Biological Oceanography Committee **ICES CM 1997/L:7**

REPORT OF THE

BENTHOS ECOLOGY WORKING GROUP

Gdynia, Poland
23–26 April 1997

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 OPENING OF THE MEETING

The Benthos Ecology Working Group met in Gdynia at the Sea Fisheries Institute (MIR) under the chairmanship of Karel Essink. A list of participants is given in Annex 1. Jan van Dalfsen was appointed rapporteur. Karel Essink proposed next meetings to have, in principle, a rapporteur provided by the hosting institute. Jan Rene Larsen pointed out that the whole meeting is responsible for the preparation of the final report.

The Working Group did regret the absence of participants from the Baltic countries and Russia. Karel Essink explained that he had not been successful in obtaining funds from C.E.C. in order to enable these scientists to attend the meeting. It was concluded that Heye Rumohr bring this matter to the attention of ICES.

1.1 Terms of Reference

The terms of reference for the 1997 meeting of the Benthos Ecology Working Group (conform Res. 1996/2:54) were to:

a) review co-operative studies throughout the ICES area.
b) report on the progress of the North Sea Benthos Survey
c) assess the results of the IMPACT II project on the effects of fishing activities on benthos
d) review studies on the small scale distribution of benthic invertebrates
e) evaluate computer aids to benthic studies.
f) review methods to increase the efficiency and quality of identification aids in benthos studies.
g) review the status of development of taxonomic coding systems with a view to recommending the adoption of a
h) single coding system for the use in ICES.
i) advise the ICES/OSPAR SGQAE in the development of quality assurance procedures for benthosmeasurements adopted for the Joint Assessment Monitoring Programme (OSPAR 1997/2:1)

1.2 Adoption of the agenda

The provisional agenda was adopted after inclusion of :

- review of other activities of interest to ICES and other organisations
- data handling

The adopted agenda is appended as Annex 2.

2 REPORT ON MEETINGS OF INTEREST TO ICES AND OTHER ORGANISATIONS

2.1 ICES Science Meeting in Reykjavik

J. R. Larsen and H. Rumohr provided information on the discussion during the last ICES Annual Science Meeting in Reykjavik concerning the new Committee structure of ICES. The BEWG will be no longer under the Biological Oceanographic Committee, which will be dissolved, but under the new Marine Habitat Committee. Severe changes for the future work of the BEWG are not expected.

2.2 Advisory Committee on the Marine Environment (ACME), incl. demands from OSPARCOM and HELCOM

J. R. Larsen reported from the 1996 meeting of the ACME, focusing on the issues of particular interest to the BEWG. The group noted the sections on the quality assurance of biological measurements in the Baltic Sea (section 6.1) and the section on the benthic issues (section 11). The group noted with satisfaction that the document on methods for the study of benthic communities on hard substrate had been included as a technical annex to the ACME report (Annex 8).

Relevant items on the draft agenda for the 1997 ACME meeting include: progress on the North Sea Benthos Survey; effects of sea bed disturbance on benthic communities; taxonomic code systems; QA of biological measurements in the OSPAR area. These items are all on the agenda of this BEWG-meeting.

A. Künitzer reported on recent activities of the Oslo and Paris Commissions (OSPARCOM) and the Helsinki Commission (HELCOM). In both Commissions the existing monitoring programme is being revised. The OSPARCOM-marine monitoring programme, called Joint Assessment and Monitoring Programme (JAMP), includes chemical contaminant and nutrient monitoring as well as biological effects monitoring in relation to contaminants and nutrients. Benthic community studies for zoobenthos and phytobenthos are included. Guidelines for the monitoring most of the parameters have been finalised. The Quality Assurance (QA) for the chemicals is undertaken via QUASIMEME. The QA for eutrophication effects will be dealt with by an ICES/OSPARCOM-Steering Group on Quality Assurance of biological measurements related to eutrophication effects (SGQAE) which had its first meeting in February 1997. The QA for contaminant effects followed a lead country approach, but since that did not work well an EU-project is proposed for accomplishing this goal. Norway is planning to organise a benthos QA-Workshop.

The HELCOM-marine monitoring programme has been revised during 2 workshops for the open-sea (Baltic Monitoring Programme, BMP) and includes monitoring of nutrients and their biological effects (including zoobenthos) as well as contaminants in biota and water. The Coastal Monitoring Programme (CMP) will be carried out on an international basis in the future and is nearly finalised. It will include phytobenthos and zoobenthos. Guidelines have been developed including for zoobenthos. The QA is dealt with since several years by two Steering Groups for 1) biological measurements and 2) chemical measurements.

2.3 Baltic Marine Science Conference in Denmark

H. Rumohr reported on the Baltic Marine Science Conference held in Rønne, Denmark, October 22-26 1996. This conference was organised by the Baltic Marine Biologists (BMB), the Baltic Marine Geologists (MGB) and the Conference of Baltic Oceanographers (CBO) (with support by ICES and HELCOM) in order to summarise the ongoing marine research in the Baltic and to stimulate new co-operation between the scientists working in the countries around the Baltic Sea. The lectures and posters comprised a wide scope of topics of Oceanography, geology and biology and were most interesting also to non-experts. Ongoing large international projects such as DYNOCS, BALTEX, BASYS, GOBEX, joint projects in the Pomeranian Bay, the Riga Bay and elsewhere were introduced and discussed in the plenary. The discussion of the "Future of Baltic Marine Science" was accompanied by keynote lectures by representatives from HELCOM, ICES, CBO, BMB and BMG who outlined the view and the future strategy of their organisations. The intended agglomeration of the latter three non-governmental organisations into one new Baltic Association for Marine scientists (BAMS) failed at this occasion since BMB could not find consensus to resolve and join the others. An intersessional Working Group was set up under the chairmanship of Thomas Andren, Stockholm, to prepare the next discussion at the joint BMB/ECSA symposium in Mariehamn/Åland in June. The main aim is to have stronger co-operation between Baltic marine scientists with regard to science and in exchange with the governmental and funding organisations. In contrast to this the scientific part was regarded as a success. The presented papers and posters showed a significant increase in quality compared with earlier single discipline conferences. The submitted papers of the Rønne Conference are now distributed for review and will be published in the ICES Coop. Res. Reports Series.

3 REVIEW OF CO-OPERATIVE STUDIES AND OTHER STUDIES OF INTEREST TO ICES

3.1 Oil spill studies in Spain and the United Kingdom

E. López-Jamar informed the group on the Final report on the effects of the *Aegean Sea* oil spill on the subtidal macro-infauna. (see Annex 3)

After four years of monitoring the effects of the oil spill (3 December 1992) no catastrophic effects on the subtidal macroinfauna have been detected, although some species experienced important changes in their temporal cycles. No major changes in species number, diversity or biomass were evident. An initial mortality of the most sensitive species (mainly amphipods) occurred in all the stations sampled. The latter group generally presented very low numbers during 1993, but abundance increased in 1994, and has practically recovered since 1995. Several months after the spill, a quick proliferation of opportunists (mainly *Pseudopolydora* cf. *paucibranchiata* and *Capitella* *capitata*) was evident in most of the stations. A decrease to normal levels was found to occur several months after the spill.

It was concluded that part of the increased abundance might be explained by interspecific interactions within the community instead of being a direct effect of the oil spill. In general terms, three years after the accident, the communities had completely recovered.

P. Kingston reported on the current state of knowledge on the impact of the *Braer* oil spill on the benthos. Sea bed samples for assessing the impact and recovery of the sea bed following the wreckage of the oil tanker *Braer* on the south-western tip of the Shetland Islands were taken in 1993, 1994, 1995 and 1997. So far funding has been made available for the analysis of the first two sets of samples. The earliest results from samples taken in May 1993, four months after the accident suggested that there had been minimal impact on the community structure and composition. There was no detectable change in species richness, abundance or diversity, although the amphipod fauna at the most heavily contaminated sites was notable by its absence. This result was unexpected given that the oil contamination levels in some of the sediments sampled exceeded 10,000 ppm and it was postulated that, in 1993, the samples may have been taken too soon after the accident for the full effect of any impact to have been manifested. However, although samples taken the following year showed a small reduction in species and diversity at the most heavily contaminated stations, the response of the faunal communities was still almost negligible when compared with the effect of oil contaminated drill cuttings discharged offshore to the sea bed, regardless of the fact that the levels of contamination eliciting a severe response may be an order of magnitude lower.

Intertidal studies in the vicinity of the *Braer* wreck carried out 9 months after the accident revealed little difference in species richness when compared with other uncontaminated areas. However, certain species such as *Patella*, were completely absent from sample sites immediately adjacent to the wreck, even though the numbers of encrusting and cryptic species were not significantly reduced. It was suggested that this might have resulted from exposure to the water borne oil having a narcotic rather than lethal effect on the fauna so that superficial species such as *Patella* became detached and perished whilst the cryptic and encrusting species remained in place, subsequently recovering.

The samples taken in 1995 and 1997 were taken in the expectation that funding may eventually become available to analyse these samples in order to investigate the longer-term fate and effects of the *Braer* oil remaining on the sea bed off the Shetland Islands.

3.2 Impact of trawling on deep water coral banks and kelp in Norway.

J. H. Fosså brought to attention of the Group a report on 'Distribution of marine benthic macro-organisms in Norway', reported to the Directorate for Nature Management. This report can be obtained from: Direktoratet for Naturforvaltning. Tungasletta 2, 7005 Trondheim. Tel: +00 47 73580500 Fax: +00 47 73915433

J. H. Fosså reported on a pilot study for the testing of equipment for detecting and mapping of *Lophelia pertusa* coral banks in a fjord sill area in western Norway. A hull mounted narrow beam echo-sounder and a towed side scan sonar were used to map the study area and the coral banks. A triangular dredge and a Van Veen grab were used for verification of the presence of corals and for taking faunistic samples. A SIT camera was applied for verification of the presence of corals and description of patch distribution of living *Lophelia*. A bathymetrical map with high resolution was made from data produced by the echo sounder. The side scan sonar was a promising tool for mapping of coral banks, and the dredge and grab were very reliable tools for verification of the presence of corals. The SIT camera gave information about the *in situ* conditions and the patch distribution of living *Lophelia*. Preliminary results indicate that *Lophelia* occurred in groups on the sea bottom elevations. Knoll-like structures, typically 1-3 m in diameter, seen on the side scan images, were scattered upon the mounds. These structures most probably large *Lophelia* colonies. Side scan sonar surveys will probably give reliable data on areal cover of scleractinian corals, but visual inspections are needed to quantify the relationship between living and dead corals. In the discussion afterwards it was emphasised that dredge sand grabbing is destructive and should be avoided as much as possible (see Annex 4).

J. H. Fosså presented a brief overview of the work on the ecological impacts of the utilisation of kelp, *Laminaria hyperborea*, along the Norwegian coast. Approximately 160,000 tonnes is harvested yearly by trawling. After trawling young recruits start growing because of better light conditions when old and large plants are removed. The trawling is changing the kelp population structure towards a more homogeneous one with younger individuals. The harvesting is following a cycle of five years, which leaves a harvested area free for regrowth for about 4.5 years. The harvesting of kelp has biological and ecological effects on the ecosystem because *L. hyperborea* serves as a habitat for many species. Several species of algae have *L. hyperborea* as a main substrate. The invertebrate fauna is also rich in both sessile and motile species. The sessile species grow on the stipe and hapteron and the motile species are found in the haptera, on the stipes and among the algae growing on the stipes. These animals serve as food for fish, but their production and quantitative importance as food is not known. Moreover, the kelp bed offers multiple functions as breeding ground, nursery area, hiding and feeding place for fish. There is a lack of quantitative understanding of the relationships between fish and kelp bed, and to determine whether kelp harvesting is affecting this relationship. This also applies to lobster and crab. Some birds utilise the kelp bed areas for feeding and might also be influenced by the kelp harvesting. Kelp beds probably modify waves and currents. The trawling for kelp is therefore partly held responsible for the increase in erosion of sandy beaches, especially in southern Norway. The possible dampening properties of the kelp bed, however, are not yet fully understood.

3.3 Studies on bioturbation of sediments

G. Duineveld reported a study on sediment mixing in the southern North Sea. Mixing rates were estimated from down-core profiles of chlorophyll-a. Rates showed a distinct seasonality related to water column productivity and, moreover, differences among subareas. The estimated annual fluxes of fresh phytodetritus were in the same order as the energy demand of the benthic communities implying that advective input is relatively unimportant.
(For further details see Annex 5)

3.4 Sand and gravel extraction in Belgium

H. Hillewaert gave an update on the Belgium monitoring programme. Sand extraction areas and dredge spoil dumping areas off the Belgian coast have been monitored since the end of the seventies. Results for macrobenthos and epibenthos for 1995 are currently available. No unusual changes with the previous year were detected.

Two new gas transport pipelines crossing the Belgian continental shelf, requiring a substantial new sand and gravel extraction, gave rise to new sampling and monitoring programmes. The concerned areas will be monitored before and after the extraction. (For further details see Annex 6).

3.5 Dutch coastal nourishment studies

J. van Dalfsen presented an overview of the main results of the RIACON project (under MAST II) on the effects of coastal nourishment to the macrobenthos, including the effects of deposition of sand on the foreshore and of subaqueous sand extraction. In the extraction area a decrease in macrofauna abundance and biomass was observed. The community structure changed. Long-living species as molluscs and echinoderms showed changes in the age structure of their populations. Opportunistic species showed increased densities. Recolonisation took place, but recovery was not yet complete two years after the extraction activity had stopped. At the nourishment area also a reduction in macrozoobenthos abundance and biomass was found. A general recovery towards the pre-nourishment situation took place within two years. However, the development of the benthic community in the nourished area deviated from that in a nearby reference area. National reports (DK, D, NL, B, ES) of the RIACON project will be available shortly. The Final Report of the RIACON project is in progress. (For further information see Annex 7 & 8).

A new practice in coastal nourishment is the so-called PinPoint^R dredging. This is a method in which a temporary borrow pit is made in the foreshore. Sand borrowed elsewhere by hopper dredgers is dumped into this pit and directly pumped onto the beach to be nourished. After completion, the pit is filled level. A study on the recovery of the benthic fauna at the location of the pit is presently conducted.

3.6 Benthic studies by CEFAS (United Kingdom)

H. Rees reviewed ongoing benthos work at the Centre for Environment, Fisheries and Aquaculture Science (formerly the Directorate of Fisheries Research). This included :

i. Effects of the extraction of marine aggregates:

Recolonisation of the benthos following experimental dredging off the English east coast has been examined through annual sampling (accounts of this work have appeared in previous BEWG reports). Community structure and biomass have returned to near-normality some 3 years after dredging. Work is nearly completed on an assessment of community variability in gravel areas around the England and Wales coastline, and the scope for developing a 'sensitivity' scale in relation to dredging activity is being examined.

Fish/benthos relationships on gravely sediments are being investigated through examination of stomach contents. A project will shortly commence on an evaluation of the cumulative effects of multiple dredging activity on benthic communities, fish/shellfish populations and dependent fisheries. Guidelines for the conduct of benthic surveys in gravel areas are in preparation.

ii. Utility of meiofauna in pollution studies:

This was initially the subject of a collaborative project between MAFF and the Plymouth Marine Laboratory, which included the production of a manual for the laboratory handling and identification of nematodes. In the last 2 years, work has been conducted by a PhD student at the Burnham Laboratory to develop 'in-house' taxonomic expertise and a field sampling/laboratory analysis capability.

The cost/effectiveness of meiofauna studies relative to macrofauna and other measures of biological effect is being evaluated. Field studies have been conducted especially at dredged material disposal sites and near to organic waste inputs, with a view to comparative assessments of impacts. Microcosm studies are planned, initially for follow-up assessment of the effects of dredged material of varying quality and quantity.

iii. Effects of fishing activities on the benthos:

Studies are continuing at the Conwy Laboratory, including input to the IMPACT II programme, and several papers on this work have been published. A project has recently commenced to identify indicators of trawl disturbance through examination of damage to individuals of selected echinoderm and bivalve species.

iv. Biodiversity studies alongside North Sea groundfish surveys:

Significant progress has been made with this EU-funded project, which is being co-ordinated at the Lowestoft Laboratory. 2-metre beam trawls are being used for epifaunal sampling. It is intended to publish papers arising from a recent review meeting in Aberdeen, probably in the Journal of Fisheries Research.

v. A comparison of benthic biodiversity in the North Sea, English Channel and Irish Sea:

On this subject Dr. Rees reported on preliminary results from two spatially extensive surveys of the benthos around the United Kingdom coastline and offshore (see Annex 9).

3.7 Benthic studies along German coasts

I. Kröncke reported on the investigations on changes in macrofaunal and micro-organism communities in intertidal sandflats caused by the input of organic material via biodeposition produced by musselbeds. Species numbers, abundance and biomass were low at the musselbed, increased in the vicinity and decreased again towards the sand flat. Interdisciplinary approach with microbiologist and geochemists revealed the importance of fresh organic material coming from the musselbeds for the structure of the benthic community. (For further details see Annex 10).

I. Kröncke also gave a brief overview of a long-term study on macrozoobenthos off Norderney from 1978 to 1995. Biomass increased in general and a shift in the benthic community was observed since the late 1980's. Good correlation's were found with meteorological conditions, whereas hot summers and storm events did hardly influence the macrofauna. Low, respectively mild winter temperatures since the late 1980's appear to have a vast impact on the macrofauna community off Norderney. (see Annex 11 for further information).

A. Künitzer reported on a study on macroalgae which was carried out along the German part of the Baltic Sea. To map the algae assemblages video recordings were made along 50 transects and the degree of coverage was estimated. For time trend monitoring detailed investigations of the macroalgae along permanent transects were undertaken by scuba-divers, which took photographs and samples at 10, 8, 6 and 2 m depth. Distribution maps will be provided for the different species but analysis is still ongoing. The research was conducted to see a) whether macrophythes distribution had changed due to eutrophication, and b) to function as a base for a future regular monitoring programme in the Baltic Sea

M. Powilleit presented results of a benthos sampling programme in the Pomeranian Bay (southern Baltic Sea) within the frame of a German multidisciplinary research project which was conducted in close co-operation with Polish colleagues. It deals with the fate of riverine material in the Bay and its impact on organisms. Effects of a severe oxygen deficiency in the summer of 1994 on the macrozoobenthos in the south western part of the study area was presented. A combination of extraordinary meteorological an hydrographical conditions along with high nutrient loads are considered to have caused the extensive hypoxia/anoxia. The structural sediment parameters did not change but redox potential shifted towards the sediment surface after the oxygen depletion. The community parameters (species numbers, biomass and abundance) decreased significantly. Oligochaetes and crustaceans were found to act as very sensitive indicator species. During succession a typical initial phase of a mass occurrence of opportunistic species did not occur. Recolonisation of the most affected site was still not yet completed two years later, whereas the less affected stations revealed nearly complete recovery within one to two years. (see Annex 13).

3.8 Polish Baltic and Arctic studies

J. Weslawski presented briefly the topics in marine benthos research in which the MIR institute is co-operating with associated scientists from the University of Gdansk and other institutions. These include a) ecological mapping of the Arctic intertidal zone- vulnerability assessment, nature protecting surveys, b) productivity and energy transfer from littoral Benthos to sublittoral in the Baltic coast, tropics and Arctic regions, c) physically controlled biodiversity along environmental gradients in Arctic glaciated fjords, d) pelago-benthic coupling in Arctic coastal waters.

A. Osowiecki informed the group about benthos sampling in the Gulf of Gdansk and in the Polish coastal zone. Multidisciplinary assessments of the benthic biotopes are carried out in order to create a basis for designation of protected areas.

3.9 Cyclical patterns in abundance of benthos (W. Sweden)

B. Tunberg provided the group with a presentation on the possibilities of climatic oscillations regulating cyclical patterns of macrobenthic abundance on the Swedish west coast.

Soft-sediment macrobenthos has been monitored at a network of stations (10-300 m depth) off the west coast of Sweden for periods of from 12 to 20 years. Macrobenthic abundance and biomass at all stations show cyclical patterns of variation with a period of approximately 7 years. Oscillation patterns at stations down to 100 m depth are generally in phase with one another, suggesting a regional causation. The North Atlantic Oscillation (NAO) index correlates with severity of winter conditions in Scandinavia. The NAO index is positively correlated with one year lagged deep (600 m) water temperature of the Skagerrak, and negatively correlated with increased stream runoff in western Sweden. Stream flows are positively correlated with benthic abundance's with lag periods depending on station depth. It was hypothesized that climatological linkages affecting surface primary production result in bottom up control of benthic population changes.

This study was carried out in combination with the HELCOM Monitoring Programme.

3.10 The BIOICE project

S. Steingrimsson presented a status report on the benthos inventory program (BioIce) that commenced in 1992. So far 400 stations have been sampled around Iceland and material from about 200 locations is already sorted to major taxonomical groups. A network of taxonomists from ten different countries are working on identifying the sorted material to species level. Species data is compiled into a special database. First analysis of the data has started.

3.11 RNA/DNA ratio as indicator of condition

G. Duineveld reported on the use of RNA/DNA ratios of marine invertebrates.(see Annex 12)
RNA/DNA ratios of the bivalves *Macoma balthica* and *Arctica islandica* were found to be correlated with shell growth but a clear temperature effect was also noticed. Different types of tissue used for the measurements gave different ratios. Therefore, care should be taken in using the RNA/DNA ratio in condition and growth studies. A possible use of the ratio in macrobenthic research in the deep sea, where temperature is constant, is under study.

3.12 Imposex and intersex in gastropods

A. Künitzer reported on the effects of organic compounds on marine molluscs in the North Sea and Baltic Sea and their applicability for a future biological effect monitoring. (see Annex 14). Two species of prosobranch mollusc (*Littorina littorea* and *Hydrobia ulvae*) were tested for specific effects of TBT on the development of imposex or intersex. High correlation's of biological indices for intersex and imposex and TBT concentrations were found in both species. *Hydrobia ulvae* is more sensitive to lower environmental TBT concentrations. At high concentrations of TBT, the snails become sterile which has implications for the reproduction success of the populations

3.13 Effects of other trawling on benthos

S. Steingrimsson introduced an experimental study on the effects of otter trawling on macrobenthos, commencing this year in Iceland. The experiment consists of four replicates of disturbed (treatment) and undisturbed transects (control). Repeated trawling will be carried out in the treatment transects. The sampling scheme is designed to assess the immediate effects of the impact and to quantify the succession of fauna within the treatment and control areas.

3.14 Gulf of Riga Project

In the absence of colleagues from Estonia and Letvia H. Rumohr transferred information about the Gulf of Riga Project to the Group. The objective of the five year project is to study environmental problems in the Gulf and its drainage area, and to determine their impact on the rest of the Baltic Sea and especially the Baltic Proper. Details can be found in Annex 15.

3.15 ICES/HELCOM intercalibration exercise

J. Nørrevang Jensen presented some results from an ICES/HELCOM intercalibration exercise in the Kattegat/Baltic Sea area. Sorting of pre-sorted samples (by a reference laboratory) showed a relative small difference between the participating laboratories and the reference laboratory (-20.6% - 11.6%). Sampling from different ships on the same station and date suggested that spatial heterogeneity can be considerable. This finding is further supported by a comparison of data from different laboratories on the same station.

3.16 BioMar marine biotope classification

D. Connor reported to the Group by letter on the progress of the development of the BioMar marine biotope classification undertaken for the EC LIFE programme. (see Annex 16)

4 NORTH SEA BENTHOS SURVEY

A sub-group discussed the goals and realisation possibilities of a North Sea Benthos Project.

P. Kingston reported that a proposal had been prepared for submission to the EC MAST Programme. The proposal involved 14 institutes which had undertaken to contribute 72 days of ship-time and involve some 75 personnel. 25 internationally recognised expert taxonomists had undertaken to contribute their time to the project. Nevertheless the bid to obtain funding from the EC MAST Programme was unsuccessful. Following the submission of an outline proposal, the MAST secretariat replied that the goals of the proposal did not fit the goals of the MAST Programme sub-area B 1.2, to which it had been directed. The Secretariat, had interpreted the objectives of the proposal as primarily a monitoring activity "which is, according to the intergovernmental agreement on the North Sea

Monitoring, a national task to be funded from national sources". It went on to state; "The work plan resembles, furthermore, a monitoring programme in that it does not have a well focused scientific question to be solved. A general improvement of knowledge of marine ecosystems, in view of the high competition level, not sufficient to justify EU funding". The Secretariat suggested that the proposal be submitted to national institutes which are responsible for North Sea monitoring.

Regardless of this setback, it was the view of the BEWG that it should pursue its intention to carry out a widely based study of the benthos of the North Sea. However, it was suggested that the name North Sea Benthos Survey be changed to North Sea Benthos Project to overcome any prejudicial connotations linking the study with monitoring programmes.

In spite of the comments of the MAST secretariat, the Working Group decided that, rather than seek funding on an individual institute basis, which would fragment the effort and make co-ordination of activities almost impossible, the BEWG should continue to pursue collective funding from one of the EC Science Research development initiatives.

It was recognised that the emphasis of the original proposal would need to be re-focused to provide more robust primary objectives. However, the originally proposed sampling protocol should be retained, as it was considered important that the section of the infauna represented by infrequent, large species formed the main faunal focus of the study. This element of the benthic macrofauna can be sampled qualitatively using conventional dredges and quantitatively by specially designed instruments such as the Dutch Triple-D Dredge.

The EC Environment and Climate work programme, Theme 1 (Research into the Natural Environment, Environment Quality and Global Change), seemed to offer some possibilities and included a sub-category (Biodiversity and Environmental Change) that fitted the objectives of a revised North Sea Benthos Project. The Working Group recognised that the participants would have a wide variety of individual objectives, but if any proposal was to be successful there would have to be a common objective that would be appealing to the funding body. A suggested title for the project was: North Sea frontal systems and benthic diversity and productivity.

The start date of the project should be in time for the 1999 sampling season, this should give participants an adequate lead-time for booking ship-time.

ICES will be a partner in the project and funding will be sought to utilise the Benthos Data Base to be set up at the ICES Secretariat to ensure that the information obtained from the work will be readily accessible for international data exchange after scientific evaluation.

J. R. Larsen informed the Group that within two weeks the Final Report of the 1986 North Sea Benthos Survey will be available as ICES Co-operative Research Report Nr. 218.

5 RESULTS OF THE IMPACT II PROJECT ON THE EFFECTS OF FISHING ACTIVITIES ON THE BENTHOS

H. Rumohr presented information on the Final Report of IMPACT II on the effects of different types of fisheries on North Sea and Irish Sea benthic ecosystems, which is in its last phase of completion. He introduced the contents of this report and gave detailed results on a subproject concerned with the comparison of historical data with those collected by the North Sea Survey in 1986 by the ICES Benthos Ecology Group.

The main chapters of the IMPACT II Final Report deal with:

Collection and analysis of historical data on benthic fauna
Collection of historical and recent data on national fleets and effort
Investigation of mortality introduced by different intensities and types of fishery
Scavenger responses to trawling
Comparison of fished and unfished areas.

In addition to his presentation he showed a video produced by the Fishery Institute in Ostende on the optimalisation of a species selective beam trawl (AIR2-CT93-1015)

M. Robertson presented to the Group the results of the Gareloch Disturbance Project.

In Loch Gareloch the effects of trawling on the benthic community were studied by experimental trawling which were carried out during 9 months. Benthic surveys were made on a 3 months interval. Epifaunal densities were estimated by Underwater TV, while the infauna was sampled by means of a $0.1m^2$ Day Grab. Samples were also collected for organic carbon and sediment particle size analysis.

Trawling disturbance had a clear effect, increasing the number of species and numbers of individuals and decreasing diversity. Certain opportunistic species (mainly cirratulids and capitellids), considered to be indicators of disturbance, became more abundant in the treated (=trawled) area when compared to a reference area both during and following the disturbance period.

The densities of some species declined relative to the reference area *(Nucula nitidosa, Scoloplos armiger, Nephtys cirrosa* and *Terebellides stroemi),* suggesting these species to be sensitive to physical disturbance.

Community structure measures of disturbance indicated that, relative to the reference area, the community at the treated area became more disturbed during the trawling period and only became comparable to the reference area after 18 months recovery. Measures of numbers of species, numbers of individuals and diversity also indicated that the sites were indistinguishable after 12 months recovery, but multivariate analysis of the community data found significant differences between the areas after 18 months of recovery. No long-term effect on epifaunal species was noted.

6 SMALL SCALE DISTRIBUTION OF BENTHIC INVERTEBRATES

A. Rowden reported on a study, conducted in New Zealand, which aimed to establish scales of macrobenthic (and meiofauna) spatial heterogeneity independent of abiotic control, and identify the biotic component principally responsible e.g. bioturbatory species. In addition, it aimed to elucidate the mechanism via which such 'keystone species' might impose spatial variation upon benthic community structure e.g. burrow construction, and quantify the associated process by which such heterogeneity is caused (e.g. sediment turnover).

A uniform intertidal area was subjected to nested hierarchical sampling on the 0.1, 1, 100, 1000m scales. At each scale of observation, replicate cores were taken for macrofauna (and meiofauna), along with measures of a number of environmental variables and the density/activity of a burrowing crab.

Preliminary analysis of the results indicate that macrobenthic spatial heterogeneity exists at the study site on scales of at least 100 and 1000 m, and that the stalk-eyed mud crab *Macropthalmus hirtipes* is the species most likely to be responsible for the distributional patterns observed. A sediment turnover rate was calculated for this 'keystone bioturbator' and found not only to be high (29 kg DW/m2/yr) but to have a clear temporal signature. The relevance of the temporal variation in the crab's activity on the scales at which spatial heterogeneity may be observed in macrobenthic community structure, unfortunately, remains unknown.

7 COMPUTER AIDS TO BENTHOS STUDIES

No oral reports were presented on this subject. L. Watling reported by E-mail on the PEET Programme of the National Science fundation (USA).

The PEET (Partnership for Enhancing Expertise in Taxonomy) Program is a new NSF initiative designed to help stem the ebbing tide of systematics expertise in the US and to a certain extent, the world. We all recognise that many of our colleagues, who were experts in the taxonomy of particular groups, have retired or died without leaving a trained successor. This is especially a problem in the US where modern biology is more molecularly based than organismal. As a result, the lack of expertise for even routine identifications of the fauna and flora is becoming quite noticeable. At the same time, of course, there is also the recognition that the world is losing very rapidly much of its biodiversity and that species are being lost before their existence is even recognised. In fact, many new species may reside in vials in museums for many years, but may never be found alive in the wild.

To help with efforts at training a new generation of systematists, NSF through the PEET Program, funded 22 groups of scientists whose interests represent a wide diversity of taxa. Each group was founded for 5 years and nearly all will be training Ph.D. students or post-doctoral candidates. Of the 22 funded projects, x are concerned with marine benthic taxa: Fautin on sea anemones, especially the genus *Urticina*; Watling on cumaceans; Brusca on cirolanid isopods; Scheltema on aplacophorans. In addition Holsinger was funded to work with crangonyctid and hadziid amphipods (subterranean freshwater).

The success and interest in the first PEET initiative has lead to a second round of proposal submissions, of which approximately 10-12 will be funded sometime this summer.

One goal of the PEET Program which is of direct interest to the BEWG is the desire of all PEET investigators to publish some of their work electronically, in particular, taking advantage of recently developed programs to produce interactive keys which can be used via web sites. To this end, there is now a PEET web site, and all interested persons are urged to periodically check that site for updates from each individual program regarding availability of electronic identification tools. The address of the PEET web site is: http://www.nhm.ukans.edu/~peet. The web page for each project will eventually be linked to the main PEET page so users should be able to find out what is happening with respect to groups of interest.

8 METHODS TO INCREASE THE EFFICIENCY AND QUALITY OF IDENTIFICATION AIDS IN BENTHOS STUDIES

M. de Kluijver gave a demonstration of the ETI CD-ROM, which is in development. The CD-ROM facilitates the identification of macrobenthic organisms (larger than 1 mm), occurring in the southern North Sea (down to depths of 100 metres). At this moment, for 9 groups (tunicates, echinoderms, sponges, anthozoans, brachiopods, phoronids, entoprocts, bryozoans and molluscs), different keys and species cards are available (see Annex 17). The relevant members of the BEWG will be asked to check these lists and to comment on them. These 9 groups include 919 species and the total CD-ROM will contain between 2000 and 3000 species. In addition, standard protocols for sampling and identifying benthic communities will be developed by combining existing methodologies. Reference will be made to guidelines of different ICES reports, of NODC numbers and of QA systems.
The BEWG strongly suggested to include the marine species of the Baltic Sea as well.

The Group supports the CD-Rom projects and members will contribute to the QA of the taxonomy.

9 TAXONOMIC CODING SYSTEMS AND DATA HANDLING

J. R. Larsen reported on the Working Group on Marine Data Management (WG MDM).

Laboratories in Belgium, Germany, Denmark, Iceland, Poland, and Sweden apply the RUBIN code system, or a similar 'home-made' system, where the code is based on the systematic name of the species. The national databases in Germany and Spain are under development, but will probably be based on the NODC system.

The group reviewed a series of WWW pages from the 'Inter-agency Taxonomic Information System (ITIS)'. ITIS has been established as a partnership between US Federal agencies with the aim of offering 'quality taxonomic information of flora and fauna from both aquatic and terrestrial habitats'.

NODC will no longer maintain and develop the present version of the NODC Taxonomic Code version 7. The ITIS has taken over the work, and has announced the publication of the NODC Taxonomic Code version 8, which, however, will assign codes on a sequential ('non-intelligent') basis.

ITIS will review the NODC Taxonomic Code version 7, and the WWW pages from ITIS described how the work has been prioritised. The subgroup reviewed the list of priority, and noted that geographically there was a focus on North American taxonomic groups.

In summary, the BEWG

1) expressed their **concern** that the present RUBIN system is no longer maintained;

2) felt that it was **too premature** to recommend the NODC Taxonomic Code version 8, since it was still under development, but **recommends** that the issue is revisited when the system is operational.

3) **decided** to contact ITIS to suggest another prioritisation of the work (see Annex 18). In addition, the RUBIN species list should be transferred to ITIS with a recommendation that the inclusion of these species are given high priority.

4) **recommends** that the exchange of data should continue based on the present systems until the situation is clarified. This includes the recommendation to continue to use the NODC Taxonomic Code version 7.

J. R. Larsen drew attention to the requests from OSPAR and HELCOM to ICES to prepare protocols for the reporting of biological data. He informed the Group that an E-mail conference will be arranged on this issue, and that members of the Group were invited to contribute.

10 ADVICE ON QUALITY ASSURANCE PROCEDURES FOR BENTHOS

A sub-group reviewed the OSPAR guidelines for benthos monitoring and a number of suggestions were made to improve the text. These suggestions are given in Annex 19.

A. Künitzer presented the results of the meeting of the ICES/HELCOM-Steering Group on Quality Assurance of biological measurements in the Baltic Sea in February 1997 in Copenhagen. The Steering Group had discussed the QA-guideline of the HELCOM-Monitoring Programme and had decided to add a biological part to the purely chemical guideline. For the macrozoobenthos part Heye Rumohr will be asked to write the relevant QA-chapter. The Steering Group also decided on the terms of reference for three training workshops which include one workshop on benthic taxonomy in November 1997 in Roskilde, DK.

Reference was made to the draft report of the new ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements related to Eutrophication Effects (ICES CM 1997/Env:7). It was noted that the benthos habitats referred to were in all cases distributed across more than one country although, clearly, their relative importance varied substantially (e.g. rocky habitats). It was therefore likely that there would be a requirement for across-country synthesis of data covering all benthic habitats, and hence a parallel requirement for consistent QA procedures at an international level.

Tabulations of QA issues relating to benthos studies (appearing as Annexes to the SGQAE report) were considered to be acceptable. It was felt that high priority should be attached to the training element in raising the quality of the data eventually generated.

The sub-group had little experience regarding the application of QA criteria for acceptance/rejection of benthos data. It was noted that commercial consultancies are presently more accustomed to operating to such criteria. There would be benefits to future presentations to the WG of case studies of their application.

Compilation of an inventory of guidelines for the conduct of benthos surveys operated by different countries would be useful (i.e. additional to recognised publications of international groups such as ICES and HELCOM). These could include countries both within and outside the OSPARCOM area.

Experience with the compilation of data from the 1986 ICES North Sea Benthos Survey was instructive, as an indication of problems that may occur in the synthesis of data from different laboratories/countries, especially with regard to taxonomy. (The relevant information will shortly be published in ICES Co-operative Research Report No. 218).

It is to be expected that the data-bank manager will be responsible for applying 'plausibility' controls on incoming data, in order to filter out nonsensical entries such as gross errors in station positions or sampling dates. Standard software is presently applied within ICES for data on chemical contaminants. Judgements on the scientific acceptability of the data will be the responsibility of expert assessors.

The specifications for benthos sampling at North Sea Task Force stations contained in the 1990 BEWG report were reviewed, in order to provide up-dated guidance on certain fundamental questions relating to the initiation of soft-bottom benthos surveys in the OSPARCOM context. This update is given in Annex 20, highlighting key points which are addressed in more detail in published ICES, HELCOM and OSPARCOM guidelines

11 ANY OTHER BUSINESS

11.1 Meetings of interest

Attention was drawn to the ICES International Symposium on Marine Benthic Dynamics: Environmental and Fisheries Impacts, to be held at Crete, Greece, 27-29 April 1998. Leaflets announcing objectives, scope and topics of this symposium will be available within a couple of weeks. Members of BEWG are strongly advised to consider submitting abstracts for oral or poster presentations.

A. Künitzer mentioned a symposium to be held in Tromsϕ, Norway, 1-5 June 1997. This symposium will present the results of the final assessment of data of the Arctic Monitoring and Assessment Programme (AMAP). Presentations focus on the effects of environmental pollution in the Arctic, including the marine and the terrestrial environment.

B. Tunberg reminded the group of the European Marine Biology Symposium to be held at Kristineberg, Sweden in June 1997.

H. Rumohr again made reference to the BMB/ECSA at Mariehamn, Åland, 9-14 June 1997.

K. Essink informed the Group that the Proceedings of the BMB/ECSA Symposium in Åland will be published in Aquatic Ecology (formerly: Netherlands Journal of Aquatic Ecology).

J. Nϕrrevang Jensen informed the Group on a regional Taxonomic workshop which will take place in Copenhagen in November 1997. This workshop will be open to people from outside the region provided the maximum number of participants has not been reached by participation from within the region.

11.2 New publications

The second revised edition of Gesa Hartmann-Schröder's, 'Annelida, Borstenwürmer, Polychaeta' in 'Die Tierwelt Deutschlands und der angrensende Meeresteile', is now available. The price is DM 298,--. The book can be ordered from: Gustav Fischer Verlag, PO Box 100537, D-07705 Jena, Germany.

12 RECOMMENDATIONS

The Benthic Ecology Working Group will meet on 23-25 April in Crete, Greece, in conjunction with, and directly before the ICES International Benthos Symposium. The BEWG will then:

1. Report on progress of the North Sea Benthos Project planning.

2. Assess the results of the IMPACT II project on the effects of fishing activities on the benthos.

3. Report on developments in computer aids in benthic studies (taxonomic and operational)

4. Provide guidance to OSPAR/ICES on Quality Assurance procedures for benthos studies through:
   - review of case studies presented by BEWG members, and
   - contributions to an inventory of national guidelines for the conduct of benthos surveys operated in different countries (within and outside the OSPAR area).

5. Prepare guidelines for epifaunal sampling and epifauna community description
   Justification:
   There is a pressing need for guidance on approaches to epifauna studies in view of increased interest in this topic, given their role in the marine ecosystem and their potential vulnerability to anthropogenic influences.

6. Review the ecological aspects of the introduction of *Marenzelleria sp.* in NW European waters.
   Justification:
   Marenzelleria is an example of a recently introduced alien species, spreading rapidly though Europe, and locally dominating benthic communities. The reasons for its success need to be evaluated along with the significance of similar events for management of the marine environment.

7. Debate the merits of different sampling approaches to benthos studies and new sampling devices, with a view to upgrading existing guidelines.
   Justification: There is an obvious need for debating the pros and cons of different sampling designs. In view of progress in sampling methods and analytical techniques there is a need for a review of the 'state of the art'. In the current climate of financial constraints there is also a need to consider the cost effectiveness of current approaches and the possibilities for optimisation of resources in the light of recent development in hardware and techniques.

13 ACTION LIST

1. Jan Helge Fosså to report on progress of studies into the ecological effects of kelp exploitation

2. Gerard Duineveld to report on the FAROES CHANNEL project

3. Hans Hillewaert to report on macrofauna in dredge spoil dumping areas

4. Hans Hillewaert to give an up-date on investigations on impact of gas transport pipelines on the Belgian continental shelf

5. Susan Smith to report on monitoring of zoobenthos in the county of Kalmar, SW Baltic Proper, Sweden

6. Jan Warzocha to report on results of long-term comparisons of macrofauna data from the Southern Baltic

7. Anita Künitzer to report on:
   - final results of studies on the distribution of macroalgae in coastal areas in the Baltic Sea.
   - QA activities in Germany with regard to benthos monitoring
   - the development on a UNIX-benthos data base.

8. Kjell Leonardsson to report on the macrofauna monitoring programme, including QA in the Northern Baltic Sea.

9. Jφrgen Nφrrevang Jensen to report on the recovery of benthic fauna in the Kattegat after an event of oxygen deficiency in 1988

10. Sigmar Steingrimsson to report on results from the BioIce project

11. Sigmar Steingrimsson to report on experimental studies on the effect of otter trawling on benthos

12. Ingrid Kröncke to report on long-term comparison of Dogger Bank macrofauna

13. Mario de Kluijver to report on progress regarding CD-Rom for the identification of macrobenthos

14. Bjφrn Tunberg to report on long-term changes within the infauna communities along the Swedish west coast

15. Ashley Rowden to report on effects of the "*Sea Empress*" oil spill on kelp holdfast fauna

16. Ashley Rowden to report on progress in studies on small scale distribution of benthic invertebrates

17. Jan Rene Larsen to report on the meeting of ACME

18. Jan Rene Larsen to report on the Annual Science Conference in Baltimore

19. Mike Robertson to report on biotope mapping in the Minches (NW Scotland)

20. Paul Kingston to report on studies on oil contamination pathways through several trophic levels

21. Karel Essink to report on developments in the Dutch biological monitoring programme

22. Johan Craeymeersch to update progress on the production of interactive computer taxonomic aids

23. Keith Hiscock to report on progress on the BIOMAR project
24. Karel Essink to report on benthos projects within Rijkswaterstaat

25. Les Watling to report on electronic means of disseminating taxonomic aids

26. Les Watling to report on methods for spatial analysis of benthos

27. Tom Pearson to report on Norwegian Arctic projects

28. Tom Pearson to report on oil pollution monitoring in Norway

29. Heye Rumohr to report on new methods or aspects of standardisation and QA

30. Chris Smith to report on eastern Mediterranean co-operative projects.

31. Hubert Rees to report on quality control of benthos data submitted to national monitoring programmes, and related QA activities within the UK.

32. Hubert Rees to develop Terms of Reference for a review of epifauna studies.

ANNEX 1

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(Gdynia, Poland, 23 - 26 April 1997)

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ANNEX 2

BENTHOS ECOLOGY WORKING GROUP

GDYNIA, POLAND

23 - 26 April 1997

AGENDA

1 Local organization of the meeting (Jan Warzocha)

2 Appointment of Rapporteur

3. Opening & Terms of Reference

4. Adoption of agenda

5. Report on ICES Science Meeting in Reykjavik

6. Report on meeting of ACME

7. Report on Baltic Science Conference in Denmark

8. Review of Co-operative Studies and other studies relevant to ICES

9. North Sea Benthos Survey

10. Results of IMPACT II project: effects of fishing activities on benthos

11. Studies on small scale distribution of benthic invertebrates

12. Computer aids to benthic studies

13. Methods to increase the efficiency and quality of identification aids in benthos studies

14. Taxonomic coding systems & data handling

15. Advice on Quality Assurance procedures for benthos

16. Any other business

17. Date and Place of next meeting

18. Closing of the meeting

ANNEX 3

ICES Benthos Ecology Working Group
Gdynia, Poland, April 1997

Working document

Final report on the effects of the *Aegean Sea* oil spill on the subtidal macroinfauna

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INTRODUCTION

After the grounding of the tanker *Aegean Sea* on 3 December 1992 near La Coruña, NW Spain, about 60 000 t of light crude oil was released to the sea. Documents presented in 1993 and 1994 in this working group dealt with the general information about this oil-spill, as well as with the initial effects on the subtidal macroinfauna. The report presented in 1995 provided some new results on the evolution of the communities after the spill in the affected area. This final report presents the main results obtained after four years of sampling (1993–1996).

MATERIAL AND METHODS

Five benthic samples were collected monthly with a modified Bouma box corer (0.0175 m^{-2} surface area) in each of 22 stations located off Ares Bay (BR1 to BR5), in La Coruña Bay (C1 to C9), in Ferrol Bay (F1 to F3), and in the continental shelf (P1 to P5). 12 stations were selected for a monthly sampling programme, although since 1994 the sampling was carried out bimonthly (Fig. 1). Details on sampling protocols and laboratory methods are given in the previous BEWG reports.

Average values of hydrocarbon concentration in the sediment for the study area was given in the 1995 report. In selected stations, sediment samples for hydrocarbon analysis were collected simultaneously to the macroinfauna sampling and freezed on board. Temporal sampling for hydrocarbon analyses was discontinued by the end of 1995, when concentration decreased to levels considered normal for each particular station.

RESULTS AND DISCUSSION

Hydrocarbon in the sediments

Oil from the *Aegean Sea* moved mainly towards Ría de Ferrol and Ría de Ares, although part of it entered Ría de La Coruña. Oil rapidly settled to the bottom. Hydrocarbon concentrations in the water column and sediments were reported by González *et al.* (1994).

Hydrocarbon concentrations in the sediment of some stations is indicated in table I. In most of the stations, maximum levels of hydrocarbon in the sediment occurred one or two months after the spill. Hydrocarbon concentration typically decreased with time, and by the end of 1993 levels were almost stable. Concentration of hydrocarbons was quite

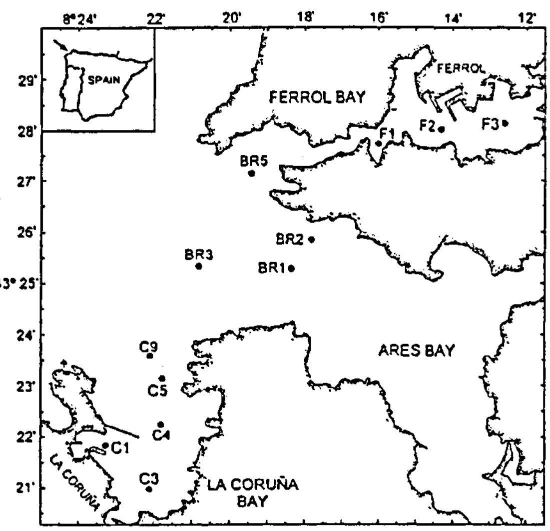

Fig. 1. Location of the sampling stations selected for temporal monitoring.

variable among different stations. Highest levels (> 4000 $\mu g\ g^{-1}$) were recorded in Station C1, located in the harbour area of La Coruña Bay, and in Station F2, located in the middle are of Ría de Ferrol. Both stations remained with relatively high levels of hydrocarbons even 3 years after the spill, which probably corresponds to the pre-spill levels as both stations are located in relatively polluted areas. In some stations (i.e., Stations BR2, BR3 and F2) hydrocarbon concentration increased several months after the spill. This anomalies could be explained by a possible mobilization of oiled sediments either by natural causes (storms) or human activities (i.e., gravel extraction, beach regeneration).

Effects on the macroinfauna

Sediment characteristics and community composition of the stations samples was indicated in previous reports. After four years of study, the main cocnlusion is that the consequences of the oil spill on the macroinfauna communities were not catastrophic in any of the studied locations. Temporal variation of the community before the spill was known in Stations C1 and C3, located in La Coruña Bay (López-Jamar *et al.*, 1995). This has permitted to compare the changes after the accident with the natural variation of the community at these sites. This information was very useful to understand the effect of the spill in the stations were the temporal variation of the communities prior to the spill was not known.

In Station C3, species number decreased from 51 to 35 just after the spill, but this drop is usual in winter months and lies within the normal range of variation. In Station C1 no decrease of species number was recorded after the spill. In these two stations diversity values did not show any variation that could be related directly to the spill (fig. 2). In the stations were temporal variation before the spill was not known, the pattern of variation of both species number and diversity did not reveal major changes in the macroinfaunal community.

However, the oil spill caused clear consequences in some species. Amphipods decreased dramatically in most stations after the spill. In Station C3, this group

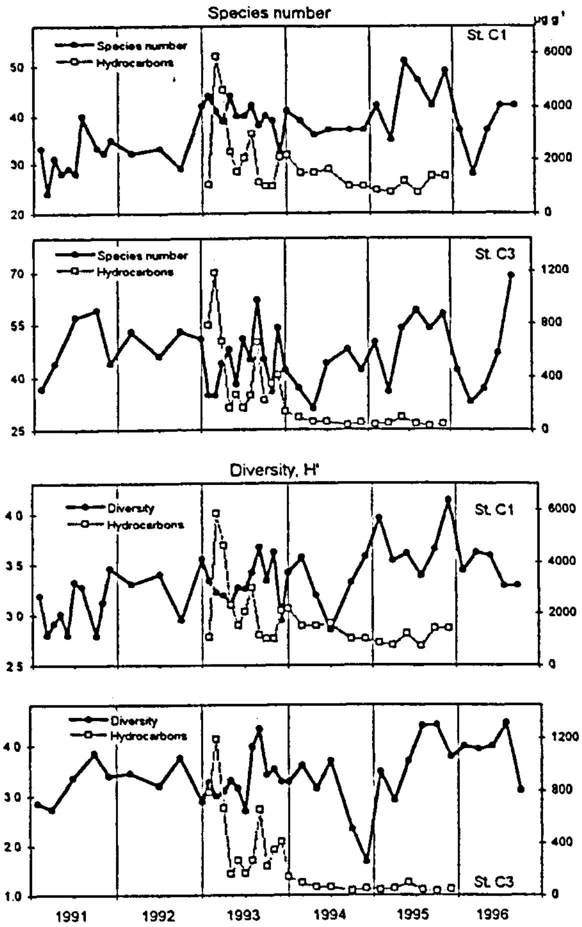

Fig. 2. Temporal variation of species number and diversity in Stations C1 and C3. Light line represents hydrocarbon concentration.

was practically absent from the sediment during the first five months of 1993, and in the rest of the year the abundances were generally lower than normal. The same pattern appears in most of the stations studied, with numbers much lower in 1993 than in the following years. In some of the stations (St. C5, F1 and F2) amphipods were almost absent from the samples during the whole year 1993 (fig. 3). Amphipods are considered to be the most sensitive species to hydrocarbon in sediments (Dauvin, 1987; Dauvin & Gentil, 1990.).

In many stations, abundance of opportunists showed an important increase after the spill. This is particularly evident

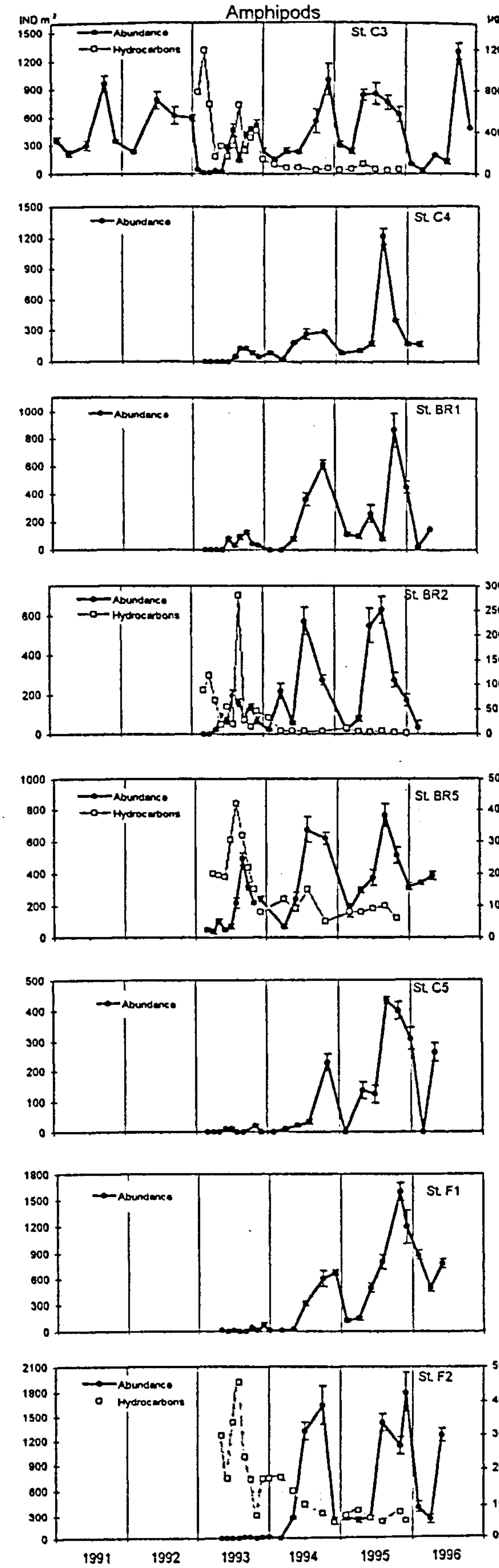

Fig. 3. Temporal variation of Amphipods in Stations C3, C4, BR1, BR2, BR5, C5, F1 and F2. Light line represents hydrocarbon concentration.

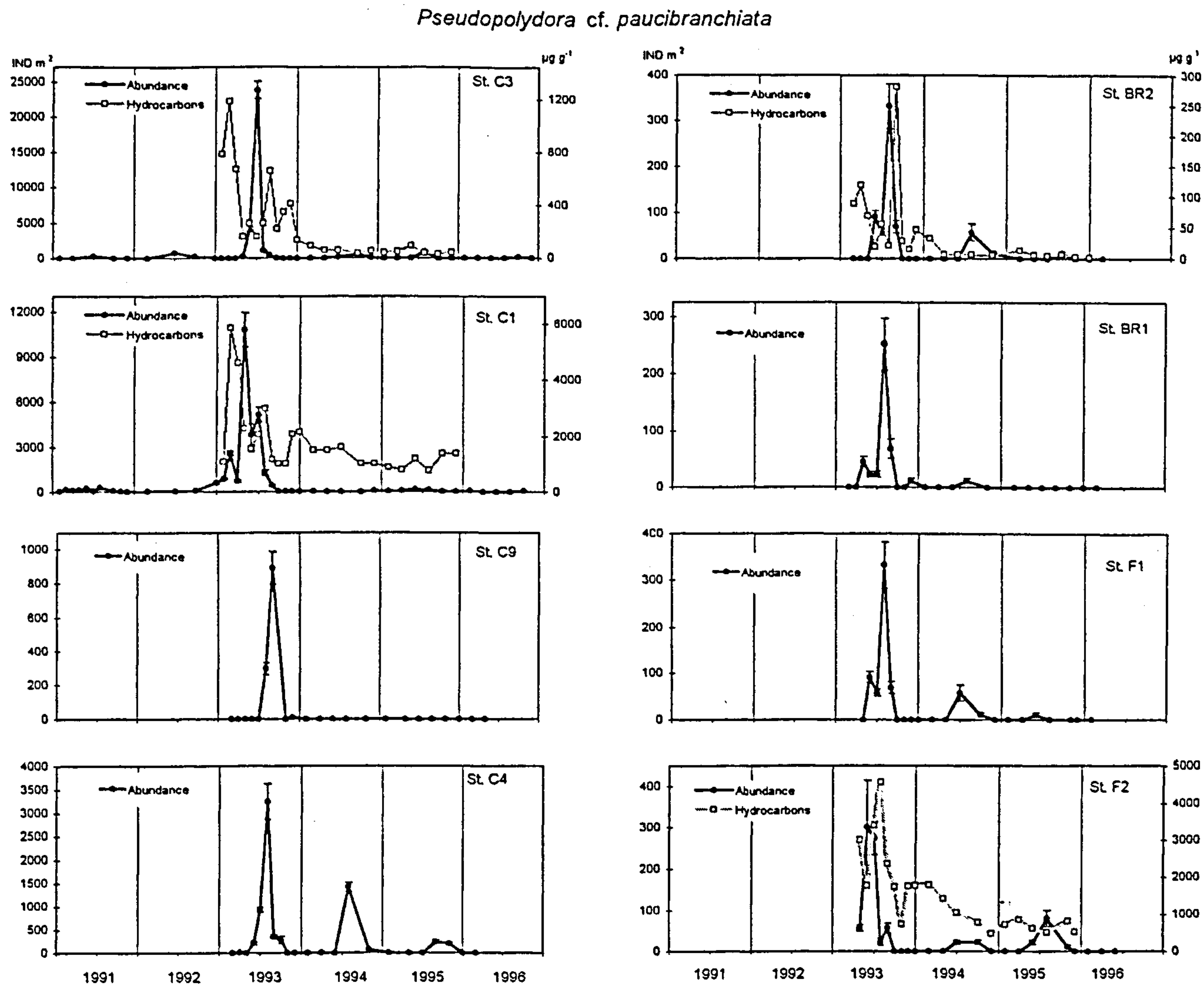

Fig. 4. Temporal variation of *Pseudopolydora* cf. *paucibranchiata* in Stations C3, C1, C9, C4, BR2, BR1, F1 and F2. Light line represents hydrocarbon concentration.

in the case of the small spionid polychaete *Pseudopolydora* cf. *paucibranchiata*, whose numbers increased dramatically in some stations. In Station C3, this species has population peaks in summer that rarely exceed 1000 ind. m^{-2} (López-Jamar *et al.*, 1995). However, abundances higher than 20000 individuals were recorded several months after the spill, but reaching normal values soon thereafter (fig. 4). This pattern is repeated in most of the stations, although the numbers were usually most smaller. In some of the stations (St. BR2, BR1, F1 and F2), a secondary peak of abundance occurs in 1994. Several species of the genus *Polydora* and *Pseudopolydora* have been cited as indicators of pollution (Pearson; 1975, Pearson & Rosenberg, 1978; Plante-Cuny *et al.*, 1993).

The capitellid polychaete *Capitella capitata* showed a very similar pattern. In Stations C1 and C3, abundance of this species during 1993 and 1994 is much higher than in previous years and than later. In other stations a clear abundance peak was recorded several months after the spill, decreasing thereafter to much lower levels (fig. 5). The opportunistic behaviour of this species has been pointed out by many authors (Pearson & Rosenberg, 1978; Ros & Cardell, 1992; Suchanek, 1993, etc.)

The polychaete *Ophiodromus flexuosus* is a common species in semipolluted sediments (Pearson & Rosenberg, 1978).

Capitella capitata

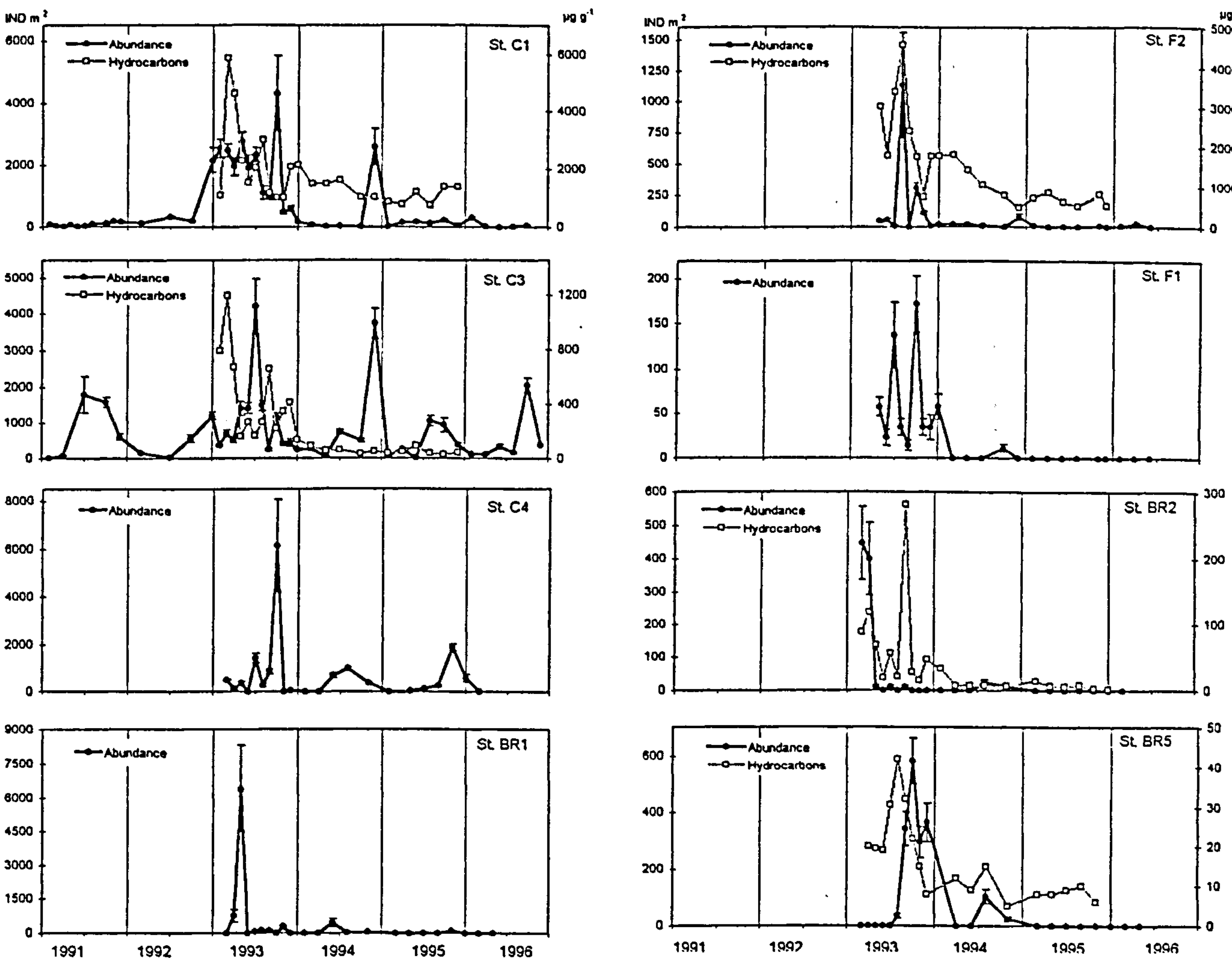

Fig. 5. Temporal variation of *Capitella capitata* in Stations C1, C3, C4, BR1, F2, F1, BR2 and BR5. Light line represents hydrocarbon concentration.

This species in present in Station C1, and its abundance experienced a moderate increase after the spill. In Station C3, the presence of this species was only occasional before the spill, but its abundance showed an important increase during 1993 (fig. 6). A similar situation occurred with the small dorvilleid polychaete *Ophryotrocha hartmanni*, which is quite abundant in Station C1 but very rare in Station C3. After the spill, this species showed a relatively important increase at the latter station (fig. 7). *O. hartmanni* is usually related to polluted harbour sediments, and its increase in Station C3 was very likely caused by the hydrocarbon pollution from the *Aegean Sea*.

The polychaete *Notomastus latericeus* is relatively common in a wide range of sediments. In Station C1 its abundance increased after the spill and remained high until 1995 (fig. 7).

In general, bivalve molluscs were not negatively affected by the oil spill. *Thyasira flexuosa* is the dominant species in Station C1, where it reaches very high abundances. The oil spill did not seem to affect this species in this station. In Station C3, *T. flexuosa* is present but always in

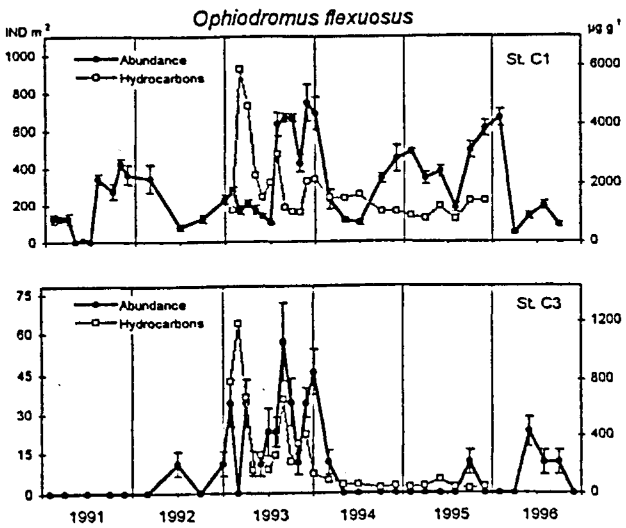

Fig. 6. Temporal variation of *Ophiodromus flexuosus* in Stations C1 and C3. Light line represents hydrocarbon concentration.

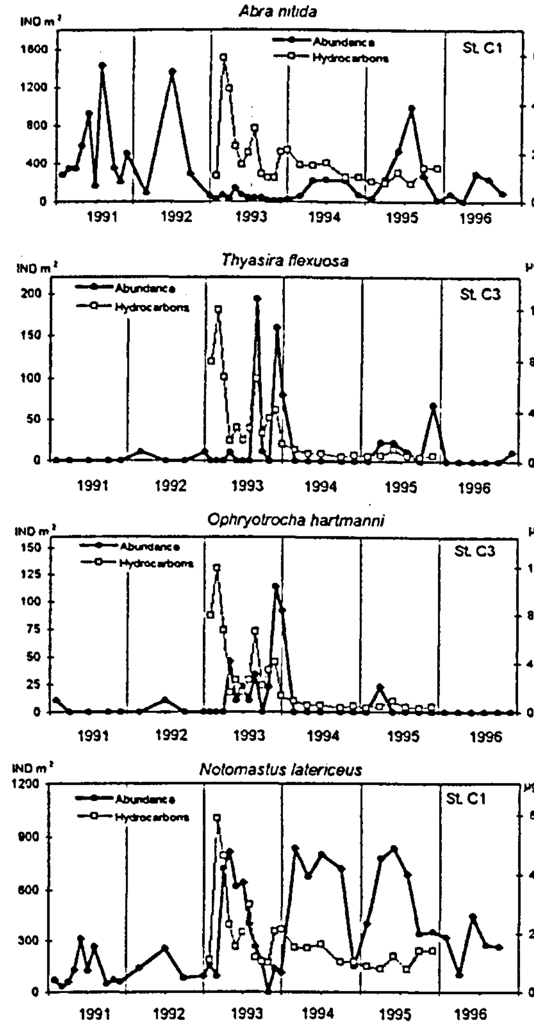

Fig. 7. Temporal variation of *Abra nitida* and *Notomastus latericeus* in Station C1 and *Thyasira flexuosa* and *Ophryotrocha hartmanni* in Station C3. Light line represents hydrocarbon concentration.

very low numbers. Similarly to the two polychaetes above mentioned, abundance of *T. flexuosa* increased significantly in Station C3 after the spill (fig. 7).

The bivalve mollusc *Abra nitida* is quite common in Station C1, where it can contribute to an important fraction of total biomass. Its abundance during 1993 decreased to very low values, increasing slowly afterwards (fig. 7). This species was the only bivalve clearly affected by the spill. *Abra alba* showed a slight decrease in this station, but numbers remained relatively high after the spill. *Tellina fabula,* one of the dominant species in Station C3, did not show any effect.

As a conclusion, we can say that the *Aegean Sea* oil spill has not caused catastrophic effects on the subtidal macroinfauna, although some species experienced important changes in their temporal cycles. Amphipods suffered initially a high mortality followed by a progressive recovery. Some opportunistic species (*Pseudopolydora* cf. *paucibranchiata, Capitella capitata,* etc.) showed strong increases in their numbers, but they decrease to normal levels several months after the spill. Three years after the accident the communities are completely recovered.

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Table I. Concentration of total hydrocarbons ($\mu g\ g^{-1}$) in the sediment of selected stations (1993–1995).

Date	C1	C3	BR2	BR3	BR5	F2
01/93	1086	788				
02/93	5862	1189	89	117		
03/03	4620	670	119	52	20	
04/93	2289	161		222		2997
05/93	1538	265	19	6	19	1768
06/93	2053	164	59	74		3384
07/93	3001	262	21	16	42	4563
08/93	1162	658	281	54		2372
09/93	1013	218	28	62	22	1747
10/93	1010	645	15	1480		731
11/93	2080	411	47	151	8	1754
12/93	2157	135				
01/94			33	700		
02/64	1504	91				1794
03/94			7	148	12	
04/94	1498	58				1412
05/94					9	
06/94	1609	59				1050
07/94			7		15	
09/94	1028	35				788
10/94			6		5	
11/94	1027	51				486
01/95	864	38				724
02/95			13		8	
03/95	786	47				858
04/95			6		8	
05/95	1204	93				626
06/95			5		9	
07/95	762	41				513
08/95			7		10	
09/95	1392	30				
10/95			3		6	810
11/95	1397	44				537
12/95			2		6	

ANNEX 4

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Working document

METHODS FOR DETECTING AND MAPPING OF *LOPHELIA* CORAL BANKS: PRELIMINARY RESULTS

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ABSTRACT

Equipment for detecting and mapping of *Lophelia pertusa* coral banks were tested in a fjord sill area in western Norway. A 38 kHz narrow beam echosounder and a towed side scan sonar with 120 and 330 kHz transducers were used to map the study area and the coral banks. A triangular dredge and a van Veen grab were used for verification of the presence of corals and for taking faunistic samples. A SIT camera was applied for verification of the presence of corals and description of the patch distribution of living *Lophelia*. Bottom currents were measured with a mini current meter. A bathymetrical map with high resolution was made from data produced by the echo sounder. The side scan sonar was a promising tool for mapping of coral banks, and the dredge and grab were very reliable tools for verification of the presence of corals. The SIT camera gave unsurpassed information about the *in situ* conditions and the patch distribution of living *Lophelia*. Banks occurred in groups on sea bottom elevations. Knoll-like structures, typically 1-3 m in diametre, seen on the side scan images, were scattered upon the mounds. These structures are most probably large *Lophelia* colonies. Side scan sonar surveyes will probably give reliable data on areal cover of scleractinian corals, but visual inspections are needed to quantify the relationship between living and dead corals. A test also showed that the side scan sonar had the capability of detecting trawl marks on soft bottom.

INTRODUCTION

In recent years new information has been provided about the size, distribution and density of *Lophelia pertusa* coral banks in the North-east Atlantic (Fredriksen *et al.* 1992, Hovland *et al.* 1994, Mortensen *et al.* 1995, Hovland *et al.* in press). It appears that banks of this coral on a scale previously not known (kilometres in length and hundred of metres across) are found on the Norwegian continental shelf (Mortensen *et al.* 1995). Thus *Lophelia* may build structures from small initial patches, through larger banks of 10-50 m in diametre (Wilson 1979), up to the large structures referred to above. Information from fishermen indicates that trawling activities on the continental shelf and break in mid Norway have destroyed parts of *Lophelia pertusa* banks. The same situation seems to be true on the west British continental shelf, where researchers are worried about the extent of the damage inflicted to the banks (John Gage, Dunstaffnage Marine Laboratory, pers. commn). In Norway we don't know how much has disappeared, or if the trawling has any ecological significance or if it is important to the biology of the species itself. *Lophelia* is found along most of the Norwegian coast and in major fjord systems (Dons 1944) and it can be said that the species is not threatened as such. But if trawling activities represent a potential threat to the larger banks which are genuine highly diverse biogenic structures, the situation may be worrying. Also, the fishery itself may suffer from the impact of bottom trawling. The variety of food species for fish may be reduced in areas with impoverished coral communities and thus may have a negative impact on certain fish stocks; in particular red fish (*Sebastes* spp.), but also tusk (*Brosme brosme*), ling (*Molva molva*), blue ling (*Molva byrkjelange*), and saithe (*Pollachius virens*). To obtain an overview of the situation, a study of the geographic distribution, size distribution and density of the banks on the continental shelf of mid- Norway is highly needed.

The purpose of the present study was to test equipment and methods for detection, mapping and morphological description of *Lophelia* reefs. It was also important to test whether it was possible to detect or confirm damages on the reefs from, for instance, trawling.

In their study Fredriksen *et al.* (1992) used triangular dredge and thus gave present/absent information about the distribution of banks. Hovland *et al.* (1994), Mortensen *et al.* (1995), Hovland *et al.* (in press), presenting results from a project by the Norwegian State Oil Company, Statoil, had the advantage of using multibeam echo sounder mounted on an ROV and visual inspection using ROV in their studies. Extensive use of such equipment is very expensive and generally not within reach of research not related to oil activities. In this study we therefore combined equipment which had the potential of fulfilling our research aims, and also was within our economical capability.

STUDY AREA

The original intention was to work offshore at the continental shelf break off Molde. The weather, however, was stormy during the whole cruise and it was not possible to work out at sea. Instead, a location in Midfjorden with a rich *Lophelia* bank (Dons 1944) was chosen (Fig. 1). Midfjorden forms the western sill area of the fjord system near Molde. Some samples were also taken in Moldefjorden east of Midfjorden for comparison purposes. Except for the severe wind, the conditions in the fjord were good for testing the equipment.

MATERIAL AND METHODS

The investigation was performed between 25 March and 3 April 1997 on board R/V *G.O. Sars*, owned by the Institute of Marine Research, Bergen.

Hull mounted echo sounder

A SIMRAD EK500 38 kHz echo sounder was used for detection and mapping of *Lophelia* banks and the surrounding bottom topography. It had an ES 5 NO 1 narrow beam (4.7 degrees) transducer, and a maximum power of 2000 watt. A narrow beam transducer was chosen to reduce disturbing side echoes from the sloping sides of the coral banks.

The procedure when surveying the area was as follows: parallel transects (thirteen in this case), approximately 90 m apart and two nautical miles long (Fig. 1), were plotted into the navigation system of the ship and displayed on a monitor using the MAX SEA pro software. This setup made it easy to perform the transects. The echograms were printed on two printers with different scaling, one with a bottom channel where the area from 0 to 10 m above bottom was expanded. The ship followed the transects with a speed of about 5.5 knots. Depth and geographical position were logged automatically on a computer every 5 seconds. Depth was also registered from the echo sounder monitor and manually punched in a PC as the transects were taken. The readings were taken every 15 s which is equivalent to a travelled distance of 40.5 m at a 5.5 knots speed. With this method it is important that the ship has the same speed during a single transect, while a little difference between transects is tolerated because the readings are distributed along the same distance, in our case 2 nautical miles. Data from this manual logging were used for producing a bathymetrical map of the investigated area for immediate use on board the ship. The map was made by processing the depth data in the surface mapping system SURFER (version 6.01).

Towed side scan sonar

A towed SIMRAD Mesotech MS 992 side scan sonar operating at 120 and 330 kHz was used. The equipment consists of a torpedo-shaped tow body with the two transducers, a surface processor built into the control panel, a DAT-recorder for logging data, a monitor and a printer. The signals from the subsurface electronics are converted to video and hard-copy signals. The depth of the tow body was regulated by means of towing speed and length of cable. Towing speed was approximately 2 knots and a wirelength of about 2.3 times the depth of the towed body was employed. The cable used was a Multi-Purpose Double Armoured Coaxial Cable with outer diameter of 11.4 mm and weight about 0.5 kg/m. The instrument was towed at about 20 m above the bottom. The view to each side was 100 m.

Six towes were taken along transect 2, 4, 5, 6, 8 and 10 with the sonar (Fig. 1) and recorded on DAT-tape. Coral knolls and mounds could be detected and distinguished from solid rock outcrops by having lighter colour due to lower reflection. When coral mounds were observed, the coordinates were noted and the position plotted on the map (the distance from the ship to the towed body was subtracted, approximately 250 m). The height of a mound (H) is indirectly given by its shadow from the sonar beam and was calculated as a simple relationship between the height of the tow body above the bottom (h), the distance from the midline below the tow body to the end of the shadows from the mounds(d), and the length of the shadow (s):

$$H = h/d \times s$$

Dredge and grab

An equilateral triangular dredge (70 cm, stretched mesh size 3 cm) and a 0.25 m^2 van Veen grab was used to take bottom samples to examine the bottom where we suspected coral banks to be located after interpreting the echograms. A wirelength of 1.6-2 times the depth was used when dredging.

Bottom trawl

A shrimp trawl with rock-hopper gear and 1.6 m^2 (1620 kg) Waco doors was used to make trawling marks on the bottom in Harøyfjorden just north of Midfjorden. This was a test of the possibility of discovering traces from bottom trawls on soft bottom by means of the towed sonar. The trawl was set at 100-140 m depth and travelled one nautical mile at a speed of 2-3 knots. Both before and after the trawling the bottom was inspected by the side scan sonar.

SIT video camera

An Osprey Electronics Ltd, light sensitive OE 1324 SIT video camera was used for direct observations of the bottom. The camera was mounted in a system of one small upper frame and a larger lower frame. The frames were connected with a 1.5 m long rope in each corner so that the frames had a flexible connection. The camera was attached to the upper frame and tilted approximately 20 degrees from a vertical position. Two 150 W lamps were used for illumination. This system was hanging freely in the water in a wire and a cable for video signals. The tracks along the bottom were watched on a black and white monitor and taped on a video cassette.

The camera was lowered to the bottom while the ship was drifting along a predestined course. When the bottom frame came close to or touched the bottom, the lowering was stopped and the wirelength was adjusted as appropriate. Due to the flexible connection of the frames, the camera was not much influenced when the lower frame hit the bottom. Because of severe wind conditions only four recordings were taken.

Current meter

A Mini Current Meter model SD-6000 from Sensordata a.s., Bergen, was used to logg date, time, temperature, current speed and direction. A progressive vector plot, current direction, current direction bar graph, current speed, current speed bar graph and a temperature plot were available on a PC as soon the data were transferred. The recording interval was set to 10 minutes. The current meter was moored on an anchor rigg and positioned 3 m above bottom, at 190 m depth, close to one of the largest coral banks in the study area (Fig. 2). Two 24 hours intervals were measured 28-30 March.

RESULTS

Bottom currents in the study area

Two 24 hour series gave information about the near-bottom currents and temperature. The first series showed that the water flowed into the fjord during ebb tide with a typical speed of 8-9 cm/s (max 11.2 cm/s), and flowed out of the fjord after high tide with current speeds of 2 to 8 cm/s. The next 24 hours the pattern related to the tide was not as clear as the day before, but still the main trend was inflow before high tide and outflow after. Both series showed a temperatur of 6.9-7.1 °C.

Hull mounted echo sounder

The transects presented in this study took about 10 hours to perform at a cruising speed of 5.5 knots. Together with the echograms, the 2 and 3 dimensional maps produced from these transects became very important tools in the detection and mapping of corals (Fig. 2 & 3). The echograms were used to locate mounds and small hills on the sea bottom having the potential of containing corals (Fig. 4 & 5). All mounds that were checked for corals, contained corals. On the echograms the mounds appeared with a strong and well defined bottom reflection (dark line) and was typically covered by a layer of weaker acoustical reflections (Fig. 5, upper part). Because of the positive feedback when checking for corals on these mounds, the weak reflections above the bottom echo of the mounds were interpreted as coral structures. To test the reliability of our echogram interpretation, a survey in the neighbouring Moldefjorden was carried out. The echograms in this fjord also revealed mounds with a layer of weak reflections just above. But in this area no *Lophelia* was found in dredge hauls. Thus, the weaker echoes seem to be side echoes. This interpretation is strengthened by the lowest part of Fig. 5 showing that the weak echoes disappear at the top of the mound.

Towed side scan sonar

The operation of the equipment from the ship and the positioning of the body at 20 m above the bottom, was quite easy. On the sonargram the surface of the mounds appeared as a rough surface with scattered knolls, typically about 1-3 m in diametre (Fig. 6). Mounds occurred seperately or merged and had a conical or round shape. The highest density of mounds was found about 500 m southwest of the centre of the studied area between 170 and 150 m depth (Fig. 2). In this area about 30 mounds were counted within an area of approximately 100 × 500 m. The average height of 20 mounds along the eastern part of transect 10 (Fig. 2) was about 7 m (min 3 m, max 10 m).

The sonar was also used in an attemt to detect trawl marks. By towing the body parallel and in small curves relative to the trawl path, furrows in the bottom sediment could be seen on the sonar display. One or two furrows were observed depending on where the tow body were positioned relative to the haul path. The distance between the furrows was approximately 55 m which corresponds to the distance between the doors of the trawl. Marks made by the dredge, however, were not detected.

Dredge and grab

The dredge proved to be reliable also under rough weather conditions and *Lophelia* corals were sampled in all of the hauls taken. The samples were used to verify the presence of corals at a locality and to collect samples for later faunistic studies. Six grab shots right on top of the coral mound were taken to obtain quantitative samples. Dredge hauls were also taken in Moldefjorden on bottom structures where we, from echograms and experience from Midfjorden, believed coral banks to be located. These hauls did not reveal any presence of *Lophelia* banks, but contained only rocks.

SIT-video camera

The camera was very useful to get acquainted with the bottom types and for the evaluation of the distribution and size of the coral patches. During the first transect we first driftet across the structure shown to the right in Fig. 4, and further eastward. The structures shown on the echogram are typical examples of coral mounds in Midfjorden. On the mounds, living *Lophelia* were patchy and spread out as knolls or heads on a grey background of, presumably, dead corals and sediments. The patchy distribution of small and larger *Lophelia* is in accordance with the results from the dredge hauls where dead *Lophelia* constituted between 87 and 95 % of the corals in the samples. To the east of the coral mounds, the bottom consisted of soft sediments with high densities of what we interpreted as *Munida sarsi* or *Calocaris macandrae* holes, since the former was present in every dredge haul and *Calocaris* was sampled in the grab on the soft bottom. Areas with boulders partly incorporated in the bottom sediments were also recorded.

DISCUSSION AND CONCLUSIONS

Mapping of bottom topography

The depth readings from the EK500 echo sounder proved to be very useful for making bathymetric maps of the study area and to get a first impression of the topography of the area. Maps in 2 and 3 dimensions can be constructed shortly after finishing the transections provided that proper software as Surfer is at hand. The resulting maps are very useful when intrerpreting the sonar images and for plotting coral banks on the map. The smallest distance between the depth data was about 40 m which means that the smaller coral mounds will not be correctly detected. The automatically logged data will be processed later and will probably be of higher resolution because of larger amount of processed data, and also because they contain information from cross sections in the north-south direction. Higher resolution can be obtained with a multibeam echo sounder.

Detecting *Lophelia* corals

The interpretation of an echogram to decide upon whether a certain kind of echo is from a coral mound or not, is not straightforward and needs experience and verification. We used the echogram from the EK500 to guess where to search for corals. The conclusion so far is that we don't have the skills to detect *Lophelia* build-ups of the size investigated in Midfjorden just by reading the echograms. On the other hand, the use of the side scan sonar gave promising results. In this study sonar recordings were taken in areas where we knew that corals were present and it was possible to distinguish between bedrock and boulders and *Lophelia* which has a different texture and density. In this process it was very helpful to plot the information on the constructed map which had a much higher resolution than the commercial navigation maps. We have not tested this equipment offshore so we don't know how well it performs in rough sea.

Verification of the presence of *Lophelia*

Triangular dredge and grab are simple and reliable equipment for the verification of the presence of *Lophelia*. They also give samples of the accompanying fauna. The combination of these two gears also give information about the condition on the reefs, by judgement of the percentage of dead and living corals in the samples. The SIT camera is technically more complicated but also gave conclusive evidence of the presence of corals in addition to information that could not be obtained by dredge and grab, *e.g.* the distribution of patches and indications of the size of the coral patches and how they grow in the terrain.

Mapping *Lophelia* corals

Initial use of the echosounder to search for topographical structures that potentially contain corals, is very useful. Reports from other cruises studying large coral banks indicate that it is possible to detect and map banks by means of an echosounder (Mortensen unpublished). This is not supported by the results from the present study. For mapping of banks, the side scan sonar is very promising because it clearly distinguishes between coral structures and hard rock. One of the reasons for this is that the transducers are close to the bottom which allows for higher resolution and finer details. It also seems possible to map fairly large areas within a reasonable amount of time.

Describing the morphology of mounds and distribution of *Lophelia*

For this kind of work a camera of any kind, for example mounted on a ROV (Remote Operated Vehicle), is of utmost importance. Direct visual observations can not be substituted by other methods. With the SIT camera it was obtained information about the size and density of patches of living *Lophelia*, and later it is possible to make more exact measurement when reviewing the tapes. It seems that the corals are located in special areas or patches, and within these larger patches the corals are found in smaller patches from small heads or knolls up to larger "bushes" severel metres high. The knoll-like structures on the mounds seen on the sonargrams are most probably large *Lophelia* colonies, as corals in the dredge and grab samples were caught in the same area.

To decide whether a mound or bank with corals on the surface, is a coral build up, or whether the corals are just forming a crust upon *e.g.* morainic material, is not easy. To measure the thickness of coral build ups Hovland *et al.* (in press) tried a Gravity corer, but without success. Probably a Vibrio corer could be the proper instrument.

Detecting marks from trawling and dredging

Furrows in the bottom sediment made by trawl doors were easely recognised and indicates the potential of the sonar for this type of documentation as is earlier shown by, *e.g.* Lindeboom (1995). We anticipate that the sonar can be used to detect linear disturbances which are not common in nature. If a disturbance of any kind gives a sort of patchy pattern with a structure similar to that of the sea bottom, it may be impossible to detect it with a sonar. Traces left behind after triangular dredging in Midfjorden was searched for, but not detected. These traces were possibly too small, or located in an unfavorable direction to the sonar beam, resulting in no formation of shadows in the sonargram.

As part of this study it was also the intention to use a ROV for visual inspection on offshore locations where information from fishermen indicates that coral reefs has been destroyed. However, it was chosen not to use a ROV for this cruise, because of the high chances of rough weather at this time of the year. The ROV test will be executed later this year.

Currents and water movements on the coral banks

There has been speculations about the importance of bottom currents for the occurrence of corals. The current velocities registered in this area were not particularly high and are typical for open sill areas. To investigate more closely any preferences the corals may have for particular current conditions, several current meters have to be used to describe local current patterns and during a long term as the velocities show seasonal variations.

ACNOWLEDGEMENTS

We are indebted to the crew on R/V *G.O. Sars* for excellent navigation during a rather windy period and to the Norwegian Research Council for financial support. Beatriz Baliño gave valuable comments on the manuscript and corrected the English.

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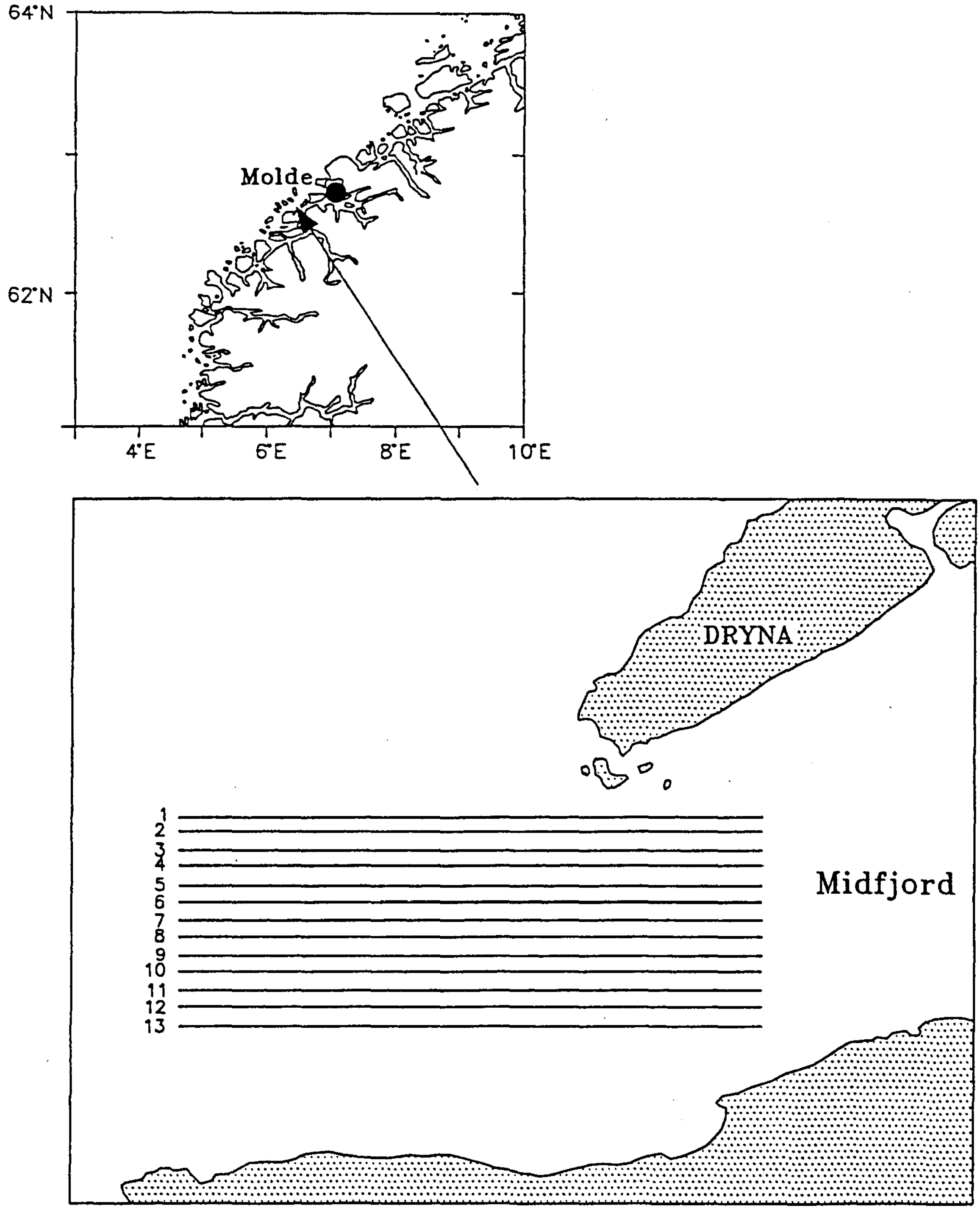

Fig. 1. The study site in outer Midfjorden. Transects 1-13 are two nautical miles long and about 90 m apart. The depth recordings along the transects were used to produce Fig. 2 and 3.

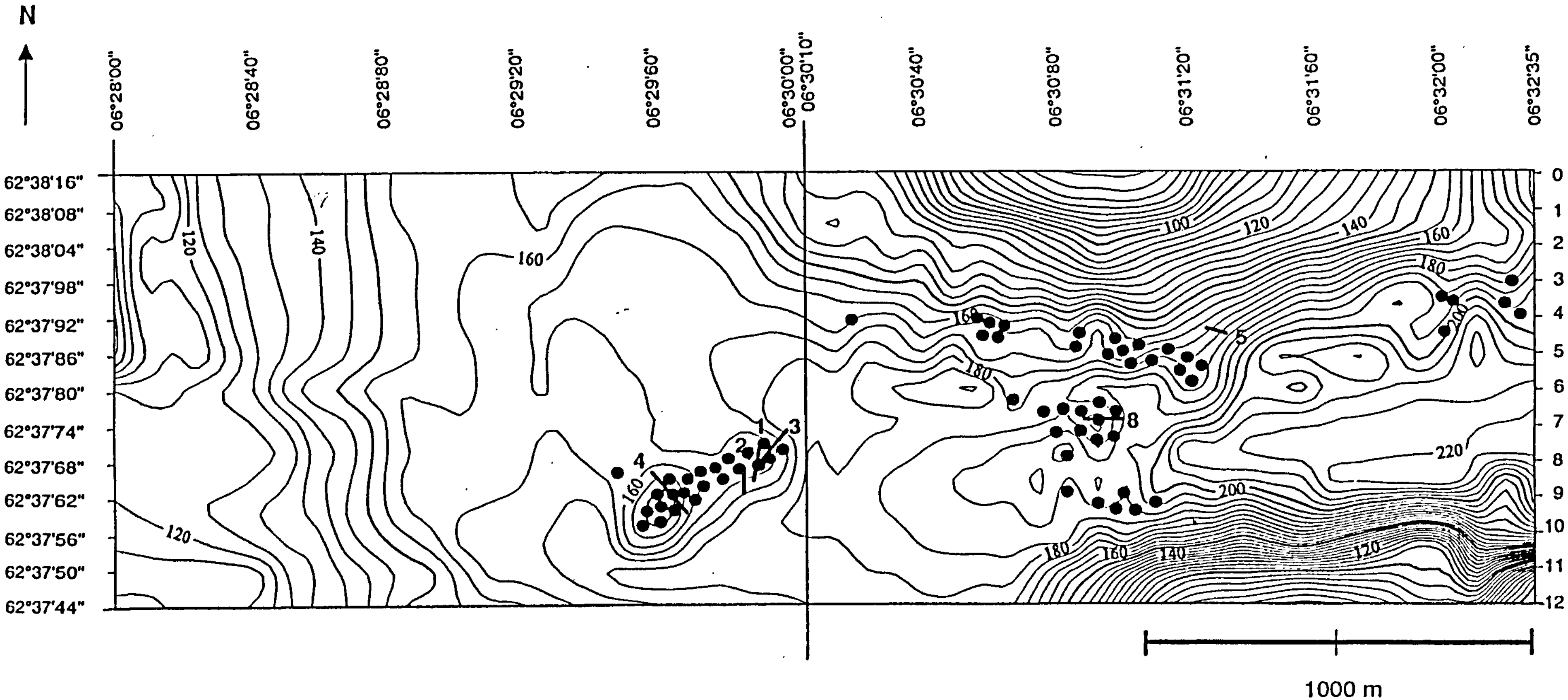

Fig. 2. Bathymetric map of outer Midfjorden produced from depth readings with the echo sounder. Distance between depth isolines is 5 m. 1-5 and 8; the position of dredge hauls. • ; positions of one or more coral mound registered during playback of DAT tapes from the towed side scan sonar along transects 2, 4, 8 and 10 shown in Fig. 1.

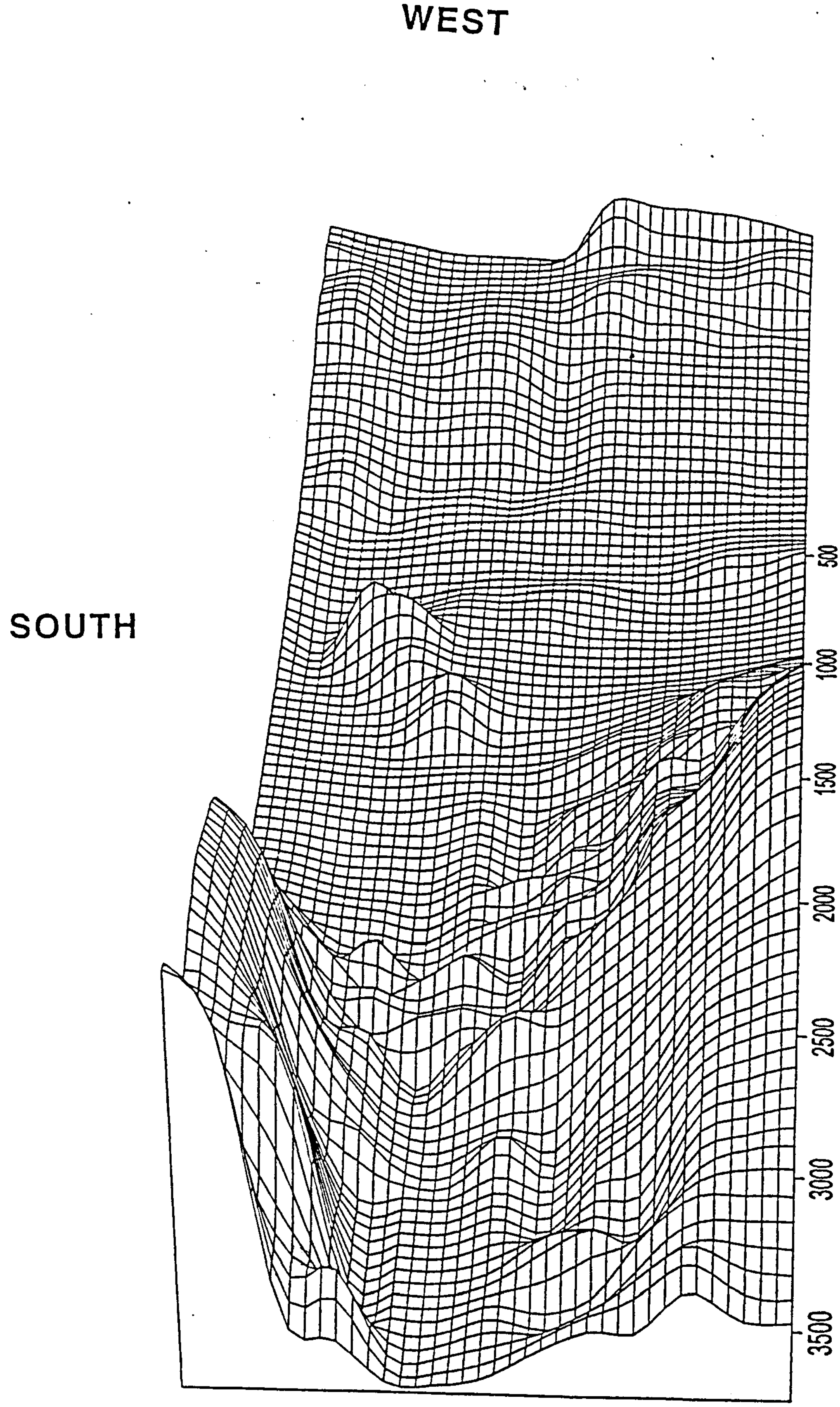

Fig. 3. Three dimensional map of the study site in Midfjorden. Some of the coral mounds are recognisable.

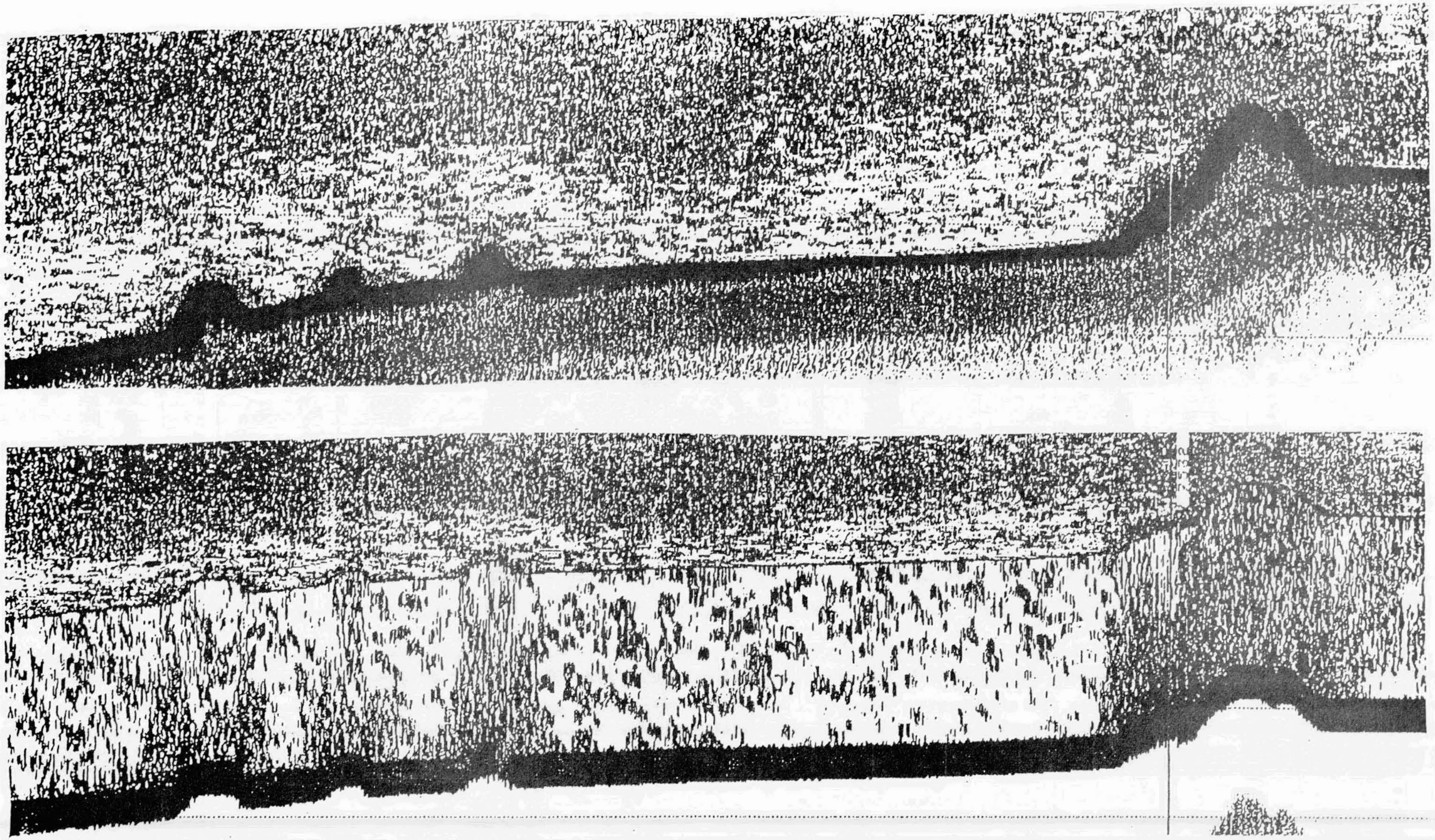

Fig. 4. Echogram showing main bottom structures along part of transect 8, from east to west. The lower part is a bottom channel showing the near bottom area between 0 and 10 m expanded. The highest hill is where dredge hauls 1-3 were taken, see Fig. 2. The three smaller hills are located on the transect in the area below dredge haul 8, Fig. 2. On the highest hill the presence of corals was confirmed with dredge samples, SIT-kamera transect, Side Scan Sonar and grab samples.

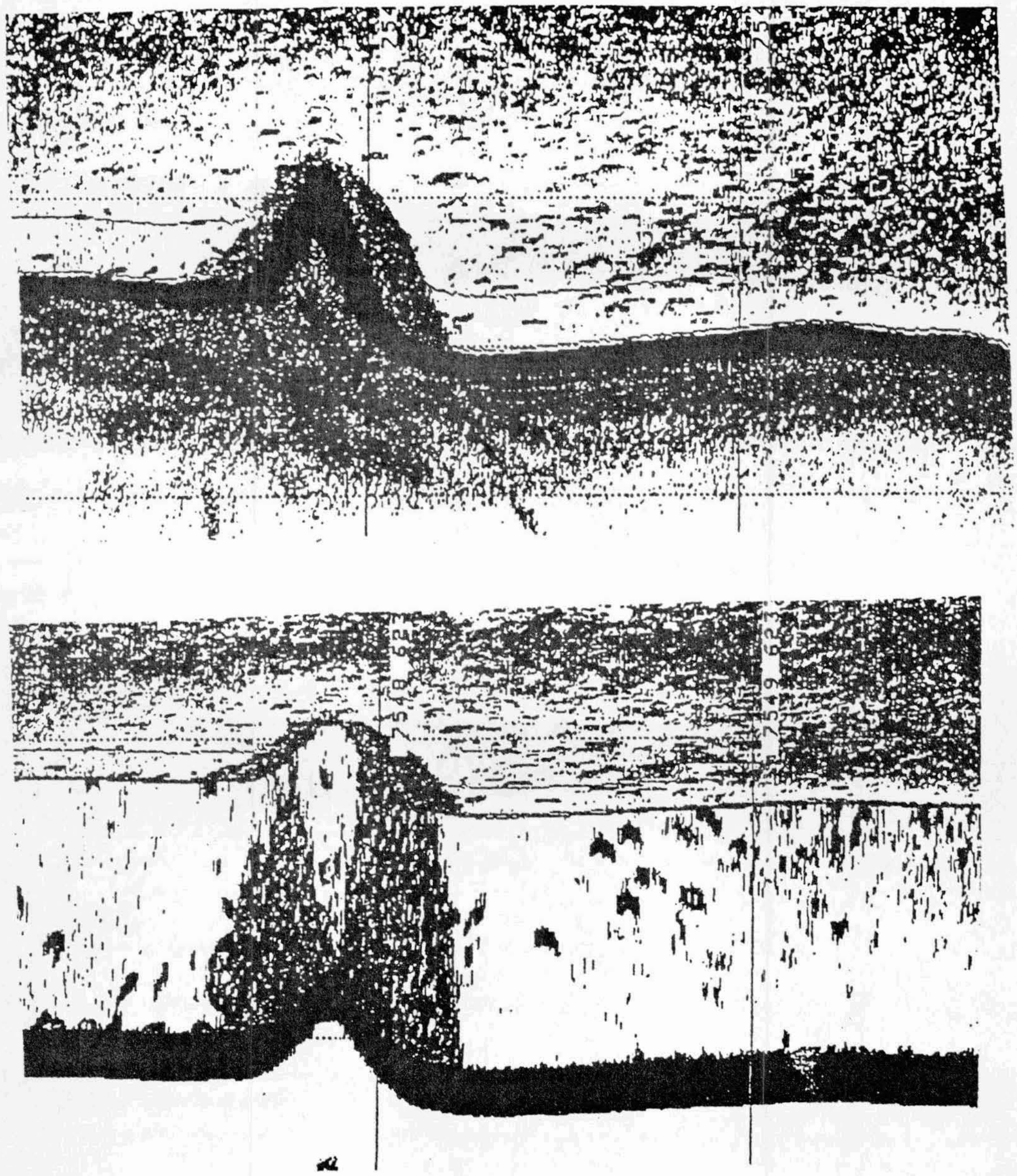

Fig. 5. Echogram showing the largest mound from Fig. 2 during a haul 28.03.97 with triangular dredge. The bottom contact presumably started at the top and the dredge sampled down the slope. The sample contained 74.6 kg corals. In the bottom channel the side echoes from the sloping sides of the mound are easely seen and characteristically the side echoes disappear when the boat crosses over the top. On a larger scale these side echoes may be mis-interpreted as corals.

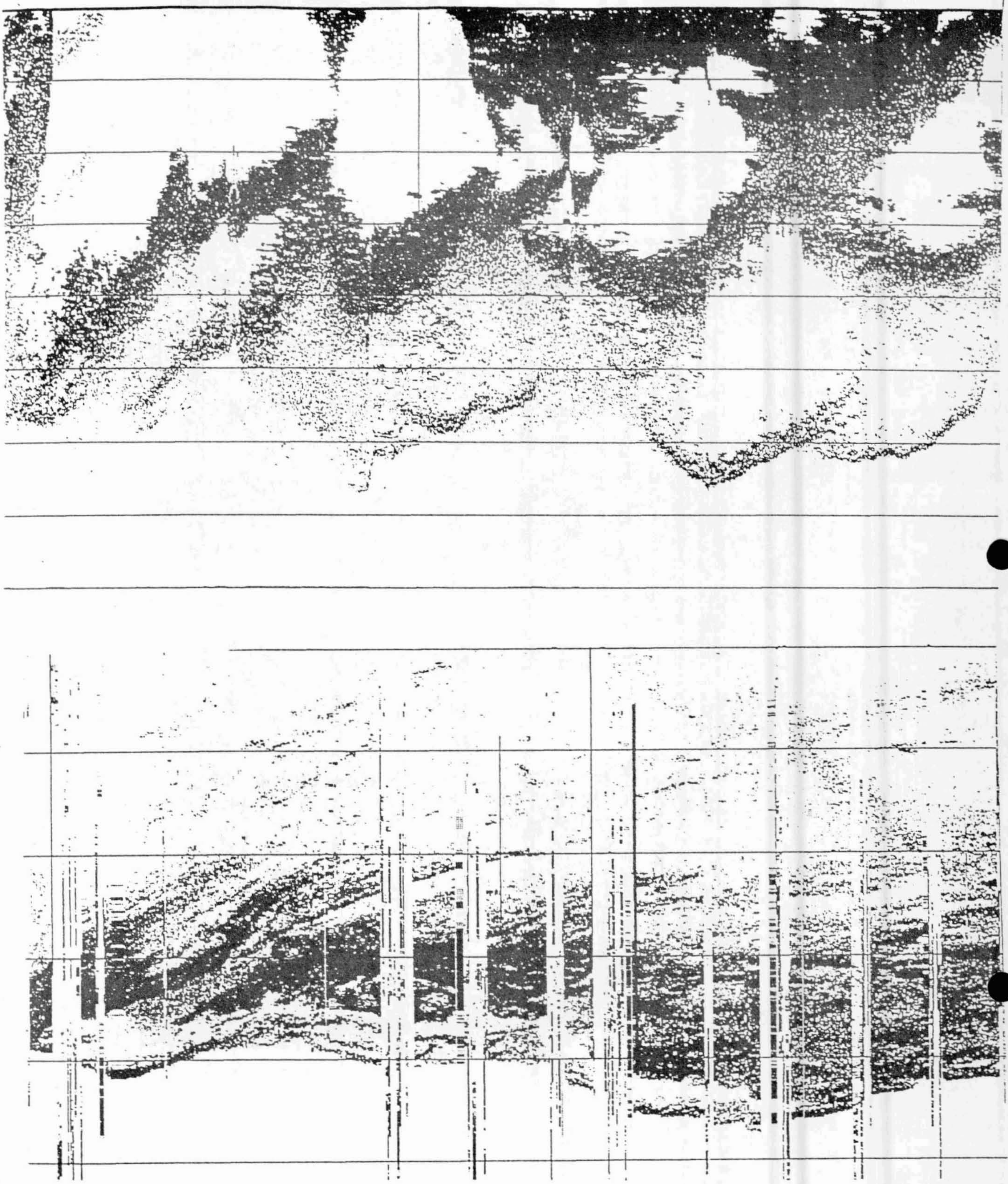

Fig. 6. The upper sonargram shows a segment of the eastern part along transect 10 with coral knolls and mounds (Fig. 2). The white areas are shadows from coral mounds or other hills. The surface structure as seen on the righ hand side is typical for corals, while exposed bedrock (lower sonargram) looks quite different and gives a stronger echo than coral mounds. Scale: 10 m between the horizontal lines.

ANNEX 5

ESTIMATES OF MIXING RATES AND FLUXES OF PHYTODETRITUS IN NORTH SEA SEDIMENTS BASED ON CHLOROPHYLL-A PROFILES

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In February, March, May, June, August and November 1993, three stations in the southern and central North Sea were visited where sediment cores were collected and sediment oxygen consumption was measured. The 3 sites were a station with clean sand (st. B) ,a station with silty-sand (20% mud) located in the Frisian Front (st. F), and a northern station with silty-sand containg less than 10% mud (st. O), respectively. The sediment cores were sliced, deep-frozen and analysed for chlorophyll-*a* by means of HPLC. The downcore distribution of this biomarker for fresh algal detritus was modeled with a random diffusive model (cf. Berner, 1980) and a non-local mixing model described by Soetaert *et al.* (1996). In most cases, the random diffusive model gave the best fit. In some cases, however, when a subsurface maximum of chlorophyll-a was found, the non-local mixing model gave a better description of the depth-distribution of chlorophyll (Fig. 1). From these models, the bioturbation rate in and the flux of chlorophyll to the sediment were calculated. As an alternative, fluxes were estimated using successive changes in the total inventory of chlorophyll-a in the sediments (Sun *et al.* 1994). The results from these two methods showed good agreement. Fluxes of chlorophyll-a were highest in spring, lower in summer and lowest in autumn and winter, a pattern which is in line with the spring bloom in the North Sea. At st. B the mixing rate showed a seasonal cycle (Fig. 2), viz. relatively low values in February and March, highest ones in May and June and decreasing ones in August. At st. F, the highest mixing rate was found in February. Apart from this early maximum, mixing coefficients at F suggest a seasonal trend with increased mixing in May and August, but the differences are not significant. The seasonal variation in mixing rates at st. O, resembled that of st. B with the, on average, highest rate in March. Due to the high variance between replicate cores, this difference was not significant. When comparing mixing rates among stations, at least the maximum rates at st. O surpassed the ones measured at st. B, but significance differences between averages could not be demonstrated. The sediment oxygen consumption at the three stations exhibited a clear seasonal cycle, with the highest values in (late) summer. When chlorophyll-a fluxes are converted into carbon units, using a C:Chlorophyll-a ratio of 50 (~fresh algae), the integrated annual carbon flux matches the annual sediment mineralisation based on the O_2 consumption measurements. These observations give rise to two speculative conclusions:

- it appears that during spring labile OM accumulates in the sediment. Part of this build-up could be fuel for the summer peak in benthic oxygen consumption.

- the match between the flux of highly labile phytodetritus and oxygen consumption, when both expressed in carbon, suggests that the benthic mineralization can be sustained by fresh, and hence local, algal detritus and no advective sources are required.

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Soetaert K., Herman P.M.J., Middelburg J.J., De Stigter H.S., Van Weering T.C.E., Epping E., Helder W. (1996) Modeling ^{210}Pb-derived mixing activity in ocean margin sediments: Diffusive versus non-local mixing. J. Mar. Res. 54: 1207-1227.

Sun M.-Y., Aller R.C., Lee C. (1994) Spatial and temporal distributions of sedimentary chloropigments as indicators of benthic processes in Long Island Sound. J. Mar. Res. 52: 149-176

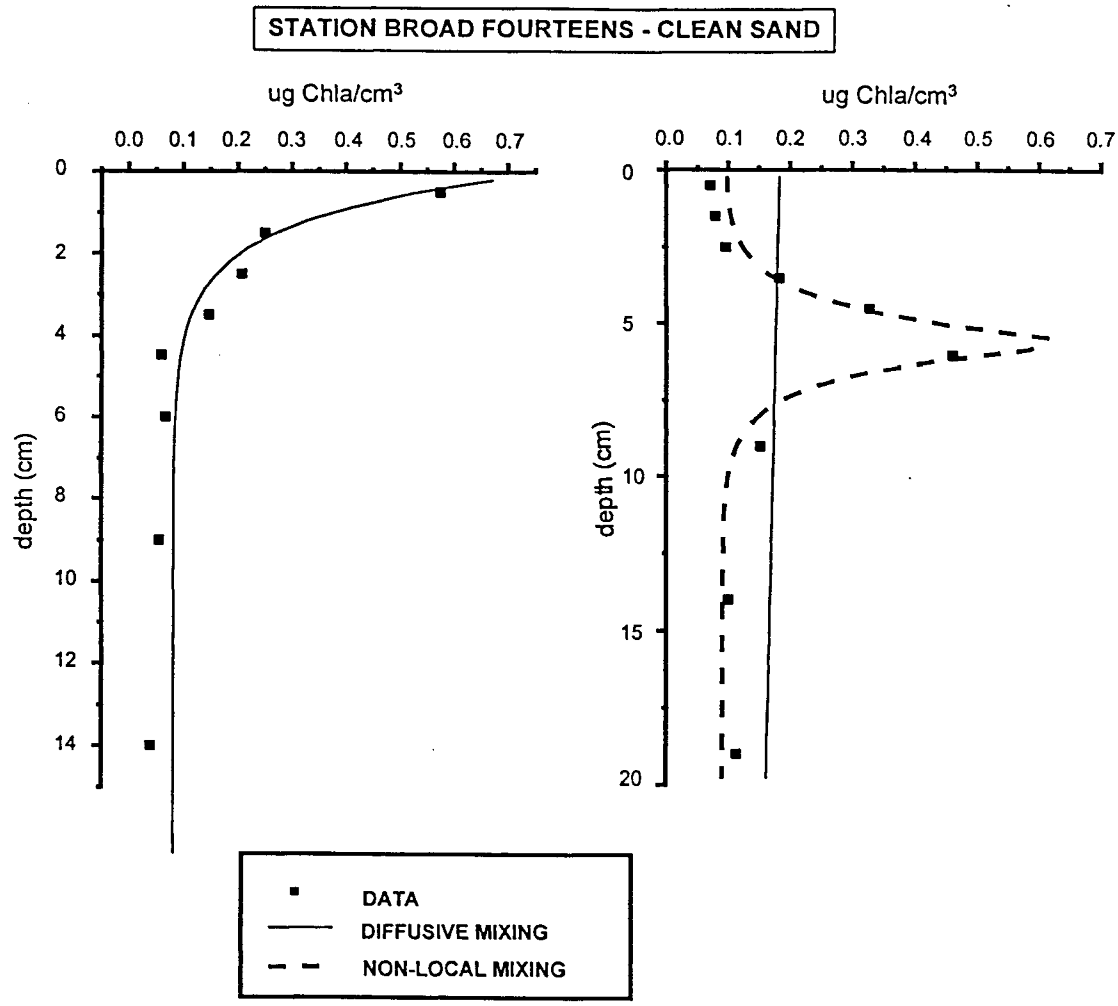

Fig. 1. Example of the fit of the diffusive (left panel) and the non-local mixing submodels (right panel).

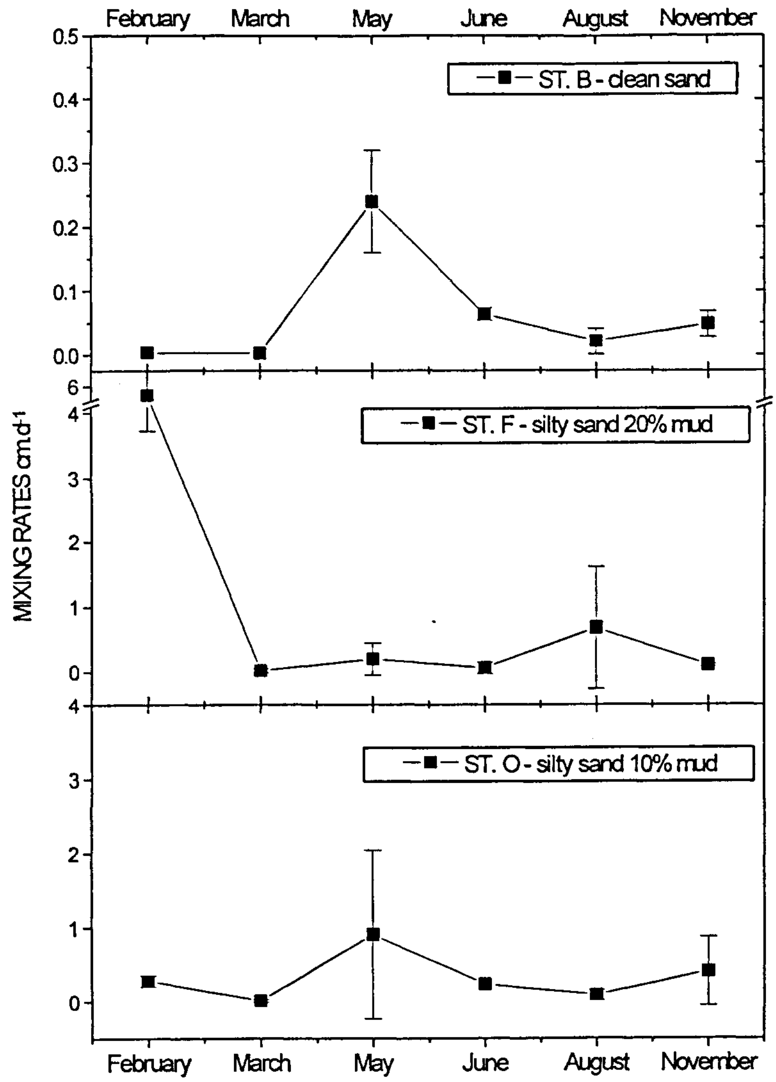

Fig. 2 Seasonal variation in mixing rates ($cm.d^{-1}$) at the 3 sampling stations.

ANNEX 6

H. Hillewaert gave an update on the Belgian report about the southern North Sea sampling programme, which included both epifaunal and infaunal macrobenthos. Data for 1995 are currently available, 1996 is being processed.

Epibenthos

A qualitative study of epibenthos was continued in 1995.

Abundancy, number of species, diversity (Shannon-Wiener diversity index), dominance (Simpson's dominance index), evenness en biomass were calculated.

Thirty-nine different epibenthos organisms were found. Richest sampling areas were Loswal S2, Westdiep en Bligh bank. Total number of organisms was considerably larger in autumn than in spring.

Most abundant species were *Crangon crangon*, *Liocarcinus holsatus* en *Ophiura spp.* for spring as well as autumn and *Spisula subtruncata* only in autumn.

Macrobenthos

In 1995 ninety-one macrobenthos species were counted with densities varying between 193 and 4433 ind/m^2. Number of species was lowest in station 'Loswal Zeebrugge Oost', which is situated just outside Zeebrugge harbour (see Figure 1), and was highest in station 'Westdiep', which is situated north of Nieuwpoort.

Polychaeta were dominant in spring (predominantly *Magelone mirabilis*, *Phylodoce maculata*, *Nephtys spp.*, *Spiophanes bombyx* and *Capitella capitata*), followed by Mollusca (*Spisula subtruncata*, *Mysella bidentata* and *Ensis directus*) and Crustacea (*Pariambus typicus* and *Abludomelita obtusata*)

Autumn showed Mollusca as most abundant (*S. subtruncata* and *E. directus*), followed by Polychaeta (*S. bombyx*, *N. spp.*, *P. maculata*, *M. mirabilis* and *Chaetozona setosa*) and Crustacea (*A. obtusata* and *Phtisica marina*).

Results are comparable to those of 1993 and to studies by J. Craeymeersch and others.

Historical macrobenthos samples (dating back to 1979) are currently being identified. Results are expected early 1998.

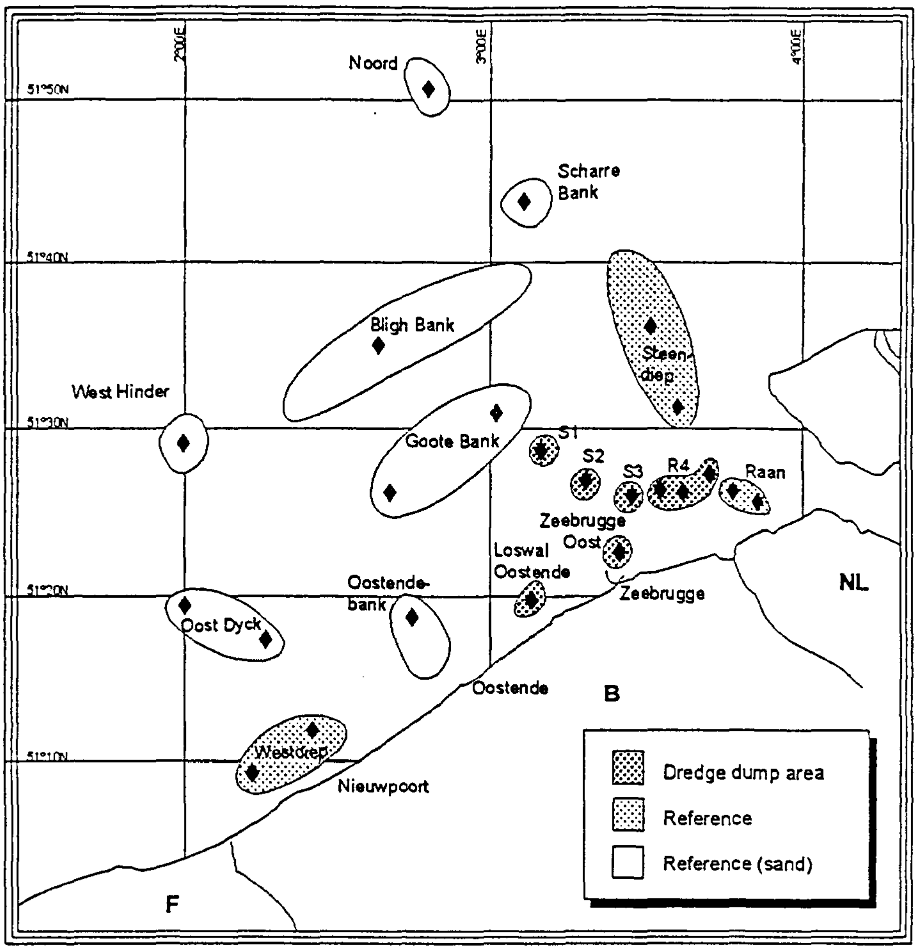

Figure 1 Sampling stations.

Two new pipelines crossing the Belgian continental shelf gave rise to new sampling and monitoring programmes.

Interconnector will cross from the United Kingdom to Zeebrugge. Monitoring of macrobenthos and demersal fishes is planned along the pipeline track. A considerable amount of sand and gravel (up to $1.6x10^6$ m^3) will be used to cover the pipeline south of the Goote Bank. The extraction areas will be monitored before and after extraction.

NORFRA (NORway-FRAnce) will cross from Norway to France. A similar study as for Interconnector will be carried out.

The map (Figure 2) shows the two planned pipelines, old and new sampling stations, and relevant sand banks.

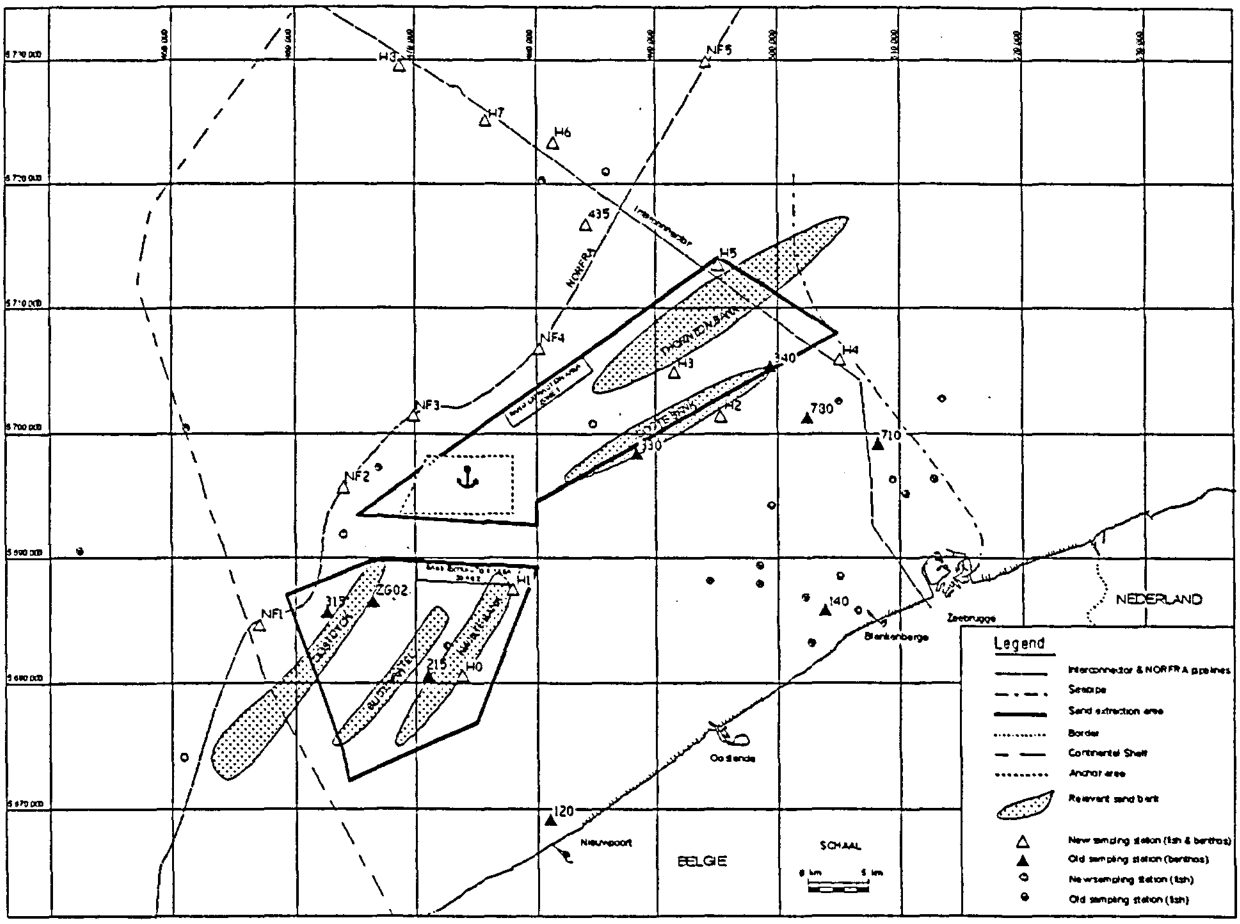

Figure 2 Map showing pipelines and sampling stations.

ANNEX 7

Working document RIKZ/OS 97.604x

THE ECOLOGICAL EFFECTS OF SUBAQUEOUS SAND EXTRACTION NORTH OF THE ISLAND OF TERSCHELLING, THE NETHERLANDS

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INTRODUCTION

In The Netherlands the exploitation of marine sand deposits in the North Sea has strongly increased since 1990. Marine sand is extracted in the shallow Dutch coastal zone primarily for coastal nourishment and large constructions works. Circa 6 to 7 million m^3 sand is needed per year to compensate for sand losses in erosive coastal sections of the nearshore zone. Future reduction of exploitation of land based deposits together with an increased demand for nourishment, due to the sea level rise, will lead to an increasing exploitation of marine deposits.

In the North Sea, only little information is available on the environmental effects of sand extraction. Benthic organisms living in or on the top of the bottom will be removed by the extraction of sand. Macrobenthic communities of the coastal zone play an important role in sea ecosystems, as they provide a food source for fish, shrimps and migrating and wintering diving ducks. To study the response of the benthic community to shoreface nourishment and the accompanying subaqueous sand extraction the RIACON program was initiated. RIACON is co-sponsored by the MAST II (Marine Science & Technology) program of the Commission of the European Communities and evaluates the ecological risk of shoreface nourishment and subaqueous sand extraction at sites in Denmark, Germany, The Netherlands, Belgium and Spain (Catalonia).

METHODOLOGY

The extraction area is situated approximately 8 km north of Terschelling at a depth between -20 m and -23m Dutch ordnance level (NAP)(Fig.1). An amount of circa 2.1 million cubm of sand were extracted from the area between May 1993 and November 1993.
Following a 'random sampling'- approach, 30 stations were selected in 1993 (T0) and 1994 (T1). In 1995 (T2) the number of stations was extended to 34 stations. At each station one sample was taken with a Reineck boxcorer (0.078 m^2). The macrofauna samples were analyzed for density, biomass and species composition.

As initially no reference site was designated, an attempt was made to indicate an area of reference within the borrow area. By comparing bathymetric maps for changes in depth, the borrow area was divided into two subareas.

subarea A (reference): +10 to -10 cm depth change
subarea B (disturbed): -10 to -150 cm depth change

RESULTS

Geomorphology

The bathymetry of the extraction area changed considerably as a result of the sand extraction. From the T0 to the T1 survey a lowering of the sea bed occurred of 0.25 m to 1.5 m in an area of circa 1.4 km^2 (Fig. 2: subarea B). From the T1 survey to the T2 survey a further deepening of circa 0.1 m. was observed in this area.

Benthos

In subarea B the abundance of polychaetes and crustaceans decreased significantly (Fig. 3). In subarea A a more gradual decline in macrofauna abundance was found from the T0 survey to the T2 survey. The density of molluscs showed little variation from the T0 survey to the T2 survey.
In the disturbed area B the reduction in biomass of worms and molluscs was significantly, whereas in the undisturbed area A no significant changes were found (Fig. 4).

The community structure changed as a result of the extraction of sand which is illustrated in the MDS ordination (Fig. 5). The different surveys form three distinctive groups of stations (stress factor is 0.103). The greater distance between the stations forming the T1 group in the ordination, indicates a much more heterogenic benthic fauna than was present at the T0 survey. In the T2 survey the benthic community seems to have shifted in the direction of the T0 survey with reduced distances between the stations.

Increased densities of opportunistic species as *Capitella capitata, Spio filicornis* and *Spiophanes bombyx* were found in the T1 survey.
The age composition of *Donax vittatus* and the Heart-urchin *Echinocardium cordatum* shifted in the extracted area (subarea B) from a population of mostly adults to juveniles (Fig. 6). In subarea A no changes were found considering the age composition. Other species which were rare before the extraction e.g. *Spisula subtruncata* and *Tellina tenuis*, showed up especially in subarea B, with high densities of juveniles at the T1 survey but were strongly reduced at the time of the T2 survey (Fig. 7).

DISCUSSION

With the extraction of sand the benthic fauna was removed from the dredged track leaving the new sediment layer open to settlement. Species that were most abundant in the pre-extraction survey (*Magellona papillicornis, Nephtys hombergii* and *Urothoe poseidonis* showed strong reduction in their density in the post-extraction surveys. Opportunistic species, having life-history characteristics such as rapid dispersal and high reproduction rates, showed up after the extraction (T1 survey) and reached high densities. Molluscs densities increased temporarily because of settlement of recruits but life condition were not favourable to sustain healthy populations.
Recolonisation processes were clearly demonstrated by the changes in population structure of long living species (molluscs and echinoderms). Adult populations were reduced and recovery of these species took place in the T1 and T2 surveys from settlement of juveniles. Recovery of this group takes place primarily through reproduction and most probably not by migration from neighbouring areas. Recolonisation of the area by the short-living and more mobile polychaetes and crustaceans may include both reproduction as well as migration (Fig. 8).

CONCLUSION

The benthic community structure at the T1 survey deviated from the pre-extraction situation but showed a recovery towards the pre-extraction situation at the T2 survey. However, recovery is not yet complete. The effects of the extraction of sand on the benthic fauna are most evident for the long-living species as molluscs and echinoderms. As no changes in sediment characteristics or hydrographic condition occurred a full recovery of the former benthic fauna should be expected, but this will take several years.

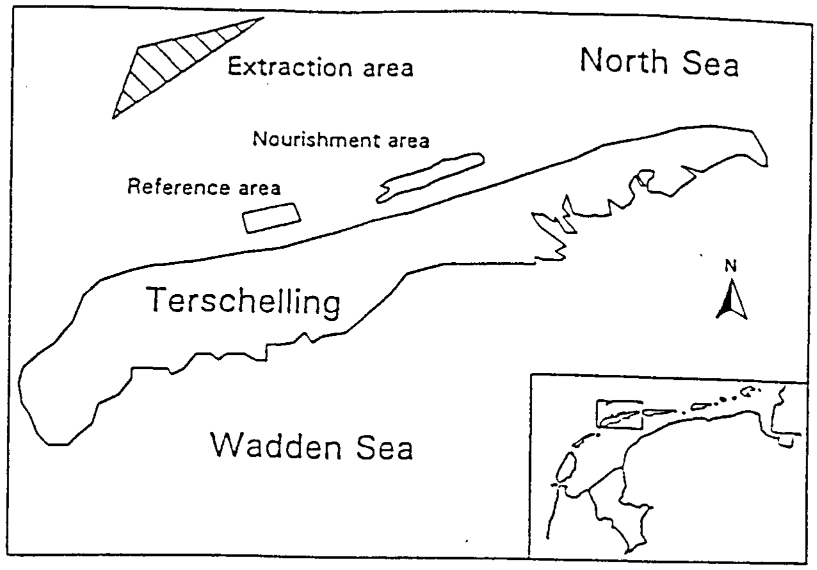


Figure 1. Map of the Island of Terschelling and position of the areas studied in the RIACON project: borrow area, nourishment area and reference area.

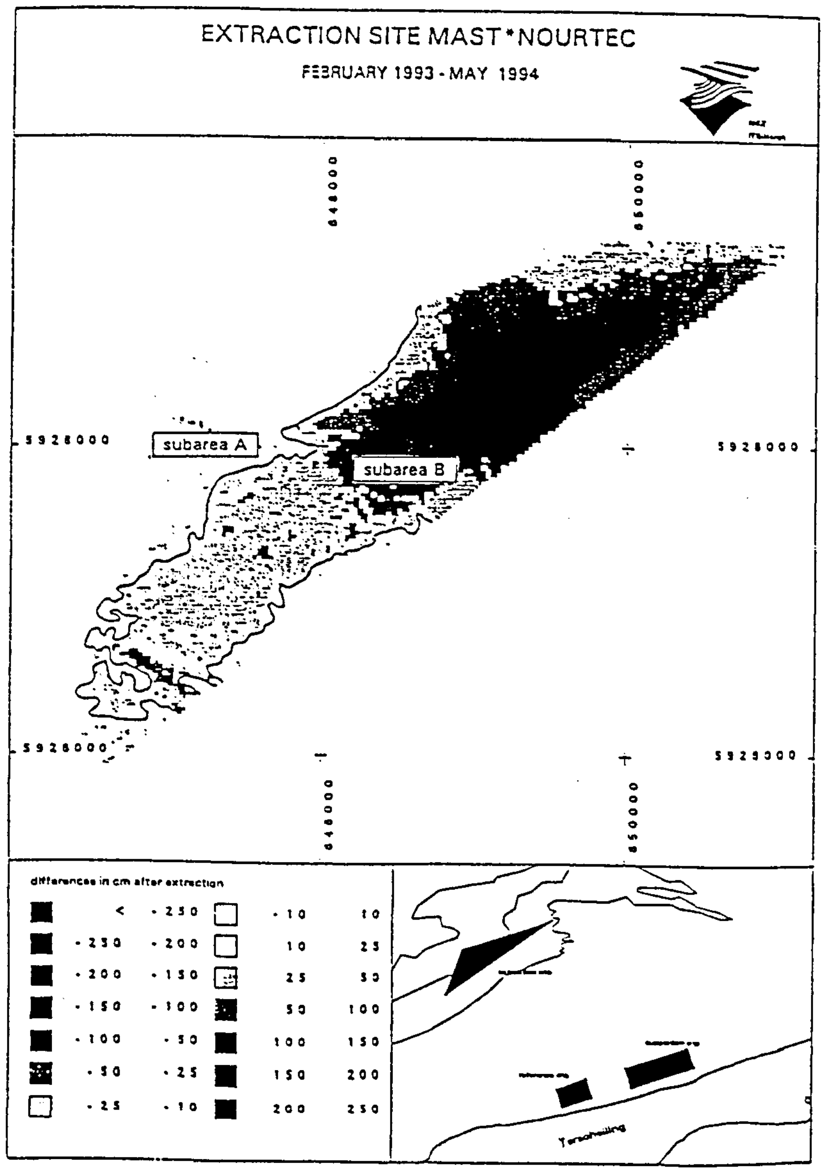


Figure 2. Map of sedimentation and erosion at the borrow area North off Terschelling between February 1993 and May 1994. Two subareas are indicated: A = 'reference area' and B = 'disturbed'.

Figure 3. Mean total abundance (n/m²) of polychaetes (a), crustaceans (b) and molluscs (c) per sample in the subareas A and B in March 1993 (T0), October 1994 (T1) and October 1995 (T2).

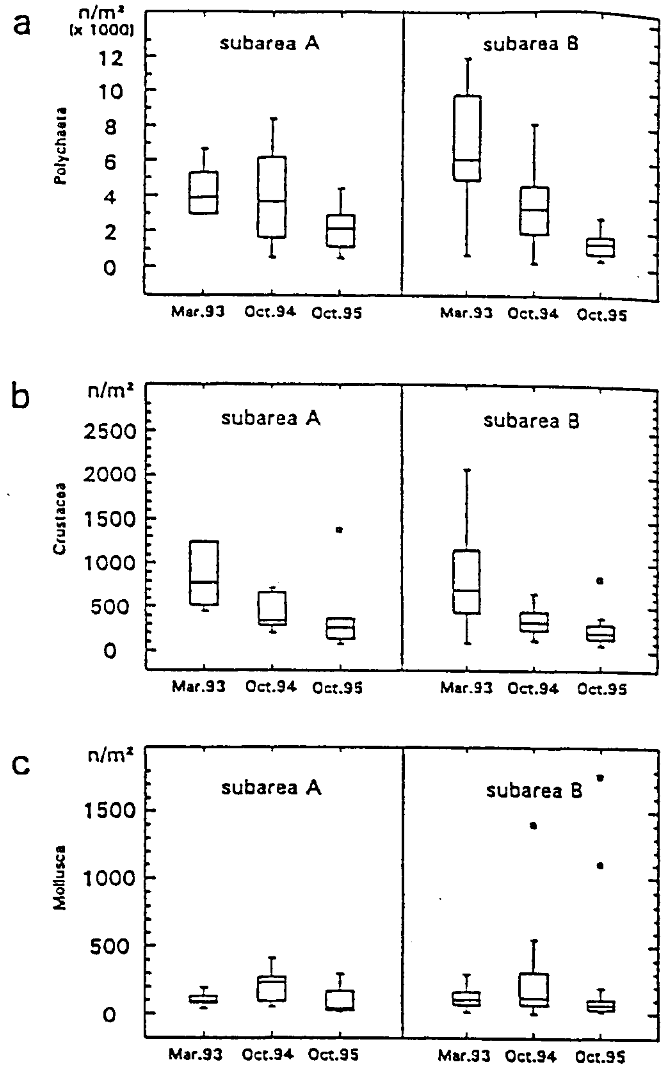
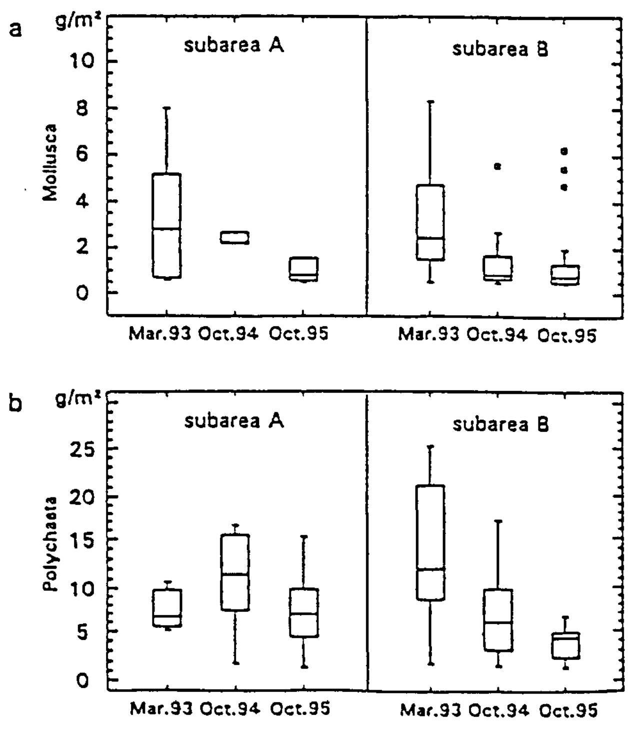


Figure 4. Mean biomass (g AFDW m²) of molluscs (a) and polychaetes (b) per sample in the subareas A and B in March 1993 (T0), October 1994 (T1) and October 1995 (T2).



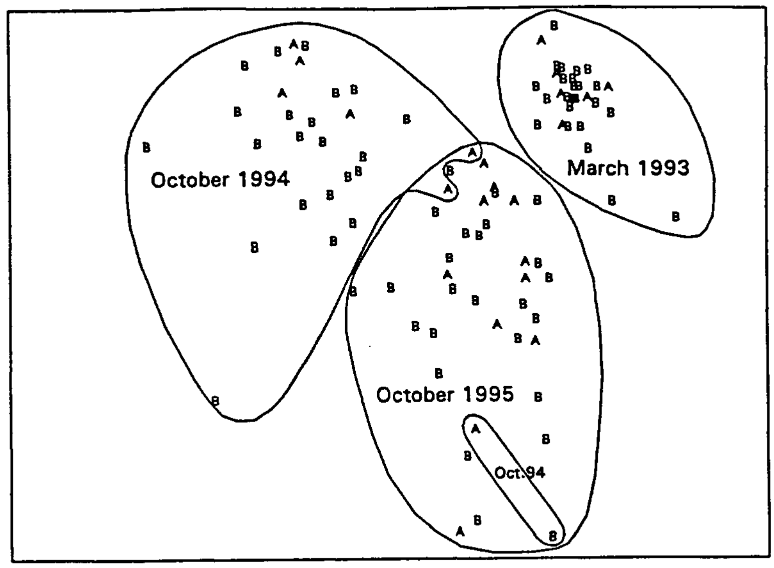


Figure 5. MDS ordination of the stations of the three successive sampling surveys (T0, T1, T2) in the extraction area North off Terschelling. Numerical densities were Log(n + 1)-transformed. Stations of subarea A and B are indicated as 'A' and 'B'.

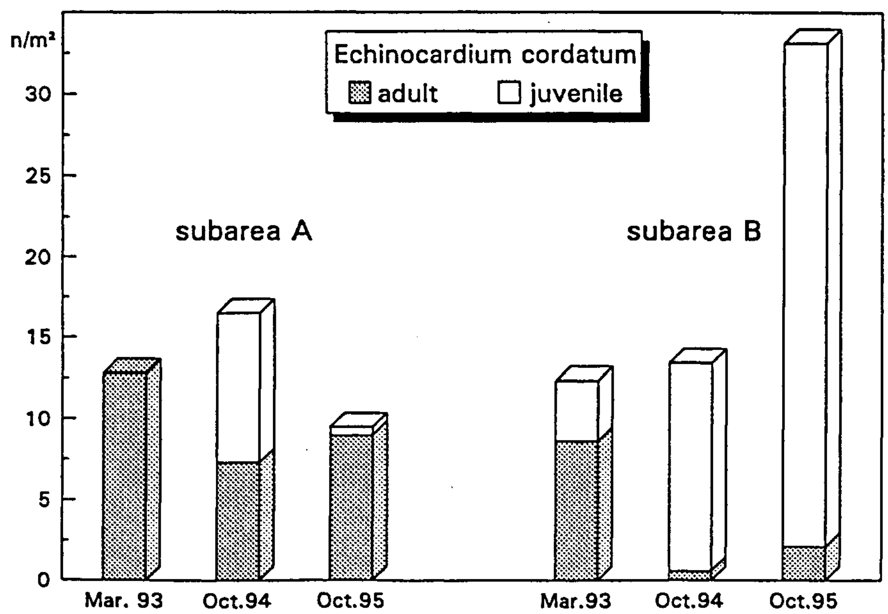


Figure 6. Abundance of adults and juveniles of Echinocardium cordatum in subarea A and subarea B in March 1993 (T0), October 1994 (T1) and October 1995 (T2).

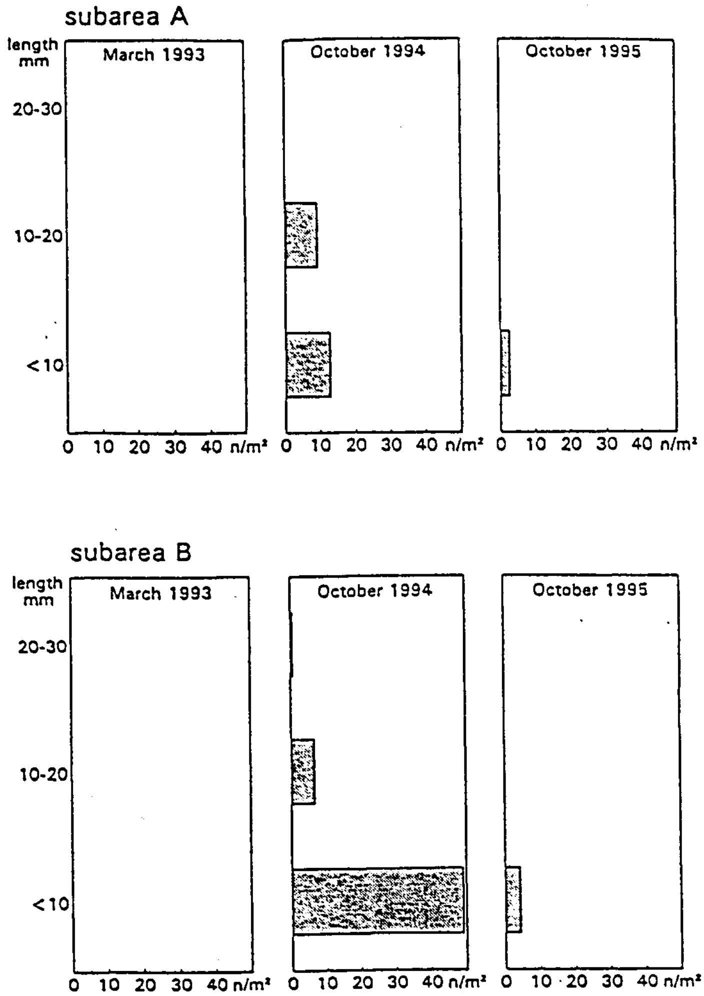


Figure 7. Abundance of different size classes (shell length) of *Spisula subtruncata* in subarea A (top panels) and subarea B (bottom panels) in March 1993 (T0), October 1994 (T1) and October 1995 (T2).

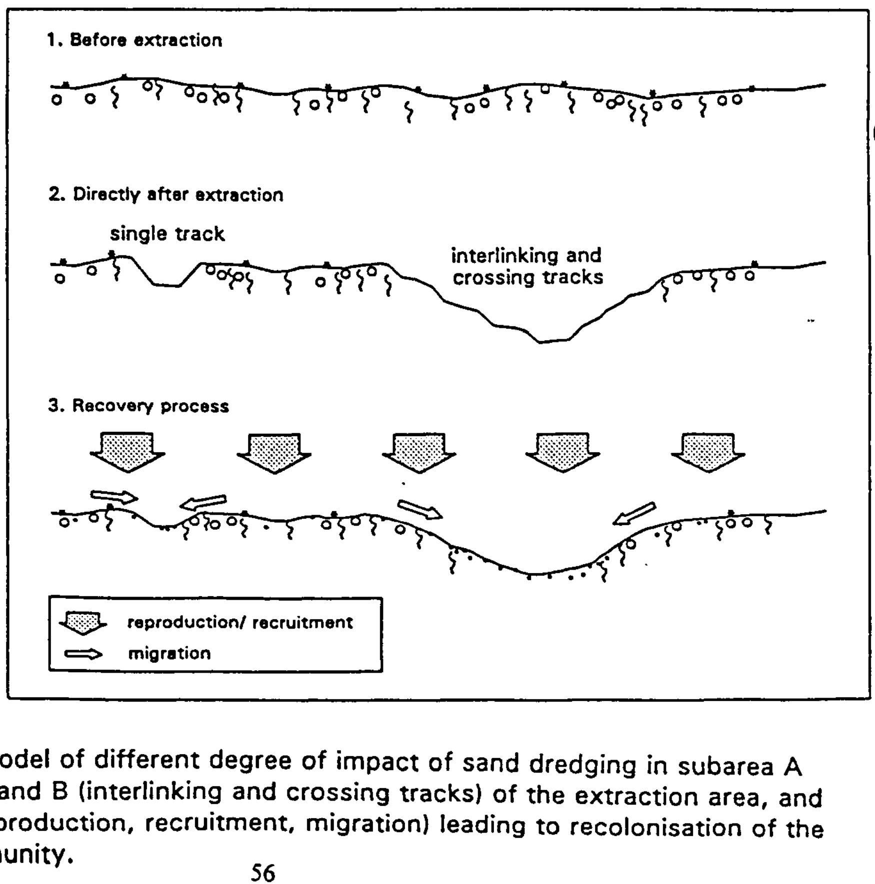


Figure 8. Conceptual model of different degree of impact of sand dredging in subarea A (single track) and B (interlinking and crossing tracks) of the extraction area, and processes (reproduction, recruitment, migration) leading to recolonisation of the benthic community.

RIACON

RISK ANALYSIS OF COASTAL NOURISHMENT TECHNIQUES IN THE NETHERLANDS

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INTRODUCTION

Circa 75% of the coastline in The Netherlands is formed by dunes and beaches. This coastline is constantly moving because of accretion and erosion. Sand nourishments are used to prevent coastal erosion and have been carried out along the Dutch coast since the 1970's. As alternative to the common used dune and beach nourishment, a recent development in coastal protection is application of shoreface nourishment. Shoreface nourishment implies the deposition of a buffer of sand on the sea floor at ca. 5 m depth in front of the beach. This buffer is intended a) to provide the beach with sand through natural onshore transport and b) to reduce erosion by dissipating wave action. Shoreface nourishment is designed to conserve the coastline for several years. Apart from being cheaper than beach nourishment, shoreface nourishment has the advantage of minimal interference with recreational activities on the beach.

Large scale nourishments will confront the benthic community with environmental changes including increased sedimentation and changes in sediment structure. To study the response of the benthic community to shoreface nourishment and to accompanying subaqueous sand extraction, the RIACON program was initiated. RIACON is co-sponsored by the MAST II (Marine Science & Technology) program of the Commission of the European Communities and evaluates the ecological risk of shoreface nourishment and subaqueous sand extraction at sites in Denmark, Germany, The Netherlands, Belgium and Spain (Catalonia).

METHODOLOGY

In The Netherlands benthic surveys were carried out North off the island of Terschelling where a section of the shoreface was nourished in 1993. (Figure 1).
The nourishment site was divided into three geomorphological strata, viz. stratum Trough, stratum North (north of the trough) and stratum South (south of the trough). The strata followed the seabed morphology which is characterized by 2 or 3 shore parallel breaker bars. The nourishment consists of filling up the trough between the outer and a middle breaker bar (Figure 2).
In the vicinity of the nourishment site a reference site was chosen with a similar morphology and depth structure as the nourishment area.

Surveys (T0, T01, T1, T2, T3, T4; Figure 3) for benthos and sediment were made in spring and autumn using a "stratified random sampling" approach. Samples were taken using a Reineck boxcorer (0.07 m²). The macrofauna samples were analyzed for density, biomass and species composition.

At the sand extraction site benthic surveys were made once a year using a "random sampling" procedure.

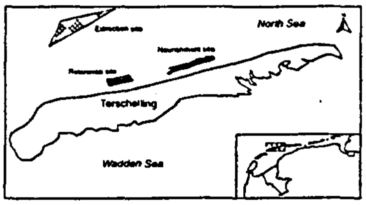

Figure 1. Location of the RIACON study sites off Terschelling

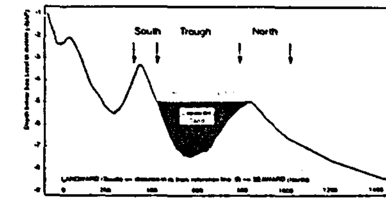

Figure 2. Schematic bottom profile at the nourishment site off Terschelling with the location of the strata

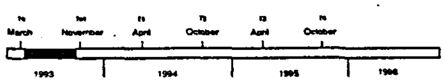

Figure 3. Time schedule of the different surveys. Red is the nourishment period.

RESULTS

Only data from the nourishment site are presented, using the results of three comparable surveys made in spring before and after the nourishment (T0=March 1993, T1= April 1994, T3= April 1995).

Geomorphology
In the trough about 2.1 million m³ of sand were deposited between May 1993 and November 1993, forming a layer with a maximum thickness of 3 metres (Figure 4).
After the nourishment was completed a gradual erosion of the nourished sand started, leading to the development of a new breaker bar-trough system.

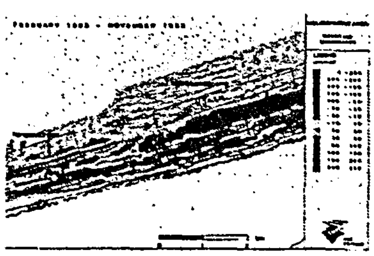

Figure 4. Map of sedimentation and erosion at the nourishment site between the sounding of February 1993 and November 1993. (blue = erosion; red = accretion)

Benthos: density and biomass
After the nourishment (T1 survey) total density and biomass were reduced in both North and Trough strata of the nourishment site (Figure 5). No changes were observed at the reference site. In the T3 survey the density and biomass increased, but this was only significant at the reference site and the North stratum of the nourishment site.

The three major taxa viz. polychaetes, crustaceans and molluscs showed a different reaction on the nourishment.
From the T0 survey to the T1 survey a decrease was observed in mollusc density, which was most distinctly at the nourishment site. One year later (T3) a strong increase in mollusc density was found in the reference site, due to increasing populations of Spisula subtruncata and Ensis directus. At the nourishment site a recovery of mollusc density was observed: pre-nourishment values occurred again.

Whereas crustacean densities showed a decreasing trend in the Trough stratum of the nourishment site, increasing densities were found in both strata of the reference area.

Polychaete density showed no direct reaction to the nourishment (T0-T1). In the T3 survey, however, densities increased much stronger in the nourishment site than in the reference site.

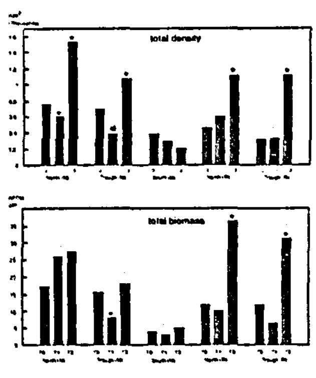

Figure 5. Average total density (n/m²) and biomass (g AFDW/m²) of macrofauna at the spring surveys (* indicates a significant deviation from the pre-nourishment survey (T0))

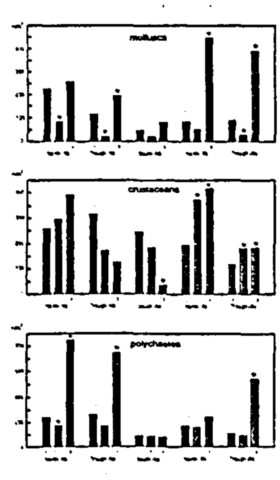

Figure 6. Average densities (n/m²) of the major taxa at the spring surveys (* indicates a significant deviation from the pre-nourishment survey (T0))

DISCUSSION & CONCLUSIONS

Six months after the nourishment was completed, density and biomass of benthic fauna were reduced mainly in the Trough stratum where the bulk of the nourishment was deposited. Recovery of the benthic community was observed within eighteen month after cessation, but differences in development were found between the nourishment site and an adjacent reference site. Polychaetes increased more strongly at the nourishment site whereas filter feeding molluscs became more dominant at the reference site.

Shoreface nourishment does interfere with the benthic community. Recovery, however, takes place within two years.

ANNEX 9

A comparison of benthic biodiversity in the North Sea, English Channel and Irish Sea

Dr. H. Rees

Two surveys were conducted. The first involved the sampling of the macroinfauna by Day grab at several stations around the England and Wales coastline as part of a wider interdisciplinary assessment of environmental quality by the regulatory authorities. The second involved epifauna sampling by 2-metre beam trawl at the above grab stations, and also at several additional stations especially in the central and southern North Sea. This is the first time that a co-ordinated assessment of these groups, employing standard methods, has been conducted over such a wide geographical scale around the United Kingdom, and the results should provide a valuable baseline against which to assess the results from future surveys.

Over 400 infaunal taxa were identified from grab samples. Analysis of the data showed that similar assemblage types occurred on both the eastern and western UK coasts in comparable environmental conditions.The degree of physical disturbance of bottom sediments, measured by sediment sorting and tidal current strengths in the vicinity, accounted for a significant amount of the observed variability in species richness.

Over 400 epifaunal taxa were identified from trawl samples. Analysis of the data indicated that coastal influences (proximity to large estuaries) and substrate type largely determined epifaunal community composition, with a coarser component in samples to the north and west of the sampling area supporting a much wider variety of sessile taxa. Furthermore, for any one habitat type, the majority of characterising taxa showed no sign of being limited in their distribution over the latitudinal range of this survey. However, analysis of the distribution patterns for rarer species is presently incomplete, and it is likely that biogeographical factors will be influential in a number of these cases.

The survey methods employed (grabs and trawls) generate different, but complementary, information on the sea bed fauna.The former provide unambiguously quantitative data which can be easily linked with substrate type within the small unit area of the sample. The latter provide integrated samples of the fauna over a much wider area than is feasible with grabs, and much of the material is amenable to immediate processing at sea. However, both the design of the trawl, and inherent uncertainties over its sampling efficiency, determine that the results are 'operationally defined', and consistency in sampling procedures is essential, especially for the analysis of temporal trends.

There is a future need to provide better working descriptions of the environment along trawl tows where sediments are variable; acoustic methods may be most suitable. There is also a need to establish an agreed framework for describing epifaunal communities within the ICES area (see Recommendations).

ANNEX 10

MACROFAUNA AND MICROORGANISMS IN RELATION TO GEOCHEMICALLY TRANSFORMED ORGANIC MATTER IN THE VICINITY OF A MUSSEL BED

Ingrid Kröncke

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This investigation deals with the changes in macrofaunal and microorganism communities in intertidal sandflats caused by the input of organic material via biodeposition produced by mussel beds.

The area of investigation was the back barrier tidal flat system behind the East Frisian Island of Spiekeroog. Due to erosion by the ebb current a plume of biodeposits extended from an area of mussel beds (*Mytilus edulis*) towards the adjacent sandy sediments. This plume represented a gradient of decreasing concentrations of organic material. Five stations were installed along this gradient to analyse the effects of this organic input on the macrofaunal communities; a control station was placed on sandy sediments. All samples (for microbiology and geochemistry also) were taken within $0.25m^2$. Macrofauna was sieved over 0.5 mm mesh size.

The macrofaunal communities differed along the transect and followed in general the Pearson & Rosenberg model: abundances, species numbers and biomasses were low in the mussel patches, increased in the vicinity of the patces and decreased again towards the sand flat, with the exception of station 5, where a new mussel patch settled in summer 1994. In the mussel patches oligochaetes and sediment-feeding polychaetes (e.g. *Capitella* spp.) dominated, whereas surface-sediment-feeding, suspension-feeding and predatory polychaetes increased along the transect.

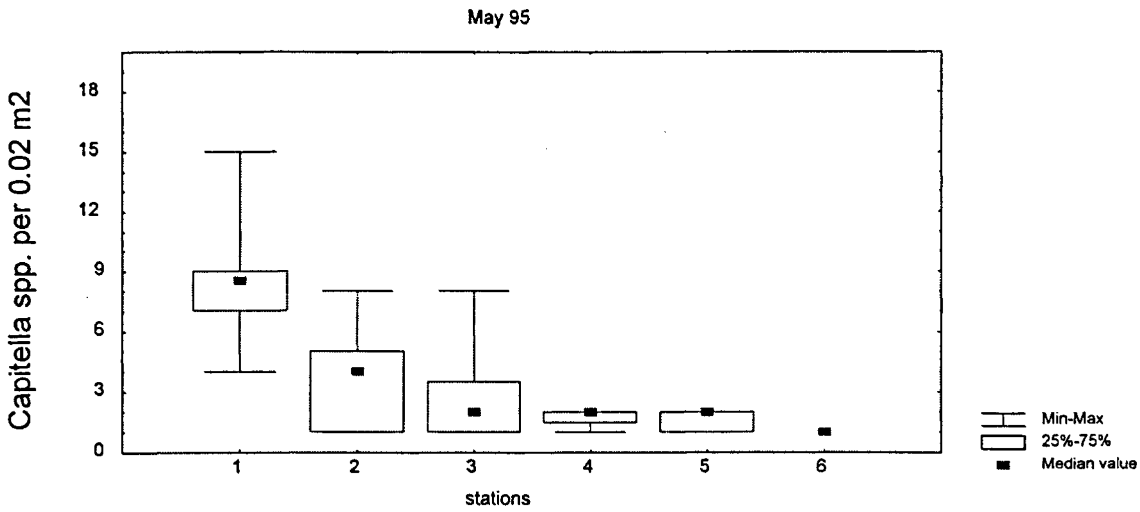
Within an interdisciplinary approach with microbiologists and geochemists from the ICBM, University of Oldenburg the amount and quality of the organic matter (biodeposits), it's remineralisation and it's role in structuring the microorganism and macrofaunal communities was investigated.

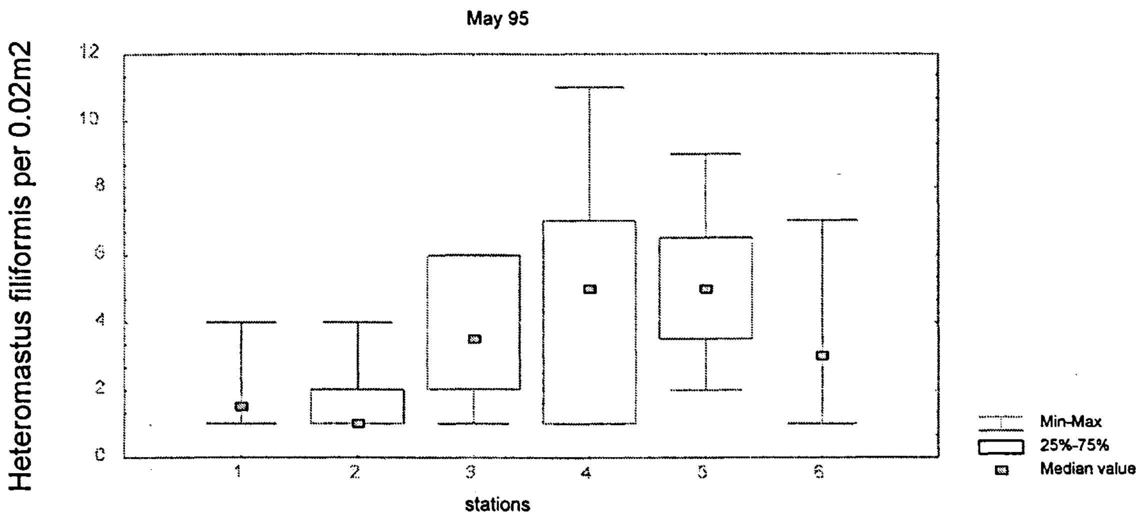
Microbial biomass and enzymatic activities of the microbial communities followed the trends along the transect obvious for macrofauna and were strongly influenced by events such as the phytoplankton spring bloom, mass occurrence of macroalgae or ice cover. The Adenylate Energy Charge and the percentage of active cells showed a contradictory trend with higher activities and higher percentage of active cells in the sand flat.

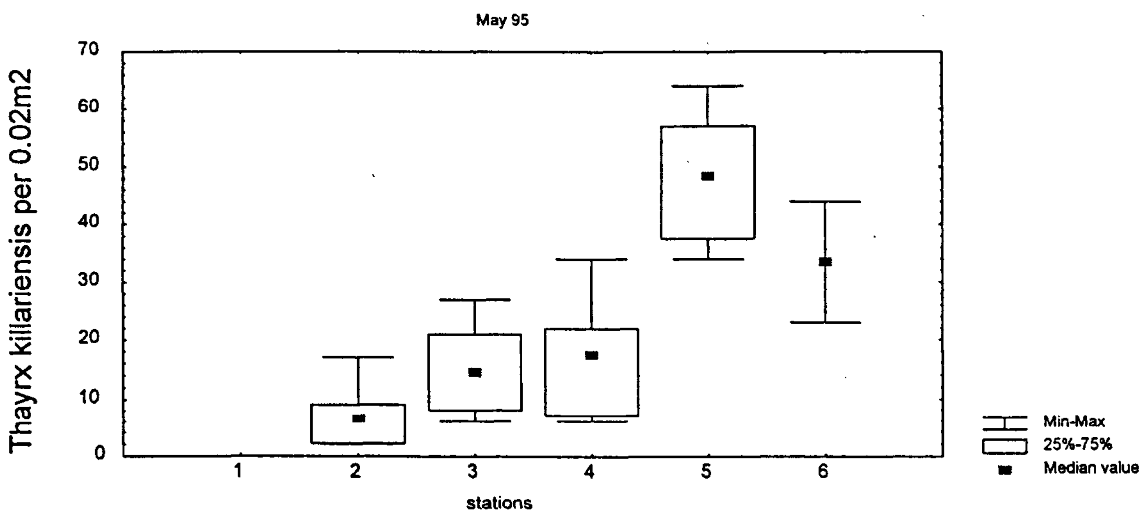
Organic carbon content was inversely related to grain size composition. Photosyntheteic pigment, hydrolysable amino acid concentrations and lipids decreased with increasing distance from the mussel bed. The pigment and sterole composition indicated an input from diatoms and macroalgae.

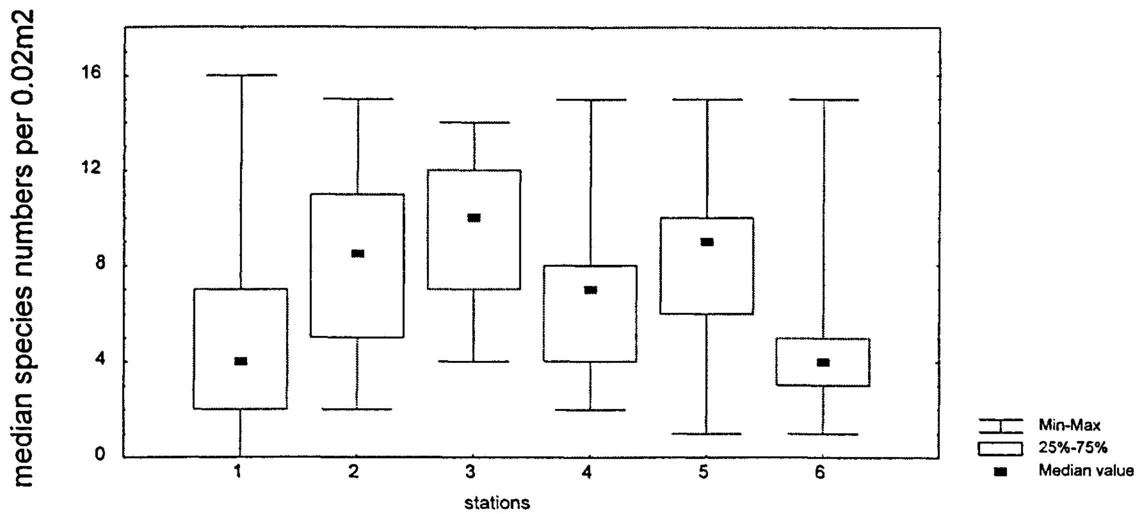
The amino acid composition exhibited seasonal changes in acidic, basic and neutral compounds as well as spatial differences along the transect, with highest contents in the vicinity of the mussel patches.

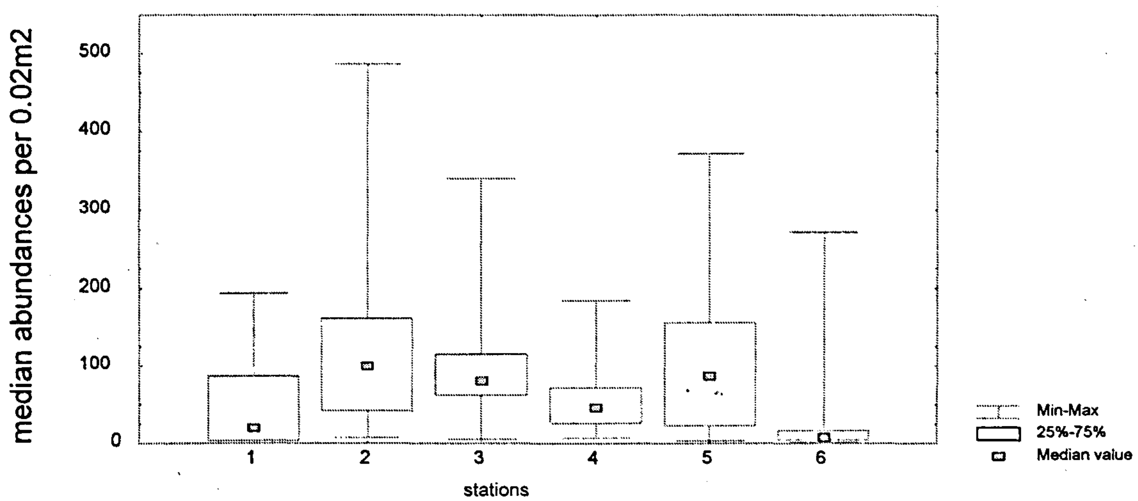
The results indicate the role of fresh, protein and lipid rich organic material for the structure and growth of microorganisms and macrofauna. Beside that sediment chemistry, especially under anoxic conditon in the mussel patches, as well as higher remineralisation of organic matter in sandy sediments play major roles for the structure of benthic communities.

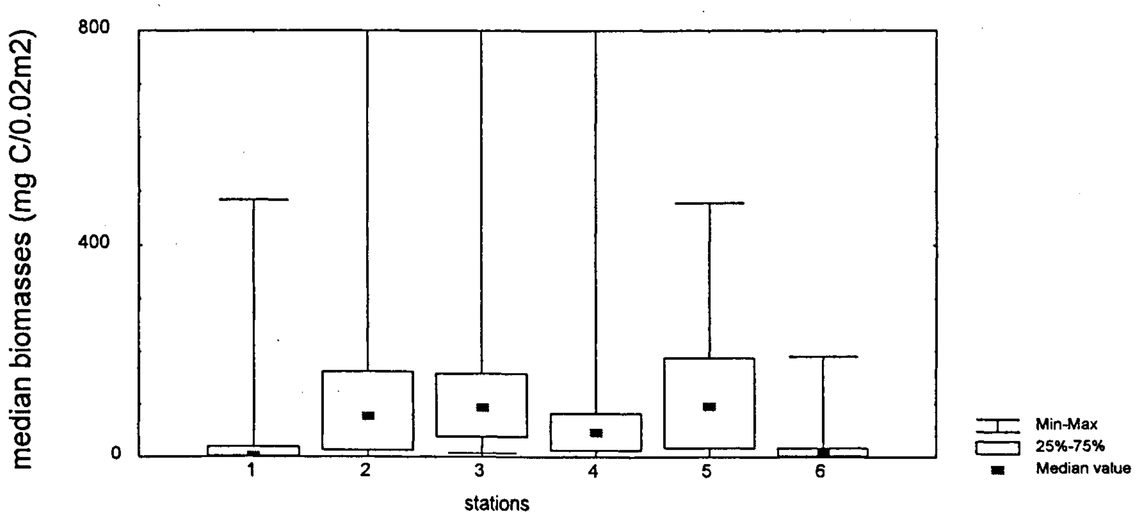

May 95
Capitella spp. per 0.02 m2
18
15
12
9
6
3
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value


May 95
Heteromastus filiformis per 0.02m2
12
10
8
6
4
2
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value


May 95
Thayrx killariensis per 0.02m2
70
60
50
40
30
20
10
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value


median species numbers per 0.02m2
16
12
8
4
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value


median abundances per 0.02m2
500
400
300
200
100
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value


median biomasses (mg C/0.02m2)
800
400
0
1
2
3
4
5
6
stations
Min-Max
25%-75%
Median value

ANNEX 11

Macrofauna long-term studies in a subtidal habitat off Norderney (East Frisia, Germany) from 1978 until 1995

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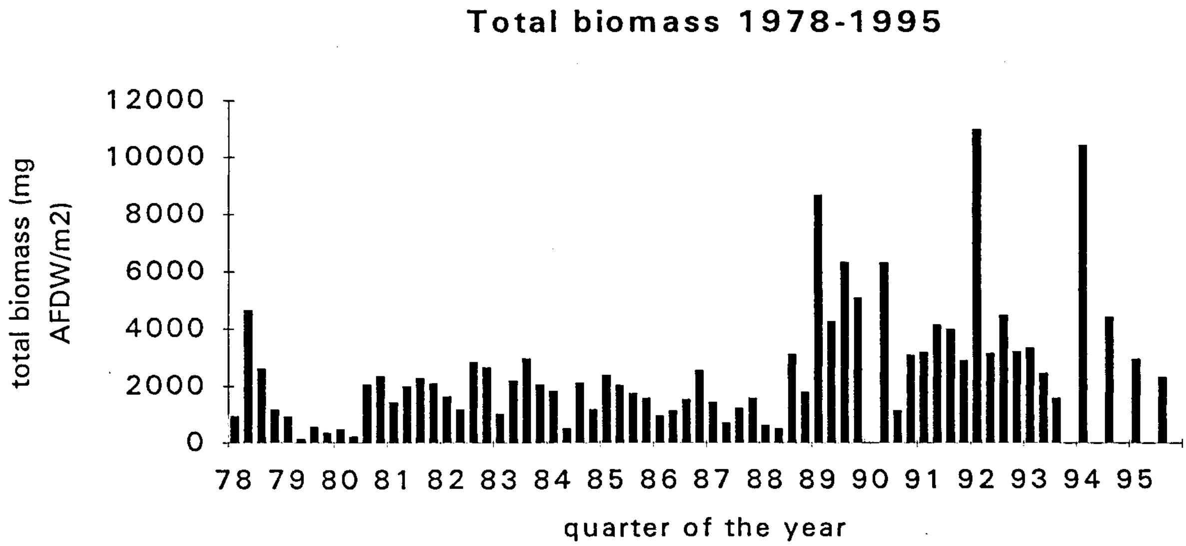
Abstract

Macrofaunal samples were collected regularly in spring, summer, autumn and winter from 1978 to 1995 in the subtidal zone off Norderney, one of the East Frisian barrier islands. Sampling was carried out from a research vessel by means of a 0.2 m^2 van-Veen grab at five sites in water depths of 10 to 20 m. Abundances, biomasses and species composition were analysed by cluster analysis and multidimensional scaling for the data sets of spring, summer, autumn and winter.

196 taxa were found over the whole sampling period. Species number and abundance are subject to seasonal changes, a slightly increasing trend in abundances has been registred since the beginning of the 90s. Polychaetes are the dominant group in the investigation area. *Magelona spp.* is the dominant species in respect of abundance, with a decreasing stock since the beginning of the 80s. The phyllodocids show a decreasing trend from 1980 to 1990 as well, while the *Nephtys* species numbers increase remarkably in the late 80s. Within the molluscs *Fabulina fabula* is the dominant species, abundance has increased since 1988. Abundance and biomass of *Donax vittatus* has become important for the community since 1988. Amphipod numbers have increased since 1988, dominant species during the whole period were *Bathyporeia elegans, B. guilllamsoniana* and *Urthoe poseidonis.* High abundances and biomasses of the echinoid *Echinocardium cordatum* have been found more frequently since 1989.

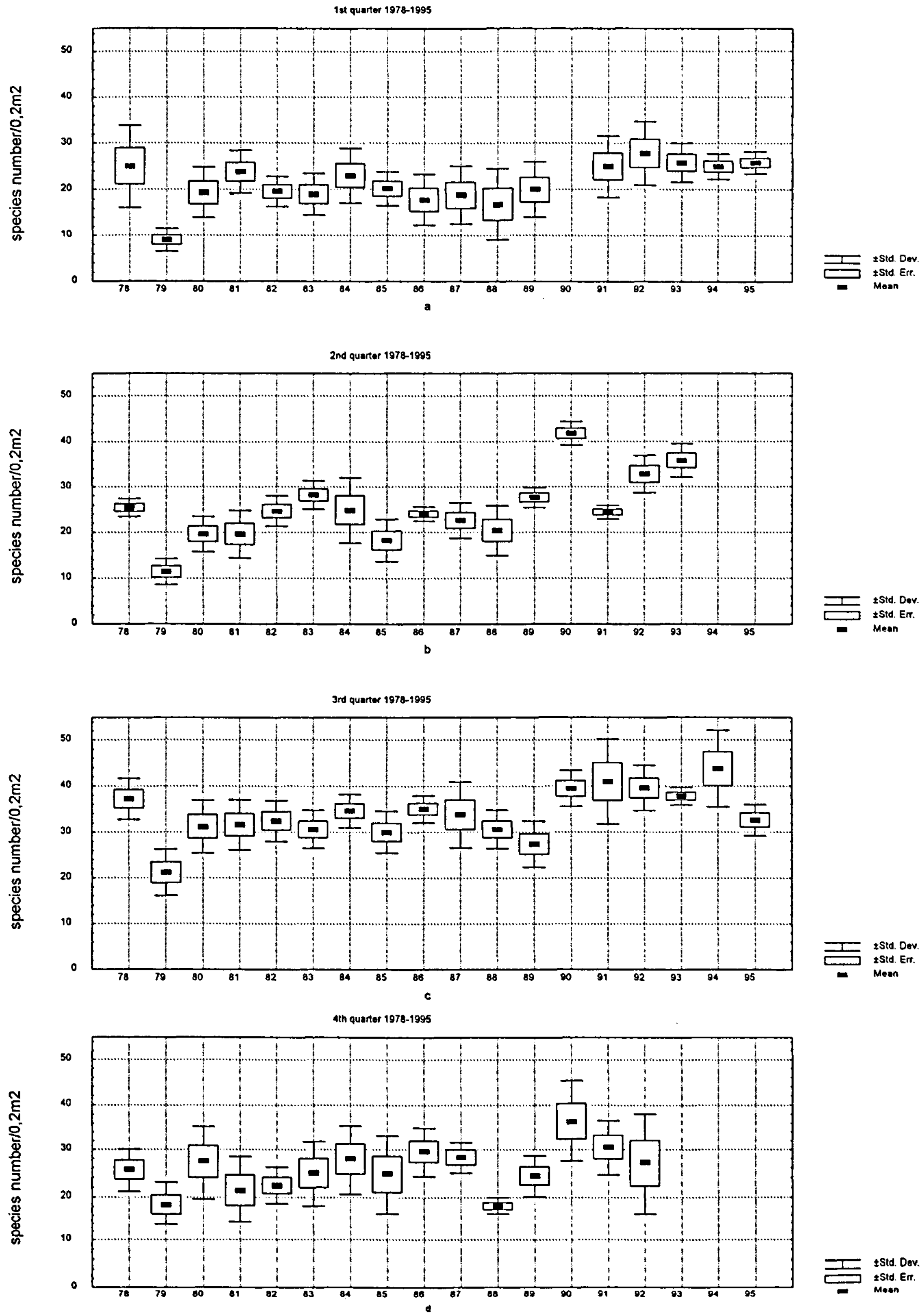
Multivariate analyses were carried out in order to reflect the change of the community structure in time. Clear differences become visible between 1979/80 (extremely cold winter), and the 80s and the 90s. The varying pattern of the community structure seems to be mainly due to changing meteorological conditions. Whereas hot summers and storm events do hardly influence the macrofauna, the impact of low winter temperatures as in 1978/79 appears to have a vast impact on the community off Norderney.

The total biomass of all four quarters displays a significant increase since 1988. The same trend was found looking only at the first quarter of each year. There is evidence that a synergistic effect of mild meteorological conditions and eutrophication result in an increase in total biomass since 1989.



Total biomass of 4 quarters per year (1978-1995), medians out of 5 samples

Species number 1978-1995



Mean species number /0.2m^2 , 1st to 4th quarter of the years 1978 to 1995

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ANNEX 12

RNA/DNA RATIOS AS INDICATOR FOR CONDITION AND GROWTH OF MARINE INVERTEBRATES

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In the past decades, a large number of studies have been devoted to attempts to establish a relationship between the growth of marine organisms and their RNA/DNA ratio. The application of this ratio is based on the premise that a cell has a constant amount of DNA, while the quantity of RNA in the nucleus and cytoplasm covaries with the rate of protein synthesis. Many of the earliest studies involving marine organisms have focused on larval and adult fish species of which an extensive review is given by Bulow (1987). In his summary, Bulow stated that, though many studies found correlations between RNA/DNA ratios and either growth rate or condition, the relationship appears to vary between species and with age of the (fish) species. External factors such as temperature also affect the activity of RNA and hence the nucleic acid ratio. Bulow, moreover, stressed the need for of standardization of the analytical procedures.

Since Bulow's review, the use of RNA/DNA ratios in growth studies has continued and the ratio has now been applied to a variety of invertebrate organisms as well. Examples of the latter are unicellular algae, bacteria and bivalves (Table 1). Some authors used the ratio of nucleic acids in whole sediment cores to discriminate between relative proportions of labile and refractory organic matter. Also improvements of the analytical procedure have been suggested after highly sensitive fluorochromes specific for DNA became available (Hoechst 33258; see Clemmesen, 1988, 1993; Mordy & Carlson, 1991). The results, however, remained largely ambiguous as shown in Table 1 especially where it concerns relationships with the actual growth rate (in terms of protein weight or length). By contrast, in general a clear difference could be established between the RNA/DNA ratios in starved and fed organisms.

In the past years we developed a method for measuring RNA and DNA using HPLC based on the procedure in Coppella *et al.* (1987). This method circumvents the use of toxic chemicals like EthidiumBromide, allows a independent quantification of the different types of nucleic acids, and is rapid (see Fig. 1). We tested this method on two bivalves, *Arctica islandica and Macoma balthica*, maintained in laboratory growth experiments with varying temperature and two food regimes (maximum food - starved). We furthermore monitored the seasonal variation in RNA/DNA of a *Macoma* population living on the Balgzand in the Dutch Wadden Sea. Among the *Arctica* that were harvested at the end of a feeding experiment conducted by Witbaard & Klein, (1997), we observed a weak relation between RNA/DNA ratio and accomplished shell growth (Fig. 2). Temperature had a clear but opposite effect on shell growth and the RNA/DNA ratio, i.e. highest shell growth at highest temperatures and highest ratios with the lowest temperature. Starved *Arctica* invariably had the lowest RNA/DNA ratios which illustrates the relation between RNA/DNA and the organisms's nutritional condition. In the laboratory experiment with *Macoma*, specimens were at time intervals taken from the experiment and analysed. Unfed specimens showed no increase or sometimes a decrease of the RNA/DNA ratio, shell length or condition index (Fig. 3). The fed animals showed concurrent increases of all three parameters during the first half of the experiment. In the second half this trend only continued in the 4 °C incubations. In the other tanks the upward trend of the parameters tended to flatten or even decline. This became especially clear in the 16 °C tank where the low final condition-index and RNA/DNA ratio suggest that food was too short to fuel metabolism at this temperature.

Similarly as with *Arctica*, temperature appears to have a negative effect on the RNA/DNA ratio in contrast to shell growth. This is best illustrated in the 8 °C tank where shell growth is almost linear throughout the experiment but the RNA/DNA ratio after an initial rises levels off at a much lower value than at 4 °C. In the field population of *Macoma*, the RNA/DNA ratio reaches its optimum earlier than the condition index which again could be interpreted as an effect of the rising temperature. In conclusion, we observed a uncoupling between the RNA/DNA ratio and other indices of nutritional condition with respect to temperature variations.

Though this certainly limits the applicability of RNA/DNA ratio's, there remain several cases where the ratio may be of value such as in the deep-sea where temperature is constant, possibilities for regular sampling are restricted, and soft-bodied invertebrates dominate (e.g. polychaetes, holothurians). Because of this it has been very hard to quantify changes in the condition of the deep sea macro- and megafauna in response to, for instance, seasonal food pulses.

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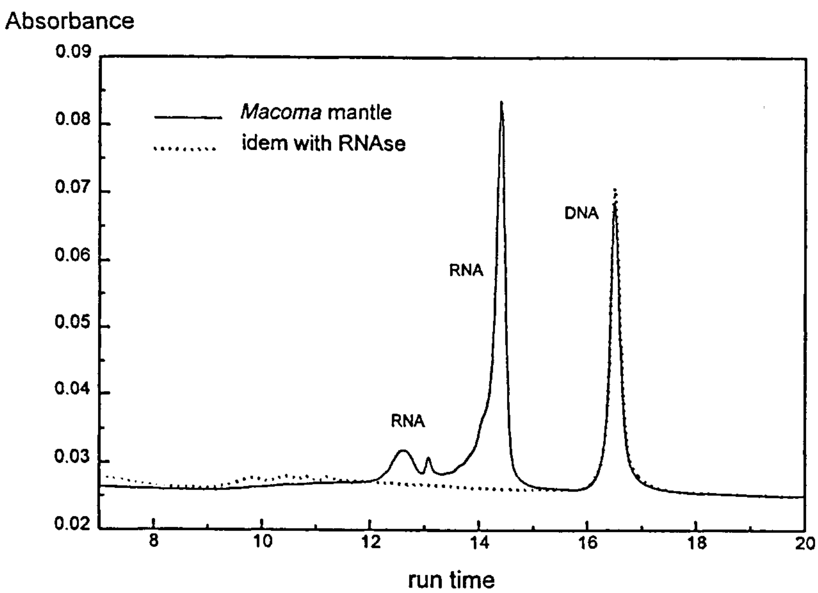

Fig. 1. HPLC chromatogram of an extract of mantle tissue of *Macoma balthica* showing three peaks of RNA followed by one peak of DNA. The identity of the RNA is confirmed by digestion with RNAse (dotted line). Total analysis time amounts to approximately 30 min.

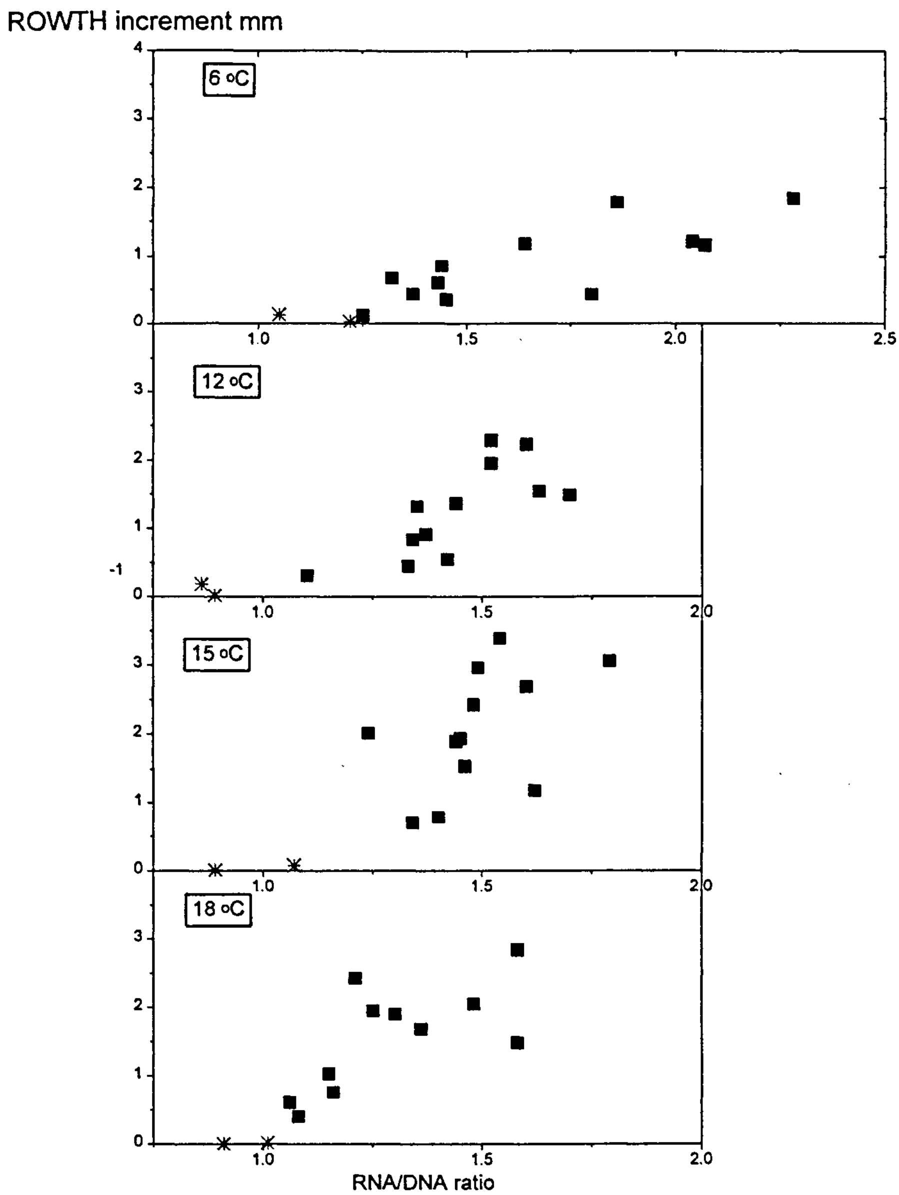

Fig. 2. Relation between RNA/DNA and the shell growth in *Arctica islandica* at the end of a growth experiment where animals were either starved or optimally fed at different temperatures.

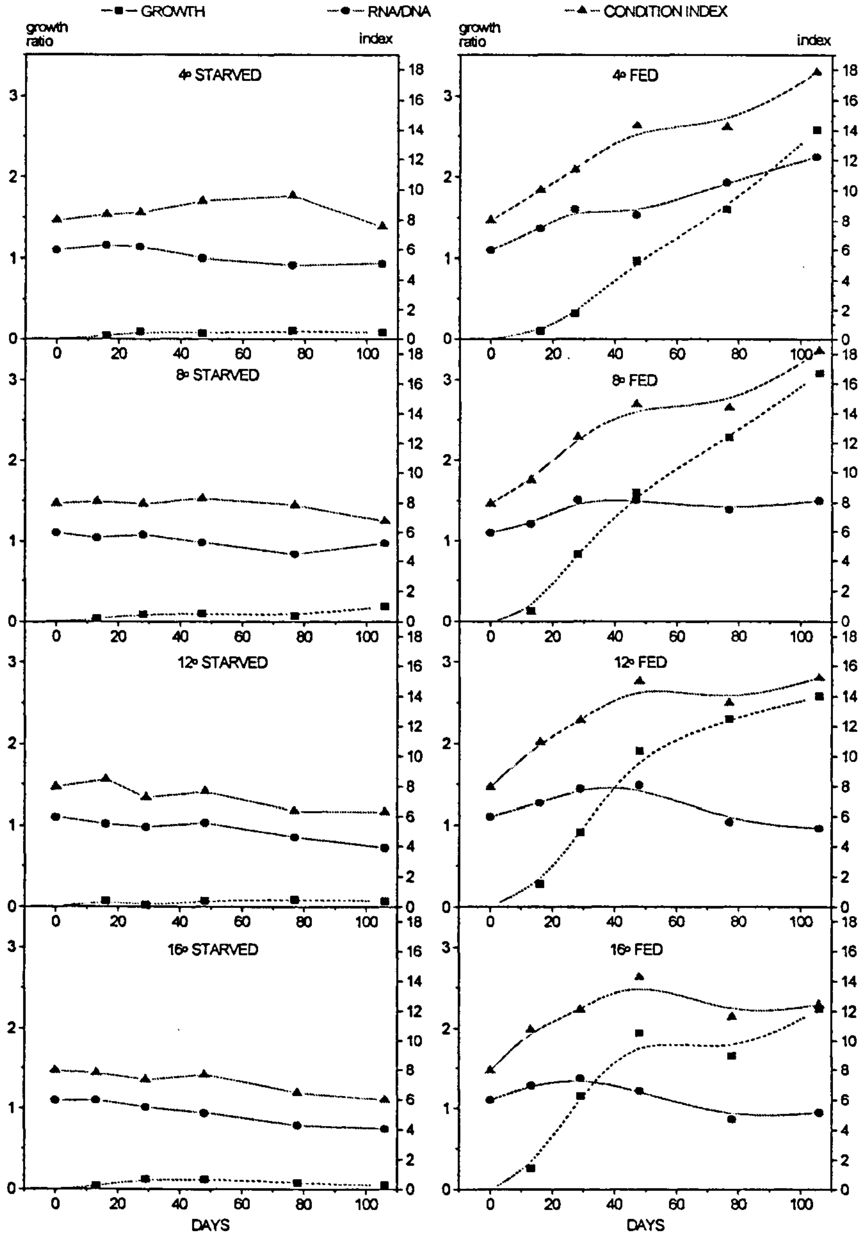

Fig. 3 Variation in RNA/DNA ratio, shell growth and condition index during a laboratory experiments with *Macoma balthica.* where animals were either starved (lefthand panels) or optimally fed (righthand panels) at different temperatures

Table 1. Selection of earlier studies on the relation RNA/DNA ratio and growth

AUTHOR(S)	YEAR	APPLIED TO	RESULT	TYPE OF RELATION
Sutcliffe	1969	various terrestrial and marine invertebrates	+	overall relation between RNA and % growth
Buckley	1979	cultured **fish larvae** (Gadus morhua)	+	linear relation with protein growth rate
Dortch *et al.*	1983	cultured marine **phytoplankton**	+	linear relation with cell division rate
Buckley	1984	various cultured **fish larvae**	+	relation with protein growth rate
Wright & Martin	1985	cultured **fish larvae** (Morone spec.)	+	relation with growth
Wright & Hetzel	1985	cultered **oyster larvae** (Crassostrea virginica)	+	relation with % shell weight change and condition index
DeBevoise & Taghon	1988	deep-sea **vermes**	+	differences among vent site
Robinson & Ware	1988	wild **fish larvae** (Clupea harengus)	+	increase of ratio in ageing larvae
Robbins *et al.*	1990	field gonads of **scallop** (Pecten maximus)	±	relation with maturity of male gonad, not with females
Frantzis *et al.*	1992	laboratory young **sea-urchins**	±	weak correlation with test growth
Steinhart & Eckman	1992	cultured **fish larvae** (Coregonus spp.)	+	relation with nutritional status depends on temp
Ueberschar & Clemmesen	1992	wild and laboratory **fish larvae** (Clupea h.)	+	relation with nutritional status
Berdalet & Estrada	1993	field samples **phytoplankton**	+	linear relation with growth rate
Frantzis *et al.*	1993	laboratory **bivalves** (Abra ovata)	-	no relation with monthly shell growth
Kemp *et al.*	1993	cultured marine **bacteria**	+	semilog relation with cell division rate
Bergeron & Boulhic	1994	cultured **fish larvae** (Solea solea)	-	no relation with inst. growth rate
Clemmesen	1994	cultured **fish larvae** (Clupea harengus)	+	relation with age and nutritional status
Mathers *et al.*	1994	cultured **fish larvae** (Clupea harengus)	-	no relation with protein growth rate or nutritional status
Nakata *et al.*	1994	adult planktonic **copepod** (Paracalanus)	+	relation with egg production
Westermann & Holt	1994	cultured **fish larvae** (Sciaenops spec.)	+	relation with daily growth of post-yolk larvae
Lodeiros *et al.*	1996	field sample of **scallop** (Euvola ziczac)	±	relation strongest with juvenile growth
Danovaro *et al.*	1993	deep-sea **sediment samples**	+	sign.correlation with conc. labile OM
Danovaro *et al.*	1995	oil-contaminated **sediment samples**	+	rel. low ratio RNA/DNA in polluted sediments

ANNEX 13

Working document

to: ICES Benthos Ecology Working Group
Gdynia, Poland
23.-26.04.1997

Effects of severe oxygen deficiency on the macrozoobenthos in the Pomeranian Bay (southern Baltic Sea): a case study in a shallow, sublittoral habitat characterized by low species richness

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Introduction

The present investigation was conducted within the frame of a multidisciplinary research project which deals with the fate of riverine material in the ecosystem of the Pomeranian Bay (von Bodungen et al. 1995). A benthos sampling programme started in April 1993 (34 stations) to get an overview of the present status of the macrozoobenthos communities. Results of this benthos programme, especially concerning distribution patterns, community structure and population dynamics of dominant species, were described in detail by Powilleit et al. (1995), Kube (1996a, b), Kube et al. (1996 a, b).

In this study four of the above mentioned sampling sites with water depth between 9 and 15 m were choosen to follow the benthic succession after the severe hypoxia in summer 1994. Macrofauna samples were taken 8 to 10 times per station between April 1993 and July 1996 with a small box corer (0.0225 m²). Sediments of three replicates per station were flushed separately through a 0.5 mm sieve. The selected stations represent the three main macrofauna assemblages in the investigation area which could be separated by cluster analysis: the organically enriched southern coastal part (station 1), the shallow and exposed Oder Bank (station 4), and intermediate communities of the deeper zone in between (stations 2 and 3).

Results (summary)

Severe oxygen depletion was for the first time detected in shallow parts of the Pomeranian Bay (southern Baltic Sea) in July/August 1994. A combination of extraordinary meteorological and hydrographical conditions along with generally high nutrient loads in this coastal area are considered to have caused the extensive hypoxia/anoxia. The structural sediment parameters medium grain size, silt content, and organic matter content did not change over the study period from April 1993 to July 1996. Profiles of redox potential indicated a shift of the redox potential discontinuity (RPD)-layers towards the sediment surface especially in September 1994 and during summer in 1995 and 1996. Re-colonization by macrofauna was analysed at four sites with different degrees of deterioration using various statistical and graphical methods of community analysis. Their sensitivities in the species-poor habitat of the Pomeranian Bay are discussed.

During macrobenthos succession after the oxygen depletion event in summer 1994 a typical initial phase characterized by a mass occurence of opportunistic species did not occur.

At station 2, the most severely affected site, species number, total abundance, and total biomass of macrozoobenthos significantly decreased following the oxygen deficiency event 1994, and re-colonization was still not completed two years later. The succession was dominated by post-larval colonization from planktonic dispersal. Stations 1 and 3, which were moderately affected, revealed nearly complete recovery with respect to species composition and abundances within 1 to less than 2 years but biomasses were still lower and MDS analyses (multidimensional scaling) still reveals slight differences compared with the pre-event period. Re-colonization by post-larval immigrants from nearby unimpacted coastal areas was accelerated by planktonic stages. Station 4 was not affected by oxygen depletion at all and showed only small variation of community parameters.

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ANNEX 14

1. Report No. UBA-FB	2.	3.
4. Report Title Assessment of morpho- and histopathological effects of organotin compounds on marine molluscs and their applicability for a future biological effect monitoring		
5. Author(s), Family Name(s), First Name(s) J. Oehlmann, I. Ide, B. Bauer, B. Watermann U. Schulte-Oehlmann, S. Liebe, P. Fioroni		8. Report Date 31.3.96
		9. Publication Date
6. Performing Organisation (Name, Adress) - University of Münster, Institute for Special Zoology and Comparative Embryology, Hüffer-str. 1, 48149 Münster - Limnomar, Bei d. neuen Münze, 22145 Hamburg - IHI Zittau, Markt 23, 02763 Zittau		10. UFOPLAN - Ref.No. 102 40 303/01
		11. No. of Pages 194
7. Sponsoring Agency (Name, Adress) Umweltbundesamt, Bismarckplatz 1, D-1000 Berlin 33		12. No. of References 210
		13. No. of Tables,Diag. 12
		14. No. of Figures 91
15. Supplementary Notes		
16. Abstract In 1994 and 1995 a research programme was performed to analyse the pathological phenomena of imposex and intersex in marine prosobranchs in relation to the TBT contamination of the environment. Therefore samples from 25 stations along the German North Sea and Baltic coast were collected and the investigations focused on the periwinkle *Littorina littorea* and the mudsnail *Hydrobia ulvae*. The compound specific effects of intersex development (*L. littorea*) and for the first time the characteristics of imposex in *H. ulvae* were described and completely resolved. The intensity of both phenomena is correlated to the degree of TBT contamination in the environment. Reduced extensions of female gland organs and gonoducts can be described as further TBT effects. An interspecific comparison of both species elucidates that *H. ulvae* is the more sensitive species at lower environmental TBT concentrations. Statistically highly significant correlations of biological indices and TBT concentrations in tissues and sediments exist for both species. Without any restrictions *H. ulvae* as well as *L. littorea* are most promising candidates for a biological TBT effect monitoring.		
17. Keywords Imposex, intersex, TBT effect monitoring, reproductive failure, Gastropoda (Prosobranchia): *Littorina littorea, Hydrobia ulvae*.		
18. Price	19.	20.

UBA - F & E - Berichtsmerkblatt (6.80)

Abstract

The use of organotin compounds as the active biocides in antifouling paints and other applications (e.g. as fungicides in agriculture and in wood preservation, as a catalyst in polyurethane foams and protectant against microbial decomposition in textiles, dispersion paints, PVC and other plastics) results in the masculinisation of many female prosobranch species (Bryan & Gibbs 1991; Fioroni *et al.* 1991); it culminates in the functional sterilisation and ultimate death of individuals. Within the scope of the R & D project 102 40 303/01 (Oehlmann *et al.* 1996) for the first time the indigenous species *Littorina littorea* and *Hydrobia ulvae* were analysed in view of virilisation in correlation to the TBT (tributyltin) pollution of the German coastal ecosystem. Females of both species, the mudsnail *H. ulvae* and the periwinkle *L. littorea* exhibited obvious signs of masculinisation and sterilisation in German coastal waters. As a result imposex development of *H. ulvae* can be described for the first time. Imposex or pseudohermaphroditism is defined as the development of male sex characteristics, e.g. a vas deferens and/or a penis in addition to the female genital system. For *L. littorea* similar pathological conditions have been observed and were summarized by the term intersex. The latter describes a gradual transformation of the female pallial tract, characterised by the development of male features on the female pallial organs (inhibition of the ontogenetic closure of the pallial oviduct) or replacement of female sex organs by the corresponding male formations. TBT-induced imposex and intersex development can be assessed by using classification schemes based on different stages in respect to the degree of masculinisation. Furthermore a reduction of the female genital glands as well as a significant decline of the number of mamilliform penial glands in males have been determined in *L. littorea* as an effect of TBT exposure. Histopathological changes of the gonad (disturbances of the reproductive cycle) may indicate effects of xenobiotics including TBT. These phenomena were mainly observed at harbour stations. The pathological occurrence of vacuoles in the female gonad, erosions of the mucosa, flattening of epithelia and necrosis of midgut gland tubules and a development of granulocytomes have been noticed often; a correlation between these findings and the actual TBT contamination cannot be assumed. In the mudsnail *H. ulvae* lysis and resorption of gonadial products and necrosis of digestive gland tubules have been found rather rarely and the most serious effects were caused by infestations of larval trematoda. There was also no evidence for a relation of histopathological changes and environmental TBT pollution in *Hydrobia ulvae*. On the other hand in male *H. ulvae* the percentage of individuals with sperm filled vesiculae decreases with increasing TBT contamination whereas the length of the male copulatory organ increases slightly. A trend in reduction of the female genital glands can be described for the mud snail, too. These effects as well as increasing values for the biological indices VDSI (vas deferens sequence index as the arithmetic mean value of the imposex stages in a sample), FPL (average female penis length), imposex incidence and percentage of sterile females of a sample are

significantly correlated with TBT concentrations in snail tissues and sediments. The same is true for *L. littorea* regarding the biological parameters ISI (intersex index = $\sum$ intersex stages in a sample ÷ number of analysed females), APL (average female prostate length) and percentage of sterile females of a sample. Furthermore, *Littorina littorea* accumulates TBT in a concentration dependent manner; the analysis of the relationship between TBT concentrations in sediments and tissues gives evidence for the existence of a hyperbolic regression.

An interspecific comparison of both species demonstrates that the mudsnail is the more sensitive species and exhibits biological effects (e.g. imposex development) at lower environmental TBT concentrations. Nevertheless, the sensitivity of the periwinkle is sufficient to assess the actual TBT contamination in German coastal waters. Therefore the mudsnail *Hydrobia ulvae* and the periwinkle *Littorina littorea* can be recommended for a biological TBT effect monitoring without any restrictions. In areas of low salinity *Hydrobia* as a typical soft sediment inhabitant is able to replace the periwinkle as a biomonitoring species completely.

The biological indices VDSI (*Hydrobia ulvae*) and ISI (*Littorina littorea*) are best suited in order to assess the actual TBT contamination of the environment. For the mudsnail imposex incidences, percentage of sterile females and average female penis length and for the periwinkle the female prostate length as well as the percentage of sterile females may be added to the list of biological effect monitoring parameters. A combination of all of them will guarantee the most precise results. Other findings which are described in the chapters 3.2.1.3 and 3.2.2.3 ("further effects") are not suited for TBT effect monitoring purposes, either because they are not specific for a TBT exposure or because they do not allow to differentiate between the TBT exposure levels at single stations.

ANNEX 15

THE GULF OF RIGA PROJECT

In the Nordic Environmental Research Programme, it was considered essential to concentrate the resources on Baltic research to a geographically limited area and to focus on reseach projects which study processes of importance for the exchange and balance of eutrophying and toxic substances between land and sea. Thus, the Gulf of Riga was chosen for scientific as well as environmental reasons.

The objective of the joint five-year Gulf of Riga Project is to study environmental problems in the Gulf and its drainage area, and to determine their impact on the rest of the Baltic Sea in general and the Baltic Proper in particular. The first three years of reseach have provided both expected and surprising results on processes, inputs, and environmental effects in the Gulf of Riga. These result will now be further complemented, elaborated and eventually fed into planning of water protection measures in the Gulf.

The Gulf of Riga Project is divided into six sub-projects:

- *Drainage basin and load to the Gulf of Riga*
- *Pelagic eutrophication and sedimentation*
- *Sediment and benthos of the Gulf of Riga - storage and processes*
- *Water exchange, nutrients, hydrography and database*
- *Budgets of persistent pollutants and heavy metals in the Gulf of Riga*
- *Production and transformation of nutrients in the littoral zone (started in May 1995).*

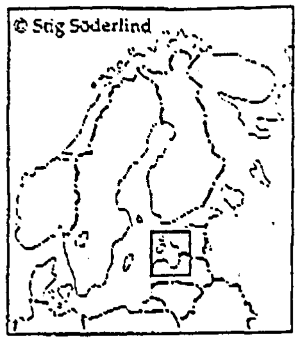
The Gulf of Riga Project also offers opportunities for Nordic scientists and scientists from Estonia, Latvia and Lithuania to join forces in a common international project. Estonian, Latvian and Lithuanian scientists in various disciplines have already done a lot of work in the Gulf of Riga and its drainage area over a long period of time, but their findings have only rarely been published internationally.

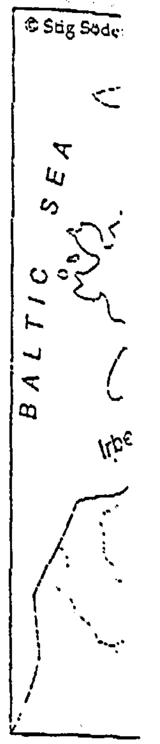
An important part of the project has been to build up a common database to serve as a basis for substance budget calculations and model analyses to test various hypotheses concerning which sources and substances have key roles in the eutrophication of the marine ecosystem.

Certain environmentally toxic substances and critical processes have also been identified and followed, particularly processes which control concentrations and distribution patterns in the Gulf of Riga and the exchange with the Baltic Proper. Another important aspect of the project is to collect data for the planning of water protection measures in the Gulf of Riga.

A prerequisite for participation in the project is that the Nordic countries contribute national resources to 50 per cent. Besides the annual funding during the five-year project period 1993 - 1997 (e.g., about 7.9 million DKK for 1995) from the Nordic Council of Ministers, special funds have also been allocated from the Nordic Academy of Advanced Study (NorFA) for "educational aspects, with the aim of strengthening the scientific base of and recruiting of new researchers". Mobility grants, scholarships and network grants are also made available within the project.

At present, about 90 scientists and research students from all countries involved are participating in the Gulf of Riga Project.





WATER MIXING COUNTERACTS OXYGEN DEFICIENCY

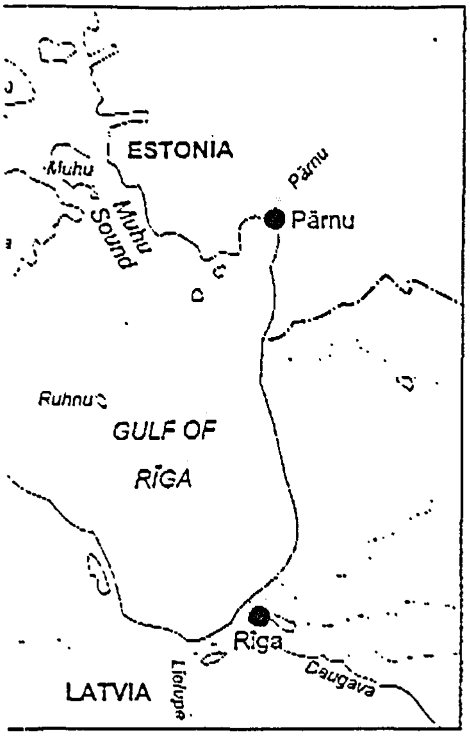
Strong currents, regular water exchange with adjacent sea areas, and weak stratification of the water mass, facilitate water mixing and prevent serious oxygen deficiency in the semi-enclosed Gulf of Riga.

The Gulf of Riga is a water body shared between Estonia and Latvia. Separated from the rest of the Baltic Sea by the two Estonian islands of Saaremaa and Muhu, the Gulf of Riga has the larger part of its water exchange with the Baltic Proper through the Irbe Strait between Saaremaa and the Latvian mainland. Normally, a hydrological front is formed, separating the brackish Gulf of Riga water from the more saline water of the Baltic Proper. At this front, the difference in salinity between the water masses can be quite large. Major inflows of saline water from the Baltic can take place during periods of prolonged south-easterly winds when the salinity front is temporarily broken.

Large input of river water

In the sub-project *Water exchange, nutrients, hydrography and database*, it has been observed that the northern, considerably smaller Virtsu Strait (or Muhu Sound) is periodically more important for the overall water exchange than previously assumed. During certain wind conditions, the net exchange through the Virtsu Strait is greater than through the Irbe Strait.

There is, furthermore, a substantial annual fresh water input from the rivers falling into the Gulf, with the largest contribution by River Daugava. This river is over 1,000 km long and with a 87,900 Km^2 wide drainage basin area extending from Russia to Belarus and Lithuania, and right across Latvia discharges about 26 Km^3 of fresh water annually into the Gulf of Riga. The annual fresh water inputs from small rivers such as River Lielupe (Latvia) and



River Pärnu (Estonia) are comparatively smaller but nevertheless quite important. As the drainage area of Lielupe includes large areas of arable land, the river runoff contributes large amounts of nutrients to the Gulf.

Efficient water mixing

A weak salinity barrier (a halocline) is formed in the open water mass between bottom water of higher salinity (about 6.5 psu) and surface water of lower salinity (about 5 psu). Being a shallow and brackish-water sea area, the Gulf of Riga is covered with ice during normal winters. Despite the ice cover, investigations on water exchange, hydrography and circulation of various substances have been carried out during the Gulf of Riga Project.

An overall feature of the Gulf of Riga is that its physical oceanography water temperature, mixing of water masses, open-sea and coastal currents can change significantly not only between seasons but also between years. Strong bottom currents and upwelling contribute to the turn-over of the water masses. Generally, the mixing of the water is efficient. However, a temperature barrier (a termocline) is formed during spring and summer, preventing water mixing and oxygenation of the bottom water in that period.

Although there is a rather frequent water exchange through the Irbe Strait, there is general oxygen deficiency in the bottom water in late summer and autumn. This lack of oxygen at the bottom of the Gulf has not yet led to the formation of hydrogen sulphide.

Remaining high levels of nutrients

No major decrease of the concentrations of nutrients has yet occurred in river transport to the Gulf of Riga, although the use of fertilizers in agriculture has been substantially reduced in recent years. A large nutrient leakage still occurs in areas with big animal farms. Studies carried out within the sub-project *Drainage Basin and Load to the Gulf of Riga* have generated a first assessment of the riverborne load of nutrients to the Gulf of Riga.

The use of fertilizers in the drainage area has decreased drastically in recent years for economic reasons. Agriculture in Latvia, as well as in Estonia and Lithuania, is far less intensive than it used to be in the late 1980's. However, preliminary results indicate that no major decrease of the concentrations of nutrients in rivers has occurred, although the inputs have been reduced. Arable land in the area has received large quantities of phosphorus and nitrogen for a long time, and no dramatic changes in the concentrations of nutrients are expected for several years to come. It could, possibly, take long before any decreased leakage of phosphorus occurs, whereas changes in the concentrations of nitrate could be noticeable sooner. However, the actual development remains to be seen.

Large nutrient losses from animal farms

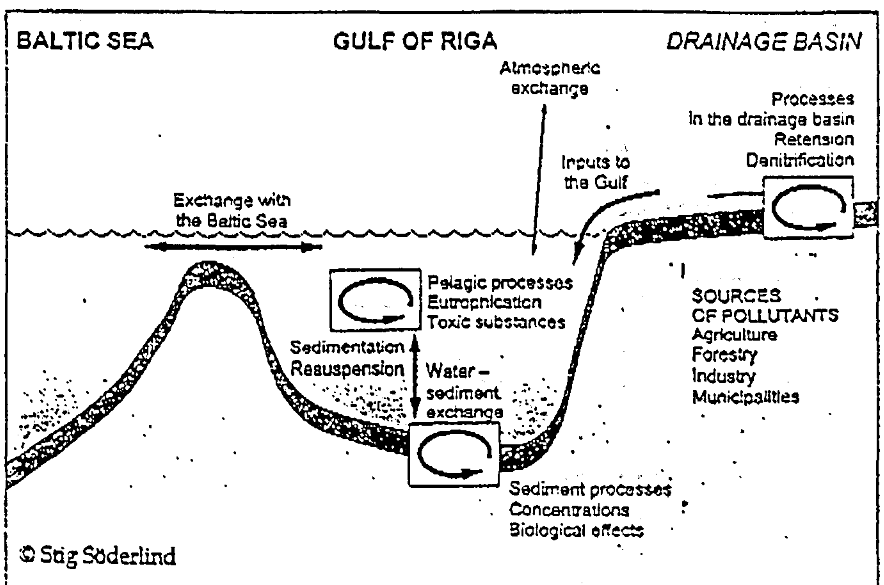
It has been recorded within the project that nutrient leakage from arable land has been low or moderate in the field catchments, ranging roughly from five to 15 kg nitrogen per hectare and less than 0.5 kg phosphorus per hectare. Nutrient losses are considerably higher (1020 times), though, in areas with very big animal farms (e.g., an annual production of 50,000 pigs) producing much manure that is stored and spread in ways that favour extensive leakage. One example is a farm where the manure from 5,000 pigs is spread over an area not larger than 50 hectares.

A scientifically interesting aspect of this study is the possibility to follow the changes in real field experiments in combination with studies on a river-basin scale. Automatic data loggers have been installed in some agricultural areas in Estonia and Latvia for continuous registration of water and nutrient flows. The results of the studies carried out thus far will now be integrated into planning for measures to control the input and leakage of waterborne nutrients to the Gulf.

Various signs of eutrophication

The Gulf of Riga is a eutrophied sea area with high levels of algal growth, changes in the species composition of algae; high growth of zooplankton (small animals in the water mass), and periodically increased abundance of larger bottom animals on shallow bottoms.

Analyses within the sub-project *Pelagic Eutrophication and Sedimentation* indicate that nitrogen is the limiting factor to primary production in the Irbe Strait towards the Baltic and in the open parts of the area. The Gulf of Riga is among the Baltic Sea areas with the highest rate of primary production (growth of planktonic algae). The highest levels of chlorophyll - a sign of algal biomass - have been obser-



ved in the vicinity of the island of Ruhnu and close to the discharge of River Daugava in the south. The biomass of dinoflagellates and blue-green algae is generally increasing in the Gulf during summer and early autumn, whereby these algal species become more dominant.

The production of organic material algae and small animals (zooplankton) in the water mass is high, but so is the overall effectiveness of the system to use and recycle this material. Nitrogen and phosphorus are recycled in the surface water layer and the losses are small. Sedimentation mostly takes place in the form of degraded detrital material.
The biomass of "medium-size" zooplankton was ten times higher in 1993 than in 1994. The average biomass of bottom-living animals in the Gulf of Riga has doubled since the 1970's.

Drastic changes in life at the bottom

High quantities of small bottom animals are found in the Gulf of Riga. However, one newly introduced worm species has in only a few years become dominant in terms of abundance among the larger animals.

Investigations carried out in the summer of 1994 as part of the sub-project *Sediment and Benthos of the Gulf of Riga* have shown that the bottom areas in the Gulf of Riga are sufficiently oxygenated to sustain bottom-living organisms. Monthly sampling have demonstrated uncommonly high quantities of microscopic animals (meiofauna). In fact, the maximum quantities registered at these stations are the highest ones measured anywhere in the world. A new species - a crustacean belonging to the family *Leimia* - constitutes the largest share of this meiofauna.

In the world of the larger bottom-living animals (macrofauna), drastic changes have taken place. Species diversity is low in the Gulf, only a handful of larger bottom-living animals are normally found, but they have until recently formed a relatively stable community.

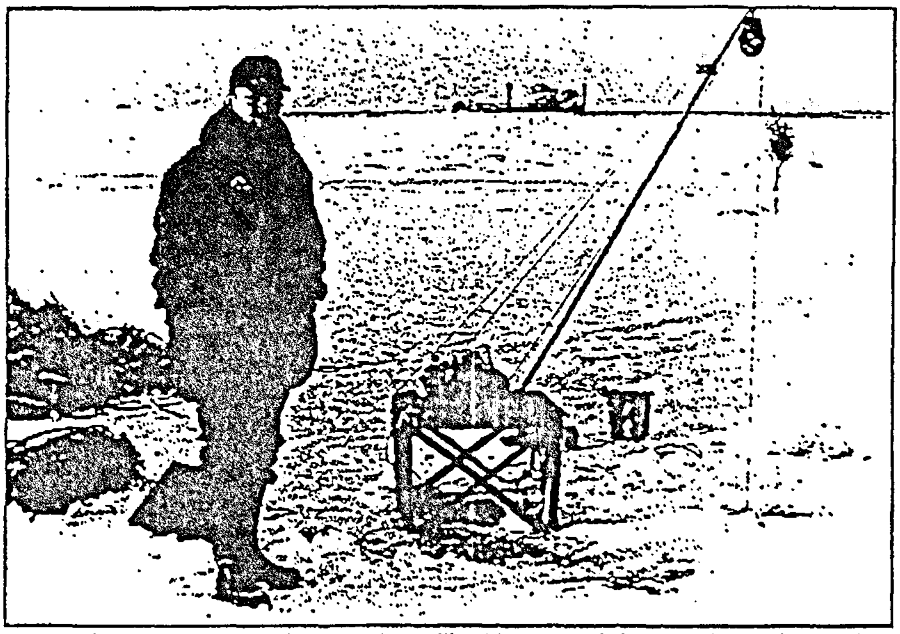
This changed in 1991, when the dominating species *Pontoporeia affinis* started to decrease sharply, and in 1993 when the bristle worm *Marenzellaria viridis* started to spread rapidly throughout the whole Gulf. Now the balance in terms of distribution and biomass has changed in favour of the newcomer *Marenzellaria*, which is presently the third most important species.

No exceptional levels of persistent pollutants

A gradient of airborne PCBs has been recorded throughout the Gulf, but concentrations drop with distance. Neither the levels of PCBs, etc., nor the levels of heavy metals are higher in the sediments in the Gulf of Riga than in other parts of the Baltic.

The sub-project *Budgets of Persistent Pollutants and Heavy Metals in the Gulf of Riga* is aimed at making an overall description of the origin, distribution and environmental effects of various persistent pollutants in the Gulf.

A gradient of airborne PCBs has been recorded in the lower atmosphere over the Gulf, from the inner part, by the city of Riga, towards the island of Saaremaa in Estonia. The concentrations declined



Despite the annual ice cover, investigations - like this one, made by Dr. Villu Astok, Estonian Marine Institute, Tallinn University - on water exchange, hydrography and circulation of various substances have been carried out during the project. Foto: Ülo Suursaar.

to background levels only some 200 km away from the source. Concentrations found at Vilsandi on Saaremaa were comparable to those found in southern Sweden.

It can, thus, be assumed that the atmospheric PCB exposure from sources in inner part of the Gulf of Riga will not lead to large-scale effects on other areas in the Baltic Sea region.

River transport of PCB

Analyses of organic pollutants such as PCBs and PAHs have shown that the concentrations are similar or lower in sediments in the Gulf of Riga than in other parts of the Baltic. It has been estimated that the yearly input of PAHs by River Daugava into the Gulf is approximately 85 kg, whereas the corresponding input of riverborne PCBs varies between 10 and over 150 kg per year. The river most likely is a major source of PCB contamination in the Gulf of Riga. Analyses of persistent pollutants in fish indicate that PCBs are discharged from one or more sources to Daugava and/or River Lielupe.

A large number of persistent chlorinated substances including PCBs, DDTs, dieldrin, and hexachlorohexanes (e.g., Lindane) have been found in fish from different locations in the Gulf.

Maps of upper sediments and their conditions have been made as part of the work to analyze heavy metals in the Gulf of Riga. It has been concluded that the concentrations of lead, copper, zinc, manganese and iron found in the Gulf are generally low or moderate and comparable to those found in the rest of the Baltic Sea.

A new sampling station has been set up on the island of Ruhnu in the centre of the Gulf for measuring heavy metals, precipitation and atmospheric deposition.

Text: Britt Hägerhäll Aniansson
Layout: Lars Rasmussen

ANNEX 16

JOINT NATURE CONSERVATION COMMITTEE

MARINE NATURE CONSERVATION REVIEW

Joint Nature Conservation Committee
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David Connor

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Dr Karel Essink
National Institute for Coastal & Marine Management
P.O. Box 207, 9750 AE Haren
The NETHERLANDS

18 April, 1997

Dear Karel

ICES Benthic Ecology Working Group, April 1997, Gdynia Poland

I trust my e-mail arrived to send my apologies for not being able to attend this meeting.

To keep the BEWG informed, I offer the following report:

BioMar marine biotope classification

Since reporting to the BEWG at Aberdeen, UK in April 1996, we have made substantial progress with development of the **BioMar marine biotope classification**, being undertaken for the EC *Life* programme.

A fully updated working classification (Connor, D.W., Brazier, D.P., Hill, T.O., Holt, R.H.F., Northen, K.O., & Sanderson, W.G. 1996. *Marine Nature Conservation Review: marine biotopes. A working classification for the British Isles. Version 96.7.* Peterborough, Joint Nature Conservation Committee.) has been disseminated to over 170 institutes/individuals in 14 countries for use and comment. This version includes descriptions of over 220 biotopes presented in a hierarchically structured classification. The classification is linked to the EC Habitats Directive Annex I types, the European CORINE/Palaearctic classifications, the HELCOM Baltic classification and the French ZNIEFF classification.

The classification has been tested through field trials by a variety of organisations, through mapping of coastal areas using a standardised national colour mapping scheme and through assessing the quality of sites for their nature conservation interests.

The classification continues to be developed through the analysis of field data (using cluster and ordination techniques) and through workshops and discussions with experts. We will submit a final classification to *Life* in June 1997.

Two other key initiatives concerning marine classifications have arisen over the past year. Firstly the European Environment Agency, through its European Topic Centre on Nature Conservation in Paris, has started development of a **EUNIS (European Nature Information System)** classification. This is a development of the current CORINE/Palaearctic classification, involving restructuring, the addition of key habitat and species parameter information and the development of a new database. They anticipate a significant degree of development is required for marine habitats to cover European waters and will probably use the BioMar classification as a basis for this. Secondly **OSPAR**, at its workshop on habitats and species in Texel, Netherlands in February 1997, recommended that a marine biotope classification for the north-east Atlantic be developed and sought to encourage its development, working through the UK and with the EEA/ETCNC EUNIS system.

Molluscs in ETI North Sea Benthos CD-Rom.
Species occurring in North Sea (excl pelagic and deep water species). Selection acc. to Seaward (1982, 1990 & 1993, i.e. North Sea areas S1, S3, S5, S6, S7, S8, S9, S10, S11, S12, S13, S13F, S50, S51, S52, S53. Scientific names following Sabelli et al., (1990) and CLEMAM.

Sorted systematically

CAUDOFOVEATA
Chaetoderma nitidulum Lovén, 1845
Falcidens crossotus Salvini-Plawen, 1968
Scutopus ventrolineatus Salvini-Plawen, 1968

SOLENOGASTRA
Neomenia carinata carinata Tullberg, 1875
Nematomenia banyulensis (Pruvot, 1890)
Rhopalomenia aglaopheniae (Kowalewsky & Marion, 1887)

POLYPLACOPHORA
Leptochiton asellus (Gmelin, 1791)
Leptochiton cancellatus (Sowerby G.B. II, 1840)
Hanleya hanleyi Bean in Thorpe, 1844
Tonicella marmoreus Fabricius, 1780
Tonicella rubra (Linné, 1767)
Lepidochitona cinerea (Linnaeus, 1767)
Callochiton septemvalvis (Montagu, 1803)
Acanthochitona crinita (Pennant, 1777)
Acanthochitona fascicularis (Linné, 1767)
Ischnochiton albus (Linné, 1767)

GASTROPODA
Anatoma crispata Fleming, 1828
Haliotis tuberculata tuberculata Linné, 1758
Emarginula fissura (Linné, 1758)
Emarginula rosea Bell T., 1824
Emarginula crassa Sowerby J., 1813
Puncturella noachina (Linné, 1771)
Diodora graeca (Linné, 1758)
Patella vulgata Linné, 1758
Patella intermedia Knapp in Murray, 1857
Patella ulyssiponensis Gmelin, 1791
Ansates pellucida (Linné, 1758)
Tectura testudinalis (Müller, 1776)
Acmaea virginea (Müller O.F., 1776)
Lepeta caeca (Müller O.F., 1776)
Iothia fulva (Müller O.F., 1776)
Propilidium exiguum (Thompson, 1844)
Margarites helicinus (Phipps, 1774)
Margarites groenlandicus (Gmelin, 1791)
Margarites olivaceus (Brown, 1827)
Calliostoma zizyphinum (Linné, 1758)
Calliostoma occidentale (Mighels & Adams, 1842)
Gibbula magus (Linné, 1758)
Gibbula tumida (Montagu, 1803)
Gibbula cineraria (Linnaeus, 1758)
Gibbula umbilicalis (da Costa, 1778)
Jujubinus montagui (Wood W., 1828)
Jujubinus striatus (Linné, 1758)
Clelandella miliaris (Brocchi, 1814)
Skenea serpuloides (Montagu, 1808)
Tricolia pullus picta (da Costa, 1778)
Lacuna vincta (Montagu, 1803)
Lacuna crassior (Montagu, 1803)
Lacuna parva (Da Costa, 1778)
Lacuna pallidula (Da Costa, 1778)
Littorina littorea (Linnaeus, 1758)
Littorina arcana Hannaford-Ellis, 1978
Littorina neglecta Bean in Thorpe, 1844
Littorina nigrolineata Gray J.E., 1839
Littorina saxatilis (Olivi, 1792)
Littorina fabalis (W. Turton, 1825)
Littorina obtusata (Linné, 1758)
Melaraphe neritoides (Linné, 1758)
Hydrobia neglecta Muus, 1963
Heleobia stagnorum (Gmelin, 1791)
Hydrobia ulvae (Pennant, 1777)
Hydrobia ventrosa (Montagu, 1803)
Mercuria confusa (Von Frauenfeld, 1863)
Cingula trifasciata (Adams J., 1800)
Obtusella intersecta (Wood S.W., 1857)
Crisilla semistriata (Montagu, 1808)
Onoba semicostata (Montagu, 1803)
Onoba aculea (Gould, 1841)
Hyala vitrea (Montagu, 1803)
Manzonia crassa (Kanmacher, 1798)
Alvania beani (Hanley in Thorpe, 1844)
Alvania cimicoides (Forbes, 1844)
Alvania jeffreysi (Waller, 1864)
Alvania punctura (Montagu, 1803)
Alvania lactea (Michaud, 1832)
Alvania subsoluta (Aradas, 1847)
Rissoa parva (da Costa, 1778)
Pusillina inconspicua (Alder, 1844)
Pusillina sarsii (Lovén, 1846)
Rissoa lilacina Récluz, 1843
Rissoa membranacea (Adams, 1800)
Assiminea grayana Fleming, 1828
Rissoella diaphana (Alder, 1848)
Rissoella opalina (Jeffreys, 1848)
Rissoella globularis (Forbes & Hanley, 1853)
Omalogyra atomus (Philippi, 1841)
Ammonicera rota (Forbes & Hanley, 1850)
Skeneopsis planorbis (Fabricius O., 1780)
Caecum trachea (Montagu, 1803)
Caecum clarkii Carpenter, 1858
Caecum glabrum (Montagu, 1803)
Turritella communis Risso, 1826
Bittium reticulatum (da Costa, 1778)
Cerithiopsis tubercularis (Montagu, 1803)
Cerithiella metula (Lovén, 1846)
Marshallora adversa (Montagu, 1803)
Epitonium clathrus (Linné, 1758)
Epitonium turtonis (Turton, 1819)
Epitonium trevelyanum (Johnston, 1841)
Epitonium clathratulum (Kanmacher, 1798)
Graphis albida (Kanmacher, 1798)
Aclis walleri Jeffreys, 1867
Cima minima (Jeffreys, 1858)
Eulima glabra (da Costa, 1778)
Eulima bilineata Alder, 1848
Haliella stenostoma (Jeffreys, 1858)
Melanella alba (da Costa, 1778)
Melanella lubrica (Monterosato, 1890)
Melanella monterosatoi (Monterosato, 1890)
Vitreolina philippi (Rayneval & Ponzi, 1854)
Pelseneeria minor Koehler & Vaney, 1908 *
Trichotropis borealis Broderip & Sowerby G.B. I, 1829
Capulus ungaricus (Linné, 1758)
Calyptraea chinensis (Linné, 1758)
Crepidula fornicata (Linné, 1758)
Aporrhais pespelecani (Linné, 1758)
Aporrhais serresianus (Michaud, 1828)
Amauropsis islandica (Gmelin, 1791)

Euspira pallida (Broderip & Sowerby G.B. I, 1829)
Euspira fusca (de Blainville, 1825)
Euspira catena (da Costa, 1778)
Euspira pulchella (Risso, 1826)
Euspira montagui (Forbes, 1838)
Velutina velutina (Müller, 1776)
Velutina plicatilis (Müller, 1776)
Lamellaria perspicua (Linné, 1758)
Lamellaria latens (Müller, 1776)
Erato voluta (Montagu, 1803)
Trivia arctica (Pulteney, 1789)
Trivia monacha (da Costa, 1778)
Simnia patula (Pennant, 1777)
Charonia lampas lampas (Linné, 1758)
Trophon truncatus (Ström, 1768)
Trophon barvicensis (Johnston, 1825)
Trophon muricatus (Montagu, 1803)
Trophon clathratus (Linné, 1767)
Nucella lapillus (Linné, 1758)
Urosalpinx cinerea (Say, 1822)
Ocenebra erinacea (Linné, 1758)
Liomesus ovum (Turton, 1825)
Beringius turtoni (Bean, 1834)
Volutopsius norwegicus (Gmelin, 1791)
Colus islandicus (Mohr, 1786)
Colus gracilis (da Costa, 1778)
Colus jeffreysianus (Fischer P., 1868)
Colus howsei (Marshall, 1902)
Colus sabini (Gray J.E., 1824)
Neptunea antiqua (Linné, 1758)
Buccinum finmarchianum Verkrüzen, 1875
Buccinum humphreysianum Bennet, 1824
Buccinum hydrophanum Hancock, 1846
Buccinum undatum Linné, 1758
Nassarius reticulatus (Linné, 1758)
Nassarius incrassatus (Ström, 1768)
Nassarius pygmaeus (Lamarck, 1822)
Troschelia berniciensis (King, 1846)
Oenopota turricula (Montagu, 1803)
Oenopota trevelliana (Turton, 1834)
Oenopota rufa (Montagu, 1803)
Typhlomangelia nivalis (Lovén, 1846)
Mangelia attenuata (Montagu, 1803)
Mangelia coarctata (Forbes, 1840)
Bela brachystoma (Philippi, 1844)
Bela nebula (Montagu, 1803)
Comarmondia gracilis (Montagu, 1803)
Raphitoma leufroyi (Michaud, 1828)
Raphitoma purpurea (Montagu, 1803)
Raphitoma linearis (Montagu, 1803)
Teretia teres (Reeve, 1844)
Acteon tornatilis (Linné, 1758)
Diaphana minuta Brown, 1827
Diaphana expansa (Jeffreys, 1864)
Colpodaspis pusillus Sars M., 1870
Retusa obtusa (Montagu, 1803)
Retusa truncatula (Bruguière, 1792)
Retusa umbilicata (Montagu, 1803)
Volvulella acuminata (Bruguière, 1792)
Cylichna cylindracea (Pennant, 1777)
Roxania utricula (Brocchi, 1814)
Scaphander lignarius (Linné, 1758)
Akera bullata Müller O.F., 1776
Philine aperta (Linné, 1767)
Philine angulata Jeffreys, 1867
Philine catena (Montagu, 1803)
Philine pruinosa (Clark, 1827)
Philine punctata (Adams J., 1800)
Philine quadrata (Wood S., 1839)
Philine scabra (Müller, 1784)
Philinoglossa helgolandica Hertling, 1932
Philinoglossa praelongata Salvini-Plawen, 1973
Runcina coronata (de Quatrefages, 1844)
Chrysallida interstincta (Adams J., 1797)
Chrysallida indistincta (Montagu, 1808)
Chrysallida sarsi Nordsieck, 1972
Chrysallida pellucida (Dillwyn, 1817)
Ondina divisa (Adams J., 1797)
Ondina diaphana (Jeffreys, 1848)
Chrysallida nivosa (Montagu, 1803)
Odostomia plicata (Montagu, 1803)
Odostomia turrita Hanley, 1844
Odostomia unidentata (Montagu, 1803)
Odostomia conspicua Alder, 1850
Odostomia acuta Jeffreys, 1848
Odostomia conoidea (Brocchi, 1814)
Odostomia lukisii Jeffreys, 1859
Odostomia carrozzai van Aartsen, 1987
Odostomia scalaris MacGillivray, 1843
Odostomia eulimoides Hanley, 1844
Eulimella scillae (Scacchi, 1835)
Eulimella acicula (Philippi, 1836)
Eulimella ventricosa (Forbes, 1844)
Ebala nitidissima (Montagu, 1803)
Turbonilla lactea (Linné, 1758)
Turbonilla crenata (Brown, 1827)
Turbonilla jeffreysii (Jeffreys, 1848)
Turbonilla rufescens (Forbes, 1846)
Aplysia punctata (Cuvier, 1803)
Pleurobranchus membranaceus (Montagu, 1815)
Berthella plumula (Montagu, 1803)
Asperspina brambelli (Swedmark, 1968)
Microhedyle lactea Hertling, 1930
Elysia viridis (Montagu, 1804)
Hermaea bifida (Montagu, 1815)
Calliopaea bellula d'Orbigny, 1837
Placida dendritica (Alder & Hancock, 1843)
Limapontia capitata (Müller, 1774)
Limapontia depressa Alder & Hancock, 1862
Limapontia senestra (de Quatrefages, 1844)
Alderia modesta (Lovén, 1844)
Tritonia hombergi Cuvier, 1803
Tritonia plebeia Johnston, 1828
Tritonia lineata Alder & Hancock, 1848
Lomanotus genei Vérany, 1846
Lomanotus marmoratus (Alder & Hancock, 1845)
Dendronotus frondosus (Ascanius, 1774)
Doto coronata (Gmelin, 1791)
Doto cuspidata Alder & Hancock, 1862
Doto dunnei Lemche, 1976
Doto fragilis (Forbes, 1838)
Doto millbayana Lemche, 1976
Doto pinnatifida (Montagu, 1804)
Corambe obscura (Verrill, 1870)
Goniodoris nodosa (Montagu, 1808)
Goniodoris castanea Alder & Hancock, 1845
Okenia quadricornis (Montagu, 1815)
Okenia leachii (Alder & Hancock, 1854)
Ancula gibbosa (Risso, 1818)
Acanthodoris pilosa (Abildgaard in Müller, 1789)

Adalaria proxima (Alder & Hancock, 1854)
Onchidoris fusca (Müller, 1776) *
Onchidoris muricata (Müller, 1776)
Onchidoris depressa (Alder & Hancock, 1842)
Onchidoris inconspicua (Alder & Hancock, 1851)
Onchidoris sparsa (Alder & Hancock, 1846)
Onchidoris luteocincta (Sars M., 1870)
Onchidoris pusilla (Alder & Hancock, 1845)
Aegires punctilucens (d'Orbigny, 1837)
Polycera quadrilineata (Müller O.F., 1776)
Polycera faeroensis Lemche, 1929
Polycera dubia Sars M., 1829
Polycera notha (Johnston, 1838) *
Thecacera pennigera (Montagu, 1815)
Limacia clavigera (Müller O.F., 1776)
Cadlina laevis (Linné, 1767)
Aldisa zetlandica (Alder & Hancock, 1854)
Rostanga rubra (Risso, 1818)
Archidoris pseudoargus (Rapp, 1827)
Geitodoris planata (Alder & Hancock, 1846)
Jorunna tomentosa (Cuvier, 1804)
Armina loveni (Bergh, 1861)
Janolus cristatus (delle Chiaje, 1841)
Hero formosa (Lovén, 1844)
Coryphella browni Picton, 1980
Coryphella gracilis (Alder & Hancock, 1844)
Coryphella verrucosa (Sars M., 1829)
Coryphella lineata (Lovén, 1846)
Coryphella pedata (Montagu, 1815)
Coryphella pellucida (Alder & Hancock, 1843)
Facelina bostoniensis (Couthouy, 1838)
Facelina coronata (Forbes & Goodsir, 1839)
Favorinus branchialis (Rathke, 1806)
Aeolidia papillosa (Linné, 1761)
Aeolidiella glauca (Alder & Hancock, 1845)
Eubranchus tricolor Forbes, 1838
Eubranchus farrani (Alder & Hancock, 1844)
Eubranchus pallidus (Alder & Hancock, 1842)
Eubranchus vittatus (Alder & Hancock, 1842)
Eubranchus cingulatus (Alder & Hancock, 1847)
Eubranchus exiguus (Alder & Hancock, 1848)
Eubranchus doriae (Trinchese, 1874)
Cuthona nana (Alder & Hancock, 1842)
Cuthona pustulata (Alder & Hancock, 1854)
Cuthona foliata (Forbes & Goodsir, 1839)
Cuthona viridis (Forbes, 1840)
Cuthona caerulea (Montagu, 1804)
Cuthona gymnota (Couthuoy, 1838)
Cuthona amoena (Alder & Hancock, 1845)
Cuthona rubescens Picton & Brown, 1978
Cuthona concinna (Alder & Hancock, 1843)
Tergipes tergipes (Forskål, 1775)
Tenellia adspersa (Nordmann, 1844)
Embletonia pulchra (Alder & Hancock, 1844)
Auriculinella erosa (Jeffreys, 1830)
Ovatella myosotis (Draparnaud, 1801)
Otina ovata (Brown)

SCAPHOPODA
Dentalium entalis Linnaeus, 1758
Dentalium vulgare da Costa, 1778
Entalina tetragona (Brocchi, 1814)
Cadulus subfusiformis (Sars M., 1865)

BIVALVIA
Nucula sulcata Bronn, 1831
Nucula nucleus (Linné, 1758)
Nucula hanleyi Winckworth, 1931
Nucula nitidosa Winckworth, 1930
Nuculoma tenuis (Montagu, 1808)
Nuculana minuta (Müller O.F., 1776)
Nuculana pernula Müller O.F., 1779
Phaseolus guilonardi Hoeksema, 1993
Yoldiella lucida (Lovén, 1846)
Yoldiella lenticula (Møller, 1842)
Yoldiella philippiana (Nyst, 1845)
Arca tetragona Poli, 1795
Striarca lactea (Linné, 1758)
Bathyarca pectunculoides (Scacchi, 1834)
Glycymeris glycymeris (Linné, 1758)
Anomia ephippium Linné, 1758
Pododesmus patelliformis (Linné, 1761)
Pododesmus squama (Gmelin, 1791)
Heteranomia squamula (Linné, 1758)
Mytilus edulis Linné, 1758
Modiolus modiolus (Linné, 1758)
Modiolus barbatus (Linné, 1758)
Modiolula phaseolina Philippi, 1844
Idas simpsoni (Marshall, 1900)
Musculus discors (Linné, 1767)
Modiolarca subpicta (Cantraine, 1835)
Musculus costulatus (Risso, 1826)
Musculus niger (Gray J.E., 1824)
Crenella decussata (Montagu, 1808)
Atrina pectinata (Linné, 1767)
Ostrea edulis Linné, 1758
Crassostrea virginica (Gmelin, 1791)
Crassostrea gigas (Thunberg, 1793)
Pecten maximus (Linné, 1758)
Chlamys varia (Linné, 1758)
Crassadoma pusio (Linné, 1758)
Aequipecten opercularis (Linné, 1758)
Pseudamussium septemradiatum (Müller O.F., 1776)
Palliolum tigerinum (Müller O.F., 1776)
Palliolum furtivum (Lovén, 1846)
Palliolum striatum (Müller O.F., 1776)
Hyalopecten similis (Laskey, 1811)
Limea loscombi (Sowerby G.B. I, 1823)
Limatula gwyni (Sykes, 1903)
Limatula subauriculata (Montagu, 1808)
Astarte sulcata (da Costa, 1778)
Astarte elliptica (Brown, 1827)
Astarte montagui (Dillwyn, 1817)
Goodallia triangularis (Montagu, 1803)
Astarte borealis (Schumacher, 1817)
Myrtea spinifera (Montagu, 1803)
Lucinoma borealis (Linné, 1767)
Diplodonta rotundata (Montagu, 1803)
Thyasira flexuosa (Montagu, 1803)
Thyasira croulinensis (Jeffreys, 1847)
Thyasira ferruginea (Locard, 1898)
Thyasira pygmaea (Verrill & Bush, 1898)
Thyasira equalis (Verrill & Bush, 1898)
Thyasira gouldi (Philippi, 1845)
Kellia suborbicularis (Montagu, 1803)
Lasaea rubra (Montagu, 1803)
Lepton squamosum (Montagu, 1803)
Epilepton clarkiae (Clark W., 1852)

Devonia perrieri (Malard, 1904)
Montacuta substriata (Montagu, 1808)
Montacuta ferruginosa (Montagu, 1808)
Montacuta tenella Lovén, 1846
Mysella bidentata (Montagu, 1803)
Mysella dawsoni (Jeffreys, 1864)
Mysella tumidula (Jeffreys, 1866)
Arctica islandica (Linné, 1767)
Kelliella abyssicola (Forbes, 1844)
Acanthocardia echinata (Linné, 1758)
Acanthocardia tuberculata (Linné, 1758)
Parvicardium minimum (Philippi, 1836)
Parvicardium ovale (Sowerby G.B. II, 1840)
Parvicardium scabrum (Philippi, 1844)
Parvicardium exiguum (Gmelin, 1791)
Cerastoderma edule (Linné, 1758)
Cerastoderma glaucum (Poiret, 1789)
Laevicardium crassum (Gmelin, 1791)
Dosinia exoleta (Linné, 1758)
Dosinia lupina (Linné, 1758)
Gouldia minima (Montagu, 1803)
Venus casina Linné, 1758
Timoclea ovata (Pennant, 1777)
Clausinella fasciata (da Costa, 1778)
Chamelea striatula (da Costa, 1778)
Mercenaria mercenaria (Linné, 1758)
Paphia aurea (Gmelin, 1791)
Paphia rhomboides (Pennant, 1777)
Venerupis pullastra (Montagu, 1803) *
Venerupis saxatilis (Fleriau de Bellevue, 1802) *
Tapes decussata (Linné, 1758)
Tapes philippinarum (Adams & Reeve, 1850)
Turtonia minuta (Fabricius O., 1780)
Petricola pholadiformis Lamarck, 1818
Mysia undata (Pennant, 1777)
Mactra stultorum (Linné, 1758)
Spisula elliptica (Brown, 1827)
Spisula solida (Linné, 1758)
Spisula subtruncata (da Costa, 1778)
Lutraria lutraria (Linné, 1758)
Lutraria angustior Philippi, 1844
Donax vittatus (da Costa, 1778)
Tellina tenuis da Costa, 1778
Tellina fabula Gmelin, 1791
Tellina donacina Linné, 1758
Tellina pygmaea Lovén, 1846
Arcopagia crassa (Pennant, 1777)
Arcopagia balaustina (Linné, 1758)
Macoma balthica (Linné, 1758)
Macoma calcarea (Gmelin, 1791)
Scrobicularia plana (da Costa, 1778)
Abra tenuis (Montagu, 1803)
Abra alba (Wood W., 1802)
Abra nitida (Müller O.F., 1776)
Abra prismatica (Montagu, 1808)
Gari fervensis (Gmelin, 1791)
Gari depressa (Pennant, 1777)
Gari tellinella (Lamarck, 1818)
Gari costulata (Turton, 1822)
Solecurtus scopula (Turton, 1822)
Ensis ensis (Linné, 1758)
Ensis arcuatus (Jeffreys, 1865)
Ensis americanus (Gould, 1870)
Ensis siliqua (Linné, 1758)
Ensis minor (Chenu, 1843)
Solen marginatus Pulteney, 1799
Phaxas pellucidus (Pennant, 1777)
Mya truncata Linné, 1758
Mya arenaria Linné, 1758
Sphenia binghami Turton, 1822
Corbula gibba (Olivi, 1792)
Hiatella arctica (Linné, 1767)
Panomya norvegica (Spengler, 1793)
Saxicavella jeffreysi Winckworth, 1930
Pholas dactylus Linné, 1758
Barnea candida (Linné, 1758)
Barnea parva (Pennant, 1777)
Zirfaea crispata (Linné, 1767)
Xylophaga praestans Smith E.A., 1885
Xylophaga dorsalis (Turton, 1819)
Teredo navalis Linné, 1758
Nototeredo norvegica (Spengler, 1792)
Psiloteredo megotara (Hanley in Forbes & Hanley, 1848)
Bankia fimbriatula Moll & Roch, 1931
Cochlodesma praetenue (Pulteney, 1799)
Thracia papyracea (Poli, 1791)
Thracia villosiuscula (MacGillivray, 1827)
Thracia convexa (Wood W., 1815)
Thracia distorta (Montagu, 1803)
Lyonsia norwegica (Gmelin, 1791)
Pandora pinna (Montagu, 1803)
Cuspidaria cuspidata (Olivi, 1792)
Cuspidaria rostrata (Spengler, 1793)
Cardiomya costellata (Deshayes, 1835)
Cuspidaria obesa (Lovén, 1846)

CEPHALOPODA
Todarodes sagittatus (Lamarck, 1798)
Todaropsis eblanae (Ball, 1841)
Illex coindetii (Vérany, 1839)
Teuthowenia megalops (Prosch, 1849)
Gonatus fabricii (Auctt., non Lichtenstein)
Brachioteuthis riisei (Steenstrupp, 1882)
Ommastrephes bartramii (Lesueur, 1821)
Galiteuthis armata Joubin, 1898
Alloteuthis subulata (Lamarck, 1798)
Loligo forbesi Steenstrup, 1856
Loligo vulgaris (Lamarck, 1798)
Sepia officinalis Linné, 1758
Sepiella japonica Sasaki, 1929
Sepiola atlantica Férussac & d'Orbigny, 1839
Sepiola aurantiaca Jatta, 1896
Sepietta oweniana (d'Orbigny, 1840)
Sepietta neglecta Naef, 1916
Rossia macrostoma (Della Chiaje, 1830)
Rossia palpebrosa Owen in J.C. Ross, 1835
Octopus vulgaris Cuvier, 1798
Eledone cirrhosa (Lamarck, 1798)

Number of spec:	
Caudofoveata	3
Solenogastres	3
Polyplacophora	10
Gastropoda	289
Scaphopoda	4
Bivalvia	158
Cephalopda	21
	488

(20/4/'97; R.H. de Bruyne, Amsterdam)

ANNEX 18

Priority list of taxonomic groups to be given to the ITIS Priority Group Rankings'. WWW page

The subgroup reviewed the WWW page http://www.itis.usda.gov/itis/priority.html, titled 'ITIS Priority Group Rankings', and suggests that the following taxonomic groups are given priority.

High priority:

Annelida: Polychaeta
Cnidaria: Anthozoa
Crustacea: Amphipoda, Cumacea, Decapoda, Isopoda, Mysidacea
Echinodermata: Echinoidea, Holothuroidea, Stellaroidea
Mollusca: Bivalvia, Gastropoda

Medium priority:

Annelida: Oligochaeta
Brachiopoda
Bryozoa
Cnidaria: Hydrozoa
Crustacea: Tanaidacea, Thoracica
Echinodermata: Crinozoa
Echiura
Mollusca: Aplacophora, Polyplacophora
Nemertinea
Porifera
Priapulida
Phoronida
Pycnogonida
Sipuncula

ANNEX 19

OSPAR guidelines for benthos monitoring : proposed amendments to the text

The following comments relate to a document entitled 'Draft Guidelines for Benthos Monitoring'submitted to the Environmental Assessment and Monitoring Committee at its meeting of 7 April, 1997 (ASMO 97/4/6-E) :

p5, Supporting measurements, line 1 : insert 'of the sediment' after 5 cm;

p6, first sentence : insert 'and associated taxonomic workshops' after 'intercalibration exercises';

p7, para 2, line 4 : '...every 5 to 10 years...';

p7, para 4, line 9 : '...every 5 to 10 years.';

p8, item h, insert 'video/photographic profiles of the transect,' before 'panoramic ...';

p8, Quantitative sampling, last line of first para : add 'and Kautsky (1993)' after 'Jespersen et al. (1991).';

p10 : add : Kautsky, H (1993). Methods for monitoring of phytobenthic plant and animal communities in the Baltic Sea. In : Plinski, M (ed), The ecology of Baltic terrestrial, coastal and offshore areas - protection and management. Proceedings of the Conference, Part 1 - Marine Environment, 21-59;

p11, end of first para : add the following sentence : 'Full use should be made of historical information in the planning of surveys';

p11, 2nd para, line 9 : add '/autumn' after 'summer';

p11, 4th para, insert new item after a. : 'depth and position of each replicate; a GPS track plot would be desirable;';

p11, item c : add 'and sea state' after 'sampling';

p11 : add the following new item after e. : 'mesh size of sieve';

p11, last para : add the following sentence after '...recorded.' : 'All samples must be treated separately, ie must not be pooled';

p12, 1st sentence : insert 'and ICES (1994)' after 'Rees et al. (1991).';

p12, 2nd para, line 4 : replace 'video profiles' with 'profile imagery (see below)';

p12, 2nd para, line 6 : a reference is required for the 'epibenthos sledge (as used by the Norwegians)'. Should this be Brattegard and Fossa (1991)?;

p12, 2nd para, line 7/8 : re-phrase as follows : '...an additional dredge tow is required. The "Triple D" dredge developed by the NIOZ (Bergman and Santbrik, 1994) is preferred for the combined sampling of rarer, larger organisms of the infauna and epifauna.';

p12, 3rd para, line 1 : delete 'and' between 'video' and 'records', and add 'Rumohr (1995)' to the end of the sentence;

p12, 3rd para, line 5 : replace 'Images' with 'These records';

p12, References : add the following :

ICES (1994). Report of the ICES/HELCOM workshop on quality assurance of benthic measurements in the Baltic Sea. ICES C.M. 1994/E:10.

Rumohr, H (1995). Monitoring the marine environment with imaging methods. Scientia Marina, 59, 129-138.

ANNEX 20

Guidance on basic approaches to be adopted in the conduct of surveys of the soft-bottom macrofauna under OSPARCOM auspices.

(These are for use alongside published ICES, HELCOM and OSPARCOM guidelines).

1. Wherever possible, representative stations should be chosen to correspond with pre-existing stations for which good historical data are available.

2. Sediments should be sampled using $0.1m^2$ grabs and/or corers, and sieved to 1 mm for the macrofauna. In cases where there may be advantages to additional investigation of the smaller macrofauna component (ie down to 0.5 mm), nested 1 and 0.5 mm meshes should be used, and the samples processed separately.

3. A minimum of five replicates should be taken at individual stations selected for the examination of temporal trends. Depending on monitoring objectives, stratified random sampling, with one replicate collected at sufficient stations to satisfy statistical requirements, is also acceptable for this purpose.

4. Co-ordination in survey timing will be essential for across-country comparisons of spatial patterns, and for the evaluation of temporal trends. Sampling in the period February-May is recommended, since this will tend to limit 'noise' arising from the transient presence of many newly-recruited juveniles. It will also facilitate sorting of samples and will reduce taxonomic problems associated with the presence of small specimens.

5. The minimum acceptable sample size for soft sediments collected by grabs is 5 l, with the exception of hard-packed sands, which is 2.5 l.*

6. Identification should be to species level, wherever possible. Records should be made at the next highest taxonomic level wherever uncertainties exist.

*Further details on criteria for judging the acceptability of samples at the time of collection can be found in the 1994 report of the ICES/HELCOM workshop on quality assurance of benthic measurements in the Baltic Sea (ICES CM 1994/E:10), and in a forthcoming revision of ICES 'TIMES' report No. 8.