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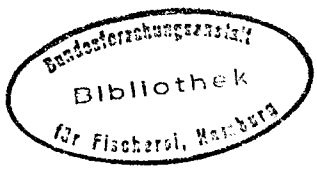

Atmospheric-Benthic Coupling (ABC)

- a proposed ICES/IOC research project.

By

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Introduction

This draft proposal was first drawn up in March 1993 as a research project to succeed the ICES/IOC Bremerhaven Workshop, addressing some of the important questions that the workshop helped to uncover, but which need further work. The full results and the problems raised have recently been published as a Special Volume of Marine Ecology Progress Series (Stebbing et al, 1992).

The present form of this proposal is that which was first considered by the ICES WG on the Biological Effects of Contaminants at its meeting in Copenhagen 31st March - 2nd April 1993. At that meeting the WGBEC agreed to maintain the momentum of its Bremerhaven and Aberdeen (EROD) workshops, by developing a proposal within the framework of the ABC proposal. The WGBEC noted the interdisciplinary nature of the proposal and required that the proposal be distributed to the Chairmen of the Working Group on Marine Sediments in Relation to Pollution and the Marine Chemistry Working Group, requesting that they nominate representatives to sit on a sub-group with others from WGBEC. The group agreed to recommend to ICES that the present author convene this sub-group, with Drs Everts and Schneider from WGBEC, two members from MCWG and from WGMS. The sub-group is to undertake the following tasks as an intersessional activity :

(a) to review the existing data (especially those in the "grey" literature) describing biological impacts potentially related to pollution in the North Sea, particularly in the Dogger Bank area;

(b) to consider relevant chemical and physical data (obtained either through ICES or by informal contacts) which may affect contaminant distribution on a seasonal basis;

(c) to prepare a firm proposal, taking these data into account, for consideration by the WGBEC and the WGMS at its next joint meeting.

To date those who are to be involved have been informed, but have not met. The group expects to complete its tasks for the meeting of WGBEC and WGMS in March 1994.

References

ICES, 1993. Report of the Working Group on the Biological Effects of Contaminants. ICES. C.M.1993/ENV:3. 33pp.

Stebbing, A.R.D., Dethlefsen, V. & Carr, M., 1992. Biological effects of contaminants in the North Sea. Mar. Ecol. Prod. Ser. 91: 1- 361.

ATMOSPHERIC-BENTHIC COUPLING (ABC)

A proposal to follow up the ICES/IOC Bremerhaven Workshop

Some Workshop findings

The ICES/IOC Bremerhaven Workshop was designed to compare a wide range of biological techniques sensitive to variations in water quality due to toxic contaminants, by deploying them on a 200 km transect from the Elbe-Weser plume to the central North Sea. The dominant trend was of improving water quality with distance offshore, as expected from historical contaminant data. Superimposed on this horizontal trend was the tendency for biological effects to occur at the sea surface and benthic interfaces, as indicated by water quality bioassays, fish embryo abnormalities and various biochemical, molecular and cellular pathology indices in flatfish. The trend of improving water quality offshore was slightly, but significantly reversed at the most offshore station, over the Dogger Bank.

Chemical analysis of contaminants in whole sediment samples taken during the Workshop decrease with distance offshore and probably account for dominant trends in the biological indices, but the effects over the Dogger Bank are more difficult to account for. Sea surface microlayer samples taken well offshore in the German Bight were toxic to various bioassay organisms, due to elevated concentrations of various contaminants (Pb, Cu, TBT) shown to occur in the same samples. High frequencies of abnormal flatfish embryos in the surface plankton occurred at stations over the Dogger Bank as well as the inshore stations in the estuarine plume. Such findings raise important unresolved questions.

Biological indices do not specifically identify their chemical causes. Nevertheless some biomarkers indicated that organic compounds such as PAHs may be responsible for effects in adult dab (*Limanda limanda*) and this is corroborated by tissue, sediment and water chemistry. However it is unclear whether abnormalities in developing dab embryos in the surface plankton are due to the same compounds, or whether due to exposure of the adults to contaminants in benthic sediments or to exposure of eggs and embryos at the sea surface. In either case the high frequencies which may affect recruitment, and their occurrence in the central North Sea makes their investigation a priority.

Flux of contaminants

There is a growing body of evidence that a significant proportion of contaminants that enter the North Sea do so by atmospheric deposition. Figures of 50 - 60% of metals (Cu, Cd), 20 - 30% of some nutrients (nitrates) and 70 - 90% of some organic compounds (PCBs) occur in the literature. It has been demonstrated that contaminants entering the sea by this route are held up at the sea surface for a period before entering the water column, resulting in accumulations to concentrations at least 5 - 10 times those in the immediate subsurface waters.

In the water column metals and organic compounds tend to bind to the organic rich and reactive fine particulate material. Results from the German ZISCH programme have shown that the central North Sea is a transient depositional area where organic-rich fine particulate material (<20μm) is deposited. Due to the affinity of some contaminants (eg. Pb) for such material, higher levels of lead are found in the fine sediments over the Dogger Bank than in surrounding waters. This finding was borne out for other contaminants during the Bremerhaven Workshop. While the benthic sediments over the Dogger Bank are relatively coarse, it is an area during the summer months when fine sediments and particulate organic material are deposited. Techniques for sampling sediments for analytical chemistry have not been optional for the mobile organic-rich superficial material that form the layer of sediments to which the benthic epifauna is exposed.

Proposal

What is required is a study of the vertical flux of contaminants from the atmosphere to the benthos that identifies the points where materials to which contaminants are bound are held up and therefore accumulate to potentially toxic concentrations. This requires an integrated study of contaminant flux that concentrates on mechanisms by which contaminants accumulate, or are secondarily reconcentrated, not only at the sea surface and benthic interfaces, but also at other less pronounced discontinuities such as the thermocline and halocline. Such discontinuities also accumulate nutrients and POC, so they are regions of naturally enhanced biological activity. The accumulation of contaminants at the same discontinuities implies that the biological effects of contaminants offshore are localised to discontinuities that retard contaminant flux and reconcentrate them to toxic levels. The results of the Bremerhaven Workshop indicate that such processes may account for some of the effects observed on the Dogger Bank. A study focused in this area would help to understand the extent to which the flux or organic carbon and contaminants are linked, to cause effects in localised regions where biological productivity and turnover is greatest.

Specific Objectives

1. To quantify the vertical flux of contaminants (metals and major classes of toxic compounds) in the central North Sea.

2. To identify interfaces and discontinuities where the vertical flux of contaminants may be arrested such that they accumulate locally to potentially toxic concentrations.

3. To establish the extent to which carbon and contaminant flux are linked such that biological activity and contaminant accumulation are likely to coincide.

4. To establish from the same samples taken at interfaces (particularly the sea surface microlayer and the superficial benthic sediments) concentrations of contaminants likely to be toxic, and their toxicity by bioassay.

5. To relate toxicity demonstrated by bioassay of water and sediment samples to naturally occurring communities.

6. To identify the specific chemical causes of effects on dab (*Limanda limanda*) observed during the Bremerhaven Workshop. Biochemical, molecular and cellular biomarkers suggest exposure to organic xenobiotics.

7. To identify the causes of elevated frequencies of embryo abnormalities in dab and other species in the surface plankton. Are they due to exposure to contaminants of adults living on the sea bottom, or the eggs and embryos in the surface waters?

The way forward

A proposal such as this emerges naturally from the results of the ICES/IOC Bremerhaven Workshop (Mar. Ecol. Prog Ser. Vol. 91, 1992). It was discussed briefly at the previous of ICES WG BEC and later by a group at the 2nd Integrated North Sea Programme Workshop. I was encouraged on both occasions to develop a proposal, which has not been possible for me until the Bremerhaven Workshop volume was completed. This draft is a first and preliminary outline of the ideas prepared as a discussion document for the next meeting of WG BEC.

The ABC study could be carried out with the involvement of ICES and IOC multidisciplinary groups, building on the experience gained during the Bremerhaven Workshop. Such a programme could also be linked to LOIS (Land-Ocean Interaction Study) which will, over the next 6 years, in a major UK programme study the flux and effects of sediments, nutrients and contaminants from the river basins to the shelf edge. Such a programme should also be part of the Integrated North Sea Programme and link strongly to the North Sea Task Force Master Monitoring Plan.