Report

The North Sea

– Invisible Decline?

Greenpeace Report* Short Version

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Note to Readers

This document is not intended to be a comprehensive overview of the state of the North Sea. Rather, it is a review of some of the most recently published literature which contains new information on the North Sea environment and provides evidence that in some areas environmental degradation is more advanced than commonly acknowledged in reports produced by government and international agenicies. It is primarily designed as an information document, and all reference sources are fully documented. It is hoped that the review will stimulate wider discussion about more suitable strategies for the protection of the North Sea than those which are already in place.

1 Executive Summary

In 1990, Ministers from the North Sea States signed an agreement to reduce inputs of certain toxic substances by between 50 & 70 %. Together with its other provisions designed to protect wildlife, the 1990 Declaration was widely hailed as the agreement which would save the North Sea environment from further degradation and which would lead to an improvement in environmental quality. As the final Ministerial Conference approaches in 1995 there is a perception that these measures have worked, that the North Sea environment is improving and that it has been saved for future generations. This is a long way from the truth. The optimism of Governments around the North Sea contrasts with the stark picture drawn by recently published scientific research. New techniques have revaled evidence of new problems, new surveys have shown that old problems have not been solved, but that they continue to worsen. Perhaps more than ever before the full scope of the threat to the North Sea has been unveiled. The invisible decline has become very obvious. It has become visible.

1.1 Monitoring

The monitoring effort upon which regulatory agreements and decisions are based is inadequate when considered on both a local and regional basis. At a local level, the regulation of individual discharges does not address the complexity and diversity of the chemicals being discharged and the sampling frequency is often not sufficient to reliably detect breaches of licence conditions. There are difficulties in evaluating diffuse sources. On a regional basis there are large uncertainties attached to the estimates of chemical inputs. The North Sea environment is simply not monitored frequently enough or intensively enough to reliably detect trends in input levels. Hence, claimed input reductions may simply reflect data artifacts rather than any real change. Problems are also evident with data derived from biological monitoring of chemical contaminants due to forced changes in population parameters of the target species.

Moreover, the quality of analytical data generated over the region as a whole has not yet been underpinned by a complete data quality assurance scheme. Finally, chemicals are introduced to the North Sea as mixtures and recent research has shown that the toxicological impact of chemical mixtures is unpredictable and cannot be assessed with existing techniques. Overall, current monitoring schemes provide no basis whatsoever for claiming that input reductions of any contaminants have been achieved. Concomitantly, there is no basis upon which planned input reductions can be verified.

2 Contaminants in the North Sea

2.1 Biological Effects

A key collaborative research programme known as the ICES/IOC Bremerhaven Workshop carried out in 1990 has

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exploded the myth that contaminants and their effects are restricted to the coastal waters of the North Sea. This study established that biological effects could be found in the central North Sea, distant from the input sources. Abnormalities in the liver of flatfish could be correlated with levels of contaminants in sediments. The induction of enzyme systems active in detoxifying chemicals suggests that organophosphates and carbamate pesticides play a toxicological role together with heavy metals and organochlorines, in stressing fish and inducing disease. The workshop also established that malformation rates in fish embryos fell with increasing distance offshore, but rose over the Dogger Bank, which acts as a sink for anthropogenic contaminants. This supplements earlier work which showed high levels of fish embryo malformation and disease in the southern North Sea, particularly in areas where titanium dioxide manufacturing wastes had been dumped. Faulty fish development, in fact, shows a general correlation with the pollution status of North Sea waters.

Another important finding of the Bremerhaven Workshop was that extracts of seawater proved to be most toxic in inshore areas. Contamination of the marine microlayer, in addition, was found to be sufficient to exert direct toxic effects upon marine organisms in areas of depressed water quality at the mouth of the Rivers Weser and Rhine. This complemented previous work carried out in the River Tees which showed that discharged chemical mixtures could be directly lethal to sensitive organisms, and that discharged chemicals could be found a considerable distance offshore. There was evidence too, that the distributions of small benthic animals was related to sediment mercury or zinc levels. The workshop also confirmed that several metals were elevated in the sediments of the Dogger Bank.

2.2 Organochlorine Contaminants

1. PCBs

Organochlorine contaminants are a significant component of the priority chemicals selected for input reduction in the North Sea. PCBs are examples of such chemicals and these have been increasingly restricted since they went out of major production in Europe after 1977. Despite the perception that these therefore constitute an historical problem, they are clearly still problematical. PCB levels in seels on the Rhine are only marginally lower than at the end of the 1970's while at some sites levels appear to be increasing. The downward trend is suspected of levelling off in the case of other organochlorine contaminants. It is thought that levels of PCBs in the Rhine Delta are sufficient to have direct impacts on biological systems, while residues isolated from some birds have been found at close to lethal levels.

PCB monitoring of sediments in UK waters has established that areas of high PCB contamination exist. Estimates strongly suggest that PCB releases to the marine environment account for a relatively small proportion of the chemicals manufactured since the 1930's. The presence of these compounds in large quantities in dumps, landfills and current applications means that they could enter the environment in large quantities in the future if measures are not taken to prevent this. The PCBs comprise a complex ecotoxicological threat given that there are 209 theoretically possible isomers with divergent properties. The coplanar PCBs represent a particular threat since they are highly resistant to degradation and exert their toxic effects in similar ways to the chlorinated dioxins.

2. Toxaphene

Toxaphene is a complex mixture of chlorinated bornanes used as an insecticide. Recent studies in the North Sea have revealed extensive contamination of biota with this pesticide. High levels have been recorded in fish and mammals. It is not in use in the North Sea states and is regarded as more harmful than technical mixtures of PCBs. It seems possible that long range atmospheric transport is responsible for the presence of this pesticide in the North Sea ecosystem. Whatever the source, it needs to be reconciled in order that remedial measures can be developed.

3. Other chlorinated chemicals

Studies of chlorinated dioxins have shown that a dominating source for these compounds in sediment deposition zones in the North Sea appears to be the electrolytic chlorine industry and chlorination reactions involved in the manufacture of PVC. Dioxins discharged into the River Rhine system are the principal source of these contaminants into the Waddensea. In other areas, significant sources are attrributable to the manufacture of chlorinated phenols while the general pattern of isomers present in the environment is dominated by combustion sources.

Hexachlorocyclohexane isomers are ubiquitous contaminants of the North Sea ecosystem and the volatilistion of these has wide ranging implications for the contamination of Arctic areas. The potential of the North Sea to act as a source for long range atmospheric transport of volatile and semi-volatile chemicals has received very little attention to date.

Despite the relatively well known distributions of priority organochlorine contaminants in and around the North Sea, the quantities of organically bound chlorine in marine organisms and sediments cannot be accounted for simply in terms of the known and identified pollutants. Recently, a new group of organochlorines has been discovered for which little toxicological information exists while studies of the effects of chloroanilines and chlorobenzenes have identified some subtle deleterious effects on fish and marine algae.

4. Triazine herbicides

The triazine herbicides are used in large quantities in the North Sea States and they have been identified as priority chemicals for reduction of inputs to marine systems. Extensive monitoring has shown that they may be present at high levels in estuarine and marine waters, and studies have indicated that the Elbe is the major source into the south-eastern North Sea. UK rivers also carry appreciable loads of these herbicides. The inputs in other areas have not apparently been evaluated and the behaviour and impact of these herbicides is not known as a result. Recent research in the Me-

diterranean has found high levels of a triazine used in antifouling paints and this merits investigation in the North Sea where there is also a high level of shipping activity.

5. Synthetic Detergents

The synthetic detergents are a group of bulk production high volume use chemicals which are present at high levels in sewage effluents and some industrial discharges. Total global consumption of surfactants is estimated at around 15 million tonnes per annum and appears to be growing. Although modern surfactants are rapidly biodegradable and linear alkylbenzene sulphonate, for example, is removed by up to 99 % by treatment plants the degradation products and their effects upon saltwater organisms and communities are not well known. Tests have shown that surfactants affect survival and growth rates of marine invertebrates, possibly the fertility rate of bivalves, and the permebility of cell membranes in algae.

Besides, recent studies indicate high bioconcentration factors in fish and mussels of nonyl phenol produced by degradation of the alkyl phenol ethoxylates. Unconverted raw materials can lead to the presence of linear alkyl benzenes in the product which do not degrade rapidly in sediments. The market for surfactants appears to be growing. The degradation products are largely unknown but nonyl phenol from the breakdown of detergents can be bioaccumulated by marine organisms. There are considerable gaps in understanding of the fate and effects of detergent chemicals in the environment, but they have the potential to interfere with cell membranes and hence affect membrane permeabilitiy to nutrients and chemicals. Ecotoxicological information is limited, but bivalve molluscs appear to be the most sensitive organisms tested so far.

3 Wildlife

3.1 Cetaceans

Several conservation agreements have recognised that cetaceans in the North Sea face considerable problems. In general accurate population estimates of cetaceans in the North Sea do not exist. The best data relate to the harbour porpoise which has declined in most parts of the North Sea. There is concern that bottlenose dolphin populations are in also in decline. A significant contributor to population decline of harbour porpoise is entanglement in fishing gear. Changes in population biology of harbour porpoise in the North Sea over the last 20 – 50 years suggest that this species is currently under considerable pressure. It is clear that urgent measures are required to reduce by catch of harbour porpoise in the North Sea. By-catch mortality of bottlenose dolphins is simply not known, but common dolphins are regarded as the second most commonly by-caught species in UK waters, and preventive measures should be taken.

Another threat to cetaceans is pollution, although there are not many data on this subjects. Elevated levels of mercury which could lead to liver disease were found in marine mammals from UK waters, reflecting high levels of mercury contamination in the Mersey area. High organochlorine residue levels have been found in cetaceans in Welsh, Danish and Dutch coastal waters, and for four of six analysed Welsh animals levels were so high that the animals could be regarded as at risk. This is even more serious if one takes into account that an estimated 80 % of the maternal organochlorine body burden may pass to the first born dolphin calf during lactation. Although direct effects upon dolphin and porpoise reproduction in the North Sea due to organochlorine contamination have not been found as yet, PCBs may have contributed to juvenile dolphin mortality in Cardigan Bay in Wales. It is suggested that PCBs in Mediterranean striped dolphins played a role in triggering the disease caused by a morbillivirus which has killed thousands of dolphins to date.

3.2 Seals

The threats faced by seals in the North Sea are similar to those faced by cetacean species. Overfishing can cause a reduction in food supplies while entanglement can lead to substantial mortality such as took place in the harp seals migrating southwards in Norwegian waters in 1987 and 1988. The full scope of this problem is unknown in the North Sea since no systematic survey has been carried out. Recent published research has also indicated that organochlorine pollutants may have played a role in the epizootic of 1988 caused by phocine distemper virus. This epizootic killed between 50 & 60 % of the harbour seal population in the North Sea. The degree to which the surviving population is now immune is unclear.

3.3 Bird Populations

Habitat destruction has been identified as an important threat to bird populations in the Netherlands. Exposure to chemically contaminated food resources has been found to cause abnormal breeding behaviour in tufted ducks. Elevated levels of heavy metals which may exert chronic effects have been found in several species of wader. High levels of embryo mortality in tufted ducks and thinning of eggshells in grebe have been attributed to PCBs. In the cormorant in Dutch waters, clutch size and number of fledglings was found to be related to seawater and sediment quality in the feeding areas.

Reproductive impairment has also been documented in common tern colonies in Germany influenced by the Elbe waters. Both the common tern and oyster catcher in the German Bight have been found to be heavily contaminated but annual differences as well as regional differences exist in the actual contaminants present. In the UK, while levels of most organochlorine pesticides in aquatic species have assumed a downward trend, this is not true of terrestrial species of predatory birds where PCB levels have tended to rise slightly. This implies that PCB sources in terrestrial environments are not adequately controlled. Comparison of living birds with museum specimens has shown a substantial rise in feather mercury content of seabirds since the beginning of the century.

4 Sewage Discharges

Sewage discharges account for a significant proportion of effluents discharged into the North Sea. Health risks have been identified in bathers exposed to sewage contaminated seawater and there appears to be considerable lack of compliance with EC Directives regulating bathing water quality. In any case, there are considerable doubts about the practical utility of the traditionally measured organisms as indicator species since some may persist in non-culturable form for long periods in both seawater and sediment while other pathogens may be much more persistent than the bacteria used as indicators. In some estuarine conditions, sewage pathogens may actually multiply in numbers. Aerosol enrichment may represent a significant pathway of contamination to occupants of beaches and coastal properties. Microbiological contamination also poses a potential hazard to shellfish consumers and there is some doubt as to the degree of protection afforded to consumers by current EC legislation.

As a result of domestic and industrial use of chemicals, sewage discharges are chemically complex and the dumping of contaminatec sludges at sea or their use on land may result in the entry of considerable quantities of chemicals into the envionment. Recently, sewage effluents have been found to exert hormonal effects on fish in rivers. The development of female characteristics by male fish is attributed to the presence of synthetic hormones from oral contraceptives or to detergent degradation products but this remains to be verified.

5 Radioactivity

The North Sea is influenced by radioactive discharges from a number of sources. The primary contributors are the reprocessing plants at Cap-la-Hague, Dounreay and Sellafield. Recent reductions in discharges from Sellafield have resulted in reduced levels of soluble radionuclides in the North Sea. Nonetheless, the proposed operation of the new THORP plant will substantially increase radioactive discharges from the Sellafield site and result in concomitant increases of impacts to the North Sea.

Considerable concerns attach to the sediment bound fraction of radioactive transuranic elements. While these are currently localised predominantly in the Irish Sea sediments, there is strong evidence that this reservoir is now contributing to dissolved levels of americium and plutonium. In addition, sediment transport is carrying large quantities of radioactivity into local estuaries. The long term implications of sediment transport of radionuclides into the North Sea are unknown. In addition to the artificial sources of radionuclides, naturally occurring nuclides are mobilised by phosphate rock prozessing and can lead to high, levels of polonium – 210 being accumulated by marine animals. The significance of radionuclides present in pipe scale and production water from North Sea offshore operations is not known.

Much of our knowledge about the consequences of radioactive discharges relate to the physical behaviour of nuclides in the environment but this is incompletely understood. Very little is known about their effects upon natural ecosystems and the test endpoints of effects of radiation have been extremely crude. Despite the known variations in chemical behaviour of individual nuclides very little effort has been directed at determining their biochemical behaviour. Nonetheless, it is clear that some organisms may exceed human dose rates substantially. In the absence of a suitably directed monitoring programme, it is entirely possible that radiation induced effects upon organisms may be occurring but have not as yet been detected.

6 Shipping and the Offshore Oil Industry

6.1 Shipping

The North Sea is an area of intensive shipping activity and a significant component of shipping activites involve the carriage of dangerous and hazardous materials. Chemical tank washings and discharge of oily ballast water represent significant sources of marine pollution. In the case of oily discharges, there is evidence that many oily water separators do not function to MARPOL standards.

Ballast water can act as a vector of toxic chemicals and as a means for the introduction of alien species. The scope of this latter problem in the North Sea has not been fully evaluated.

6.2 The Offshore Oil Industry

The offshore oil industry is a substantial source of contaminants into the North Sea. The greatest inputs of oil occur with the discharges of oil based drilling muds with drill cuttings and these can impact benthic communities several kilometres from the rigs and platforms. As survey techniques become more sensitive so the recognised areas of impacts have had to be extended. In addition a veriety of production and drilling chemicals may be discharged.

Oil is introduced from the discharges of production waters also, but in addition these waters contain high levels of dissolved organic chemicals derived from the oil and from the formation rocks. Recent studies have drawn attention to elevated levels of cadmium and reactive mercury in the waters adjacent to offshore platforms possibly derived from operational discharges. Elevated levels of PCBs in seawater in these areas has not yet been explained. Discharges of production water will increase with the lifetime of the fields.

The problem of mobilisation of natural radionuclides from formation water was identified on the North Sea in 1981. Since then little seems to have been published on the subject and certainly no evalution of the significance of this in marine ecosystems appears to have been carried out.

7 Fisheries

The fisheries of the North Sea have been consistently over exploited and this has resulted in the collapse of stocks of mackerei and herring. Currently cod stacks are being over fished even though the spawning biomass estimated at

around one third of biologically acceptable levels. Fishing mortality of haddock, saithe and whiting has been very high for the last 25 years. Flatfish fishing mortality has recently increased with considerable intensification of the plaice fishery in Dutsch waters. It is generally accepted that current management strategies have failed to work and that despite attempts at control fishing mortalities have actually increased for some stocks.

Some effects of overfishing on bird populations have been recorded particularly as a result of exploitation of shellfisheries. There have caused mortailities in eider duck and knots. On the other hand catch discards and fish offal seem to have favoured some species. Overall, the effect of fishing activities in the North Sea are uncertain, but the stress of pelagic ecosystems and changes in food web balance could ultimately lead to a shift of the whole ecosystem into a new, irreversible steady state dominated by non-resource species.

There are chemical impacts associated with aquacultural activities. A variety of antibiotics and pesticides are used to control disease and parasites in farmed fish and these may create problem with residues in marketed fish and also allow antibiotic resistant bacteria to enter wild populations of fish. In addition the escape of farmed fish from cages may alter the genetic composition of wild stocks due to the selection of characteristics and genetic manipulation of farmed stocks. The output of nutrients and organic matter from farm cages is significant on both a local and a regional basis.

Diseases in wild populations of fish have attracted increasing scrutiny particularly with respect to their relationship with pollution. Exposure to chemical contaminants can not only result in large scale mortalities but may also affects behavioural and reproductive patterns. Deformities have been recorded in fish exposed to pulp bleaching effluents. Liver abnormalities have been found in fish exposed to contaminated sediments. Skin lesions on the blind side of flatfish have been found to more prevalent in fish from waters close to urban areas. A growing body of evidence tends to confirm that US findings are reproduced in North Sea areas.

The fecundity of fish and the survival of larval fish have both been found to be related to contamination in North Sea fish. Accumulation of contaminants in the ovaries of fish results in a lowered hatching success while abnormal development of embryos was found to be highest in contaminated areas and in estuarine plumes.

8 Marine Litter

Marine litter items include plastics, wood, discarded fishing gear glass and metal. Marine litter can impact populations of marine animals by ingestion and entanglement and arises from a number of sources. In addition lost cargoes may include hazardous chemicals. The disposal of obsolete oil industry platforms is likely to lead to increased littering of the sea bed in the future, while the impact of existing dumps of munitions and industrial wastes may also have significant consequences.

9 Nutrients

Levels of nutrients in coastal have risen by an order of magnitude in some coastal waters. It is admitted that control measures are not smoking and that agreed input reduction targets are unlikely to be achieved. The increased eutrophication has been associated with a apparent increase in the frequency of unusual algal blooms. In addition, there is evidence that the species composition of North Sea phytoplankton is changing over the region as a whole. Algal blooms are associated with a number of deleterious effects including oxygen depletion of sediments and water. This, in turn, can lead to large mortalities of benthic fauna and fish. In estuarine mud flats, europhication can lead to the formation of algal mats, to the detriment of key components of the food web.

The overall implications of eutrophication for the North Sea as a whole are profound. The potential interactions with other stressed components of the ecosystem are unknown, but may conspire to irreversibly change the ecology of the whole region. Nutrients require control as a matter of urgency and priority.

News & Views

Environmental Chemistry of the Heavy Elements

Editor: John S. Thayer
Publisher: The VCH Publishing Group

1995. Ca X, 250 pages with ca 16 figures and ca 13 tables.
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Environmental Chemistry of the Heavy Elements provides a critical review and discussion of roles played by hydrides and alkyls of the heavier elements in the natural environment. Research into the environmental chemistry of alkylmetal and alkylmetalloid compounds has been steadily expanding and diversifying over the past three decades. Unexpected vistas have opened up with the recent discovery that hydride derivatives of many of these same elements also form and exist under environmental conditions. Marked similarities in many properties of alkyls and hydrides have not yet been fully appreciated. While numerous specialized writings on these varied compounds exist, little has been written about the more generalized picture. The book aims to combine breadth with brevity by providing both general understanding and reference to more specialized literature. This book also discusses roles that microorganisms play in the formation, distribution, and degradation of heavy element compounds, and points out future possibilities and needs in this field.

Environmental Chemistry of the Heavy Elements will be of interest to environmental scientists, geochemists, toxicologists, certain biotechnology professionals, and persons interested in waste recycling.

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