International Council for the Exploration of the Sea

C.M. 1991/E: 11
Marine Environmental Quality Committee

PRECAUTIONARY PRINCIPLE VERSUS ASSIMILATIVE CAPACITY APPROACH

- A review from the interface between marine science and policy making -

by

Stephan Lutter
c/o WWF, Ökologiestation, Am Güthpol 9
W-2820 BREMEN 70
Federal Republic of Germany

ABSTRACT

The Precautionary Principle as adopted by the 2nd and 3rd North Sea Conference is far from being implemented in national legislation by the riparian states at present. Implementation in the framework of OSPARCOM and other international bodies such as the EC, covering adjacent marine and/or catchment areas, is in gradual progress. However, there are just a few binding decisions so far. By giving attention to dumping and incineration of industrial waste at sea this process was focussed on the most obvious and direct inputs of contaminants.

In the first part the paper presents a review of reports dealing with the prevalence of fish-diseases as well as malfunctions in invertebrate populations and/or increasing levels of micro-pollutants from certain disposal areas in the North Sea. This is to elucidate the reason for time-lags between scientific indication, accepted evidence and political action in the past.

In the second part the current status of the Precautionary Principle is examined with regard to terrestrial point and diffuse sources which account for the majority of inputs and contaminants to the North Sea both via run-off and atmospheric deposition. The key substances referred to are as follows: Cadmium, γ–HCH, PCP, TBT, Dichlorvos, DEHP. It is observed as a common feature that well-known hazardous substances are widely dispersed before the problem is addressed and action taken. Examples are given in the paper.

The reasons for this discrepancy are discussed in a conclusive chapter: Environmental Quality Objectives, if applied as predominant tools without restrictive Uniform Emission Standards at source, are identified as an obstacle at the policy making level. At the marine scientific level the status quo of the Assimilative Capacity Approach is supported by seeking after monocausal links between emissions and effects where multicausal interrelationships and synergic effects are most probable and the criteria "persistent, toxic, liable to bioaccumulate" would be sufficient as preliminary diagnosis. Therefore it is recommended to invoke the precautionary approach in the

interpretation of field data and to enhance the development of precautionary research methods, eg enzymatic monitoring of sublethal effects. With regard to recent distress signals from eutrophicated areas it is suggested to extend the Precautionary Principle to substances and practices that strictly speaking are not covered by the ministerial definition at present.

INTRODUCTION

The term Precautionary Principle was introduced by the 2nd International North Sea Conference 1987 (INC) and reaffirmed by the 3rd INC in order "to take action to avoid potentially damaging impacts of substances that are persistent, toxic and liable to bioaccumulate even where there is no scientific evidence to prove a causal link between emissions and effects" (NORTH SEA CONFERENCE 1990 a). International conventions for the protection of the marine environment accepted this definition (OSPARCOM 1990 a). Yet, the role of the precautionary approach as a basic principle of the Oslo and Paris conventions is still under consideration.

There has been eager discussion on the Precautionary Principle amongst jurists, economists (eg POLEY 1989, GRÜNDLING 1990) and marine scientists (eg MacGARVIN & BOOTH 1988, GRAY 1990, JOHNSTON & SIMMONDS 1990, LUTTER 1990, NOLLKAEMPER 1991), both with regard to justification and applicability and to the relationship between objective science and environmental policies.

In the early eighties distress signals from the marine environment were often translated from the scientific community to the level of policy-making. The mediating role of NGOs and its implications are discussed by WETTESTAD & ANDRESEN (1990).

One decade later the situation has changed: Scientific publications are taking up a precautionary point of view (LOHSE 1988 a, b, SÜNDERMANN & DEGENS 1989, LOZAN et al 1990, JOSEFSON 1990a) even though this is still regarded as an exception. New institutions, such as the North Sea Task Force (NSTF), are established "to provide more consistent and dependable data and to permit links between inputs, concentrations and effects to be established with greater confidence" (NORTH SEA CONFERENCE 1987 a). The work of NSTF and the status achieved are described by FERM (1989), REID (1990) and HOOGWEG et al (1991). However, opinions are still differing as to what extent data sets have to be reliable in order to justify immediate preventive measures.

1. Environmental hot spots - the starting point

The origin of the precautionary approach was closely linked to the dumping debate. Additional concern was created by biological changes in major estuaries and adjacent coastal zones, affected by effluent waters from the North Sea catchment area.

1.1 Dumping sites concerned

As far as it concerns the North Sea the dumping discussion started in the late seventies, mainly referring to a dumping site located 11-13 nautic miles NW off Helgoland (54°20' - 54°25' N; 7°35' - 7°52,5' E) which was in use for disposal of liquid industrial waste from 1969-1988. During the same period the incineration site near Dogger Bank (54°17,5' N; 3°45' E; radius 15 nautic miles), which was disused in 1990, was rather subject to public and political debate than to scientific interest. In comparison with these predominant issues an old-established dumping practice was fairly neglected in scientific discussion: Sewage sludge disposal by vessel or pipeline, which has been quite common in the Thames estuary since 1887 according to MORRIS (1988) but was also practiced in the German Bight from 1961-1980.

1.2 Scientific evidence and administrative response

1.2.1 Liquid industrial waste

Early concern about potentially negative effects of waste from the titanium dioxide production, due to flocculation and heavy metal contamination, was expressed about 30 years ago (VACCARO et. al. 1972). Abnormally high prevalence of diseases in populations of less migratory fish species such as dab (*Limanda limanda*) was indicated by DETHLEFSEN for the German dumping ground as early as in 1978. After intensifying the effect monitoring various malfunctions and diseases could be specified in the sample area NW off Helgoland and certain lesions turned out to be correlated to chromium exposure (DETHLEFSEN 1980, 1984 a, DETHLEFSEN & WATERMANN 1980). This syndrome was suspected to be a singularity and/or coincidence with other factors until BOS (1987) reported similar effects from other areas which had been exposed to the same dumping practice under different hydrographic conditions. In order to determine the relative significance of anthropogenic impacts in dumping areas DETHLEFSEN (1988) emphasized that they had to be estimated in the context of the whole range of natural and man-made factors potentially suppressing immunocompetence and promoting diseases.

It is regarded as a follow-up of this discussion that dumping of liquid industrial waste in the North Sea was phased out by the 2nd INC and OSCOM by the end of 1989 (OSPARCOM 1990 b). This happened without definitely referring to the Precautionary Principle but reflecting its meaning: Even though ultimate proof for causal links between inputs and effects could not be presented political action was taken and a sum of consistent indications resulted in the same political consequences as 95% significant monocausal correlations.

1.2.2 Waste incineration

COMPAAN (1988) made clear that doubts about environmental safety of incineration at sea also entered Europe from US waters. McINTYRE (1989) stressed the fact that incineration of

organochlorine solvents at sea was terminated on the basis of a far by shorter chain of reasoning than dumping of waste from the TiO_2-production. KARCHER (1990) explaines the "terrestrial viewpoint": In order to reduce production and waste streams of organochlorine solvents in general NGOs and other bodies aimed at making incineration as difficult and expensive as possible. Forced by public opinion and the shift to land-based options both INC and OSPARCOM (1990 c) decided on termination of incineration at sea by the end of 1994. Yet, by screening the North Sea for organochlorine residues LOHSE (1988) detected key tracers of incomplete combustion, ie OCS and HCB in sediments near the incineration site. Due to these chemical footprints and additional reports on contaminated waste streams the deadline of INC and OSCOM was anticipated by the riparian states concerned. Thus two processes interlaced with each other. Marine scientific evidence played a decisive but not the dominant part.

1.2.3 Dredged materials

FÖRSTNER & SALOMONS (1988) reviewed the discussion on dredged materials which is still going on in scientific journals as well as in the OSCOM-context in a sophisticated way, aiming at technical options and strategies to minimize the level of contamination and the impact of remobilization. Weighing the advantages against disadvantages of "dispersion vs. containment " FÖRSTNER & SALOMONS (1988) are aware that dredged materials work as a trap for contaminants at the "end of the pipe". Marine ecological experience and technological know-how has to cope with deficiencies still existing at the very sources of river pollution (cf. HUPKES 1990).

1.2.4 Sewage sludge

Most of the investigations on sewage sludge disposal sites have been concentrating on local physical effects, deoxygenation and acute toxicity. In a summary PARKER (1988) pointed out that accumulation of disposed material is said to be likely in periodically stratified waters (eg at the former disposal site SE off Helgoland) whereas contaminants and nutrients from disposal sites located along the UK coast are supposed to be dispersed due to different oceanographic regime.Temporal trends and/or spatial gradients, eg trails of sediments containing high levels of heavy metals could be demonstrated on sporadic occasions (IRION & SCHWEDHELM 1983). According to ap RHEINALLT (1988) monitoring programmes in the Thames estuary as well as case studies from the Elbe area resulted in the same dilemma: Apparently it is extremely difficult to link elevated contaminant levels or malformation rates to the sewage sludge issue, due to the overlap with other impacts and to the variety of sources in the nearby inner estuary. New studies presented by DETHLEFSEN (1991) indicate high infection rates of dab near the Humber estuary which may be a synergic phenomenon caused by sewage sludge disposal with pollution effects tipping the balance. Notwithstanding the lack of proof, it can be stated that an overall

environmental stress on fish populations exists in these areas (DETHLEFSEN 1980, MÖLLER 1984, JOHNSTON & FEIL 1987, ap RHEINALLT 1988) and that heavy metal and organochlorine content of modern sewage sludge is still critical (O'DONNELL & MANCE 1984, PARKER 1988, NORTH SEA CONFERENCE 1990 b). Political restrictions were postponed by the NORTH SEA CONFERENCE (1990 a) due to the uncertainties in field observations.

1.2.5 River inputs and estuarine point sources

Since there is little chance to discriminate riverine substances from those introduced by dumping or atmospheric pathways most of the studies on the fate and/or effect of micropollutants from riverine and estuarine inputs are biased with regard to their geographic range and detection limits. Scientific attention of many authors (eg IRION & SCHWEDHELM 1983, cf ERNST et al 1988) and of NGO-reports (eg WORLD WIDE FUND FOR NATURE 1987) was drawn to distinct water bodies related to estuarine systems, preferably dealing with the inputs of Rhine, Ems, Weser and Elbe. Referring to the Wadden Sea HÖPNER (1989) assessed the impact of nutrient loads that are focussed along the German Bight and Jutland by horizontal fronts. MORRIS (1988) concluded that more knowledge on the effects of Humber and Thames would be desirable with regard to their contaminant content (cf NORTH SEA CONFERENCE 1987 b, HUPKES 1990). There may be even a need for additional investigations about the effects of Tyne and Tees if the high residence time of coastal water bodies influenced by these rivers is taken into consideration (cf KERSTEN et al 1988).

Biomagnification of persistent chemicals such as DDT, PCBs, Mercury etc and their potential effects in marine top predators played a major role in estimating riverine pollution in the southern North Sea. Monocausal links between inputs and effects could only be established in the case of extraordinary events such as heavy pesticide emission causing seabird mortality (KOEMAN 1972). Data from harbour seals (*Phoca vitulina*) as presented by DRESCHER et al (1977) and REIJNDERS (1980) stimulated the discussion on xenobiotics in the North Sea ecosystem and tended to verify alarming results from laboratory tests. Comprehensive expertises from governmental authorities (RAT VON SACHVERSTÄNDIGEN FÜR UMWELTFRAGEN 1980) favoured preventive measures against further inputs of persistent chemicals from the North Sea catchment area.

Seven years later the governments of the Wadden Sea countries stated that "...existing international directives and regulations concerning cadmium, mercury, PCB, HCH and other relevant pollutants have not had substantial positive effect on the water quality of the Wadden Sea". The NORTH SEA CONFERENCE (1987 a) took the arbitrary decision to cut riverine inputs of hazardous substances by one half until 1995 on the basis of immission data of 1985.

2. Diffuse sources and dispersed inputs -the big unknown?

It should be mentioned here that most of the studies on sublethal effects in fish larvae and invertebrates in the southern North Sea (eg DETHLEFSEN et al 1986, CAMERON et al 1989, KNUST 1990) were still in preparation when the keystone of North Sea policy in terms of the 50% reduction was established. The same applies to interdisciplinary research projects that have been elaborating a synoptic North Sea wide view on the distribution of contaminants: The new data provided by KEMPE et al (1988) and SÜNDERMANN & BEDDIG (1988) raise the question of dispersed anthropogenic compounds from neglected and diffuse sources and reveal another set of environmental "hot spots" but formally do not influence North Sea policy until the 3rd Quality Status Report is presented in 1993.

It can hardly be explained by the previous lack of overall distribution patterns, however, that more than one decade passed until it was laid down as an intergovernmental agreement to phase out PCBs completely (NORTH SEA CONFERENCE 1990 a). Long time before PCB distribution patterns in sediments and fish from the entire North Sea could be presented by LOHSE (1988 b) and BÜTHER (1988) the dramatic situation was already evident: van AALST et al (1983) communicated the results of measurements and modelling on atmospheric deposition of PCBs and ended up in figures exceeding the estimated river inputs. The dominant role of atmospheric PCB inputs was confirmed by WARMENHOVEN (1989). Ultimate *in situ* proof for a monocausal pollutant - effect -relationship is still lacking despite of various studies from different areas and food web links (eg HELLE et al 1976, DETHLEFSEN et al 1986, REIJNDERS 1986). The PCB issue, meanwhile exhausted in scientific debate, is a typical example for the tremendous time-lag between scientific evidence and administrative response.

It is taken for granted that just a small part of man-made xenobiotics, especially the family of halogenated hydrocarbons, their derivatives and metabolites, is identified in routine investigations and monitoring programmes covering the North Sea at present (HOLDEN 1981, LOHSE 1988 b). Even keeping to the small selection of traditional tracers and approved analytical standards LOHSE (1988 b) showed that most of the substances concerned are making for the open sea. KERSTEN et al (1988) and SÜNDERMANN & BEDDIG (1988) pointed out that significant regional differences exist in heavy metal concentrations of water, suspended matter and deposited sediment. Increasing gradients towards the northern North Sea gave the lie to the patterns usually expected. Irregular distribution of heavy metals was also reported from monitoring organisms by KARBE et al (1988).

2.1 Trouble making Dogger Bank

Both with regard to contaminant levels and malformation rates the Dogger Bank area is one of the best documented irregularities in the North Sea. DETHLEFSEN (1984 b) referred to the frequent occurrence of diseases in flatfish. CLAUSSEN (1988) and BÜTHER (1988) identified

contaminant levels higher than average in liver tissue of dab (*Limanda limanda*). KRÖNCKE (1988) recorded elevated contents of heavy metals in benthic invertebrate macrofauna. All authors conclude that pollution problems do not seem to be restricted to coastal water bodies as assumed for years. It is still unclear whether their findings are caused by biomagnification and/or atmospheric inputs, physical transport and deposition processes. DETHLEFSEN et al (1987) suggested combined effects with considerable influence from estuaries or scattered disposal sites along the UK coast.

2.2 Case studies on selected contaminants

In order to elucidate the mechanisms at the interface between marine science and policy making it is useful to refer to single compounds being in the focus of environmental argument:

2.2.1 Cadmium

The distribution patterns of cadmium compiled by KERSTEN et al (1988) clearly display increasing contents in suspended matter towards the northern North Sea whereas concentrations in seawater decrease from land to sea. According to this study there is no reason at all to assume that increased atmospheric deposition rates from anthropogenic and/or geochemical sources cause such a unique feature. On the contrary, intensified upwelling and increased seasonal productivity in the transition zone between North Sea an northern Atlantic waters was identified as the most probable mechanism transferring comparably low concentrations of dissolved cadmium into the particulate state. Major sedimentation events were supposed to "sweep" the water column for this contaminated material, potentially causing local enrichment of cadmium in deposited sediment (SÜNDERMANN & BEDDIG 1988). Indeed KARBE et al (1988) came across such local "hot spots" in the northern North Sea when using hermit crabs (*Pagurus bernhardus*) as monitoring organisms. Recorded contamination levels partly exceeded those from the Elbe estuary where cadmium input from run-off and atmospheric deposition is supposed to be much higher. One has to conclude that even the average anthropogenic cadmium input rate presently added to the geochemical background may be as incompatible with natural processes as the estuarine peak values. The latter, however, gave rise to marine environmental policies on cadmium (PHILLIPS 1980).

Despite of this background most of the measures taken to reduce the cadmium input into marine biota are enigmatic and contradictory: Binding EC directives still refer to environmental quality objectives above the level regularly assessed in surface waters (EUROPEAN COMMUNITY 1983). The Paris Commission started developing a strategy to phase out the use of cadmium in pigments, stabilizers and plating (OSPARCOM 1990 e) but had to take note during its 1991 meeting, "...that no progress had been made with regard to the elaboration of a PARCOM decision on the phasing out of cadmium in applications other than batteries...". On the one hand

the NORTH SEA CONFERENCE (1990 a) decided "...to achieve reductions between 1985 and 1995 of total inputs (via all pathways) of the order of 70% or more..." for cadmium amongst other substances causing a major threat to the marine environment. On the other hand land-based incineration of hazardous and municipal waste is expanding in most of the North Sea states and taking advantage of existing Environmental Quality Standards even if Best Available Technology is applied.

2.2.2 γ-Hexachlorocyclohexane (HCH)

The bibliography of BARTLETT & MOULDER (1976) provides plenty of reports on the effects of lindane (γ- HCH) to marine and estuarine ecosystems. Accumulation in lipid tissue of marine mammals from the southern North Sea is two orders of magnitude lower than for PCBs (VAGTS, pers. comm.). BÜTHER (1988) showed that the lipophilic pesticide is also accumulated in liver tissue of North Sea fish. Elevated levels, decreasing from land to sea but not restricted to coastal areas, are known from benthic macrofauna and zooplankton (KARBE et al 1988, SÜNDERMANN & BEDDIG 1988). LOHSE et al (1989) pointed out that lindane is the only routinely monitored organochlorine pesticide exhibiting an upward trend in surface water contents of the North Sea (eg by factor 4 from 1981 to 1987). This result is consistent with the fact that highest values can be recorded in the top layer of sediments from typical lindane-sinks such as the Skagerrak and the Norwegian trench (LOHSE 1988 b).

A case study for a certain area bordering on the Wadden Sea BULTHUIS (1991) recently confirmed that lindane inputs to the sea stem from diffuse sources exclusively. Atmospheric deposition, having obviously increased during the past decade seems to be higher than river run-off (van AALST 1983, LOHSE et al 1989, HUPKES 1990).

Regardless of this extraordinary results fairly little has been undertaken to further reduce the inputs of lindane for precautionary reasons. As far as it concerns the European Community which is still without a directive especially referring to lindane, this pesticide is only produced by two companies located outside of the North Sea catchment area. Yet, some 100 tons are imported to and applied in each North Sea country per year in various formulations. Instead of phasing out production and/or further use of lindane the NORTH SEA CONFERENCE (1990 a) decided in favour of general technical measures to combat the dispersion of pesticides.

2.2.3 Pentachlorophenol (PCP)

ERNST et al (1988) reported on a steep gradient of PCP concentrations from the Elbe and Weser estuary towards the German Bight. The dispersion of PCP can be clearly linked to estuarine water bodies gradually mixing with sea water. This is also reflected in a recent study of HÜHNERFUSS et al (in press) who demonstrated the influence of changing meteorological conditions on the fluctuation of PCP contents, caused by the diluting effect of water bodies

pressed into the German Bight from central parts of the North Sea. It can be concluded from these data sets that the highly toxic Black List Substance is present in water of the southern North Sea in concentrations comparable to those reported from lindane.
PCP is covered by the priority list of hazardous substances endorsed by the NORTH SEA CONFERENCE (1990 a). Moreover a total ban was announced by the North Sea Ministers. Legally binding agreements took the opposite way: Due to a recent regulation of the European Commission PCP has to be licensed for certain outdoor purposes even in those member states that already have phased out the production and use of PCP.

2.2.4 Tributyltin (TBT)-compounds

When STEBBING (1985) published a review on the deleterious effects of organotin anti-fouling paints containing TBT the problem seemed to be mainly restricted to coastal zones. Organotin compounds released from marinas at toxic levels clearly interfered with oyster cultures and local fishermen's welfare in the 60ies and 70ies. The toxic potential of TBT was examined in detail and with regard to various taxa (cf WOOD 1986). Innovative approaches aimed at minimizing the leaching rate from the anti-fouling paint and/or substitution of organotin by for instance copper compounds.
The political "lesson of TBT" (STEBBING 1985; ELLIS 1991) was learned rather quickly but stopped halfway: Soon a partial ban on TBT was put into action in some EC member countries covering boats less than 25 m but neglecting the bigger vessels. The NORTH SEA CONFERENCE (1990 a) intends to prepare a worldwide agreement for ships longer than 25 m and included TBT in the priority list.
The survey of COUGHLAN (1990) suggests that administrative response was not able to keep up with deterioration of the marine environment. Nowadays elevated surface concentrations of TBT in the southern and central North Sea exceed the levels causing imposex in gasteropods and approach the levels causing reproductive failures in oysters.

2.2.5 Dichlorvos

It seems to be worth mentioning that there is a considerable lack of field data on this chlorinated organophosphorous pesticide. Dichlorvos is preferably used as parasitic control agent in salmon farming and known as highly toxic to non-target organisms (ROSS & HORSEMAN 1988). Field records as presented by TULLY & MORRISSEY (1989) from waters outside the North Sea area are rather scarce in general. So there is low confidence from scientific literature as to what extent dichlorvos is dispersed by its widely scattered point sources. The input of this marine pesticide is to reduce by the order of 50% as well (NORTH SEA CONFERENCE 1990 a) although the UK recently renewed the licenses for the most important formulation NUVAN.

2.2.6 Diethylhexylphthalate (DEHP)

Only short time after their introduction COLE (1981) predicted conflicts between the new generation of plastizicers (phthalates) and environmental processes. Bad experiences with PCB substitutes from other industrial sectors such as UGILEC and DBBT subsequently justified his doubts (de JONG 1989). It is still unclear whether this also really applies to the non-chlorinated DEHP and DBP. These substances are readily degradable in laboratory tests and under conditions of purification plants. Informations on biomagnification are still inconsistent. At any case many unidentified high peaks in gaschromatographic analyses from different marine compartments are attributed to the presence of pthalates (BRAUNGART, LOHSE, HÜHNERFUSS, pers. comm.). Considering the DEHP levels reported from soft bottom sediments in the German Bight by ERNST et al (1988) - 0,2-20 µg/g wet- and from North Sea waters and Mid European estuaries –up to 0,3 µg/l- by DEUTSCHES HYDROGRAPHISCHES INSTITUT (1986) and PRESTON & AL-OMRAN (1986) there is, nevertheless, some reason for concern. These DEHP levels can cause various sublethal effects on organism and/or community level, eg adversely affect microbial activity and zooplankton reproduction (SANDERS et al 1973).

Since DEHP apparently accumulates in naturally occuring anoxic sediments its behaviour in certain compartments of the ecosystem has not been properly assessed so far. Based on misleading and simplified premises the North Sea Ministerial Conferences omitted this important group of contaminants although it partly fulfills the criteria of the Precautionary Principle.

2.3 New sensitive issues

During the last three years a significant increase of benthic macroalgae in the Wadden Sea (ie Chlorophyta) was observed, both with regard to biomass and to covered soft bottom area. Observations were started in the middle eighties. In 1989 up to 30 % of the mud flats were covered by macroalgae, 10 % by thick algal material, thus suffocating the benthic invertebrate community (eg *Cerastoderma edulis*) and affecting the important nitrification and denitrification processes at the water/sediment interface. This was not a singularity: In 1990 the affected area was twice as big as in previous years, covered during the whole vegetation period. In 1991 the trend continued even though the process of oxygen depletion was not enforced by an extraordinary climatic situation (MICHAELIS pers. comm.). In addition increasing numbers of "black spots" were reported even from coarse Wadden sediments with the anoxic layer breaking through to the surface. Data from aerial surveys and local field investigations on these phenomena are provided by KOLBE (1991).

Eutrophication by nitrogen compounds is discussed as the dominant factor causing the phenomena mentioned. The long-term monitoring of mean nutrient concentration and N/P ratio

versus phytoplankton carbon and/or flagellate/diatom ratio evaluated by BERG & RADACH (1985) and RADACH et. al. (1989) give another hint. Even extraordinary blooms of *Phaeocystis globosa* may be primarily due to excess nitrogen loads (ZOMER pers. comm.). JOSEFSON (1990 b) expects irreversible changes on benthic community level in Skagerrak and Kattegat linked to increased nitrogen inputs.With regard to the Wadden Sea HÖPNER (1989) makes his point on the nitrogen issue describing a naturally eutrophic system with high energy flows, adaptable to a wide range of nutrient input rates. REISE (1990) and others have their doubts about the high regenerative capacity of the Wadden Sea.

3. Precautionary Principle - a guideline for marine research ?

BOEHMER-CHRISTIANSEN (1990) discussed the tension between Environmental Quality Objectives (EQO) and Uniform Emission Standards (UES) in juridical and economical terms. She made clear that there is not any *per se* contradiction between EQO and UES but that conflicts can arise dependent on economic pre-conditions and monitoring philosophy. Referring to contaminant levels EQO can be used as precautionary supplement to UES if any deterioration of the environmental *status quo* is inhibited by additonal regulations. As in the case of some national river and sewage sludge policies EQO can be misused as a carte-blanche for the dilution and dispersion of hazardous inputs if additional juridical tools are not implied. Finally it depends on the approach of and advice from the scientific community which of either attitude will become the prevailing one both at the administrative and political level. After many years of research it still seems impossible to set up monitoring standards describing the health status of the North Sea ecosystem with high confidence. It is even more difficult to ensure that certain contaminant levels do not harm marine life cycles in the synergic context.

Random processes play a crucial role in pelagic and benthic invertebrate and microbial community dynamics, as shown for cadmium, and can shift system status or change equilibrium very rapidly. Statistical analysis is, generally speaking, based on a mechanistic approach and sometimes unable to cope with non-cyclic, non-linear, unpredictable phenomena. The potential of diffuse, multicausal interrelationsships, however, has been steadily increased by new anthropogenic implications during the last decades. From this the self-evident postulation results that is necessary to minimize man-made impacts and/or substances alien to nature. As historical data sets are scarce the virgin situation of the marine environment is hard to describe with respect to eg heavy metals, nutrients and other non-synthetic compounds that also occur in natural cycles. Nevertheless, it is reasonable to invoke the Precautionary Principle in scientific interpretation. This would mean to point out potentially persistent and toxic substance streams as soon as they are detected instead of waiting until significant correlations to ecological changes are established.

Regarding the "tip of the iceberg", that is organochlorine emissions from indirect and diffuse

sources, preventive measures are merely taken on sporadic occasions. German and Dutch NGOs conclude after scrutinizing the existing policies that even the few legal tools available in this field are hardly employed (BERENDS & STOPPELENBURG 1990, WINTELER & AHRENS 1990). Scientific evidence, however, has been gathered over years, that the majority of organochlorine compounds interfere with marine biota in a very typical and similar way (cf HOLDEN 1981). Moreover, they are closely related to each other within the production process. Even though this "family" of substances strictly speaking fits in the criteria concerned ("liable to bioaccumulate, persistent, toxic") precautionary action to reduce their impact on man and nature is very poor and dilatory: Policies have been concentrating on single substances and/or groups of congeners such as PCBs and DDT and their special fields of application, thus neglecting the vast range of unknown or unidentifiable compounds instead of dealing systematically with the problem at the very source of chlorine production. Preventive measures at source can be improved if this background is better reflected in marine environmental research.

Another way to incorporate the precautionary approach into research methodology is to develop better and more sensitive monitoring schemes, in order to indicate detrimental trends already in an early, sublethal stage. The current research on enzymatic systems (MFO) in fish liver tissue, to be interpreted as an indication of overall environmental stress before immuno-competence breaks down and the visible disease syndrome arises (KÖHLER-GÜNTHER 1989), seems to become succesful in this respect.

Last but not least there may be sufficient evidence to apply the Precautionary Principle to new areas of concern: GERLACH (1988) estimated that today's nitrogen input to the North Sea is 3-4 times as high as the riverine and atmospheric background in the beginning of large scale industrial and agricultural activities.This figure would urge precautionary action and justify drastical reduction of nitrogen inputs from diffuse sources even without accepted evidence on long-term changes in planctonic or benthic communities caused by eutrophication.

REFERENCES

AALST, R.M. van, R.A.M. van ARDENNE, J. F. de KREUK & T. LEMS (1983): Pollution of the North Sea from the atmosphere. Report CL 83/152 TNO, Delft

BARTLETT, C. A. & D. S. MOULDER (1976): A bibliography on marine and estuarine pesticide pollution. Marine pollution information centre, Plymouth, 96 pp.

BERENDS, W. & D. STOPPELENBURG (1990): Van keukenzout tot gifcocktail. Chloor: toepassingen, milieu-effecten en alternatieven. Rapport Vereniging Milieudefensie/ Landelijke Vereniging tot Behoud van de Waddenzee. Amsterdam/Groningen, 60 pp.

BERG, J. & G. RADACH (1985): Trends in nutrient and phytoplankton concentrations at Helgoland Reede (German Bight) since 1962. ICES C.M./L:2, 1-16

BOEHMER-CHRISTIANSEN, S. (1990): Environmental Quality Objectives versus Uniform Emission Standards. pp. 139-149 in: FREESTONE, D. & T. IJLSTRA (eds.): The North Sea: Perspectives on regional environmental co-operation. Special issue of the International Journal of Estuarine and Coastal Law, Graham & Trotman, London, 356 pp.

BOS, H. R. (1987): A summary on the results of the monitoring of the Dutch TiO_2 -dumping grounds between 1986 and 1988. SACSA 16/4/6-E

BÜTHER, H. (1988): Distribution of chlorinated organic compounds in livers of dab (*Limanda limanda*) of the southern and central North Sea. pp. 497-541 in:KEMPE, S., G. LIEBEZEIT, V. DETHLEFSEN & U. HARMS (eds.): Biogeochemistry and distribution of suspended matter in the North Sea and implications to fisheries biology. Mitt. Geol.-Paläontol. Inst. Univ. Hamburg 65, 546 pp.

BULTHUIS, R. A. (1991): Diffuse lozingen van bestrijdingsmiddelen naar de Waddenzee ten gevolge van landbouwkundig gebruik in de provincie Groningen. Rapport. Werkgroep Eemsmond, Groningen, 40 pp.

CAMERON, P., J. BERG, V. DETHLEFSEN & H.v. WESTERNHAGEN (1989): Untersuchungen über Mißbildungen an Fischembryonen von Fischen der südlichen Nordsee. Biol. Anst. Helgoland, Jahresbericht 1988: 107-108

CLAUSSEN, T. (1988): Levels and spatial distribution of trace metals in dabs (*Limanda limanda*) of the southern North Sea. pp. 467-496 in: KEMPE, S., G. LIEBEZEIT, V. DETHLEFSEN & U. HARMS (eds.): Biogeochemistry and distribution of suspended matter in the North Sea and implications to fisheries biology. Mitt. Geol.-Paläontol. Inst. Univ. Hamburg 65, 546 pp.

COLE, H. A. (1981): Grim outlook for the twenty-first century. Editorial. Mar. Pollut. Bull. 12(3): 69-71

COMPAAN, H. (1988): Waste incineration at sea, pp. 258-274 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

COUGHLAN, A. (1990): Lethal paint makes for the open sea. New Scientist 12: 16

DETHLEFSEN, V. (1978): Occurence and abundance of some sceletal deformities, diseases and parasites of major fish species on dumping areas off the German coast

DETHLEFSEN, V. (1980): Observations on fish diseases in the German Bight and their possible relation to pollution. Rapp. P.-v. Réun. Cons. int. Explor. Mer 179: 110-117

DETHLEFSEN, V. (1984 a): Untersuchungen zur Erkennung subletaler Schadstoffeffekte an Fischen in der Deutschen Bucht: Krankheiten, Biochemie, Physiologie, Rückstände. BMFT Forschungsbericht M 84-007. Bundesforschungsanstalt für Fischerei, Institut für Küsten- und Binnenfischerei, Hamburg, 427 pp.

DETHLEFSEN, V. (1984 b): Diseases in North Sea fishes. Helgol. Meeresunters. 37: 353-374

DETHLEFSEN, V. (1988): Ten years fish disease studies of the Federal Research Board Fisheries Hamburg, ICES C.M./E: 23; Mar. Env. Quality Comm.

DETHLEFSEN, V. (1991): Hohe Befallsraten der Kliesche (*Limanda limanda*) mit Flossenfäule vor der Humbermündung. Infn. Fischw. 38 (2): 67-71

DETHLEFSEN, V. & B. WATERMANN (1980): Epidermal papilloma of North Sea dab, *Limanda limanda:* histology, epidemiology and relation to dumping of wastes from TiO_2 industry. ICES Spec. Meeting on diseases of commercial important marine fish and shellfish 8: 30

DETHLEFSEN, V., P. CAMERON, H. von WESTERNHAGEN & D. JANSSEN (1986): Morphologische und chromosomale Untersuchungen an Fischembryonen der südlichen Nordsee in Zusammenhang mit der Organochlorkontamination der Elterntiere. Veröff. Inst. f. Küsten- und Binnenfisch. 96: 1-56

DETHLEFSEN, V., B. WATERMANN & M. HOPPENHEIT (1987): Diseases of North Sea dab (*Limanda limanda*) in relation to biological and chemical parameters. Arch. FischWiss. 37: 107-237

DEUTSCHES HYDROGRAPHISCHES INSTITUT (1986): Überwachung des Meeres. Bericht für das Jahr 1986. Teil II Daten. DHI, Hamburg

DRESCHER, H. E., U. HARMS & E. HUSCHENBETH (1977): Organochlorines and heavy metals in the harbour seal (*Phoca vitulina*) from the German North Sea coast. Mar. Biol. 41: 99-106

ELLIS, D. V. (1991): New dangerous chemicals in the environment: Lessons from TBT. Viewpoint. Mar. Pollut. Bull. 2 (1): 8-10

ERNST, W., J. P. BOON & WEBER, K. (1988): Occurence and fate of organic micropollutants in the North Sea. p. 284-299 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

EUROPEAN COMMUNITY (1983): Directive 83/513/EEC on limit values and quality objectives for emission of cadmium.

FERM, R. (1989): How is scientific knowledge incorporated into North Sea Conference decisions? pp. 191-195 in: TEN HALLERS, C. C. & A. BIJLSMA (eds.): Distress signals, signals from the environment in policy and decision-making. Proceedings of the 3rd North Sea Seminar, Werkgroep Noordzee, Amsterdam, 253 pp.

FÖRSTNER, U. & W. SALOMONS (1988): Dredged materials, pp. 226-245 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

GERLACH, S. A. (1988): Nutrients - an overview. In: NEWMAN, P. J., & A. R. AGG: pp. 147-175 Environmental protection of the North Sea. Heinemann Professional Publ., Oxford and London, 886 pp.

GRAY, J. S. (1990): Statistics and the Precautionary Principle. Viewpoint. Mar. Pollut. Bull. 21 (4): 174-176

GRÜNDLING, L. (1990): The status in international law of the principle of precautionary action. pp. 23-30 in: FREESTONE, D. & T. IJLSTRA (eds.): The North Sea: Perspectives on regional environmental co-operation. Special issue of the International Journal of Estuarine and Coastal Law, Graham & Trotman, London, 356 pp.

HELLE, E., M. OLSSON & S. JENSEN (1976): DDT and PCB levels and reproduction rates in Ringed Seal from Bothnian Bay. Ambio 5(4): 188-189

HÖPNER, T. (1989): The quality state of the Wadden Sea - attempt of an assessment, Wadden Sea Newsletter 2: 16-20, Common Wadden Sea Secretariat, Wilhelmshaven

HOLDEN, A.V. (1981): Organochlorines - an overview. Viewpoint. Mar. Pollut. Bull. 12 (4): 110-115

HOOGWEG, P., J.-P. DUCROTOY & B. VAN DE WETERING (1991): The North Sea Task Force. The first two years. Mar. Pollut. Bull. 22 (7): 328-330.

HÜHNERFUSS, H., H. DANNHAUER, J. FALLER & P. LUDWIG (1991): Concentration variations of anthropogenic and biogenic organic substances in the German Bight due to changing meteorological conditions, Dt. Hydrogr. Z. (in press)

HUPKES, R. (1990): Pollution of the North Sea imposed by West European rivers (1984-1987). International Centre of Water Studies (ICWS), Amsterdam, 103 pp.

IRION, G. & E. SCHWEDHELM (1983): Heavy metals in surface sediments of the German Bight and adjoining areas. pp. 888-891 in: Proc. Int. Conf. Heavy metals in the environment, Heidelberg

JENSEN, A. (1989): Co-operation of policy and science. Viewpoint of a scientist. p. 197-203 in: TEN HALLERS, C.C. & A. BIJLSMA (eds.): Distress signals, signals from the environment in policy and decision-making. Proceedings of the 3rd North Sea Seminar, Werkgroep Noordzee, Amsterdam, 253 pp.

JOHNSTON, P. A. & R. L. FEIL (1987): Diseased Flounder (*Platichthys flesus*) from the inner Thames estuary, Greenpeace UK, 16 pp.

JOHNSTON, P. & M. SIMMONDS (1990): Statistics and the Precautionary Principle. A reply to J. S. Gray. Letter, Mar. Pollut. Bull. 21 (8): 403-404

de JONG, F. (1989): Effluent waters: national policies and concepts. pp 81-92 in: TEN HALLERS, C.C. & A. BIJLSMA (eds.): Distress signals, signals from the environment in policy and decision-making. Proceedings of the 3rd North Sea Seminar, Werkgroep Noordzee, Amsterdam, 253 pp.

JOSEFSON, A. B. (1990 a): Statistics and the Precautionary Principle, Letter, Mar. Pollut. Bull. 21 (12): 598-599

JOSEFSON, A. B. (1990 b): Increase of benthic biomass in the Skagerrak-Kattegat in the 1970s and 1980s. Effects of organic enrichment. Mar. Ecol. Prog. Ser. 66: 117-130

KARBE, L., J. GONZALEZ-VALERO, T. BORCHARDT, M. DEMBINSKI, A. DUCH, H. HABLIZEL & R. ZEITNER (1988): Heavy metals in fish and benthic organisms from the northwestern, central and southern North Sea: Regional patterns comparing dab, blue mussel and hermit crab (*Limanda limanda, Mytilus edulis, Pagurus bernhardus*). ICES C. M. 1988/E:22

KARCHER, M. (1990): Options for waste disposal. A reply to Alasdair Mc Intyre. Letter. Mar. Pollut. Bull. 21 (3): 157-158

KEMPE, S., G. LIEBEZEIT, V. DETHLEFSEN & U. HARMS (eds.) (1988): Biogeochemistry and distribution of suspended matter in the North Sea and implications to fisheries biology. Mitt. Geol.-Paläontol. Inst. Univ. Hamburg 65, 546 pp.

KERSTEN, M., M. DICKE, M. KRIEWS, K. NAUMANN, D. SCHMIDT, M. SCHULZ, M. SCHWIKOWSKI & M. STEIGER (1988): Distribution and fate of heavy metals in the North Sea, pp. 300-347 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

KNUST, R. (1990): The black spot disease in *Crangon crangon* (L.) of the German Bight, ICES C.M./E: 32 Ref. K; Mar. Env. Quality Comm.

KÖHLER-GÜNTHER, A. (1989): Histochemie und Pathologie der Fischleber für das biologische Schadstoff-Effekt-Monitoring, Biol. Anst. Helgoland, Jahresbericht 1989, p.111-112

KOEMAN J. H. (ed) (1972): Side-effects of persistent chemicals on birds and mammals in the Netherlands. TNO-Nieuws 27: 527-632

KOLBE, K. (1991): Zum Auftreten "schwarzer Flecken", oberflächlich anstehender, reduzierter Sedimente, im ostfriesischen Wattenmeer. Bericht Forschungsstelle Küste, Niedersächsisches Landesamt für Wasser und Abfall, Norderney, 26 pp.

KRÖNCKE, I. (1988): Heavy metals in North Sea macrofauna. pp. 455-465 in: KEMPE, S., G. LIEBEZEIT, V. DETHLEFSEN & U. HARMS (eds.): Biogeochemistry and distribution of suspended matter in the North Sea and implications to fisheries biology. Mitt. Geol.-Paläontol. Inst. Univ. Hamburg 65, 546 pp.

LOHSE, J. (1988 a): Ocean incineration of toxic wastes: a footprint in North Sea sediments. Mar. Pollut. Bull. 19, 366-371

LOHSE, J. (1988 b): Distribution of organochlorine pollutants in North Sea sediments. pp. 345-365 in: KEMPE, S., G. LIEBEZEIT, V. DETHLEFSEN & U. HARMS (eds.): Biogeochemistry and distribution of suspended matter in the North Sea and implications to fisheries biology. Mitt. Geol.-Paläontol. Inst. Univ. Hamburg 65, 546 pp.

LOHSE, J., P. JOHNSTON, T. JEWELL & M. MacGARVIN (1989): Lindane and other pesticides in the North Sea: Reasons for concern. 22 in: 0-2000 No half measures. July PWG key paper, Greenpeace International, Amsterdam

LOZAN, J. L., W. LENZ, E. RACHOR, B. WATERMANN, H. v. WESTERNHAGEN (eds.) (1990): Warnsignale aus der Nordsee - wissenschaftliche Fakten, Verlag Paul Parey, Hamburg, 431 pp.

LUTTER, S. (1990): Statistics and the Precautionary Principle. A reply to J. S. Gray. Letter, Mar. Pollut. Bull. 21 (11): 547-548

MacGARVIN, M. & A. BOOTH (1988): Preparing for the Third North Sea Conference. A submission to the IMSO meeting for the 3rd North Sea Conference, Greenpeace International, Amsterdam, 26 pp.

McINTYRE, A. D. (1989): Options for waste disposal. Editorial. Mar. Pollut. Bull. 20 (10): 479-480

MÖLLER, H. (1984): Dynamics of fish diseases in the lower Elbe river. Helgol. Meeresunters. 37: 389-413

MORRIS, A. W. (1988): The estuaries of the Humber and Thames. pp. 213-224 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

NOLLKAEMPER, A. (1991): The Precautionary Principle in international environmental law: What's new under the sun?, Mar. Pollut. Bull 22 (3): 107-110

NORTH SEA CONFERENCE (1987 a): Ministerial Declaration. Second International Conference on the Protection of the North Sea, London, 24/25 November 1987, 15 pp.

NORTH SEA CONFERENCE (1987 b): Quality Status of the North Sea. A report by the Scientific and technical working group. 2nd International Conference on the protection of the North Sea, Department of the Environment, London

NORTH SEA CONFERENCE (1990 a): Ministerial Declaration. Memorandum of understanding on small Cetaceans. 3rd International Conference on the Protection of the North Sea, Den Haag, 198 pp.

NORTH SEA CONFERENCE (1990 b): The implementation of the ministerial declaration of the Second International Conference on the Protection of the North Sea. 3rd International Conference on the Protection of the North Sea, Den Haag, 553 pp.

O'DONNELL, A. R. & G. MANCE (1984): Quantities of some dangerous substances discharged to British coastal waters. Mar. Pollut. Bull. 15 (8): 284-288

OSPARCOM (1990 a): PARCOM Recommendation 89/1 of 22 June 1989 on the principle of precautionary action. p. 28 in: Progress report on the activities of the Oslo and Paris Commissions, London, 51 pp.

OSPARCOM (1990 b): OSCOM decision 89/1 of 14 June 1989 on the reduction and cessation of dumping industrial wastes at sea. pp. 40-41 in: ibid.

OSPARCOM (1990 c): OSCOM decision 88/1 of 24 June 1988 on the termination of incineration at sea. p. 45 in: ibid.

OSPARCOM (1990 d): Line of future work on EQO and UES. p. 27 in: ibid.

OSPARCOM (1990 e): Strategy for a future work programme to combat the pollution of convention waters by cadmium. p. 32 in: ibid.

PARKER, M. (1988): Sewage sludge disposal in the North Sea, pp. 246-256 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

PHILLIPS, D. J. H. (1980): Toxicity and accumulation of cadmium in marine and estuarine biota. pp. 425-569 in: NRIAGU, J. O. (ed.): Cadmium in the environment. Part I: Ecological cycling. John Wiley & Sons, New York, 682 pp.

POLEY, J. Ph. (1989): Equitability, the bridge over troubled waters. pp. 149-163 in: TEN HALLERS, C.C. & A. BIJLSMA (eds.): Distress signals, signals from the environment in policy and decision-making. Proceedings of the 3rd North Sea Seminar, Werkgroep Noordzee, Amsterdam, 253 pp.

PRESTON, M. R. & L. A. AL-OMRAN (1986): Dissolved and particulate phthalate esters in the river Mersey estuary. Mar. Poll. Bull. 17 (12): 548-553

RADACH. G., J. BERG & E. HAGMEIER (1989): Long-term changes of the annual cycles of meteorological, hydrographic, nutrient and phytoplankton time series at Helgoland and at Lv Elbe 1 in the German Bight. Continent. Shelf Res. 10 (4): 313 - 329

RAT VON SACHVERSTÄNDIGEN FÜR UMWELTFRAGEN (1980): Umweltprobleme der Nordsee - Sondergutachten. Verlag Kohlhammer, Stuttgart/Mainz, 503 pp.

REID, P. C. (1990): The work of the North Sea Task Force. pp. 80-88 in: FREESTONE, D. & T. IJLSTRA (eds.): The North Sea: Perspectives on regional environmental co-operation. Special issue of the International Journal of Estuarine and Coastal Law, Graham & Trotman, London, 356 pp.

REIJNDERS, P. J. H. (1980): Organochlorine and heavy metal residues in harbour seals from the Wadden Sea and their possible effects on reproduction. Neth. Sea. Res. 14: 30-65

REIJNDERS, P. J. H. (1986): Reproductive failure in common seals feeding on fish from polluted coastal waters. Nature 324: 456-457

REISE, K. (1990): Break down in the ecology of the Wadden Sea? (A response to the contribution of T. Höpner), Wadden Sea Newsletter 3/4: 48-52, Common Wadden Sea Secretariat, Wilhelmshaven

ap RHEINALLT, T. (1988): Impact of sewage sludge. pp. 489-509 in: SALOMONS, W., B. BAYNE, E. DUURSMA & U. FÖRSTNER (eds.): Pollution of the North Sea: an assessment, Springer-Verlag, Berlin, 687 pp.

ROSS, A. & P. V. HORSMAN (1988): The use of Nuvan 500 EC in the Salmon farming industry. Marine Conservation Society, Ross-on-Wye, 24 pp.

SANDERS, H. O., F. L. MAYER, & D. F. WALSH (1973): Toxicity, residue dynamics and reproductive effects of phthalate esters in aquatic organisms. Environ. Res. 6: 84-90

STEBBING, A. R. D. (1985): Organotins and water quality - some lessons to be learned. Viewpoint. Mar. Pollut. Bull. 16 (10): 383 - 390

SÜNDERMANN, J. & S. BEDDIG (eds.) (1988): Zirkulation und Schadstoffumsatz in der Nordsee (ZISCH). BMFT-Projekt MFU 0545, Abschlußbericht Univ. Hamburg, 323 pp.

SÜNDERMANN, J. & E. T. DEGENS (eds.) (1989): The North Sea - water exchange and pollution, University of Hamburg, 49 pp.

TULLY, O. & D. MORRISSEY (1989): Concentrations of dichlorvos in Beirtreach Buí Bay, Ireland. Mar. Pollut. Bull. 20 (4): 190-191

VACCARO, GRICE, ROWE & WIBE (1972): Acid-iron waste disposal and the summer distribution of standing crops in the New York Bight. J. Water Res. 6: 231-256

WARMENHOVEN, J. P. et al (1989): The contribution of the input from the atmosphere to the contamination of the North Sea and the Dutch Wadden Sea. Report R 89/349 A, TNO, Delft

WETTESTAD, J. & ANDRESEN, S. (1990): Science and north sea policy making: organization and communication. pp. 111-122 in: FREESTONE, D. & T. IJLSTRA (eds.): The North Sea: Perspectives on regional environmental co-operation. Special issue of the International Journal of Estuarine and Coastal Law, Graham & Trotman, London, 356 pp.

WINTELER, S. & A. AHRENS (1990): Chlor hat keine Zukunft. Daten zur Chlorchemie in der Bundesrepublik Deutschland, Institut für Ökologie und Politik, Hamburg, 82 pp.

WOOD, E. (1986): Organotin anti-fouling paints - an environmental problem? Marine Conservation Society, Ross-on-Wye, 19 pp.

WORLD WIDE FUND FOR NATURE (1987): The ecological state of the North Sea - an assessment on the occasion of the 2nd International Conference on the Protection of the North Sea, WWF, Gland, 45 pp.

ICES Paper C.M. 1991/E:11

Addendum

The following definitions are referred to in the text:

Precautionary Principle

"...to take action to avoid potentially damaging impacts of substances that are persistent, toxic and liable to bioaccumulate even where there is no scientific evidence to prove a causal link between emissions and effects" (NORTH SEA CONFERENCE 1990 a)

Assimilative Capacity

"...covering the range of conditions between the uncontaminated situation and that in which contamination becomes deleterious" (ICES 1986)

When comparing the social implications of both approaches during verbal presentation additional reference is taken to the following basic passages from ACMP-Reports:

"Exactly what constitutes a deleterious effect depends very largely on what society is prepared to accept." (ICES 1986)

The application of the Assimilative Capacity Concept for regulatory purposes... (para 22.3 in ICES 1987)

ADDITIONAL REFERENCES:

ICES (1986): Report of the ICES Advisory Committee on Marine Pollution, Cooperative Research Report 142, International Council for the Exploration of the Sea, Copenhagen

ICES (1987): Report of the ICES Advisory Committee on Marine Pollution, Cooperative Research Report 150, International Council for the Exploration of the Sea, Copenhagen