 1988	*Chrysochromulina polylepis*	South Coast of Norway, Skagerrak, Kattegat, Great Belt
	Phaeocystis pouchetii	Coastal areas of the Southern North Sea
June - July 1988	*Noctiluca scintillans*	E North Sea, Limfjord
	Gyrodinium aureolum	Skagerrak
July 1988	*Dinophysis acuminata*	Le Havre
	Gyrodinium aureolum	Rade de Brest, Baie de Douarnenez (western Channel)
July-August 1988	*Noctiluca scintillans*	E North Sea, Limfjord
	Ceratium fusus	E North Sea
August 1988	*Nodularia spumigena*	Kattegat
	Gyrodinium aureolum	Kattegat to N Norway
	Prorocentrum micans	Rade de Brest
August - September 1988	*Ceratium furca*	E North Sea
August - November 1988	*Gyrodinium aureolum*	E North Sea, Limfjord
September 1988	*Alexandium minutum*	Aber Wrach
April - May 1989	*Halospaera viridis*	Skagerrak - mid Norway
May 1989	*Phaeocystis pouchetii*	Boulogne (southern North Sea)
	Phaeocystis pouchetii	E Friesian Islands
June 1989	*Corymbellus aureus*	E North Sea
July 1989	*Prorocentrum minimum* *Alexandium minutum*	Kattegat Baie de Morlaix (western Channel)
	Dinophysis acuminuta	Le Havre (eastern Channel)
August 1989	*Prymnesium parvum*	Fjords, Western Norway
	Gyrodinium aureolum	Mounts Bay, S W England

2.1.6 The distribution of exceptional blooms recorded in 1988/1989 is a reflection of hydrographic divisions of the North Sea and areas which experience enhanced nutrient inputs. The majority of blooms have been recorded in the Kattegat and continental coastal waters, areas with reduced salinity due to the influence of large freshwater inflows. Such riverine sources contribute to the formation of algal blooms in two ways: first, by providing nutrients to the sea in proportion to riverine waterflow and, second, by enhancing the stability of the water column to provide improved conditions for algal growth. Temporal variability in riverine flow may be a further factor influencing the development of exceptional blooms.

2.1.7 The precise events leading up to an exceptional algal bloom and the nature and effects of individual incidents differ. An example may be provided by the *Chrysochromulina polylepis* bloom in the Skagerrak and Kattegat in May-June 1988, which illustrates a fairly typical course of events.[1]

2.1.8 During the winter of 1987/1988, water with a high nutrient content and possibly with distorted nitrogen to phosphorus to silicate ratios was advected by the Jutland Current from the southern North Sea into the Skagerrak/Kattegat area. Precipitation during the winter was higher than normal, causing increased nutrient input by land runoff into the Skagerrak/Kattegat area. A normal spring bloom of diatoms depleted the silicate, leaving a high nitrate level and a high nitrogen to phosphorus ratio.

2.1.9 Atmospheric conditions allowed effective stratification of the water and, prior to the registration of the bloom, *Chrysochromulina polylepis* is assumed to have grown at the pycnocline[2] over an extensive area of the Kattegat/Skagerrak during the latter part of April and in early May. At this stage, *Chrysochromulina* was probably one of several species and occurred in a low or non-toxic mode. It seems likely that the "epicentre" of the bloom was in the Kattegat, possibly in the northern region.

2.1.10 From this sub-surface layer, it is assumed that *Chrysochromulina polylepis* and nutrients were mixed into the upper layer of the outflowing Baltic Sea water through entrainment and upwelling. The outflow from the Baltic was considerably greater than normal. *Chrysochromulina polylepis* used up the nutrients rapidly and increased to bloom proportions, with growth mainly above a stable pycnocline at about 15 metres. It seems possible that, due to high nitrogen to phosphorus ratios of the entrained or upwelling water, *Chrysochromulina polylepis* at this stage experienced phosphate limitation and became toxic. The action of the toxin on nearby pelagic biota may then have allowed a further growth of *Chrysochromulina polylepis*.

Effects of algal blooms

2.1.11 Blooms have caused harmful effects such as fish kills, bottom invertebrate kills, discoloured water, production of foam and odour problems. Several of the species involved are known to affect other plankton and may cause changes in the ecosystem. Degradation of the blooms consumes oxygen, leading to oxygen deficiency.

2.1.12 Some species of dinoflagellates can cause toxic effects at low cell numbers without forming blooms. Accumulations of toxins, e.g., in mussels, are now routinely checked for by toxicity tests and the mussel fishery and marketing of shellfish has often had to be stopped for periods, in several North Sea states, as a precautionary measure. However, not all such incidents represent new phenomena.

2.1.13 Plankton blooms and the concentrations of toxic species have caused problems for fishery, aquaculture, tourism, and other recreational interests. Some blooms have had serious economic consequences, e.g., the bloom

1 Report of the ICES Workshop on the *Chrysochromulina polylepsis* Bloom in the Skagerrak and Kattegat in May-June 1988. ICES Cooperative Research Report (in press).

2 Layer of maximum rate of increase of density with respect to depth.

of *Prymnesium parvum* in Norway in 1989 killed fish in farms amounting to a value of 30 million Norwegian kroner.

2.1.14 Research carried out since the Second International Conference on the Protection of the North Sea tends to confirm the existence of a link between the input of nutrients and the occurrence of exceptional algal blooms in continental coastal zones, but it is also now apparent that other factors contribute to the extent of these blooms and their accompanying effects. One such factor is the normal counterclockwise circulation of water through the North Sea, which is of basic importance for the distribution of nutrients and the observed algal bloom frequencies. Nutrient enriched outflow of rivers tends to enrich coastal zones and interconnected sedimentation areas (Wadden Sea, German Bight, Kattegat). Summaries of recent research developments in member countries of the North Sea Task Force are given in the following section.

Recent research developments in North Sea Coastal States

2.1.15 In Belgian coastal waters, the occurrence of high concentrations of *Phaeocystis pouchetii* has been observed more frequently, with the associated nuisance of the formation of foam accumulating near shores. It is assumed that the blooms are related, amongst other factors, to high concentrations of nutrients which originate in the Channel (mouth of the Seine). The main research activity in Belgium concentrates on the EC *Phaeocystis* programme, which is to be concluded in 1991.

2.1.16 In France, a research programme to examine the environmental conditions and ecophysiological mechanisms behind algal bloom events is now in progress. Also, a monitoring network for phytoplankton perturbations has been in operation along the French coast since 1985. It includes an alarm system and reports of toxic effects and economic consequences.

2.1.17 Recent model studies in the Netherlands indicate that a 50% reduction in the nitrogen load on Dutch coastal waters will lead to a reduced geographical area subject to enhanced algal biomass. Similarly, a 50% reduction in the phosphorus load will result in a reduction by 10-20% of the maximum algal biomass along the Dutch coast. As oxygen depletion is confined mainly to areas of sedimentation and stratification (e.g., German Bight), this phenomenon causes few problems in the Dutch coastal waters. Variations in nitrogen to phosphorus ratios are expected to influence the species composition of algae. Nowadays, blooms of *Phaeocystis* are a yearly recurring event along the Dutch coast.

2.1.18 Exceptional algal blooms have been observed in the German Bight for a long time. However, a matter of concern since 1978 has been the quite regular occurrence of blooms of the planktonic algae *Phaeocystis* in coastal waters, and mass developments of benthic green algae (e.g., *Enteromorpha* and *Ulva* species) in the Wadden Sea. These phenomena are considered to be due to increased levels of nutrients. Model calculations indicate that the exceptional spring runoff from the rivers of the Federal Republic of Germany in 1988 is not likely to have reached the Skagerrak and the Kattegat early enough to have contributed to the *Chrysochromulina* bloom of that year.

2.1.19 In UK waters, exceptional blooms involve only a small number of species. They are experienced infrequently and usually only affect small areas of the coastline; there is no evidence of an upward trend in the occurrence or intensity of exceptional blooms. Where blooms have occurred and the benthos is affected, a rapid recovery is seen, and the main adverse impact has been limited to fish mortalities associated with caged fish farms in Scotland. Monitoring of UK nutrient inputs over a long period shows that elevated concentrations can be detected for only a few miles from the mouth of estuaries, while long-term monitoring at sea has shown that winter nitrate levels have not increased in the last twenty years. The UK's current research projects on nutrients include comprehensive measurements of nutrient-related factors in the NERC North Sea Project and new studies to measure net fluxes of nutrients to the sea. The role of nutrients in supporting phytoplankton blooms is also being studied, including possible links between localized blooms associated with mariculture.

2.1.20 Recent research in Denmark, Norway, and Sweden has emphasized the importance of nutrient ratios in addition to nutrient load. A considerable research effort is being directed to examination of connections between eutrophication, the stratified physical environment and growth of harmful algae. The waters of the Kattegat and inner Skagerrak are part of the counterclockwise circulation pattern of the North Sea. Thus, an extra load of nutrients from the coastal areas of the southern North Sea makes an important contribution to the eutrophication of the eastern Skagerrak, whereas no such effects are seen in the central and western Skagerrak.

2.1.21 Recent research in Denmark and the Federal Republic of Germany has indicated that an increased input of nutrients may also have adverse effects on macrophytes. There has been a change in macrophyte composition: perennials are being replaced by short-lived species causing nuisances to fisheries by clogging nets and to recreational uses of the coast due to foul smelling colonies of algae washed on shore. Furthermore, a significant decrease in depth distribution of macrophytes has been noticed and this has been linked to eutrophication, mainly due to shadowing effects of phytoplankton. This phenomenon has adverse effects on fish, as some of the macrophyte-covered areas are important breeding grounds and residence areas for commercially important fish species.

Recommendations of the North Sea Task Force

2.1.22 In the light of the above, the North Sea Task Force recommends that:

(i) further research should be carried out into the occurrence of algal blooms, and their implications for the dynamics of coastal ecosystems;
(ii) research should be initiated about the life cycle of toxic algae, and more particularly about the resting stage (cysts);
(iii) research should be conducted into the possible association between the presence of fish farms and localized exceptional algal blooms; and
(iv) monitoring of the proliferation of macroalgae should continue and research into exceptional occurrences carried out.

2.2 Epidemic deaths of seals in the North Sea

Background

2.2.1 In the 1987 QSR, the status of marine mammal populations was said to be improving. The main causes of adverse effects were attributed to direct human impact, such as hunting, and the accumulation of anthropogenic contaminants. The populations of both grey seals *(Halichoerus grypus)* and harbour seals *(Phoca vitulina)* had increased on the majority of North Sea coasts since the beginning of the century. Instances of seal populations disappearing (e.g., Western Scheldt) or growing significantly (e.g., around the coast of Denmark) were cited. Mention was made of the finding that seal populations in the western Wadden Sea were in decline due, at least in part, to reproductive failure, probably as a result of accumulated levels of PCBs.

2.2.2 The Ministerial Declaration of the Second Conference on the Protection of the North Sea did not contain specific provisions for safeguarding seal populations. Rather, reliance was placed on measures intended to reduce the level of contaminants entering into the North Sea environment. For example, Annex A of the Declaration advocated programmes for phasing out existing uses of PCBs/PCTs and the drin insecticides, substances thought to cause reproductive damage in seals.

2.2.3 In April 1988, an epidemic seal disease broke out which has had a significant impact on many seal populations in the North Sea. The disease was first observed on Anholt Island in the central Kattegat, where increasing numbers of aborted seal pups were found and the seals over one year old were observed to be dead or dying. Similar trends were reported around the same time on the island of Hesselo, the western Kattegat and the eastern Kattegat and the Danish, German, and Dutch Wadden Sea. In June, the disease was found among Skagerrak seal herds and in the Limfjord area. In early July, the seals in the Oslo Fjord were found to be affected, followed shortly thereafter by the first reports in the southwestern Baltic Sea. Seals on the British coast were observed to be affected around the beginning of August and the disease is now known to have affected a number of British harbour seal colonies, especially around the Wash and Moray Firth. It will not be possible to make a full assessment of the effects of the disease until the results of all aerial surveys conducted during the moult period in August 1989 are available. Recent evidence shows, however, that stocks around the coast of Scotland appear to have been affected much less than those in other parts of Europe.

2.2.4 The total number of found and registered deaths among harbour seal stocks in Northern European waters up to December 1988 was approximately 18,000. Relatively few deaths of grey seals have been caused by the disease, although some were found to be affected, while no ringed seals (*Phoca hispida*) have been found to be affected. A review of the impact of the seal disease epidemic prepared by the International Council for the Exploration of the Sea at Annex A of this report.

2.2.5 The primary cause of the epidemic is generally attributed to a previously undescribed morbillivirus now called Phocine Distemper Virus (PDV). Most diagnoses of the disease have been based on the presence of pathological and clinical symptoms characteristic of the Canine Distemper Virus (CDV).

2.2.6 In 1989, relatively few cases of dead seals have been reported compared with the same period in 1988.

2.2.7 The North Sea Task Force draws attention to the fact that seal mortalities also occur for other reasons. For example, it is estimated that in 1988 to 1989 around 60,000 harp seals were killed by being trapped in fishing nets in the region of the Barents Sea. However, these mortalities will have limited impact on the overall population, which is estimated at greater than one million individuals. Hence, the decline of population of harp seals would have been less than 8%, whereas in the Wadden Sea and other eastern North Sea coastal areas the decline in numbers as a result of the seal epidemic of 1988 was about 60%.

Recent research developments in North Sea Coastal States

2.2.8 An extensive array of research projects has been started in the wake of the seal epidemic. In Denmark research is being carried out into the presence of antibodies to the Phocine Distemper Virus (PDV) in past and present populations of harbour seals and other seal species. Antibodies have been identified in samples of harp seal (*Pagophilus groenlandicus*) and ringed seal (*Phoca hispida*) collected in the Arctic region in the years 1984 - 1987. Investigations concerning the presence of antibodies in the Antarctic crab eater seal (*Lobodon carcinophagus*) are being made, while samples from harp seals migrating from the Arctic area to the west coast of Norway are also being examined. In addition, investigations concerning a possible link to the Canine Distemper Virus (CDV) in mink showed that morbillivirus deriving from diseased harbour seals had *in vivo* characteristics of acute virulent CDV. In mink, the infection induced a disease resembling the acute systemic and nervous form of canine distemper.

2.2.9 Denmark has established twelve seal sanctuaries. A three-year project to examine the contamination in seal tissues of PCBs and other organochlorine contaminants was started in 1989.

2.2.10 In Norway, a research project has been initiated to study the reasons for the observed mortality of harbour seals. More than eighty seals were analysed. Antibodies similar to those for Canine Distemper Virus were observed in blood samples from sick animals. In connection with the investigation of the possible link to pollution, concentrations of selected heavy metals and PCBs were analysed. Research has continued on the population size of coastal seals and on the epidemic disease.

2.2.11 In Sweden, the harbour seal population has been thoroughly studied for several years both with regard to population parameters and effects of environmental toxicant. After the seal epidemic in 1988, reproduction decreased substantially, with the result that in some parts of the Kattegat area only one-third of the expected numbers of cubs were found during the count in 1989. As a result of these findings, emphasis has been placed on studying whether or not the surviving cubs have antibodies to the seal virus. Furthermore, a large number (1,200) of dead seals were collected during the seal epidemic in 1988. From these, 200 have been selected for more detailed epidemiological research.

2.2.12 In the United Kingdom, mathematical modelling studies of the epidemiology of the seal virus are being carried out. Studies of the structure of the seal virus and its relationship to other morbilliviruses are also being conducted. Studies of the prevalence of antibodies to the seal virus in common seals and grey seals have been carried out which indicate that there were no detectable antibodies in blood samples collected from grey seals before 1988. However, significant antibody levels were detected in 71 of 73 adult grey seals sample during October and November 1988. Blood samples collected from live common seals in 1989 indicated that 88% of animals older than two years had significant antibody levels, but only 12% of animals born in 1987 and 1988 had significant levels. A system has been established for examining as many dead seals as possible in 1989 and conducting full post-mortems.

2.2.13 It is not possible at the present time to give a credible prognosis of the long-term influence of the seal epidemic on Wadden Sea seal stocks. Largely for this reason the governments of the Wadden Sea states (Denmark, the Federal Republic of Germany and the Netherlands) have agreed an action programme for trilateral measures to restore the seal population in the Wadden Sea. Included in the programme are measures to coordinate the scientific evaluation of seal epidemics, in particular in the fields of virology, pathology, bacteriology and research on environmental factors and the cause and spread of diseases. A joint inventory of research projects will be the first step in the coordination of research among Wadden Sea states. A joint scientific project has also been initiated aimed at obtaining an insight into the migration of seals in the Wadden Sea in relation to the network of protected areas and the quality and size of these areas. Included in this project is the development of better methods for the estimation of the seal population. It is intended that the results of the project be used for planning conservation and other management actions.

2.2.14 On a more detailed level, the scientific research carried out by the Wadden Sea states is directed towards three main issues:

(i) analysis of samples and data from the seal epidemic in 1988;
(ii) research on the causes of the seal epidemic in 1988 (immuno-competence, ecotoxicological research, effects of pollutants); and
(iii) studies of population dynamics, aimed at obtaining information on management aspects.

All Wadden Sea states are carrying out analyses of samples under the first category. Under the second, the Danish studies mainly emphasize toxicological effects, while German studies deal with several scientific fields (pollutants, immune system, virology, parasites and mycoplasms). The emphasis of the Dutch studies is on immuno-competence, and ecotoxicological research. Most of the research under the third category is being carried out in the Netherlands.

Recommendations of the North Sea Task Force

2.2.15 In the light of the above, the North Sea North Sea Task Force recommends the following:

(i) research should continue to establish the source and full characteristics of the 1988 epidemic;
(ii) research should be conducted into the immune response of seals to the Phocine Distemper Virus and research on the role of contaminants should continue, in particular, to establish the role played by contaminants in the 1988 seal epidemic, using existing cooperative mechanisms, where possible; and
(iii) in order to permit future studies of pathogens and contaminants in seal tissues, a blood and tissue bank should be established

2.3 Sensitive issues

Background

2.3.1 A number of specific issues of concern were identified in the 1987 QSR. The build-up of pollutants in sea water and sediments in some areas, such as the Wadden Sea and the German Bight, was attributed to large inputs from land-based sources and local hydrographic conditions. The build-up of nutrients in the water along the coastal belt from the Netherlands to the north of Denmark and in the Skagerrak and Kattegat was also highlighted as being the result of inputs of waste water and losses from agriculture, and as a result of the prevailing hydrographic conditions. Similarly, pollution from oil discharged illegally or accidentally was recognised as an issue of concern. The importance of these issues was assessed with regard to their effect on: planktonic life, benthic communities, fish, sea birds and mammals. It was concluded that, in general, deleterious effects could only be seen in certain regions, in particular, in the coastal margins and near identifiable pollution sources.

2.3.2 The Ministerial Declaration of the Second International Conference on the Protection of the North Sea acknowledged these issues and adopted measures to reduce inputs of nutrients, atmospheric emissions, dumping and incineration at sea, as well as pollution from ships and offshore installations. At the same time, the Declaration called for the enhancement of scientific knowledge and understanding of the North Sea environment. The North Sea Task Force was established to help coordinate the latter activity. This report provides a review of progress in understanding the sensitive issues identified in the 1987 QSR and recognised in the London Declaration. It also highlights new issues raised as a result of increased understanding of the North Sea environment.

Table 2 Gaps in Scientific Knowledge of the North Sea

1.	A need for better quality input data.
2.	An improved understanding of nutrient dynamics and in particular their relation to occurrences of exceptional algal blooms.
3.	More epidemiological information and a greater understanding of the factors causing diseases in marine organisms, including fish, birds and mammals.
4.	An increased knowledge of the different ways in which classes of contaminants behave in the North Sea, and their sources and fates.
5.	An assessment of the critical load of nutrients and persistent, bioaccumulable and toxic substances (metals and organic compounds).
6.	More information on the levels of contaminants in the marine environment obtained on an internationally comparable basis.
7.	More knowledge of general ecosystem effects, on plankton, on benthos, birds, fish and mammals, and especially on North Sea seal stocks.
8.	Increased emphasis on quality assurance of mathematical models used in North Sea assessments.
9.	Other specific problems: for example, the problem of estimating inputs of contaminants to coastal waters from estuaries; the significance of sediment movement in the context of contaminant transport.

Initial work of the North Sea Task Force

2.3.3 In its terms of reference, the North Sea Task Force developed its Terms of Reference, which included an undertaking to fill gaps in knowledge based on those identified in the previous Quality Status Report. The list of gaps so identified is given in Table 2.

2.3.4 The North Sea Task Force has taken initial steps to address these gaps, particularly by developing a Five Year Plan leading to the preparation of the next Quality Status Report in 1993.

New sensitive issues

2.3.5 Although the most sensitive environmental issues of concern in the North Sea remain the same as those identified in 1987, the 1988 seal epidemic and the occurrence, also in 1988, of the *Chrysochromulina polylepis* bloom in the eastern North Sea, have focused attention on the issues of seal deaths and algal blooms. In addition, the North Sea Task Force has identified the following four additional sensitive issues which are to be addressed in future. In doing so, the North Sea Task Force regarded a sensitive issue as either one of which the public is already aware or one which the scientific community considers deserves attention because of recent developments in scientific knowledge and understanding.

The impact of the fishing industry on the North Sea ecosystem

2.3.6 This issue, which relates to Gaps in Scientific Knowledge number 7 (see Table 2), arises from a general concern about the lack of knowledge on the impact of fishing activities on the marine ecosystem as a whole, not merely on fish stocks. There has been public concern that specific fishing practices may have an adverse effect on higher trophic levels, such as certain populations of sea birds and marine mammals. This area of concern is well known.

2.3.7 A rather different concern has also been expressed within the scientific community; this concern is about the possible impact of fishing activities on the sea bed, in terms of physical disturbance, and the effect this could have on benthic ecosystems. Some North Sea countries have already been conducting controlled pilot studies to determine what effect trawling may have on benthic ecosystems.

2.3.8 A third concern is that of discarding fishing gear at sea, and indeed the general problem of what may best be described as litter, which is becoming ubiquitous in both coastal and offshore areas.

Surveillance for chemicals not usually covered in routine monitoring programmes

2.3.9 Scientists are concerned that insufficient work is being done - due primarily to the lack of adequate resources - to study the rates of input and fate of chemicals which are not usually analysed for in routine monitoring programmes (see Gaps in Scientific Knowledge number 6). It is clearly not possible, and not necessary, to include all known chemicals in such programmes; but an increased effort is required to widen the range of present analyses, particularly in areas of likely input to the North Sea, and in biological tissues. This would ensure that current effort is being directed towards those chemicals of greatest concern, and ensure that we are aware of a wider spectrum of chemicals entering the North Sea from both point and diffuse sources.

Environmental impact of persistent chemicals

2.3.10 Although the concentrations of a number of persistent chemicals are already being routinely monitored, there is still insufficient knowledge of their actual environmental effect (see Gaps in Scientific Knowledge number 4). Without such knowledge, there is scientific concern that action may be taken to replace these chemicals with others, about which we have even less knowledge of their long-term environmental effect. It is therefore suggested that a greater effort is required to study the toxic effects of both existing (e.g., PCBs, lindane) and new chemicals, the means of reducing their introduction to the environment at source, as well as monitoring changing levels of environmental concentration.

Role of atmospheric input as a source of contaminants to the North Sea

2.3.11 Scientists are concerned that they still have insufficient data on what are the principal sources of many contaminants into the North Sea, and thus where effort should best be directed in order to reduce inputs at source (see Gaps in Scientific Knowledge number 1). Data are particularly lacking with regard to the roles of dry and wet atmospheric deposition on the input of organic compounds, although data are of a poor quality in relation to the atmospheric input of contaminants in general. It is also important to integrate such information into mathematical models. This is necessary to ensure that predictive models of environmental inventories of chemicals take full account of all sources of input and loss. If this is not done, it may perhaps be difficult to explain in the future why environmental levels of particular chemicals have not declined, even though expensive measures have been taken to reduce their direct input via other routes.

Future work

2.3.12 In preparing the next Quality Status Report for the North Sea, the North Sea Task Force will devote particular attention to the sensitive issues identified above and to filling gaps in knowledge. The aim will be to enhance scientific understanding of the North Sea environment to provide a firm basis for decision making on the actions needed to address each sensitive issue.

3. INPUTS OF CONTAMINANTS TO THE NORTH SEA

3.1 Direct inputs and river inputs

3.1.1 With respect to the assessment of river inputs and direct inputs, this report relies basically on the estimates of inputs which are available within the Paris Commission. For cadmium, mercury and PCBs, information has been gathered in the framework of the Paris Commission since 1980. Additional information has been gathered since 1986 on copper, zinc, lead and, on a voluntary basis, gamma-HCH. Although the Contracting Parties to the Paris Convention are required to submit data on a mandatory basis, they are free to choose any methods they deem appropriate for estimating land-based inputs. In addition, Contracting Parties are currently only reporting on a limited number of their rivers.

3.1.2 Against this background, it is not recommended to compare the data presented here with the estimates presented in the 1987 QSR, because the methods applied in the various studies may vary considerably and may yield different results. In addition, figures for different years may differ considerably as a result of natural variations in river flows.

3.1.3 A comprehensive input study will be conducted in 1990 on the basis of agreed methods and in many cases under extended commitments of Contracting Parties so that from 1990 onwards a much improved data base will become available. The aim is to monitor on a regular basis 90% of the inputs of each selected pollutant in order to assess, as accurately as possible, all riverborne and direct inputs to Paris Convention waters. Table 3 presents the parameters which will be monitored on a mandatory basis.

Table 3 Parameters to be monitored on a mandatory basis: the Paris Commission Comprehensive Study on Riverine Inputs 1990 and the Paris Commission Comprehensive Atmospheric Monitoring Programme

Parameters	Rivers	Atmosphere
Nitrates (N)	*	*
Ammonium compounds		*
Total-N	*	
Orthophosphates (P)	*	
Total-P	*	
Total		
- Cadmium	*	*
- Mercury	*	*
- Copper	*	*
- Lead	*	*
- Zinc	*	*
- Chromium		*
- Nickel		*
- Arsenic		*
gamma-HCH	*	*
alpha-HCH		*
Salinity	*	
Suspended particulate matter	*	

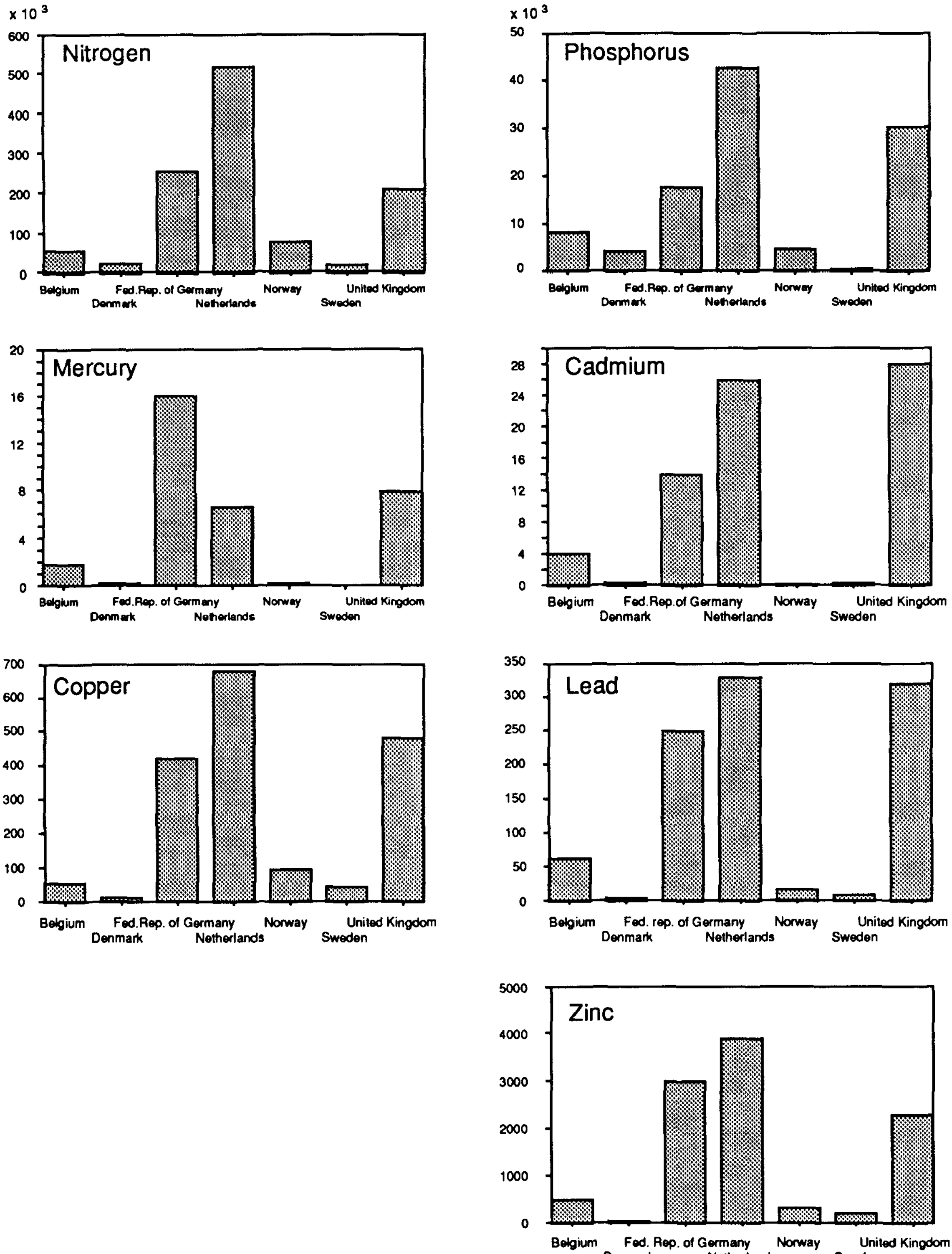

Figure 2 Direct and river inputs (tonnes/year) to the North Sea (see text paragraph 3.1.4)

3.1.4 Figure 2 shows the most recent information available on direct inputs and river inputs to the North Sea. This figure is based on the data as contained in Annex B (section 1).
In many cases the latest information on direct inputs and river inputs available is related to 1988; in some cases (Denmark and the United Kingdom) 1986 figures are the latest data available. With regard to Norwegian river inputs, the data as contained in the 1987 QSR have been used.
For nutrient inputs, data from the Working Group on Nutrients of the Paris Commission were used. These figures have been obtained by combining the 1987 QSR data with recent estimates by several North Sea states. Consequently, the figures for nutrient inputs are the best available estimates, which are mainly based on 1985 data.
As was the case for the 1987 QSR, no French input data are available.

3.1.5 It is important to note that in the cases of Belgium, the Netherlands and the Federal Republic of Germany the river input data include all discharges into the rivers concerned, and not only those which originate in the country where the rivers enter the North Sea.

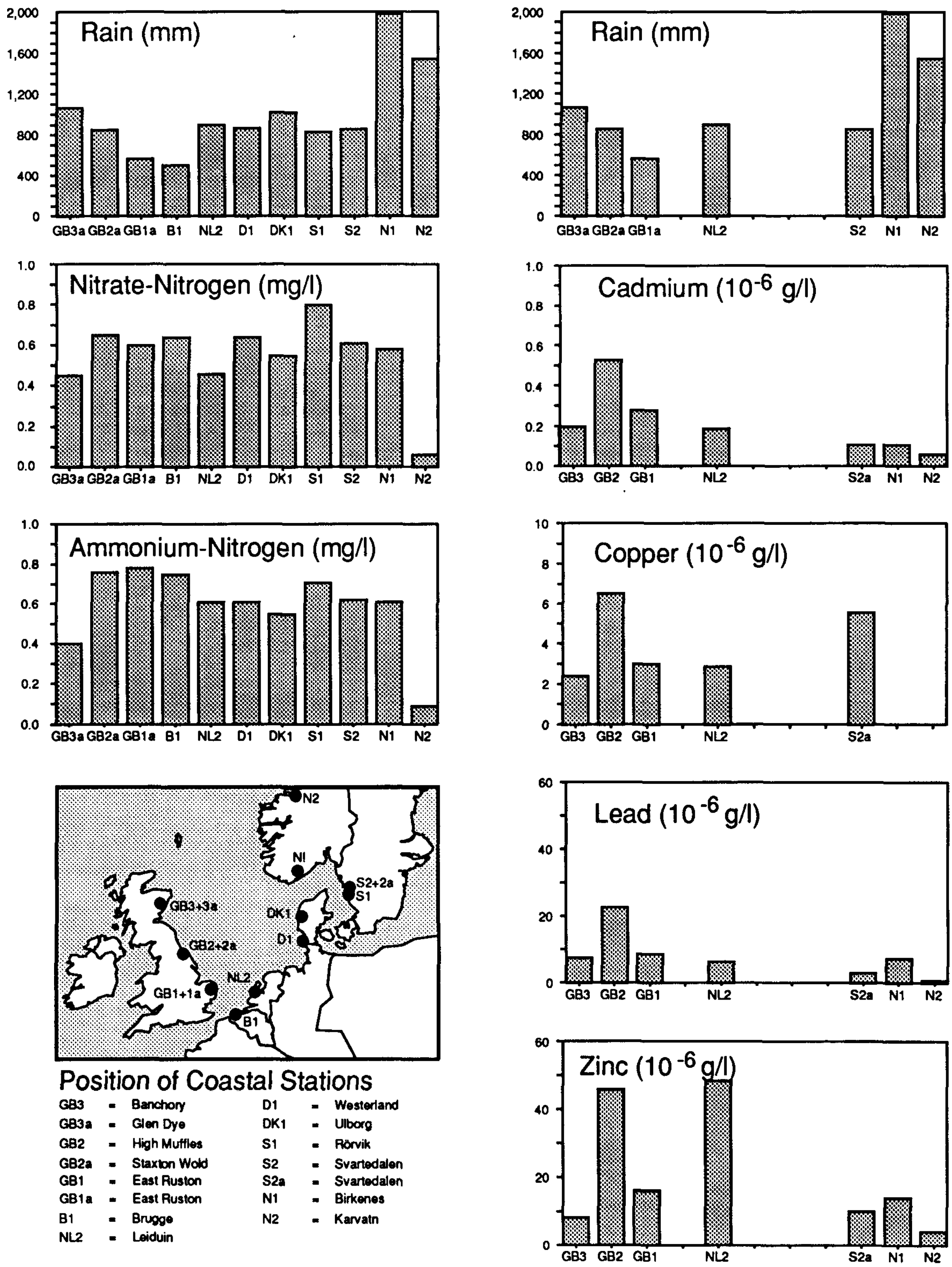

Figure 3 Annual weighted mean concentrations in precipitation in 1988

3.2 Atmospheric inputs

3.2.1 The estimates of the atmospheric inputs to the North Sea as contained in the 1987 QSR were compiled by the Working Group on Atmospheric Inputs of the Paris Commission. There was considerable uncertainty as to the accuracy of these estimates as they had been extrapolated from measurements made at only a few coastal stations. The 1987 QSR also indicated that preliminary model calculations resulted in lower values.

3.2.2 The Second International Conference on the Protection of the North Sea encouraged the Paris Commission to develop its monitoring programme on atmospheric deposition from its pilot phase and to establish a comprehensive, long term monitoring programme. In 1989 the Paris Commission decided to establish such a programme which will comprise substances as contained in Table 3 to be measured on a compulsory basis from 1990 onwards. All Contracting Parties to the Paris Convention which are coastal states of the North Sea will embark upon this programme in 1990.

3.2.3 Figure 3 indicates the stations at the North Sea coast which measured, within the framework of the pilot project of the Paris Commission, a common set of parameters on concentrations and deposition densities. These parameters are the concentration in precipitation and wet deposition densities of nitrate-nitrogen, ammonium-nitrogen, cadmium, copper, lead and zinc, together with the volume of rain. For 1988, the mean results of complete ranges of monthly measurements regarding concentrations in precipitation are shown in Figure 3. Caution has to be applied when comparing the results from the different locations because the methods used by the various stations might give considerably different results.

3.2.4 The Working Group on Atmospheric Inputs is elaborating a calculation method for the atmospheric input of pollutants into the North Sea on the basis of measurements of atmospheric deposition. As a first step, the Working Group on Atmospheric Inputs has produced new estimates of atmospheric inputs to the North Sea based on 1988 measurements for some substances. These estimates are reproduced in Annex B (section 2). Except for nitrogen and copper, the maximum estimates resulted in lower values compared with the maximum estimates as contained in the 1987 QSR.

3.2.5 Continued efforts may result in new and more reliable estimates of atmospheric inputs into the North Sea in future years. An inventory of atmospheric emissions of heavy metals from seven industrial sectors is being compiled by the Working Group on Atmospheric Inputs. This may also enhance the knowledge of atmospheric emissions, transport processes and deposition at sea.

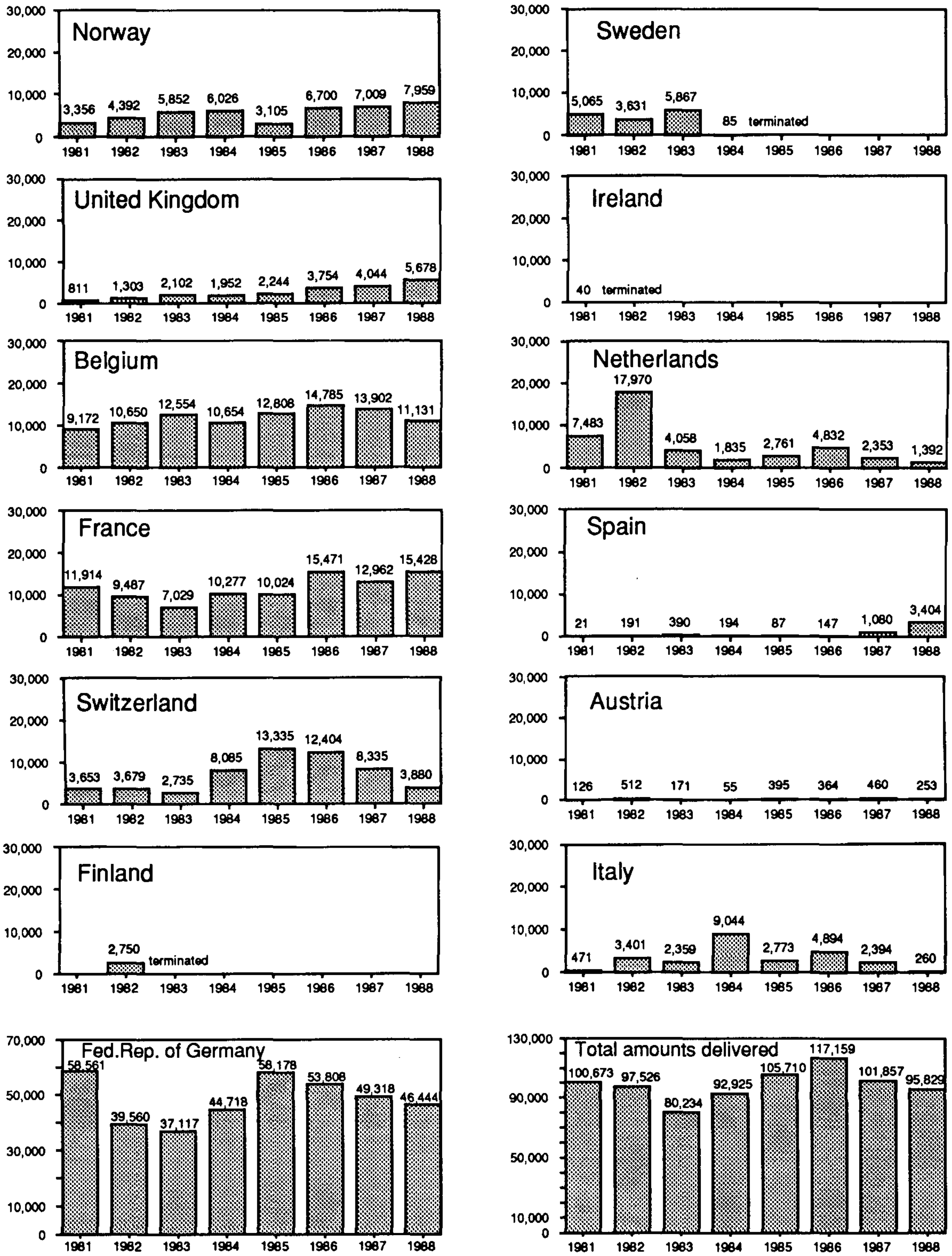

Figure 4 Quantities delivered for incineration at the North Sea by the various countries in the period 1981-1988 (tonnes/year)

3.3 Incineration at sea

3.3.1 In 1988 incineration operations were carried out from the ports of six countries where the wastes were loaded to be incinerated at the North Sea common incineration site. These ports were located in Belgium, France, the Netherlands, Norway, Spain and the United Kingdom.

3.3.2 During 1988 approximately 95,800 tonnes of waste were delivered to be incinerated in the North Sea. Figure 5 is a graphical representation of the 1988 data on the origin and quantities of waste delivered to the ports of loading, as contained in Annex B (section 3).

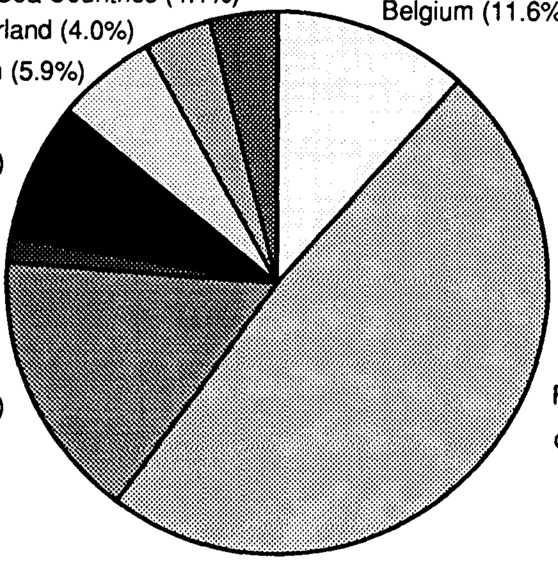

Figure 5 Origin of quantities of waste delivered to ports of loading in 1988

3.3.3 The majority of these wastes (66,246 tonnes = 68%) was loaded at Antwerp, including the wastes from three non-Contracting Parties to the Oslo Convention (Austria, Italy and Switzerland).

3.3.4 Figure 4 gives an overview of the quantities delivered for incineration in the North Sea by the various countries of Europe for the period from 1981 to 1988, including the total amounts delivered by all countries during this period. The total amounts delivered to ports of loading and the amounts incinerated at sea oscillated around 100,000 tonnes/year. A decreasing trend can be observed since 1986. Between 1986 and 1988 the amount of waste delivered to be incinerated decreased by 18%.

3.3.5 On the basis of the Ministerial Declaration of the Second International Conference on the Protection of the North Sea regarding marine incineration, and in accordance with its duties under rule 2(3) of Annex IV of the Oslo Convention, the Oslo Commission has taken a Decision to reduce and ultimately terminate incineration at sea by 31 December 1994. The decrease from 1986 to 1988 will continue in future years as a result of this Decision.

3.3.6 Norway, Sweden and the Federal Republic of Germany have already completely phased out the use of marine incineration. The Netherlands and France are very close to such a situation. Switzerland, the United Kingdom and Belgium are progressing well towards reducing the use of marine incineration and expect to achieve the 65 % reduction by 1 January 1991 and termination by the end of 1994.

3.4 Dumping of sewage sludge

3.4.1 The United Kingdom is the only country which dumps sewage sludge from vessels in the North Sea. The total amount of sewage sludge dumped by the United Kingdom in 1987 was approximately 5,077,000 tonnes, which is a slight increase compared with 1985. At present, sewage sludge dumped at sea accounts for 30% of all United Kingdom sludge arisings.

3.4.2 Annex B (section 4) presents data on the quantities of contaminants which were contained in this sludge. The differences between the 1985 and 1987 figures do not seem to be substantive, except for the quantity of zinc which shows a considerable increase.

3.4.3 In the United Kingdom, procedures to control the disposal of sewage sludge at sea, already established under existing legislation, go a long way towards meeting the aim of the London Declaration. As a further initiative the United Kingdom has augmented its existing practice of reviewing all dumping licenses, which includes an assessment of the availability of practicable land based alternatives, by including a reassessment of the restrictions on sludge loads of persistent toxic substances to ensure that their total quantities do not exceed the levels dumped in 1987.

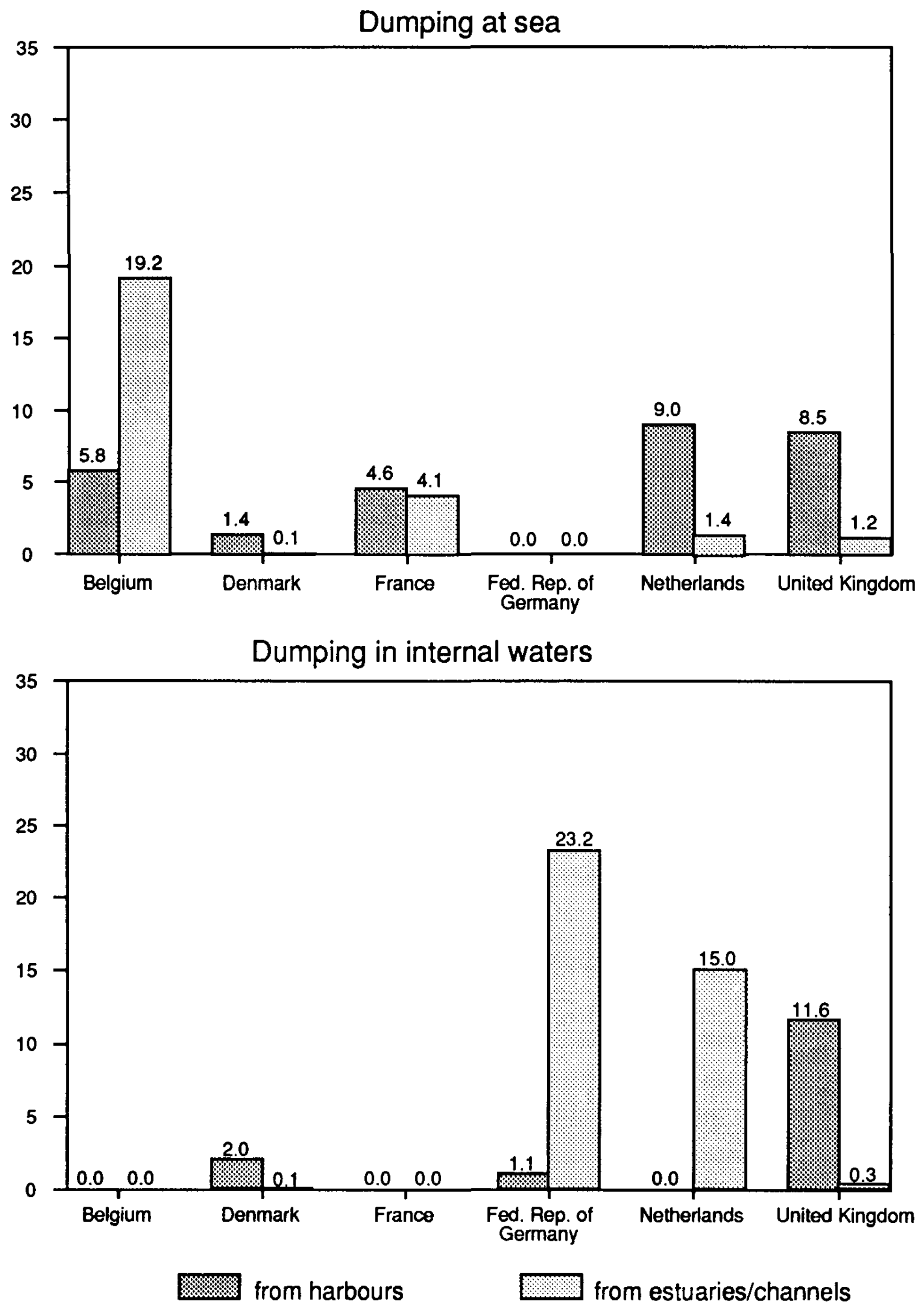

Figure 6 Million tonnes of dredged materials originating from harbours and from estuaries and navigation channels, being dumped at sea and in internal waters.
The data cover 1988. As far as the Netherlands is concerned, this is the case for dredged materials dumped at sea. The other Netherlands data and the figures for Denmark and the United Kingdom refer to 1987.

3.5 Dumping of dredged materials

3.5.1 The disposals of dredged spoil materials notified to the Oslo Commission comprise data on dumping at sea and in internal waters. These materials result from dredging operations in harbour areas, estuaries and navigation channels.

3.5.2 Annex B (section 5) presents the total amount of dredged materials dumped at sea by North Sea states in 1988 (the data of Denmark and the United Kingdom cover 1987). These amount to approximately 55 million tonnes.

3.5.3 Approximately 50% of the dredged materials dumped at sea originates to from harbour areas, the remaining 50% from estuaries and navigation channels. Figure 6 gives a graphical representation of the origin of the dredged materials which were dumped in the North Sea and in internal waters.

3.5.4 It should be noted that much dredging represents a relocation of seabed materials. The dumping of dredged materials varies from year to year due to various conditions which influence the extent of the dredging operations, e.g., hydrological conditions, capital dredging programmes and maintenance dredging schemes. For these reasons, it is difficult to draw definite conclusions by comparing one year's data with the next; it may, however, be possible to detect trends (if any) over a longer timescale.

3.5.5 Annex B (section 5) also gives an overview of the available data on the amounts of contaminants which were contained in the dredged materials dumped in the North Sea. Due to some limitations (e.g., dredged material from clean areas is exempt from chemical analysis) the data do not represent the total amount of contaminants contained in dredged material dumped in the North Sea. However, such shortcomings may be of minor importance in view of the fact that it is almost impossible to quantify the impact of dredged material and its contaminants on the marine environment. The amount of contaminants actually released from dredged material dumped and during dredging and dumping operations is unknown because this depends , *inter alia*, on the actual chemical conditions. Certain dumping operations of dredged material do not represent an increase of the contaminant load to the marine environment because material in that environment is only relocated.

3.5.6 In future years the amounts of contaminants in dredged spoils may show a downward trend, in particular as a consequence of the measures to reduce pollution of the North Sea via rivers and estuaries.

3.6 Dumping of industrial waste

3.6.1 Annex B (section 6) presents the amounts of **liquid industrial wastes** dumped in the North Sea in 1988 (the data for the United Kingdom cover 1987, but the UK reported that the figures for 1987 and 1988 are very similar). These figures result in a total amount of approximately 1.7 million tonnes of industrial waste. Most of the waste originated from the titanium dioxide industry in Belgium and in the Federal Republic of Germany.

3.6.2 Figure 7 represents the amounts of liquid industrial waste dumped in the North Sea in 1981-1988. This figure shows that the dumping of liquid industrial waste in the North Sea has decreased by 43% during this period.

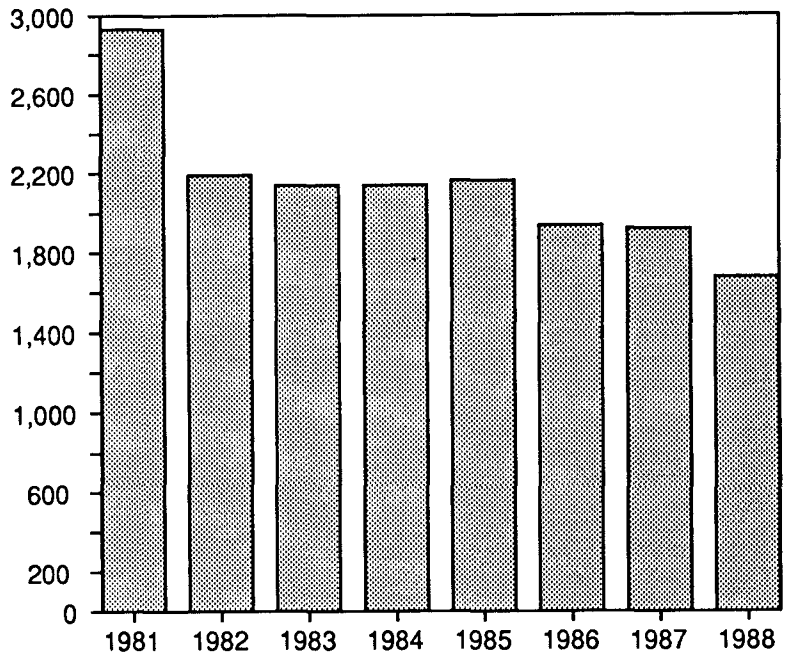

Figure 7 Amounts of liquid industrial waste dumped to the North Sea from 1981-1988 (thousands of tonnes)

3.6.3 Annex B (section 6) also contains information on the load of contaminants in the wastes. As regards the load of contaminants discharged into the environment by the dumping of industrial waste, a reduction can be observed comparing the 1985 and 1988 data. Figure 8 shows that in relation to the reduction in the amounts of liquid waste dumped during this period (21%), the reduction percentages of cadmium, mercury, copper, zinc, nickel and arsenic show an even larger decrease (35 to 99%).

3.6.4 In 1988 the United Kingdom dumped approximately 2 million tonnes of **solid industrial waste** (largely colliery waste) in the North Sea. Annex B (section 7) shows the quantities of contaminants contained in the total amount of solid industrial waste which was dumped in 1987. In 1985 only 1.6 million tonnes of solid industrial waste was dumped into the North Sea as a result of the miners' strike in the UK which ended in March 1985.

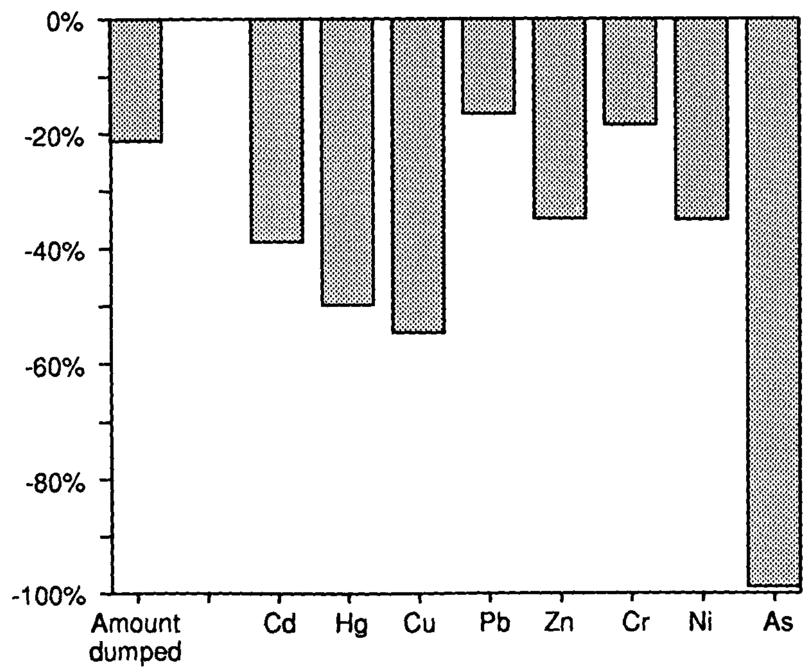

Figure 8 Reduction of the total amount liquid industrial waste and of contaminants contained in liquid industrial waste in 1988 compared with 1985

3.6.5 At the Second International Conference on the Protection of the North Sea it was agreed that the dumping of industrial waste should be phased out by 31 December 1989, except for inert materials of natural origin or other materials which can be shown in the competent international organizations to cause no harm in the marine environment.

3.6.6 As to the dumping of colliery spoil by the UK (as an inert material of natural origin), efforts will continue to be made to find alternative environmentally acceptable disposal methods.
Studies have also commenced in the UK into alternative methods for the disposal of fly ash. If sea disposal of these wastes is to continue beyond 1989, the licensing authority will have to be satisfied that there are no practical land-based alternatives and that the waste will not harm the marine environment.

3.6.7 The same provisions are applied by the UK to the dumping of liquid industrial waste. Both in the case of fly ash and liquid industrial waste, the harmlessness of the material will have to be shown to the competent international organizations.
Other countries have completely stopped the dumping of industrial waste in the North Sea.

3.7 Discharges from ships

3.7.1 Operational discharges of chemicals

3.7.1.1 The current international regulations as contained in Annex II of MARPOL 73/78, for the control of pollution by noxious liquid substances carried in bulk by ships, divide these substances into four categories referred to as A, B, C, and D according to their pollution hazards. The discharge provisions under Annex II vary for each category. This leads to the following estimates of legal inputs for each category.

3.7.1.2 As regards category A substances, being the most severe pollutants, there are no legal inputs by virtue of the total discharge prohibition for these substances.
As regards category D substances, being the least harmful pollutants, no estimates of inputs are given as the discharge standards for these substances contain no quantity limitations in view of the fact that they pose only a minimal hazard to the marine environment and are practically non-toxic to aquatic life.

3.7.1.3 As regards category B and C substances the following observations can be made.
The discharge provisions for category B substances limit the quantity of cargo residues expected to be discharged into the sea to 0.1 m^3 per cargo tank on board. For category C this figure is 0.3 m^3.
The amount of category B substances shipped in bulk across the North Sea is about 1.5 million tonnes per annum. Based on the calculated average size of ships and cargo tanks involved in this transport, it is estimated that some 6,000 cargo tanks are needed. This would lead to an input estimate of about 600 m^3 being about 480 tonnes of category B substances.
For category C substances 2.4 million tonnes per annum are shipped in an estimated 9,600 tanks, which leads to an input estimate of 2,880 m^3 or about 2,304 tonnes.

3.7.1.4 It is most important to recognize, however, that the said estimates of 480 tonnes and 2,304 tonnes for categories B and C respectively are hardly liable to create any harm to the marine environment since, by virtue of the other applicable discharge criteria, these substances will only enter the marine environment in a concentration of 1 ppm outside the 12 miles zone from the nearest land.

3.7.1.5 It should also be noted that sampling surveys in the North Sea carried out by the United Kingdom have confirmed this view. In virtually all the samples, the concentrations of the chemicals were below the limits of detection.
The results of the various surveys carried out confirm the expectation that the implementation of Annex II of MARPOL 73/78 will lead to the required reduction in the concentration in the North Sea of the chemicals governed by this Annex.

3.7.2 Trends in observed oil slicks

3.7.2.1 In the 1987 QSR the annual quantity of oil legally discharged by ships sailing the North Sea was estimated at between 1,000 and 1,500 tonnes. The estimates of the illegal discharges varied from 1,100 to 60,000 tonnes. There was no consensus among North Sea states on estimates of accidental oil discharges from ships.

3.7.2.2 No information has since become available which could improve the estimates on oil discharges from ships contained in the 1987 QSR. On the basis of the information provided by North Sea states, no clear or significant trend in observed oil slicks can be detected for the North Sea area since the Second International Conference on the Protection of the North Sea. It should be noted that vessels are not the only sources of oil pollution; offshore platforms have also been identified as a cause of oil slicks.

3.7.2.3 Annual surveys of oil pollution caused by the shipping industry around the coasts of the United Kingdom show a 44% reduction in the number of oil pollution incidents between 1980 and 1987, the decrease mainly occurring between 1980 and 1985.

Denmark reports no clear trends in the number of observed oil slicks.

As far as the Netherlands is concerned, no significant changes have occurred in the pattern of reports for oil slicks in the period 1986-1988.

In the Federal Republic of Germany (German Bight), the results of airborne surveillance operations show that oil pollution has decreased during the last few years, both in terms of the area covered and the quantities involved.

The Swedish Coast Guard observed an increase of oil slicks in Swedish waters in 1988 compared with 1987, in particular a 49% increase on the west coast of the country.

In Norway the number of recorded oil pollution incidents has increased since 1987. However, the main causes for this are:

- introduction of new reporting routines for offshore oil companies which implies notification of spills smaller than $1 m^3$ in addition to larger spills; and
- extended reporting of spills by local authorities and private persons.

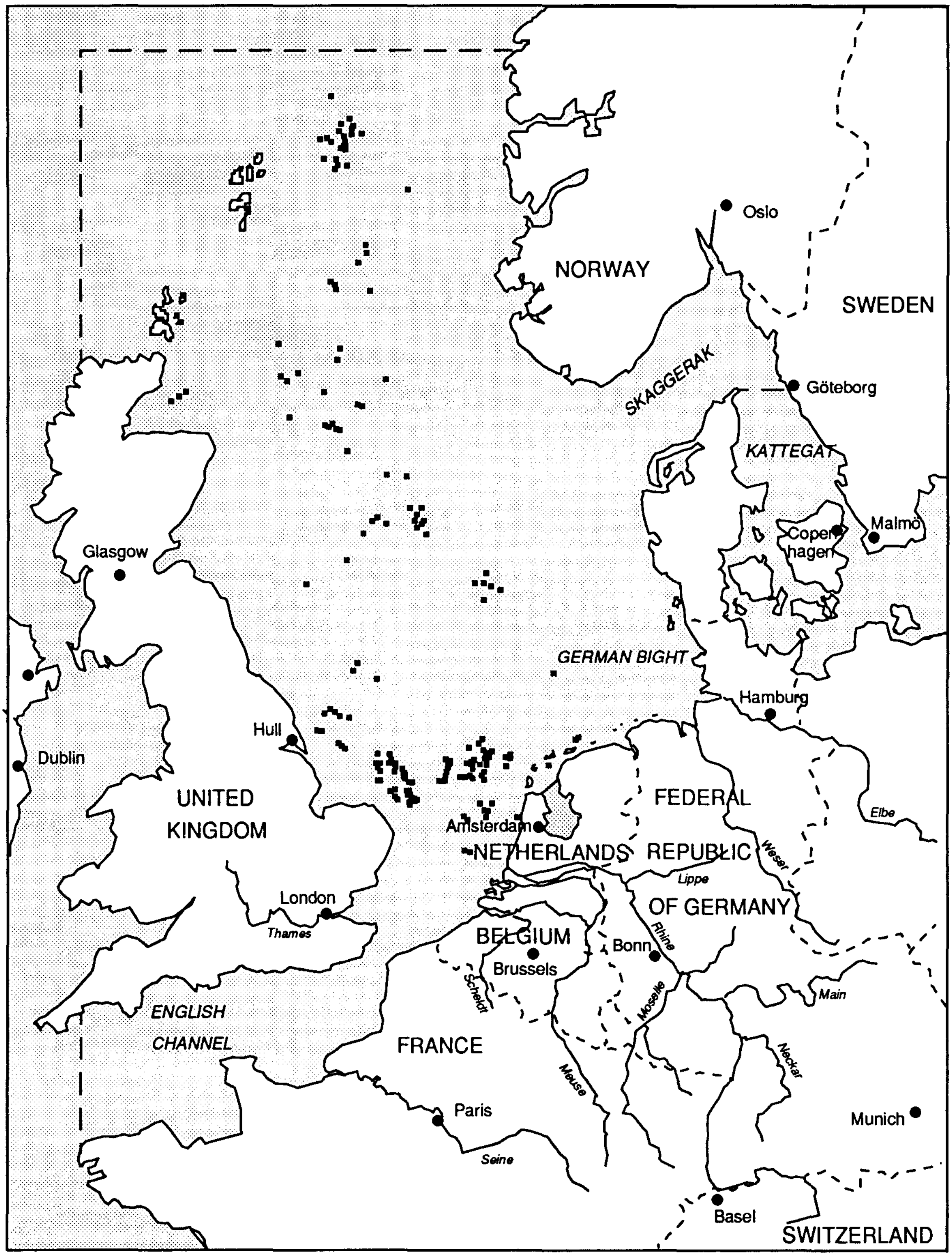

Figure 9 Offshore installations at the North Sea in 1988

3.8 Discharges from offshore installations

3.8.1 The Secretariat of the Paris Commission is informed on an annual basis by North Sea coastal states about the number of wells drilled and the quantities of hydrocarbons discharged from exploration and exploitation platforms. The 1988 data are contained in Annex B (section 8). Figure 9 shows the location of most of the platforms which produced oil or gas in the North Sea in 1988.

3.8.2 As regards inputs from these platforms, the discharges can be split into three components:

(a) Discharges of produced water and storage displacement water. The Paris Commission has set a target standard for the oil content of these discharges of 40 mg/l water. This oil is in the form of well dispersed droplets usually less than 40-50 microns in size. As reported to the Paris Commission, various gas-condensate platforms in most countries have problems in reaching these standards.

(b) Accidental oil spills, also as a consequence of flaring operations.

(c) Discharges of drainage and sewage water, which contribute insignificantly to the total inputs to the North Sea.

3.8.3 North Sea states reported to the Paris Commission that 500 exploration and exploitation wells were drilled during 1988. The cuttings resulting from these drilling operations are usually discharged into the North Sea. They are contaminated with substances which are contained in the muds used to facilitate the drilling operations. Except for the oil content of these discharges, no data have been reported.

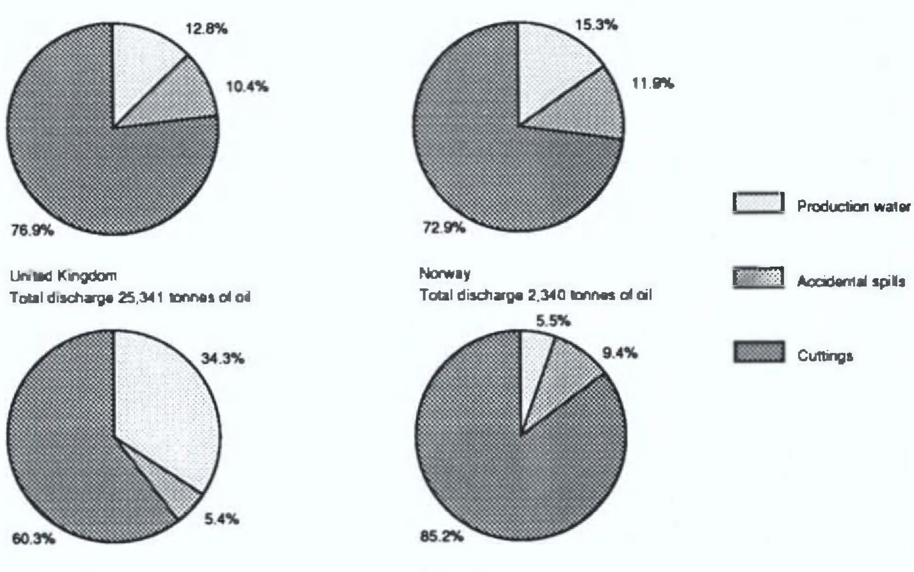

Figure 10 Input of hydrocarbons from platforms to various sectors of the North Sea in 1988

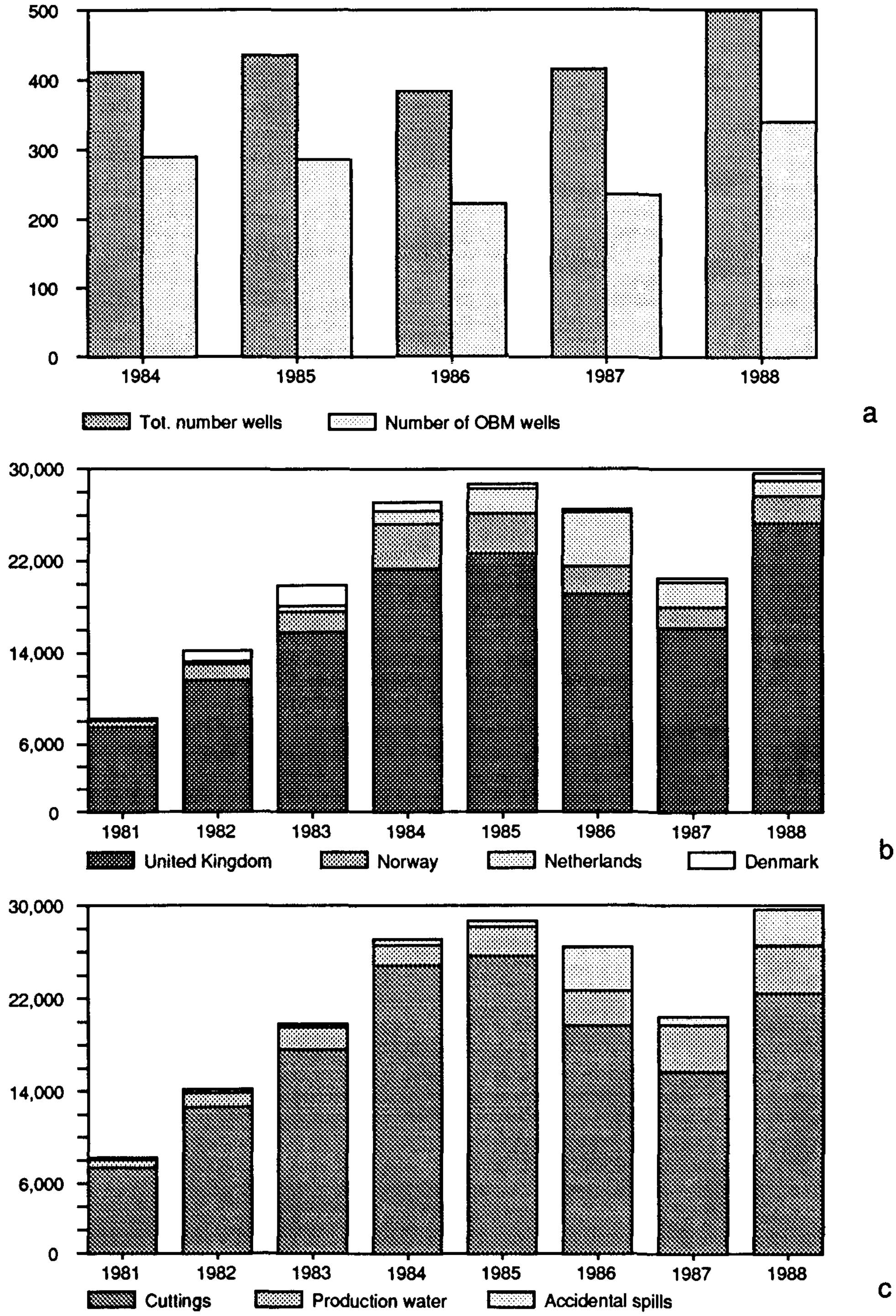

Figure 11 Development of (a) number of wells drilled (1984-1988), (b) total oil input (tonnes) from platforms into the various sectors (1981-1988), (c) total oil input (tonnes) resulting from the various types of discharges (1981-1988)

3.8.4 Depending on the operational requirements, use is made of oil based drilling mud or water based drilling mud. During 1988, 68% of wells were drilled using oil based drilling muds. Scientific research has shown that discharges of oil contaminated cuttings have deleterious effects on the marine environment, in particular on benthic organisms in the direct vicinity of the discharging platforms.

3.8.5 Figure 10 presents the quantities of oil discharged from platforms to the various sectors of the North Sea in 1988. A distinction has been made between accidental oil spills, oil discharged in production water and the amount of oil contained in discharges of cuttings. The oily waste from both platforms in the sector of the Federal Republic of Germany is disposed of on land.
The total amount of oil discharged from offshore platforms is estimated at approximately 29,700 tonnes in 1988, being equal to the amounts discharged in 1985 and an increase of approximately 9,000 tonnes compared with the 1987 estimates. This increase is mainly caused by:

- a 50 % increase in the number of wells drilled with oil based muds in the UK sector of the continental shelf; and
- two accidental spills (together 2,250 tonnes) in the UK sector of the continental shelf.

3.8.6 From Figure 11 it can be observed that:

- most of the oil discharged from platforms results from the discharges of oil contaminated cuttings;
- the amount of oil discharged with production water shows an upward trend during the period 1981-1988; the increase since 1985 is 63%.

1 Dounreay	11 Doel	21 Ringhals	31 Mulheim-Kärlich
2 Sellafield	12 Mol	22 Barseback	32 Kahl
3 Hartlepool	13 Tihange	23 Brunsbüttel	33 Gravenrheinfeld
4 Sizewell	14 Gravelines	24 Brokdorf	34 Biblis
5 Harwell	15 Cap la Haque	25 Stade	35 Philipsburg
6 Bradwell	16 Flamanville	26 Unterweser	36 Obrigheim
7 Winfrith	17 Paluel	27 Krümmel	37 Karlsruhe
8 Dungeness	18 Chooz A	28 Grohnde	38 Neckarwestheim
9 Borssele	19 Cattenom	29 Würgassen	39 Fessenheim
10 Dodewaard	20 Nogent sur Seine	30 Hamm-Uentrop	

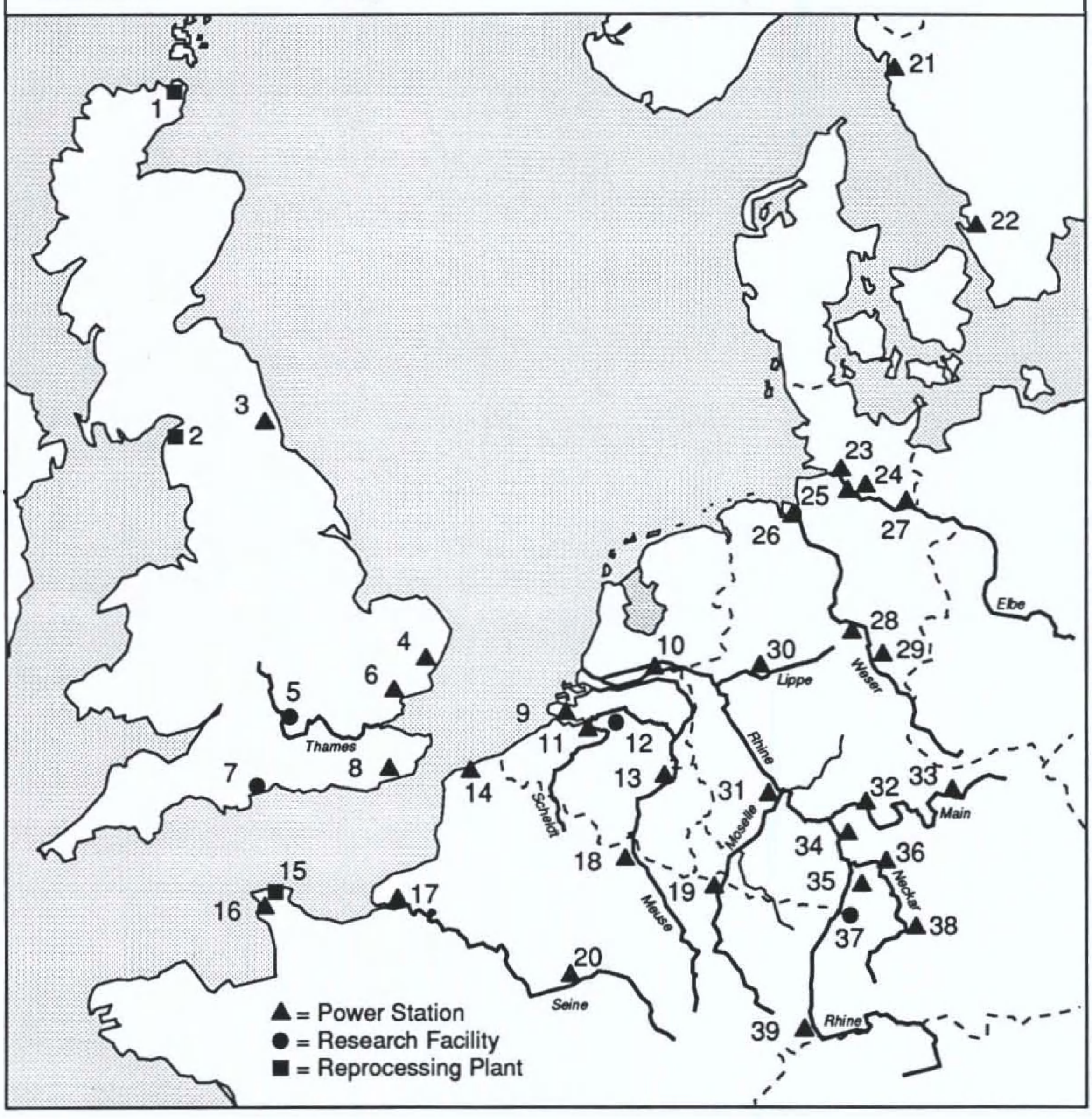

Figure 12 Location of nuclear installations

3.9 Inputs of radioactivity in liquid wastes discharged to the North Sea

3.9.1 The main sources of inputs of radioactivity to the North Sea are discharges by nuclear reprocessing plants, nuclear fuel fabrication plants and nuclear power plants. As was the case in the 1987 QSR, this update discriminates between:
- direct inputs to the North Sea;
- inputs to rivers entering the North Sea; and
- inputs via adjacent sea areas.

3.9.2 As regards the inputs of radioactive substances to rivers, most of the discharged tritium reaches the North Sea; the other radioactivity may to a certain extent be absorbed to riverbed sediments. Except for tritium, much of the radioactive substances discharged into adjacent sea areas is not likely to enter the North Sea, but will be absorbed on the seabed sediments.

3.9.3 Figure 12 is a map showing the location of sources:
(a) which directly discharge radioactive substances to the North Sea;
(b) which discharge radioactivity to rivers entering the North Sea; and
(c) which discharge radioactivity to adjacent sea areas and which affect the radioactivity levels in the North Sea.

Annex B (section 9) contains information on the 1985 and 1988 discharges by the installations indicated in Figure 12, as reported to the Paris Commission (the 1988 data for the Federal Republic of Germany and the Netherlands cover 1987).

3.9.4 Figure 13 shows that - in spite of an increase in installed capacity of nuclear power plants - the discharges into rivers of other radioactive substances have been reduced by 75% between 1985 and 1987/8, as a consequence of measures taken to considerably reduce discharges. The direct inputs of other radioactive substances also show a considerable decrease.

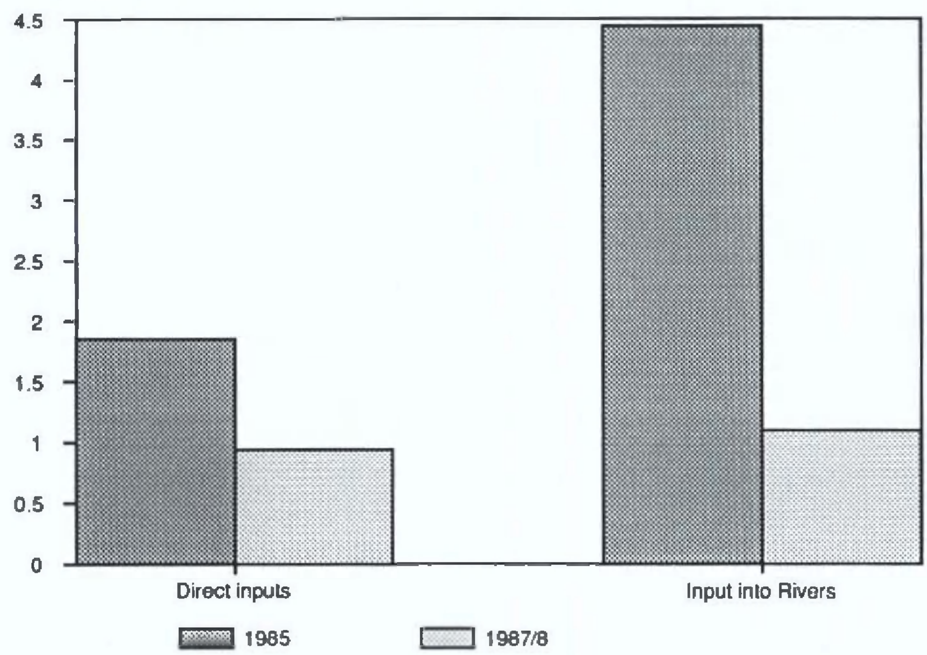

Figure 13 Radioactive inputs (except from tritium) in 1985 and 1987/8, direct and into rivers entering the North Sea (TBq)

3.9.5 Figure 14 shows that the direct inputs of tritium to the North Sea have slightly decreased between 1985 and 1987/8. As regards the inputs of tritium to rivers entering the North Sea, the total discharge has increased by approximately 70% mainly due to the increased capacity of nuclear power plants along the rivers Rhine, Meuse, Scheldt and Elbe.

3.9.6 An important source of radiation from artificial nuclides in the North Sea is the Sellafield reprocessing plant on the west coast of the United Kingdom, via the inflow of Atlantic water, with small contributions from the reprocessing plant at Dounreay. Other inputs come from the inflow of English Channel water and from the Baltic Sea, the latter probably being negligible. Most of the activity that enters from the English Channel is from Cap la Hague discharges.
As can be observed from Annex B (section 9), the discharges from the Sellafield plant other than tritium decreased considerably. The discharges from Cap la Hague to the English Channel show a decrease for all types of radioactivity.

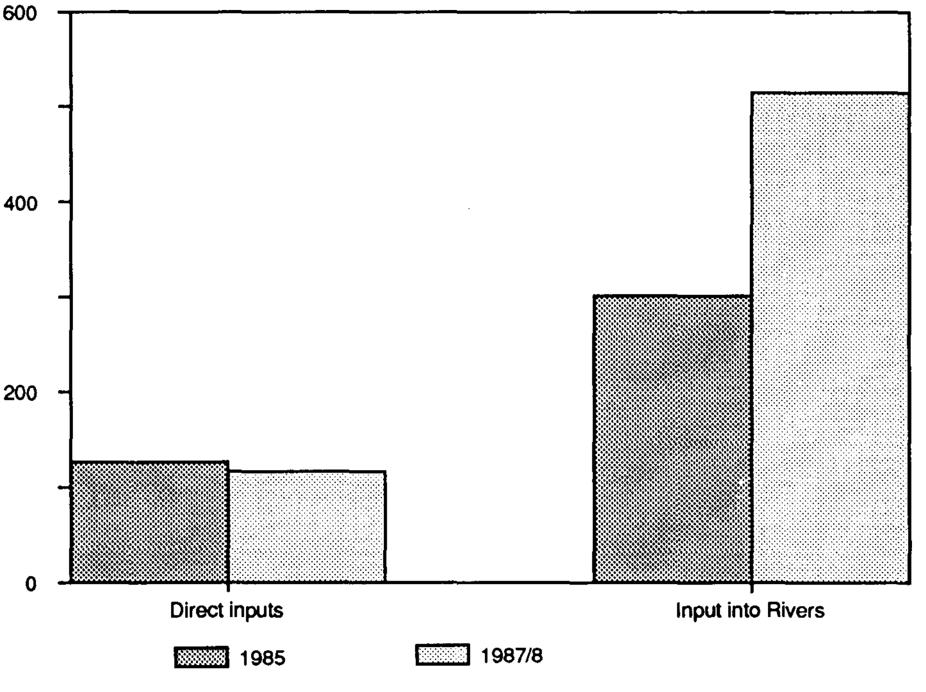

Figure 14 Direct inputs and inputs into rivers entering the North Sea of tritium (TBq) in 1985 and 1987/8

ANNEX A

SUBMISSION BY THE INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA ON THE IMPACT OF THE SEAL DISEASE EPIDEMIC

The impact of the disease epidemic that affected seals around Northern Europe in 1988 was addressed by a joint meeting of the Working Group on Baltic Seals and the Study Group on the Effects of Contaminants on Marine Mammals, held in Helsinki on 15 - 18 May 1989. A summary of the findings of this meeting is given below.

1. The Size of Seal Populations and the Impact of the Phocine Distemper Virus Epidemic

1.1 Harbour Seals (Phoca vitulina)

Since mid-April 1988, more than 17,000 harbour seals have been found dead at various sites around the coasts of northern Europe. It is generally accepted that the primary cause of death for most of these animals was infection with a previously undescribed morbillivirus tentatively named as Phocine Distemper Virus. Most diagnoses of the disease have been based on the presence of characteristic pathological and clinical symptoms or of antibodies to the closely related Canine Distemper Virus in serum. In a few cases, it has been possible to detect the presence of virus antigen in tissue using immunofluorescent techniques. It will not be possible to assess the full impact of the epidemic on most seal populations until aerial surveys are conducted during the moult period in August 1989. However, preliminary estimates of the previous abundance and numbers of dead animals found in 1988 are given in the following paragraphs.

Baltic Sea
There were approximately 300 harbour seals in the Baltic Sea before the start of the epidemic. There has been no unusual mortality among the group of about 80 seals at Öland and of 4 - 5 seals at the south end of Gotland. But there had been 60 - 70% mortality among the harbour seals in the southwestern Baltic Sea and only about 50 animals remain at the largest colony. Reproductive rates amongst the seals in the southwest Baltic Sea appear to be reasonably good, but up to 50% of the pups have been found dead within the first months after pupping between 1984 and 1987. The low size of this population (less than 300) and the severe mortality suffered during the epidemic in 1988 mean that the status of this population is now critical.

Kattegat and Skagerrak
Until 1988, the harbour seal population in the Kattegat and Skagerrak had been increasing at an exponential rate of 0.12; it had been anticipated that, if this rate continued, aerial surveys in August would have revealed 8,215 animals. However, since April 1988, 4,847 animals have been found dead in the area and only 2,900 animals were counted in the annual aerial survey after the period of highest mortality. The overall mortality was estimated to be 60%; about 95% of the pups born in 1988 were thought to have died. Since the beginning of February 1989, only two animals have been found dead.

Norway
950 dead animals had been found in Norway out of an estimated population of 4,300. Most of the dead animals (500) were from the Oslofjord area. This was more than the estimated local population size and it was considered that some of these bodies had been washed northwards from the Skagerrak. No dead seals had been found north of Trondheim, although there was a substantial harbour seal population of 1,200 to 1,400 animals in this area. There were no recent reports of dead seals.

Limfjord and Wadden Sea
850 dead seals had been found in the Limfjord area; this was more than the highest previous count from aerial surveys. 8,550 dead harbour seals had been found in the Wadden Sea area out of an estimated minimum population of 9,500 at the end of the pupping season in 1988. Since January 1989, 20 to 40 times more dead seals than normal had been found in Schleswig-Holstein. Twenty-five percent of the seals brought into the rescue centre at Pieterburen during the winter did not have antibodies to the virus; most of these were young animals. Seals with clinical symptoms of virus infection were still being reported from the Netherlands, Schleswig-Holstein and Denmark early in 1989.

United Kingdom
Over 3,000 dead seals had been reported from the UK coast since the end of July 1988. Of the 1,183 animals for which there was a positive identification as to species, only 185 were grey seals, although the population of this species was estimated to be more than 90,000. This suggests that about 2,500 dead harbour seals were found from a population of at least 25,000 at the start of the epidemic. Of these, 1,765 were from the North Sea coasts of England and Scotland and 750 from the North Atlantic coasts of England, Scotland, Wales and Northern Ireland. Very few dead seals (48) had been reported from the Shetland Islands and none of these had shown clear clinical symptoms of virus infection or virus antibodies. It was believed that mortality had been substantially underestimated because of the extensive areas of poorly populated and rocky shore line, where bodies were unlikely to be found, and the prevailing offshore winds. There had been very few reports of dead seals during the winter, but the numbers had increased since the end of March from all around the coast, including an animal with clinical symptoms from Shetland.

France
The small group of animals in the Baie de Somme appeared to be unaffected by the virus. Five dead animals had been found in the Dunkirk area, but none had symptoms of the disease; however, an animal with symptoms of the disease, as shown by histological analyses, had recently been found dead on the south coast of Brittany.

1.2 Grey Seals (Halichoerus grypus)

Four dead grey seals with symptoms of virus infection had been found in the southwestern Baltic Sea. These were all old animals suffering from the adreno-cortical hyperplasia previously reported in Baltic seals, which is believed to involve immune system depression. The status of the grey seal population in the Baltic Sea remains critical.

No dead grey seals with symptoms of the disease had been found in Norway, the Federal Republic of Germany or France but three seals with symptoms (including one pup) had been found in the Kattegat. One dead animal from the small Netherlands Wadden Sea population of about 80 animals had been found with pathological symptoms in May 1989.

In the United Kingdom, 185 of the animals reported dead were positively identified as grey seals and the total number of dead grey seals was about 500. However, very few of these had shown symptoms of the disease and only one animal had been confirmed to have virus antigen. More sick and dead animals with disease symptoms had been reported since the end of March 1989, including some pups born in 1988. Samples of blood from 70 breeding females and 3 pups taken at a number of Scottish colonies in 1988 had shown a very high (97%) prevalence of antibodies to distemper virus. No trace of antibodies had been found in 60 adult females and 80 pups sampled between 1977 and 1987. Pup production at a number of colonies on the North Sea coast was 20 - 30% lower than expected in 1988. This could have been due to abortion of foetuses or death of females caused by the disease, or by some extraneous factor.

1.3 Ringed Seals (*Phoca hispida*)

No ringed seals showing symptoms of the disease had been seen in the Baltic Sea. However, one ringed seal brought into the rescue centre at Pieterburen had developed clinical symptoms although it had later recovered. Antibodies to distemper virus have been found in ringed seals from west and east Greenland sampled since 1985.

2. Implications of the Epidemic for the Future of European Seal Stocks

It may be concluded that the threat to the surviving harbour seal population in the Kattegat and Skagerrak in 1989 will be less than in 1988 because only the pups of that year were likely to be vulnerable to the virus. As a result, the probability of an infected animal carrying the virus to ringed and grey seals in the Baltic Sea was less in 1989 than in 1988.

Data from the UK indicated that only a small percentage of animals born in 1987 and 1988 had been exposed to the virus, possibly because they were widely dispersed by the time the virus reached the UK. As a result, between one-quarter and one-half of the surviving seal population was probably still vulnerable to infection in 1989. The same is probably true in the western Wadden Sea. Elsewhere, all age classes appeared to have been equally exposed and the main risk was to pups born in 1989.

The surviving European harbour seal stocks are unlikely to increase at any greater rate than that which was observed before the epidemic. If animals which had survived infection had damaged lungs or decreased resistance, then the rate of recovery could be substantially lower than this.

The prospects for European grey seal stocks are still unclear.

3. Experimental and Field Evidence Linking Contaminants with the Epidemic

In its 1987 report, the ACMP had noted that a number of organochlorine compounds have been implicated in observed cases of reproductive failure and immune system problems amongst seals.

It is apparent that the primary cause of the wide-scale mortality amongst harbour seals in the North Sea, Baltic Sea and northeast Atlantic in 1988 was infection by a morbillivirus. Organochlorines and some heavy metals are known to have an immunosuppressive effect on other mammals under experimental conditions, so it was possible that they had contributed to the severity of the epidemic.

At this stage, it is difficult to draw any firm conclusions regarding the possible influence of contaminants. Although only a limited number of samples from dead seals had been analyzed to date, none had shown abnormally high levels of any contaminant measured. However, since the threshold level for the effect, if any, of these compounds on the immune system of seals is not known and since all of the implicated compounds had yet to be analysed, this was not conclusive proof that contaminants were not involved. Studies planned in the UK to compare organochlorine levels in the blubber of seals which died in the epidemic and in those which survived on an area-by-area basis might resolve some of these problems. In addition, the studies planned by the UK and the Netherlands on the effects of organochlorines on the immune system under field and laboratory conditions should indicate whether immunosuppression could have occurred.

Annex B Section 1

Direct en River inputs (tonnes)	year[1]	N	P	Cd	Hg	Cu	Pb	Zn	Cr	Ni	As	g-HCH	PCBs
Belgium[2 3]	1988	57,400[4]	8,200[4]	4.1	1.8	55	62	495	NI	NI	NI	0.1	0.05
Denmark	1986	24,978	4,195	0.4	0.2	13	4.3	44	NI	NI	NI	NI	NI
Fed. Rep. of Germany[3] .	1988	255,700	17,6000	14	16	420	250	3,000	NI	NI	NI	0.7	<0.2
Netherlands[3]	1988	518,510	42,800	26	6.6	680	330	3,900	NI	NI	NI	1.4	0.2
Norway	1988[5]	78,690	4,670	0.2	0.2	95	17.3	337	NI	NI	NI	NI	0.09
Sweden	1988	20,883	429	0.3	0.02	44	9.5	210	NI	NI	NI	NI	<0.01
United Kingdom	1986	210,406	30,425	<28	<7.9	<480	<320	<2,300	NI	NI	NI	<0.4	NI
Total[6]:		1.200,00	108,000	<73	<33	<1,790	<990	<10,290				<2.6	<0.6

NI: No Information
1 Figures for N and P cover 1985
2 Input at border between Belgium and the Netherlands in the river Scheldt
3 Input including load from upstream countries
4 Including channel "Gent-Terneuzen" and Dutch load on Westernscheldt
5 Sum of data on direct inputs 1988 and river input data from QSR 1987 (1984-data)
6 Order of magnitude only (rounded figures)

Annex B Section 2

Atmospheric input[7] (tonnes)		N	P	Cd	Hg	Cu	Pb	Zn	Cr	Ni	As	g-HCH	PCBs
Estimates based on 1988 deposition measurements													
	MIN	326,000	NI	42	NI	1,050	2,570	3,150	NI	NI	NI	NI	NI
	MAX	614,000	NI	84	NI	1,680	4,830	6,090	NI	NI	NI	NI	NI
Estimates based on emission values for various years (1983-1986)													
	MIN	383,000	NI	14	NI	130	2,310	970	NI	NI	NI	NI	NI
	MAX	525,000	NI	18	NI	135	2,600	1,200	NI	NI	NI	NI	NI

NI: No Information
7 Minimum and Maximum results of different calculation methods, Working Group on Atmospheric Input, 1989 calculated for an area of 525,000 km^2 north of the Strait of Dover

Annex B Section 3

Incineration (tonnes)	Quantity delivered to the port of loading in 1988	Cd	Hg	Cu	Pb	Zn	Cr	Ni	As	g-HCH	PCBs	Orga-no-X	Halogenate substances	PAH
Belgium	11,131													
Fed. Rep. of Germany	46,444													
France	15,428													
Netherlands	1,392													
Norway	7,959													
United Kingdom	5,678													
Switzerland	3,880													
Non-North Sea Countries[8]	3,917													
	Estimated maximum quantities of heavy metals and halogenated substances released into the environment in 1988 (kg)[10]													
Total	95,829[9]	79	28	2,000	2,300	6,700	1,000	1,200	60	NI	NI	NI	4,900[11]	

NI: No Information
8 Austria, Italy, Spain
9 This figure does not include appr. 40 t of waste water arising from the cleaning of the tanks of an incineration vessel in Antwerp
10 Order of magnitude only, due to incomplete data and different methods of calculation
Total for the wastes incinerated based on the average destruction efficiency of 99.995% and the assumption that 100% of the wastes consisted of organohalogen compounds
11 kg C12

Inputs of radioactivity in liquid waste to the North Sea, 1985 and 1988 — TBq/annum

Country	Establishment	Type	Capacity M We	Receiving water body	Tritium 1985	Tritium 1988	Other activity 1985	Other activity 1988
(a) Direct inputs								
United Kingdom	Hartlepool	P	1,320	North Sea	22.0	33.8	0.2	0.24
	Sizewell	P	420	North Sea	9.9	0.8	1.0	0.46
France	Gravelines	P	5,400	North Sea	95.0	82.0	0.655	0.462
b) Inputs via rivers entering the North Sea								
United Kingdom	Harwell	RF		Thames	2.3	1.4	0.62	0.23
	Bradwell	p	245	Blackwater	1.3	0.79	1.5	0.45
France	Chooz A	P	300	Meuse	30	71	0.194	0.0023
	Fessenheim	P	1,800	Rhine		33		0.124
	Cattenom	P	5,200	Mosel		23		0.043[15]
Belgium	Doel	P	2,680	Scheldt	36.3	72.8	2.1	0.011[16]
	Tihange	P	2,800	Meuse		69.2		0.07
	Mol	RF		Mol/Neet				0.158
Netherlands[17]	Dodewaard	P	58	Waal	0.17	0.17	0.014	0.0137
	Borssele	P	485	Scheldt	5.7	4.6	0.0057	0.0019
Fed. Rep. of Germany[17]	Karlsruhe	RF		Rhine	96	96	0.0012	0.00075
	Obrigheim	P	345	Neckar	5.3	5.7	0.00077	0.0004
	Würgassen	P	670	Weser	0.71	0.39	0.0019	0.0006
	Stade	P	662	Elbe	6.2	6.1	0.0012	0.0013
	Biblis 'A'	P	1,204	Rhine	18	15	0.0017	0.0029
	Biblis 'B'	P	1,300	Rhine	15	10	0.00074	0.0009
	Neckar-Westheim	P	855	Neckar	13	12	0.0003	0.0001
	Brunsbüttel	P	806	Elbe	0.87	0.5	0.00081	0.0004
	Unterweser	P	1,300	Weser	27	14	0.00072	0.00023
	Philipsburg KKP1	P	900	Rhine	0.9	0.62	0.00078	0.0006
	Philipsburg KKP2	P	1,268	Rhine	13	13	0.00005	0.0003
	Grohnde	P	1,365	Weser	7.2	16	0.00011	0.00001
	Krümmel	P	1,316	Elbe	0.76	1	0.00036	0.00001
	Grafenrheinfeld	P	1,299	Main	22	16	0.00004	0.00007
	Kahl	P	16	Rhine	0.09	0.004	0.00005	0.0001
	Mulheim-Kärlich	P	1,308	Rhine		4.9		0.00013
	Brokdorf	P	1,365	Elbe		25		
	Hamm-Uentrop	P	300	Lippe		3.4		0.00001

(c) Inputs into adjacent sea areas

Country	Establishment	Type		1985	1988
Affecting northern inflow form Atlantic Water					
United Kingdom	Dounreay	RP	Total activity	25	14.2
			Strontium 90	4	1.7
			Total alpha	0.37	0.16
	Sellafield[18]	RP	Tritium	1,221	1,433
			Total alpha	0.7	0.2
			Plutonium 241	17	3
			Strontium 90	136	12
			Caesium 137	800	12
			Caesium 134	30	0.9
Affecting inflow the English Channel					
France	Cap la Hague	RP	Tritium	2,590	2,553
			Other nuclides	1,200	576
			Strontium 90 + Caesium 137	76	48
			Alpha emitters	0.72	0.36
	Paluel	P	Tritium	31	100
			Other activity	0.518	0.324
	Flamanville	P	Tritium	0.07	36
			Other activity	0.003	0.718
	Nogent sur Seine	P	Tritium		14
			Other activity		0.022
United Kingdom	Dungeness	P	Tritium	46.8	23.3
			Other activity	2.4	0.65
	Winfrith	RF	Strontium90	0.29	0.0308
			Other activity	70	112.2
Affecting inflow of the Baltic Current					
Sweden	Ringhals	P	Tritium	37	53
			Other activity	0.17	0.22
	Barseback	P	Tritium	0.6	0.57
			Other activity	0.06	0.04

P: Power Station
RF: Research Facility
RP: Reprocessing Plant
15 2 of the 4 reactors were still being built during 1988
16 1985 figures cover 1984
17 1988 data cover 1987
18 The transit time of about two years has been taken into account, and the data thus derive from 1986
The discharges are modified to represent input into the North Sea

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