Biological Oceanography Committee

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REPORT OF THE BENTHOS ECOLOGY WORKING GROUP

Torshavn, Faroe Islands

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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK-1261 Copenhagen K Denmark

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1 OPENING OF THE MEETING

The Benthos Ecology Working Group met at the Tørshaven Marine Biological Laboratory, Faroe under the chairmanship of Dr Paul Kingston. D J Basford was appointed rapporteur. A list of participants is given in Annex 1

1.1 Terms of Reference

a) Prepare and forward to ACME for consideration a plan for a North Sea Benthos Survey in 1996, taking into consideration quality assurance procedures.

b) Evaluate the use of computer aided taxonomic systems for the identification of benthos species.

c) Review the co-operative benthic studies throughout the ICES area.

d) Review methods for studying hard bottom substrata and intertidal communities.

e) Review studies on the effects of fishing disturbance on benthic communities.

f) Define indicator species which are sensitive to the effects of physical disturbance and report to ACME and the Working Group on Ecosystem Effects of Fishing Activities.

g) Prepare a detailed implementation plan for the establishment of a benthos database in the ICES Secretariat, and report to ACME and the Working Group on the Ecosystem Effects of Fishing Activities.

2 ACTIVITIES OF INTEREST TO ICES AND OTHER ORGANISATIONS

2.1 Advisory Committee on the Marine Environment (ACME)

Mr J. Larsen presented relevant sections of the 1994 ACME report and 1994 ICES Annual Science Conference report. He informed the group that ACME had incorporated the advice given by the group on indicator species and the establishment of an ICES benthos data base into the report of ACME. He further informed the group that the Biological Oceanography Committe had endorsed the proposal from the group to conduct a North Sea survey in 1996. ACME had recommended that 'considerations should be given in the design of the survey to ensure that issues relevant to tasks of the ACME are incorporated into the plan'. This could comprise issues like 1) ecosystem effects of fisheries 2) contaminants monitoring, and 3) biodiversity and criteria for identifying species and habitats at risk.

Mr J. Larsen drew the meetings attention to the 1995 ICES Annual Science Conference and other ICES activities relevant to benthic research.

2.2 OSPAR Commission (OSPARCOM) inc ASMO & JAMP

Dr Kunitzer informed the group that in June 1995 the OSPAR Commission (OSPARCOM) will agree on a Joint Assessment and Monitoring Programme (JAMP) for the whole of the North East Atlantic. The JAMP was finalised by 2.4.95 during the meeting of the Environmental Assessment and Monitoring Committee (ASMO). Benthic monitoring will be carried out in relation to eutrophication, fisheries impact, habitats, and regions of likely anthropogenic influence. (Annex 2). This year the guide-lines for the JAMP will be reviewed and may be further developed, this includes a review of the ICES guide-lines on benthic monitoring.

Dr Kunitzer reported on the production of a Quality Status Report (QSR), in the form of the North Sea QSR produced in 1993, for the whole North Eastern Atlantic region. The North East Atlantic is divided into 5 regions with lead countries being responsible for the monitoring and assessment for regional QSRs

Dr Rees explained that within the larger North East Atlantic area the Celtic Sea will be reviewed by the Celtic Sea Project which aims to assess the current state of knowledge in the area and decide on what further research is required prior to producing the QSR for this sub-region. This sampling is in addition to the National Monitoring which is undertaken annually in Britain (Annex 3).

2.3 Helsinki Commission (HELCOM)

Dr Kunitzer informed the group that the new Baltic Monitoring Program (BMP) is still under revision. Contracting parties to the BMP have reported to the coordinator on their national plans for the BMP, including benthic monitoring at international monitoring stations.

The assessment of the state of the Baltic Sea, the 3rd Periodic Assessment is on going. The report will contain a chapter on changes in the benthos of different regions within the Baltic Sea.

Within the framework of the ICES / HELCOM Steering group on Biological Quality Assurance within the Baltic Sea, a workshop on quality assurance of phytoplankton measurements will be carried out in September 1995 in Warnemuende. An intercalibration exercises on benthos will be carried out during 1995 based on four regions of the Baltic Sea. Heye Rumohr is the coordinater of the benthic intercalibration exercise. Next year the ICES Steering Group on Biological Quality Assurance will widen its responsibility to Biological Quality Assurance over the whole ICES area.
Dr Rees explained that a Benthic Quality Assurance Scheme also existed in Great Britain with some 25 -30 institutes participating. This scheme is administered as part of the National Monitoring Plan. The latter being an extension of the monitoring initially undertaken by the North Sea Task Force.

2.4 European Community Projects (IMPACT II)

Mr Basford gave a brief outline of work being carried out in a Scottish sea loch, the Gareloch, where fishing has been excluded due to the presence of a naval base. An attempt has been made to assess the fauna that has developed, in the absence of fishing disturbance. Thereafter fishing gear was towed on one day per month in a restricted area. The trawled area was then compared with an undisturbed control area.

The European Community project to study the impact of anthropogenic influences on the marine environment (IMPACT) requires both background data and information on species that may be used to indicate change. It is felt that this group is the appropriate body to supply this information and it should be supplied directly to ACME as, and when, they request it.

2.5 Joint Global Ocean Flux Study (JGOFS)

Dr Watling reported that the main focus of work within JGOFS was in studying monsoon forcing of biogeochemical dynamics of the Arabian Sea. Further studies in the Ross Sea include studies at the polar front and the ice edge. Internationally, JGOFS has planned a follow up study to the North Atlantic Bloom Experiment undertaken in the late 1980s.

Work within this project includes studies in the Northern Atlantic and in the southern seas around the Antarctic. However due to reduced funding Dr Watling explained that work in these areas undertaken as part of JGOFS has been reduced.

2.6 Coastal Ocean Processes Programme (CoOP)

This project aims to study the hydrodynamic processes, both vertical and along the shelf edge, which are utilised by benthic invertebrate larvae during recruitment. It is likely to involve new techniques to sample the larvae and quantify the related physical environmental factors. Dr Watling explained that requests for proposals under this funding are now being sought.

2.7 Westerschelde

Mr Craeymeersch reported on the monitoring in the Westerschelde, Netherlands. This is a cooperative study between the Netherlands and Belgium to study the effects of sedimentation and erosion on the benthic fauna. The study is related to additional dredging of the river Schelde necessitated to permit larger ships access to Antwerp. The study involve benthos, fish and the effects on seabirds. Work is in progress, no report has been produced yet.

2.8 Biological Diversity in Marine Species (BIOMAR)

Mr Connor reported that an EU Life funded programme started in 1992 and will report in 1997. Partners in the UK, Ireland and Netherlands are working towards an integrated approach to survey mapping and assessing coastal marine habitats. A GIS model has been developed to predict wave exposure gradients along the coast. In 1995 this will be tested in the field through rapid shore surveys and aerial photography to map shore habitats. In the subtidal zone use of RoxAnn acoustic surveys, with ground truthing using remote video cameras, are used to produce broad scale biotope maps which are then further sampled by diver or with the use of grabs. Detailed surveys are undertaken throughout Britain and Ireland to describe habitats and provide data to support assessment of nature conservation interests. A major part of the programme is the development of a marine biotopes classification which, through a European workshop held in 1994, should have wide application in the North East Atlantic (see later report). The biotope classifications will be used to enhance the European CORINE classification which is currently poorly developed for marine habitats. Following meetings with HELCOM during 1994 it was decided that the Baltic area will be treated as a separate area within CORINE with its own classification. The Mediterranean is likely to be treated separately also.

2.9 Arctic Monitoring and Assessment Programme (AMAP)

Dr Kunitzer reported on this on going programme involving the marginal countries around the Arctic in monitoring and experimental work in both the marine and terrestrial environment to assess the present state of the Arctic. Currently an assessment of the state of the Arctic environment is being carried out and will be published as a Quality Status Report.

2.10 Long Term Changes in the Gulf of Gdansk

Dr Warzocha reported on a long-term programme to study changes to the macrofauna communities in the Gulf of Gdansk. Within the bay there is a deep area which periodically suffers from anoxia causing faunal depletion. Occasional influxes of saline water aid in the recolonisation of the benthic fauna. Statistical analysis of samples from above the halocline indicate the fauna in this region fluctuates less than the deeper water fauna. Further studies of the shallower area are proposed. Results of recent work are published under HELCOM.

2.11 Marine Science and Technology Programme (MAST)

Dr Duineveld reported on a large cooperative study of the Dogger Bank studying benthic coupling with pelagic processes. The Dogger Bank was specifically chosen for this research following the discovery by German workers of large scale winter production. Research will include growth ratios of benthic organisms, sediment respiration, comparing the faunal structure with areas where winter production does not occur and foodweb studies.

Dr Duineveld also reported on Ocean Margin Exchange (OMEX), a study to investigate the input of organic matter from the continental shelf to the deep sea. Studies were initially located in the Celtic Sea but there is also an intention to study the Iberian Slope off Lisbon.

This work has lead to further similar studies in the Eastern Mediterranean. Several scientists also outlined proposals they had put forward for the next funding round under this initiative.

2.12 North Sea Survey Benthic Faunal Atlas

Mr Craeymeersch presented a report giving area maps for the species found in the North Sea Synoptic Survey. Approximately100 species have been mapped and the information is presented on two computer discs. A comprehensive report including diagrams of the distributions has been to be published in the ICES Cooperative Research Report series.

2.13 Global Ocean Ecosystem Dynamics (GLOBEC)

A report forwarded from Dr Taylor informed the meeting about the U.S. GLOBEC project which aims to study the dynamics of marine animal populations, particularly with reference to climate change. The principal activity at present has been undertaken as part of the ICES Cod and Climate Program in the North East Atlantic. The US program focuses on the role of stratification in the Georges Bank region in determining the population dynamics of zooplankton and ichthyoplankton. Further plans involve population fluctuation studies to adequately address any change in species structure due to global change. There is a plan to extend this survey to the south where considerable amounts of data have been accumulated through projects such as TOGA-TAO array, CalCOFI., GLOBEC-PICES Carrying Capacity and Climate Change study (SPACC) and the California Current Program.

2.14 Land Margin Ecosystems Research Program (LMER)

Dr Taylor forwarded a report on the Land Margin Ecosystems Research Program. The major US part of this study, the Tomales Bay (Biogeochemical Reactions in Estuaries) and Waquoit Bay programs, were extensively reported at the working group last year and are now being run down.
One new LMER program has been initiated to compare the watershed and ecosystem dynamics of five rivers in coastal Georgia in the southeast United States

3 REVIEW OF CO-OPERATIVE STUDIES

3.1 Benthic Invertebrates of Faroes Waters (BIOFAR)

The BIOFAR programme is now at the stage where specialist taxonomists are returning the material to the laboratory. Some material is retained by the expert and some specimens are sent to the Zoological Museum, Copenhagen. Some 35 scientific papers have been published - an updated list will be sent to the participants of the meeting.

The initial BIOFAR programme, planned to run for three years, surveyed the sediments the area below 100m. A new project BIOFARCOS has been formed by amalgomating BIOFAR 2, suverying the ground above 100m, and FARCOS, abseline oil survey.BIOFAR2 is financed by the Carlsberg Foundation while BIOFARCOS is sponsered by oil companies. The latter programme will include classification and mapping of biocoenoses along the Faroe coastline, and is planned to end up with a detailed map by the end of 1998. The two programmes will be planned together, but the data will be kept separate. The BIOFAR(1) database will be built up so that results from both scientific programmes can be managed within the same database framework.

BIOFARCOS started by April 1 1995, so results may be presented at the next meeting of the BEWG.

3.2 Benthic Invertebrates of Icelandic Waters (BIOICE)

Dr Steingrimsson reported on the large scale benthic survey round Iceland. Historically little benthic research has taken place since the Ingolf Expedition of 1895 - 1896.
The objectives of BIOICE were to

(a) Produce a benthic species inventory

(b) Study the relationship between Iceland fauna and that of adjacent regions

(c) Study species distribution, abundance and diversity

(d) relate physical parameters to the faunal distributions

The sampling scheme is based on a random stratified protocol with the stratification based on a grid. (0.25 lat x 0.5 long) Bottom temperature and the slope within the area are recorded at each station. Since 1994 about 300 sites have been visited. The gear used varied with the type of sediment but where possible samples were collected for infauna, epifauna and hyperbenthos. This has resulted in 530 samples being collected. The fauna is then separated into major taxa and forwarded to expert taxonomists for specific identification. Although relatively few samples have been analysed fully already there are about 300 new records for Iceland and many new species.

3.3 Arctic Studies

In the summer of 1993 a cruise to the Laptev Sea was undertaken by the German Research Vessel *Polarstern*. The main area of work was on the Laptev Sea shelf and down the slope to the deep basin. An interdisciplinary group of scientists studied geology, biology and undertook a sea-ice study. In the summer of 1995 a second cruise to the Laptev Sea is planned. It will be a cooperative venture again involving the Alfred Wegener Institut for Polar and Marine Research vessel Polarstern's and Russian Vessels. The aims will then be to sample from the Laptev Sea towards the Lomonosov Ridge.

3.4 Coastal Nourishment of Terschelling

Dr Essink reported on the Risk Analysis of Coastal Nourishment Techniques (RIACON) a project run under MAST II to study the effects of shoreline nourishment on the macrofauna. Studies are underway at North Sea sites by Denmark, The Netherlands and Belgium. At the Denmark site samples were taken both before the addition of the sediment, and afterwards to study the recovery of the benthic fauna. After one year there has been considerable recolonisation. Community studies including species diversity, abundance and biomas are on going. The RIACON project will be concluded in June 1996. (Annex 4).

3.5 Coastal Research

Change of Strategy for Monitoring Macrozoobenthos in the Dutch sector of the North Sea

Following a statistical review of the monitoring data in the Dutch sector of the North Sea the sampling positions were changed to increase the statistical power by increasing the number of strations and decreasing the number of samples taken per station. All the samples collected in the different ecological areas, mapped from previous work, are now considered as replicates. (Annex 5)

Impact of biodeposition on intertidal macrofaunal communities

Dr Kronke reported on an East Frisian Island study on the impact of organic input from a *Mytilus edulis* bed to nearby intertidal sandflats. A gradient in community composition was evident between the two habitats. Sampling continued after the *Mytilus* bed disappeared over winter to follow any recovery of the sandflat communities (Annex 6).

3.6 Benthic Atlas of Dutch Marine Waters

Dr Asjes reported that the project to map benthic communities of the Dutch estuarine and subtidal areas was now complete and that copies of the atlas, which contains the distribution of macrofaunal and meiofaunal species, will be distributed to members of the Working Group.

3.7 National Programme for Coastal Oceanography (PNOC)

Dr Dewarumez reported on a French research project to model the fluxes of carbon in coastal ecosystems. All trophic levels are covered from bacteria, microfauna, meiofauna, to macrofauna, and phytoplankton. The study also includes physical parameters associated with the sediment, faunal biomass and diversity, as well as respiration, nutrition and primary production estimation.

The project was started in1992. Physical modellers worked closely with biologists and attempted to model a coarse sand community and the adjacent water column from data collected at 6 sites in the English Channel. One of the sites, off the Straits of Dover, is situated on an extensive Ophiuroid (*Ophiothrix fragilis*) bed. Each site was sampled 6 times in 18 months (1993 - 94) and all stations were sampled in the spring 1993 - 94 for the complete range of parameters. Some additional benthic chamber experiments have been conducted. Reports will be produced at the end of 1995.

Long term Time Series

More than 15 years data has now been accumulated from four benthic sites belonging to the *Abra alba* community. Fluctuations in the data can be partially explained by climatic variation; particularly winter temperature. Regional events such as the oil spill in Brittany and pollution from the Seine are also likely to cause faunal variability. There appears to be a 7 year cycle at the Grovelines site in the southern North Sea. Maximum levels (higher community diversity) are related to different species becoming more abundant rather than reductions in the population of *Abra alba* . In 1980 *Lanice conchelega*, *Pectinaria koreni* and *Mya truncata* were involved whereas in 1987, seven years later, *Spiophanes bombyx* and *Macoma balthica* were responsible. During the intermediate years *Abra alba* always predominated. (Annex 7).

Following the National Program on Recruitment Determination (PNDR) GLOBEC France was started in 1995. Three areas are studied, a) the Mediterranean, b) Atlantic Ocean and c) the English Channel and Southern North Sea. The study investigates the interaction between the different compartments of the coastal ecosystem and their effects on recruitment. Field experiments are planned to investigate the interactions between zooplankton, ichthyoplankton and meio, macro and hyperbenthos. Laboratory experiments to study the temporary and permanent meio and macrobenthos will also be undertaken. Both field and laboratory studies are related to recruitment.

Several Laboratories are directly involved including Roscoff, Dinard, Wimereux and the Paris Museum and more institutes are collaborating.

Dr Kronck reported on a long term macrofauna study in a subtidal habitat off Norderney (East Frisia, Germany) from 1978 - 1994 An abstract is given in Annex 8.

3.8 Pomeranian Studies

Dr Powilleit reported on the TRUMP-project (Transport and Transformation Processes in the Pomeranian Bight) which started in February 1994. It is a national interdisciplinary research programme of the IOW (Institute for Baltic Sea Research), comprising physical, chemical and biological studies in the Pomeranian Bight. The programme aims are to describe and understand the physical, chemical and biological processes governing the distribution, transport and transformation of dissolved and particulate matter discharged by the Odra river through the lagoon water into the Pomeranian Bight.

The sub-project B3 deals with macrozoobenthos and sediments and especially with distribution patterns, population structure, bioturbative activity and sediment metabolism.

Pilot studies were performed in spring and autumn 1993 in close co-operation with Polish colleagues from the Academy of Agriculture in Szczecin and the Sea Fisheries Institute in Gdynia. Results of the pilot studies will be published soon.

Up to the end of 1994, 6 German and 1 Polish cruises were performed under this framework. Preliminary results concerning distribution patterns, population structure, structure of different macrozoobenthic assemblages and bioturbative activity (in terms of fluid exchange rates) are presented (Annex 9).

4 THE EFFECTS OF PHYSICAL DISTURBANCE OF THE SEA FLOOR ON BENTHOS

4.1 Canadian experiments on the effects of trawling on the seabed

Dr W. Rowell, who was unable to attend the meeting, sent in following report.

The Department of Fisheries and Oceans (DFO) initiated a trawling impact study in 1993 with the establishment of three paired sets of experimentally trawled and untrawled (control) corridors, each 13 km-long, within a closed area on the Grand Bank. Historically, the study area had supported only a limited fishery and showed no evidence of any recent trawling. The Canadian study is unique in that it addresses not only the immediate effects of trawling but also the short and longer-term effects. The details of the experimental design were presented in a WP (Rowell *et al.* 1994) to the WG in 1994. After trawling the corridors in 1993, sled and grab samples were immediately collected to determine initial impacts. Two months later the corridors were again sampled to determine short-term residual impacts. One year after trawling, in July 1994, the corridors were again sampled to determine longer-term residual impacts. On completion of this longer-term impact sampling,, the corridors were again trawled and another immediate impact sampling undertaken. Further and final sampling and trawling are planned for July 1995. On completion of the experiment, there will be three data sets reflecting the short-term impacts (two months), and two sets reflecting the longer-term impacts (one and two years after initial impact). Because of the numbers of samples and operational problems, much of the meiofaunal and bacterial material is still unanalysed. All mega and macrofaunal materials from the 1993 and 1994 samples have been sorted and identified and preliminary analyses are underway.

4.2 Quantifying the impact of trawling on benthic habitat using high resolution acoustics and chaos theory

Dr Schwinghamer, who was unable to attend the meeting, sent the following report.

Very high resolution and broadband acoustics were used to estimate the small-scale structural properties of surficial sediments as part of a trawling impact experiment on the sandy sediment of the eastern Grand Banks. The seabed was ensonified by a 12cm x 30 cm, 40-element acoustic array (DRUMS-tm.) deployed on the frame of a 0.5m2 bottom grab. Acoustic images of the upper 4.5 cm of the sediment were taken before and after intensive otter trawling in 10 sampling blocks along each of two 13km-long corridors. The acoustic return signals were Hilbert -transformed and divided in to 5 depth strata of 50us, or approximately 1cm, from slightly above the average sediment surface to 4.5cm depth. Fractal values of the transformed signal from each acoustic element were calculated for the five depth strata. The fractals of the acoustic returns from pre-trawled sediments are consistently and significantly higher than those from trawled sediments in all but five depth strata in both corridors. The chaos model provides an analytical framework in which the structural effects of physical disturbance of the benthic habitat can be quantified.

4.3 United Kingdom experiments on the effects of trawling on the seabed

Mr Craeymeersch gave a report about the IMPACT II project which aims to estimate the direct and indirect effects of different types of fishing gears on the ecosystem of the North Sea. This project supports several sub-projects.

1 Collection and analysis of historical and present day data involving both, catch and discard data, and information about fishing effort.

2 Comparitive field research to study the effects of different gears on the benthic communities.

3 The comparison of fished and unfished sites.

4 The impact of discarded material on benthic ecosystems.

Under part 3 an investigation has been undertaken in Loch Gareloch, Scotland, an unfished sea loch. Fishing has been restricted since 1967 but anecdotal evidence indicates that trawling has not taken place for at least 25 years.

A preliminary survey (Nov 1993) proved with sidescan, RoxAnn, towed underwater TV and epifaunal trawls that the area was flat and that the epifauna was evenly distributed. Two areas were thereafter chosen for study One was trawled with otter trawl ground gear on one day per month for 15 months while the other acted as a control area. The resulting disturbed area was compared to the undisturbed area on 6 monthly research cruises. Sidescan and RoxAnn data showed considerable disturbance in the trawled area. Faunal analysis is underway of both the epifauna and the macrobenthic infauna.

4.4 The effects of fishing on *Actica islandica*

Dr Duineveld gave a presentation on behalf of Dr Witbaard who had studied the shells of *Arctica islandica* a long lived (>100 years) bivalve from the Fladen Ground in the Northern North Sea.. An attempt has been made to associate environmental changes to changes in the fine structure of the shell. Although clear variations were found there was no correlation with environmental factors. A small scale study comparing shells from the north of the Fladen Ground with those on the south showed opposite growth was occurring. It was concluded Arctica may therefore be responding to localised events which occurred on such a small scale that the general comparison with the grow was unable to reflect the effects.

4.5 The effect of dredging on benthic fauna

Dr Rees gave a report on a study on an experimental gravel extraction site off the Norfolk coast where a small area had been dredged by a commercial dredger. Approximately 45,000 tons of gravel had been removed causing disruption to about 70% of the sediment surface. Samples before and after the dredging have been collected and the recovery of the fauna is being monitored. After 8 months the tracks were still clearly visible with sidescan, 1 year after the dredging the disturbance was much less evident and the fauna had started to recover. After 2 years the community structure was near normal but the biomas remained significantly lower, partly due to the large, older specimens from the initial survey not being present. (Annex 10)

4.6 Long Term Faunal Changes - an analysis of by-catch data

Mr Craeymeersch reported that since 1969 The Netherlands Institute for Fisheries Research (RIVO-DLO) performs a bottom trawl survey once or twice a year (Tridens Sole Net Survey) in the Dutch, German and Danish continental waters.

In autumn and for some years, in spring, several trawls have been taken along 14 transect.

During these years benthic species were identified and counted. The first analysis of these data were presented to the working group. (Annex 11)

5 INDICATOR SPECIES SENSITIVE TO PHYSICAL DISTURBANCE

In 1994 the Working Group was asked by the Advisory Committee for the Marine Environment to: "prepare information on and, if possible, compile an initial list of indicator species, particularly with reference to species sensitive to physical disturbance of the seabed and report to ACME".

A preliminary report from the BEWG for 1994 provided a definition of "physical disturbance", some examples of physical disturbances that might commonly occur in benthic habitats, and a broad discussion of the characteristics of benthic species that might make them vulnerable to these disturbances.

This year the ACME requested the Working Group to prepare a report defining indicator species. This is given in Annex 12.

6 METHODS FOR STUDYING HARD BOTTOM SUBSTRATES

Mr Connor prepared a report reviewing techniques for studying benthos of hard bottom substrates and presented his findings to the Working Group. The text of the report is given in Annex 13.

7 NORTH SEA BENTHOS SURVEY

In response to the request by ACME to prepare a plan for a North Sea benthos survey, a sub-group was set up to discuss objectives and further details. Also, as requested by ACME, the Group took into consideration the ecosystem effects of fisheries, contaminants monitoring and biodiversity and species/habitats. The overall proposal, presented in Annex 14, was then discussed by the Working Group as a whole before being adopted.

8 COMPUTER AIDED TAXONOMY

A sub-group was set up to report on the evaluation of computer aided taxonomic systems for the identification of benthos. Their report is given in Annex 15.

9 MARINE BIOTOPE CLASSIFICATION FOR THE NORTH-EAST ATLANTIC (BIO-MAR)

Mr Connor gave an update on progress with development of a marine biotopes classification by the UK Joint Nature Conservation Committee within the EU Life-funded BioMar programme (initially reported to the BEWG in 1994). The scope, purpose and general structure of the classification were outlined. Recent progress included release of an updated working classification for UK coastal waters and a workshop in Cambridge, UK for 50 participants from 10 north-east Atlantic countries. Workshop discussions ensured the general structure for the classification would be applicable throughout the north-east Atlantic. Workshop participants were encouraged to feed into the classification to ensure it adequately represented biotopes throughout the north-east Atlantic. The future programme was outlined, including a further workshop at the Dublin ECSA meeting in September 1995 before submission of the classification to the EU for incorporation into the CORINE classification.

10 OIL SPILLS

10.1 The *Braer* Oil Spill

Dr Kingston gave a report on the 1994 results of benthos studies of the sea bed affected by the wreck of the oil tanker *Braer* which went aground off Shetland on January 5th 1993.

The localized areas of oil accumulation in the sediments observed in the previous year were very much in evidence in 1994, showing, if anything, a slight increase in some of the transect stations (up to 11,000 ppm).

Samples were taken along the main transects established in 1993. This included the primary transect west of Burra Isle and the transect across the contaminated area off Fair

Isle. A similar approach was adopted as in 1993, with 5 $0.1m^2$ grab samples from each station. The data obtained was subjected to univariate, multivariate and population structure analysis.

Regardless of the continued exposure to relatively high concentrations of oil in sediment, there was no major disruption of community structure, although there was a small reduction in number of species and diversity (as measured by Hs) at the most highly contaminated sites. Opportunistic species, such as *Capitella* were conspicuous by their absence, with the small numbers observed in 1993 being reduced to a single individual taken over the whole survey.

There was a slight increase in the number of amphipods, although adundances were well below those that might be expected in the area. The intense settlement, in 1993, of unidentifiable juvenile *Thyasira* species in the most contaminated areas proved to be of *Thyasira sarsi*, a species known to carry oleotrophic bacteria on their gills with the ability to metabolize hydrocarbons. An MDS plot of the benthos data did not reveal any gradients of effect and simply separated the muddier stations of the south east Fair Isle area from the West Burra stations.

The high levels of residual oil in the sediments surveyed suggest that their is very little degradation of the oil taking place. The presence of diverse animal communities in these areas support this notion and suggests that the oil is of relatively low toxicity. A detailed account of the work will be published in *Marine Pollution Bulletin* in July 1995.

10.2 The *Aegean Sea* Oil Spill

In December 1992 the oil tanker *Aegean Sea* grounded near La Corunna, N.W. Spain, releasing about 60,000 tonnes of light crude oil. Benthic studies were undertaken to estimate the consequences of the spill on the subtidal infaunal benthos of Ria de La Corunna, Ria de Ares, Ria de Ferrol and the adjacent continental shelf. Studies were udertaken during 1993, 1994 , 1995 and are continuing. The paper in Annex 16 presents the results of the study in the first two years after the accident.

Temporal variation of infauna before the oil spill was known in two stations of La Corunna Bay, and thus the effect of the spill on the communities of these two sites could be ascertained. In the sandy station, species richness decreased and a high mortality of certain taxa occurred. At the other station, no major effect on species richness was recorded, probably because this community is better adapted to periodic disturbances. In both sites a dramatic increase in the abundance of opportunists was evident. Multivariate analysis revealed some changes in the community after the spill.

In other areas, previous information on benthic infauna was not available. However, a high mortality of the most sensitive species (*ie* amphipods) and a proliferation of opportunists was noted.

In all the studied areas most of the species affected by the oil spill have already recovered their normal densities. At this stage, we can conclude that the effect of the spill on the subtidal infauna was not catastrophic, and that the communities have recovered their normal structure.

11 ICES BENTHOS DATA BASE

The establishment of an ICES Benthos Data Base was discussed in a subgroup with participation of J. Craeymeersch, J.R. Larsen, H.J.J.F Hillewaert, and S. A. Steingrimsson.

J. R. Larsen gave some background information on this issue. As a follow up to the 1986 ICES North Sea Benthos Survey, The Benthos Ecology Working Group had recommended that ICES establishes a benthos data base. The work had been initiated at the meeting of the Working Group in 1994, where a feasibility study had been conducted. The background for this study is that the data from the 1986 survey is presently held at the NIE-CECE institute, Yerseke, The Netherlands. The working group had been ask to consider if it is possible to integrate the Yerseke-database into the ICES Environmental Data Bank held at the ICES Secretariat, and the conclusion was that this is possible. Unfortunately, no decision has been made yet, if ICES should establish a Benthos Data Base.

J. Craeymeersch described the BEDMAN database system and explained some of the problems that had been associated with the organisation of the data for the 1986 ICES North Sea Benthos Survey. These problems related to the lack of a common data reporting protocol for the survey and had resulted in a significant amount of work, mainly in checking species codes.

H.J.J.F Hillewaert demonstrated the data entry/data base system developed at the Belgium Fisheries Research Station. The system provides an easy and user-friendly way of getting all relevant data into a well defined structure. The system allows pictures of the species to be displayed on the screen.

S.A. Steingrimsson gave a presentation of the data base system presently held at the Marine Research Institute, Iceland. He explained that an integrated system for the management of marine benthos data has been partly developed and will be completed, once some basic problems are solved.

The presentations was followed by a discussion on species codes an how to maintain a data base of codes, taking problems with synonyms, splitting/lumping into account. It was agreed that there is no need to choose between the various systems, as long as there is a unique way of linking one system to the other (usually the latin name).

J.R. Larsen had prepared a description of the structure of a benthos data base (Annex 17). The structure serves two purposes: It could be a data reporting protocol for the 1996 North Sea Benthos Survey, and it could define the structure for an ICES benthos data base. The structure is generic in that it contains no assumptions about the software or hardware that will process and store the data. The structure is hierarchical, suited for implementation in a relational data base, but assumes the use of simple ASCII-files for the transfer of data between the national institutes and the data centre.

It was pointed out that the description is focused on soft bottom sampling and needed to be revised in order to support hard bottom activities. Moreover, the following discussion showed that additional information should be included as well. It was agreed that these revision should be coordinated by J.R. Larsen, based on inputs from other members of the subgroup.

The sub group felt that the data base description could serve as a data reporting protocol for the 1996 ICES North Sea Benthos Survey. It was agreed that a data entry program should be developed to facilitate the data handling for the survey.

The sub group recommends that the ICES Environmental Data Bank in cooperation with the sub group organises the data handling for 1996 ICES North Sea Benthos Survey. This commits participants in the survey to report the data to the ICES Environmental Data Bank, using the agreed protocol.

The rights to use the data was discussed. The ICES Environmental Data Bank uses a coding system according to which data can be made available to 1) the data originator 2) members of ICES working groups 3) persons outside ICES. This ensures that data submitted to the Data Bank is only made available to other persons, if the data originator permits this.

Problems regarding species lists, synonyms, etc. should be solved in cooperation between the ICES Environmental Data Bank and members of the BEWG.

After discussion with the Working Group as a whole it was recommended that:

1) ICES establishes a benthos data base,

2) the ICES Environmental Data Bank in cooperation with members of the BEWG defines a data reporting protocol for benthos data and develops a data entry program to support this protocol,

3) the ICES Environmental Data Bank in cooperation with members of the BEWG organises the data handling for the 1996 ICES North Sea Benthos Survey,

4) participant in the 1996 ICES North Sea Benthos Survey reports data to the ICES Environmental Data Bank, applying the agreed protocol. This should be done prior to an agreed deadline.

12 LIAISON WITH THE EFFECTS OF EXTRACTION AND MARINE SEDIMENTS OF FISHERIES WORKING GROUP

The chairman asked the Working Group to consider a request from the Extraction of Marine Sediments on Fisheries Working Group to hold its next meeting with them in Orkney so that the two Working Groups might liaise more effectively. However, since arrangements for the BEWG meeting in Aberdeen were already fairly advanced, it was suggested that a joint meeting be held in Aberdeen. The chairman agreed to contact Dr de Groot, chairman of the Extraction Working Group, to put this suggestion to him.

13 RECOMMENDATIONS

The Benthos Ecology Working Group recommends that the Benthos Ecology Working Group Meets at Aberdeen, Scotland on 1-4 May to:

1. Review co-operative benthic surveys throughout the ICES area.

2. Review studies on the effect of sea bed disturbance on benthic communities.

3. Finalize plans for a second North Sea Benthos Survey.

4. Report on progress in the use of computer aided taxonomy systems for the identification of benthos.

5. Review studies of the spatial relationship of benthos.

6. Review methods for the study of community structure of the benthos of hardsubstrata.

14 ACTION LIST

1 J Asjes to report on the effects of shellfish fisheries (*Spisula subtruncata*) activity on seabirds (black scoter).

2 D.Basford to report on the impact of trawling on benthos experiments in Gareloch.

3 D Connor, A Norrevang, H Rees and (S Steingrimsson) to review methods for the study of benthic communities of hard substrata.

4 D. Connor to report on progress on the BIOMAR project.

5 J Craeymeeersch to report on studies of the impact of beam trawls of benthos. J Craeymeersch to report on impact of shell fishing on benthos.

6 J Craeymeersch to distribute the BEDMAN program together with an extract of the data base together with the species data base.

7 J Craeymeersch, D Basford and L Watling to report on progress in the use of computer aided benthos identification systems.

8 J Craeymeersch, H J J F Hillewaert, S A Steingrimsson to submit comments on the proposed data base structure to J R Larsen.

9 J-M Dewarumez to report on long-term studies on an *Abra* community in the southern North Sea and English Channel.

10 J-M Dewarumez to report on progress on the GLOBEC project in the English Channel.

11 J-M Dewarumez to report on studies on meroplankton distribution in the southern North sea.

12 J-M Dewarumez will determine a sampling strategy for surveying the English Channel

13 G Duineveld to report on bioturbation studies.

14 G Duineveld to report on the use of DNA/RNA to study sediment quality and growth status of organisms.

15 K Essink to report on Dutch coastal nourishment studies.

16 K Essink to report on the Dutch Monitoring Programme and other projects of the Rijkswaterstat.

17 H Hillweit to report on monitoring the impact of sand and gravel extraction off the Belgian coast.

18 M Kaiser to report on impact of fishing activity on benthos in the Irish Sea.

19 P Kingston to contact the relevant scientists in Norway, Denmark and Sweden in order that they may choose relevant sampling sites in the Norwegian Deep, Skagerrak and Kattegatt for North Sea benthos survey.

20 P Kingston will prepare and present a propsal to the EEC in attempt to get some funding for the survey before the end of this summer (1995).

21 P Kingston will contact taxonomic experts in Norway, Sweden and Denmark for input into North Sea benthos survey and collate information on expertise supplied by other members of the Working Group..

22 I Kronke to report on long-term benthic studies off Nordeney.

23 I Kronke to report on studies in the Waddensea.

24 A Kunitzer to report on AMAP.

25 A Kunitzer to report on Arctic studies.

26 A Kunitzer to report on studies of the distribution of macroalgae in the shallow areas of the Baltic Sea.

27 Anita Kunitzer to report on progress on the Joint Assessment Monitoring Programme.

28 J-R Larsen to report on the ICES Science Meeting in Aalborg.

29 J-R Larsen to report on the meeting of ACME.

30 E Lopez-Jamar to report on long-term studies of benthic infauna off the north coast of Spain.

31 H. Rees to report on studies on coarse gravel habitats.

32 H. Rees to report on time series studies on benthos at marine waste disposal sites.

33 H Rumohr to report on the Baltic intercalibration exercise.

34 J Warzocha and M. Powilleit to report on further results of benthic studies in the Pommeranian Bight, including aspects of epifaunal distribution and bioturbative activity.

35 J Warzocha to report on long-term monitoring studies in Gdnya Bay.

36 L Watling to report on effects of trawling activity on benthos.

37 L Watling to report on studies of large scale patchiness of mega-infauna.

38 All working group members should attempt to find taxonomic experts willing to assist with the survey. Group members to inform the Chairman of their responses.

PARTICIPANTS BENTHOS ECOLOGY WORKING GROUP MEETING
(Faroe 3 - 6 May 1995)

Dr Jakob Asjes
Min of Transport, Publ Works and
Water Management,
North Sea Directorate
PO Box 5807, 2280 HV RIJSWIJK
The Netherlands
Tel +31 70 3366609
Fax +31 70 3900691

Mr D J Basford
Marine Laboratory
PO Box 101
Victoria Rd
Torry
Aberdeen
Tel +44 1224 876544
Fax +44 1224 295511
E-mail VAX::Basford@Marlab.AC.UK

Mr David Connor
Joint Nature Conservation Committee
Monkston House
PETERBOROUGH, PEI IJY UK
Tel +44 733 866837
Fax +44 733 555948

Mr Johan Craeymeersch
Netherlands Institute of Ecology
Vierstraat 28
4401 EA YERSEKE
The Netherlands
Tel +31 1131 1920
Fax +31 1131 3616
E-mail Craeymer@nioo.nl

Dr Jean-Marie Dewarumez
Station Marine de Wimereux
URA CNRS 1363
28 Av. FOCH,
BP 80
62930 WIMEREUX
France
Tel +33 21992919
Fax +33 21992901
E-mail dewa@loalit.univ-littoral.fr

Dr Gerard Duineveld
NIOZ
PO Box 59
1790 AB Den Burg
TEXEL
Netherlands
Tel +31 2220 69533
Fax +31 2220 19674
E-mail duin@nioz.nl

Dr Karel Essink
RWS Nat Inst for Coastal and Marine Management
PO Box 207
9750 AE HAREN
The Netherlands
Tel +31 50 331373
Fax +31 50 340772
E-mail essink@minvenw.rikz.nl

Mr Hans Hillewaert
Fisheries Research Station
Ankerstraat 1
B-8400 OOSTENDE
Belgium
Tel +32 59 320805
Fax +32 59 330629
E-mail hans.hillewaert@infoboard.be

Dr Paul Kingston (Chairman)
Institute Offshore Engineering
Heriot Watt University
EDINBURGH, EH144AS,
Scotland, UK
Tel +44 131 451 3303
Fax +44 131 449 6254

Dr Ingrid Kröncke
Forschungsinstitut Senckenberg
Schleusenstrasse 39a
26382 WILHELMSHAVEN
Germany
Tel +49 4421 947532
Fax +49 4421 947550

Dr Anita Künitzer
Umweltbundesamt
Bismarckplatz 1
14193 BERLIN Germany
Tel +49 30 8903 2824
Fax +49 30 8903 2285

Dr Jan Larsen
ICES, Palaegade 2-4
DK 1261 COPENHAGEN
Denmark
Tel +45 33 154225
Fax +45 33 934215
E-mail jrl@server.ices.inst.dk

Dr Eduardo López Jamar
Inst Espanol de Oceanografia
Apdo 130 15080 LA CORUNA
Spain
Tel +34 81 205362
Fax +34 81 229077

Dr Arne Norrevang
Univ. of the Faroes
Noatun
FR 100 TORSHAVN
FAROE ISLANDS
Tel +298 15306
Fax + 298 16844
E-mail arneoe@nvd.fo

Dr Martin Powilleit
Inst for Baltic Sea Research (IOW)
Seestrasse 15
D 18119 WARNEMUENDE
Germany
Tel +49 381 5197242
Fax +49 381 519744
E-mail powilleit@io-warnemuende.400.de

Dr Hubert L Rees
MAFF Fisheries Laboratory
Remembrance Av.
Burnham-on-Crouch
ESSEX
United Kingdom
Tel +44 1621 7872658
Fax +44 1621 784989

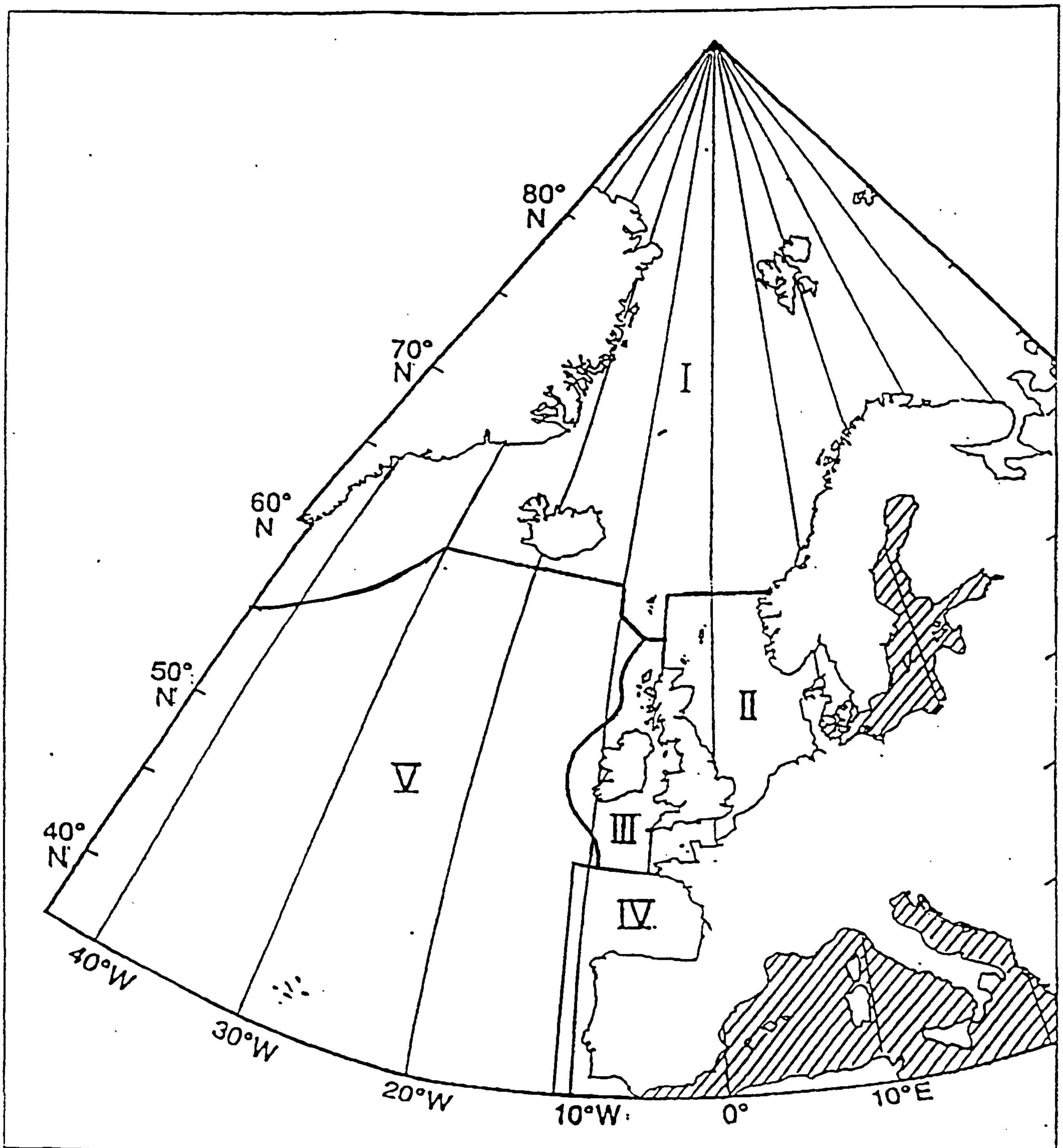
Dr Sigmar A Steingrimsson
Marine Research Institute
Skulagata 4
PO Box 1390
121 REYKJAVIK
Iceland
Tel +543 5520240
E-mail simmi@hefro.is

Dr Jan Warzocha
Sea Fisheries Institute
Ul Kollataja 1
GDYNIA Poland
Tel +48 58 201728
Fax +48 58 202831
E-mail Janw@miryb.mir.qdynia.pl

Dr Les Watling
Darling Marine Center
University of Maine
WALPOLE ME 04573
USA
Tel +1 207 563 3146 ext248
Fax +1 207 563 3119
E-mail watling@maine.maine.edu

National Monitoring Plan for the North East Atlantic

Figure 1: Map of the regions



Description of the Regions of the Maritime Area

Region I **Arctic Waters**

The region of the North-East Atlantic covered by AMAP from south of Greenland via Iceland, including the Faroes and along 62°N to the Norwegian coast (see Figure 1).

Region II **Greater North Sea**

As defined for the purposes of the North Sea Conferences (but extended to cover the Kattegat) i.e.:

a. southwards of 62°N and eastwards of 5°W, at the north-west side;

b. in the Kattegat, northwards of the line from Hasenore Head (DK) to Gniben Point (DK), from Korshage (DK) to Spodsbjerg (DK) and from Gilbjerg Head (DK) to Kullen (S);

c. eastwards of 5°W and northwards of 48°N, at the south side.

Region III **The Celtic Seas**

Western boundary: following the 200 m depth contour to the west of 6°W along the western coasts of Scotland and Ireland from 62°N to 48°N;
Eastern boundary: 5°W and the west coast of Great Britain from 62°N to 48°N.

Region IV **Bay of Biscay and Iberian Coast**

The region to the south of 48°N, to the east of 11°W and to the southern limit of the maritime area.

Region V **Wider Atlantic**

The region to the south of Region I, to the west of Regions II, III and IV and to the western and southern limits of the maritime area.

Holistic Joint Assessment and Monitoring Programme (JAMP)

	Issue	Monitoring and Assessment Procedure	Action by (comments)
1. Contaminants			
Cd, Hg, Pb	1.1 Are agreed measures effective in reducing inputs?	• undertake trend monitoring of atmospheric, riverine and direct inputs and other sources where appropriate.	INPUT
	1.2 What are the concentrations and fluxes in sediments and biota?	• monitor concentrations; • develop background values and assessment criteria; • compare concentrations with ecotoxicological assessment criteria.	SIME
TBT	1.3 To what extent do biological effects occur in the vicinity of major shipping routes, offshore installations, marinas and shipyards?	• establish standard methodology and quality assurance; • assess the inter-relationships between concentrations, biological effects and shipping intensities; • extend the imposex survey to the entire maritime area;[1] • compare concentrations with ecotoxicological assessment criteria	SIME (contact IMO)
PCBs[2]	1.4 What are the sources and input pathways?	• establish and assess sources and input pathways; • improve methods for quantifying inputs.	INPUT (consult DIFF)
	1.5 Are agreed measures effective in reducing inputs?	• undertake temporal trend monitoring of inputs;	INPUT
	1.6 Do high concentrations in marine mammals disturb enzyme systems?	• establish and assess concentrations, and temporaltrends in concentration, in marine mammals (particularly with regard to non-ortho and mono-ortho CB's); • establish and apply assessment criteria.	SIME (consult ICES)
	1.7 Do high concentrations pose a risk to the marine ecosystem?	• establish and assess concentrations in fish, mussels, birds and sediments.	SIME
	1.8 Do high concentrations of non-ortho and mono-ortho CB's in seafood pose a risk to human health?	• establish and assess concentrations in fish and shellfish for human consumption.	SIME

1 Possible repetition of this exercice in the North Sea in due course

2 These are as follows: CB 28, CB 52, CB 101, CB 118, CB 138, CB 153 and CB 180

PAHs[3]	1.9 What are the major sources and how large are the inputs?	• identify sources and input pathways; • monitorand quantify inputs;	INPUT (consult DIFF, SEBA, ICES)
	1.10 What are the concentrations in the maritime area?	• monitorconcentrations in sediments,mussels and suspended particulate matter; • establish background concentrations; • compare concentrations with background concentrations ; • establish assessment criteria; • compare concentrations with ecotoxicological assessment criteria.	SIME
	1.11 Do PAHs affect fish and shellfish?	• undertake biological effects monitoring.	SIME (consult ICES)
other synthetic organic compounds	1.12 How widespread are synthetic organic compounds within the maritime area?	• establish a selection mechanism for identifying compounds of concern .	SIME (consider DIFFCHEM results and work by EU and OECD)
offshore chemicals	1.13 Which chemicals are discharged and in what quantities?	• identify, quantify and assess inputs.	ASMO (consult SEBA)
	1.14 How and to what extent do the discharges affect marine organisms?	• undertake risk assessments; • undertake biological effects monitoring	ASMO (consult SEBA)
chlorinated dioxins and dibenzofurans	1.15 What concentrations occur and have the policy goals (for the relevant parts of the maritime area) been met?	• assess existing information on inputs	INPUT
		• assess existing information on the spatial distribution of chlorinated dioxins and dibenzofurans and the results of measures taken.	SIME (take account of NSCs)
environmental transport and fate of pollutants	1.16 What are the fluxes and environmental pathways? Where do persistent pollutants end up?	• model transport routes; • undertake research.	ASMO
biological effects of pollutants	1.17 Where do pollutants cause deleterious biological effects?	• identify biological effects monitoring techniques for important groups of pollutants; • establish quality assurance procedures; • identify, develop and apply biological effects monitoring criteria and techniques.	SIME (consult ICES)

[3] These are as follows: Phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*a*]pyrene, benzo[*ghi*]perylene, indeno[*1,2,3-cd*]pyrene.

oil	1.18 What are the inputs and concentrations in the maritime area and what are the effects on benthic communities and seabirds? Are agreed measures (for the shipping and offshore industries) effective?	• identify, quantify and assess river inputs; • identify, quantify and assess other inputs; • improve analytical methods for aromatics;	INPUT (take account of other fora e.g. BONN)
		• establish and assess concentrations; • establish and apply assessment criteria; • assess effects on benthic communities and seabirds.	SIME
	1.19 What are the effects of aromatics discharged with production water?	• establish and assess concentrations in water • undertake biological effects monitoring • compare concentrations with toxicity data	
radionuclides	1.20 What are the sources, inputs and temporal trends?	• assess RAD report	ASMO (consult RAD and EURATOM)
accidents in the shipping and offshore industry	1.21 What is the risk of accidental losses of oil and other chemicals to the maritime area? What is the risk of their transport to coastal and offshore ecosystems?	• develop and apply models and risk assessment procedures.	ASMO (take account of other fora e.g. IMO, BONN and FIPOL)

2. Eutrophication

nutrients	2.1 Are agreed measures effective in reducing inputs?	• assess temporal trends in inputs from all sources	INPUT
phytoplankton	2.2 Where do elevated nutrient concentrations or fluxes from anthropogenic sources cause an increase in the frequency and/or magnitude and/or duration of phytoplankton blooms and a change in species composition?	• define satisfactory monitoring programme	SIME
		• model nutrient concentrations	ASMO
eutrophication effects on community structure	2.3 How and to what extent does increased phytoplankton abundance and/or changed phytoplankton species composition and/or the presence of toxic phytoplankton species result in ecological disturbance?	• monitor to detect and assess the ocurrence of eutrophication effects; • monitor appropriate community components [illegible]	SIME
		• develop foodweb models	ASMO

3. Litter

sources and occurrence	3.1 What are the sources, composition and occurrence of litter at the sea surface, on the seabed and along shorelines?	• establish and assess sources, composition, occurrence and quantities of litter; • define common monitoring methodology; • trend monitoring.	IMPACT (take account of MARPOL)
	3.2 Are agreed measures effective?	• assess the effectiveness of measures.	IMPACT (take account of MARPOL)

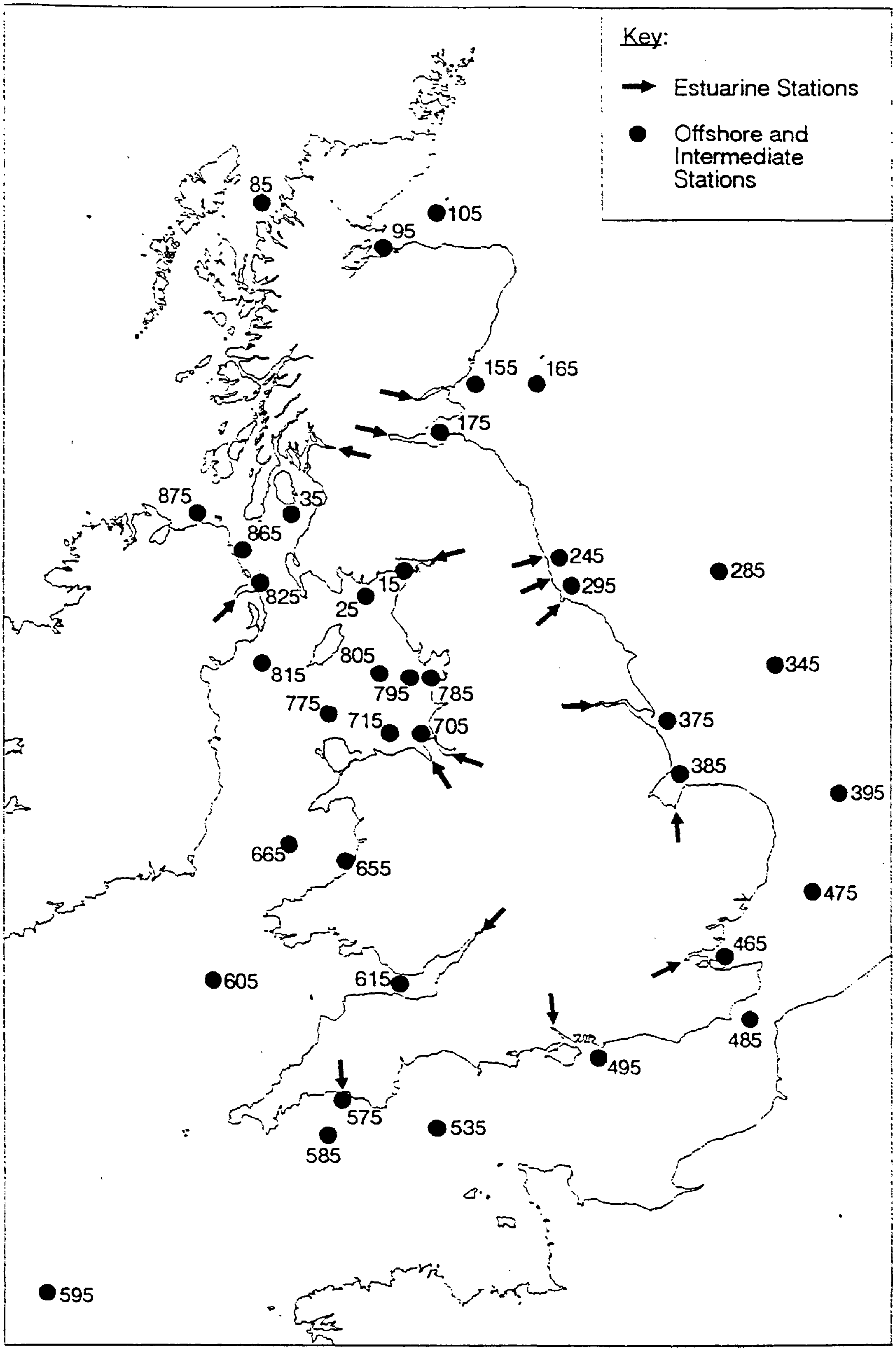
effects on birds and marine organisms	3.3 What are the effects of ingesting small plastic particles on marine coastal birds and other marine organisms?	• assess information on stomach contents in relation to health.	IMPACT
4. Fisheries			
impact of fisheries on ecosystems	4.1 How and to what extent do fisheries (including industrial fisheries) affect stocks of target and non-target species?	• assess available information on fish stocks and fishing intensities, particularly that relating to temporal trends; • assess available information on fisheries discards; • assess available information on by-catches.	IMPACT (take account of work by EU,ICES and national programmes)
5. Mariculture			
Genetic disturbance	5.1 To what extent do cultured fish and shellfish stocks affect the genetic composition of wild stocks?	• establish the genetic composition of wild stocks	IMPACT (consult ICES)
Transfer of diseases and parasites	5.2 What risks do cultured fish and shellfish stocks pose to wild stocks by possibly introducing diseases?	• Monitor diseases and parasites in wild stocks • Undertake risk assessments	IMPACT (consult ICES)
Chemicals used	5.3 In which areas do pesticides and antibiotics affect marine biota?	• Undertake a survey of concentrations/biological effects	IMPACT (consult ICES)
6. Habitats and Ecosystem Health			
ecosystem health	6.1 How can ecosystem health be assessed in order to determine the extent of human impact?	• develop background concentrations; • develop and apply ecotoxicological assessment criteria;	SIME
		• develop EcoQOs and identify suitable indicator species; • define a biological monitoring programme in relation to EcoQOs.	IMPACT
habitat changes	6.2 What are the areal extents, frequencies and inter-relations between the different types of habitat within the coastal and offshore environment?	• undertake habitat inventories	IMPACT
	6.3 What are the roles of different habitat types in the ecological functioning and the integrity of marine and coastal ecosystems?	• undertake literature survey	IMPACT
	6.4 How and to what extent do dredging and sand and gravel extraction affect communities (particularly benthic communities), coastal habitats and spawning areas?	• monitor benthic communities, coastal habitats and spawning areas	IMPACT (consult ICES)

	6.5 How and to what extent do coastal protection schemes and land reclamation activities affect coastal habitats, communities and species?	• monitor coastal habitats, communities and species	IMPACT (consult ICES)

Explanatory notes:

BONN Bonn Agreement
ICES International Council for the Exploration of the Sea
IMO International Maritime Organisation
EU European Union
NSC's North Sea Conferences

NMP Sampling Station Positions



Workingdocument

Ministry of Transport, Public Works and Water Management
Directorate-General for Public Works and Water Management
National Institute for Coastal and Marine Management / RIKZ

To
ICES Benthic Ecology Working
Group
Torshavn, Faroe Islands
May 3-6, 1995

From
Dr. Karel Essink
Date
27 april 1995
Document nr.
RIKZ/OS-95.607x
Subject
Developments in macrozoobenthos

Telephone
+31.50.331373
Appendices
-
Project
INTERNAT

SOME RECENT DEVELOPMENTS IN ZOOBENTHIC RESEARCH IN THE NORTH SEA

1. INTRODUCTION

In this document a selection of ongoing zoobenthic studies and results or publications will be shortly presented. The selected studies etc. are considered to be relevant to the work of the Benthic Ecology Working Group.

2. EASTERN SCHELDT

The integrated scientific report on the response of the Eastern Scheldt ecosystem to the construction of the storm-surge barrier in the mouth of that sea arm was published (NIENHUIS & SMAAL, 1994). This book contains 6 papers on macrozoobenthos and one on meiobenthos. A book review will appear in the Journal of Experimental Marine Biology and Ecology in 1995.

REFERENCE:

NIENHUIS, P.H. & A.C. SMAAL, 1994. The Oosterschelde estuary: a case-study of a changing ecosystem. Developm. in Hydrobiol. 97. Kluwer. Acad. Publ., Dordrecht-Boston-London.

Office Haren
P.O. Box 207, 9750 AE Haren, The Netherlands
Visiting address Kerklaan 30

Telephone +31 50 331331
Telefax +31 50 340772

Accessible with buslines 51, 53 and 59 from the Groningen station

3. MARINE EUTROPHICATION

Within the framework of the Rijkswaterstaat/RIKZ studies into the effects of eutrophication on the marine ecosystem a progress report was published on mesocosm experiments (SMAAL *et al.*, 1994). These studies are performed in close collaboration with the Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology (Yerseke, NL).
The report by SMAAL *et al.*(1994) contains the following parts:

* General introduction.
* Description of mesocosms, methods and comparison with North Sea conditions.
* Phytoplankton dynamics along phosphate gradients in mesocosms.
* The interrelationships between mussel grazing, nutrient cycling and phytoplankton dynamics.
* Nitrogen and phosphorus balances of the 1993 mesocosm experiments.
* Mesocosm model developments.
* Synthesis and conclusions.

REFERENCE:

SMAAL, A.C., J.C.H. PEETERS, H.A. HAAS & C.H.R. HEIP (Eds.), 1994. The impact of marine eutrophication on phytoplankton and benthic suspension feeders. Progress report I: results of mesocosm experiments with reduced P-load and increased grazing pressure. Rijkswaterstaat, National Institute for Coastal and Marine Management/RIKZ, Middelburg, Report RIKZ-94.035//Centre for Estuarine and Coastal Ecology, Yerseke, Report NIOO/CEMO-1994-2.

3. FURTHER DISPERSAL OF ENSIS AMERICANUS.

Following its first appearance in the inner German Bight in 1978, the North American Jackknife Clam *Ensis americanus* (syn. *Ensis directus*) spread in northern as well as in southwesterly direction along the coasts of NW-Europe. The first record in Belgium was in 1986. It lasted till 1991 before the first live specimens were observed along the coast of Northermn France (LUCZAK *et al.*, 1993).
Further dispersal along the U.K. coast of the North Sea seems likely; no observations have been reported yet.

REFERENCE:

LUCZAK, C, J.-M. DUWAREMEZ & K. ESSINK, 1993. First record of the American jack knife clam Ensis directus on the French coast of the North Sea. J. mar. biol. Ass. U.K. 73: 233-235.

4. MARENZELLERIA VIRIDIS IN NORTH SEA AND BALTIC SEA.

Based on the time sequence of first records of this North American spionid polychaete in the North Sea and Baltic Sea ESSINK & KLEEF (1988) postulated routes of dispersal along the western shore of the North Sea and into and in the Baltic Sea.
Recent results of enzyme electrophoresis by BASTROP *et al.*(1994) revealed major differences between North Sea (Ems estuary, Weser

estuary) and Baltic Sea populations, whereas there was a high degree of homogeneity among populations from the same area (Ems, Weser; Greifswalder Bodden, Darss-Zingst Bodden, Oderbucht). These findings gave rise to at least two hypotheses:

1) The observed genetic differences have been caused by selective pressure by environmental conditions, and
2) the polychaetes in the North Sea and the Baltic Sea are of different genetic origin; they may even be different species.

REFERENCES:

BASTROP, R., M. RÖHNER & K. JÜRSS, 1995. Are there two species of the polychaete genus Marenzelleria in Europe? Mar. Biol. 121: 509-516

ESSINK, K. & H.L. KLEEF, 1988. Marenzelleria viridis (Verrill, 1873)(Polychaeta: Spionidae): a new record from the Ems estuary (The Netherlands/Federal Republic of Germany). Zool. Bijdr., Leiden 38: 1-13.

5. EFFECTS OF COASTAL NOURISHMENT.

The MAST II programme Risk Analysis of Coastal Nourishment Techniques (RIACON) is being carried at North Sea sites in Denmark (Torsminde), The Netherlands (Terschelling) and Belgium (De Haan), as was reported at the BEWG meeting in Yerseke, May 1994.
Benthic fauna surveys have been made before and after the nourishment of the shoreface, and also before and after extraction of sand at the borrow site North of Terschelling.
Preliminary results indicate a rather quick recolonization of the sediments deposited at the nourishment site, among others by the opportunistic polychaete *Magelona papillicornis*. Sample analysis and data interpretation has not proceeded so far that statements can be made regarding the state of recovery of the benthic community in terms of species abundance, biomass or structure.
Survey reports on the Dutch sites are listed below.

REFERENCES:

DUYTS, O., 1995. The effects on benthic fauna of shoreface nourishment off the island Terschelling, The Netherlands. Report 2: Post-nourishment survey, April 1994. Rijkswaterstaat, National Institute for Coastal and Marine Management, Haren. Working Document RIKZ-94.604x.

VAN DALFSEN, J.A. & C. PINKHAM, 1994. The effects on benthic fauna of shoreface nourishment off the island Terschelling, The Netherlands. Report 1: Pre-nourishment survey, March 1993. Rijkswaterstaat, National Institute for Coastal and Marine Management, Haren. Working Document RIKZ-94.622x.

VAN DALFSEN, J.A. & J. OOSTERBAAN, 1995. The effects on benthic fauna of sand extraction off the island Terschelling, The Netherlands. Report 3: Pre-extraction survey, March 1993. Rijkswaterstaat, National Institute for Coastal and Marine Management, Haren. Working Document RIKZ-95.605x.

Workingdocument

Ministry of Transport, Public Works and Water Management
Directorate-General for Public Works and Water Management
National Institute for Coastal and Marine Management / RIKZ

To
ICES Benthic Ecology Working Group
Torshavn, Faroe Islands
May 3-6, 1995.

From
Dr. Karel Essink

Date
27 april 1995

Document nr.
RIKZ/OS-95.606x

Subject
Monitoring macrozoobenthos in the North Sea.

Telephone
+31.50.331373

Appendices
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Project
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CHANGE OF STRATEGY FOR MONITORING MACROZOOBENTHOS IN THE DUTCH SECTOR OF THE NORTH SEA

1. INTRODUCTION.

From 1991 onwards, the macrozoobenthos of the Dutch Continental Shelf has been monitored by annual sampling in May of 25 stations. At each station 5 cores were taken with a 0.068 m^2 box corer. Samples were sorted to species level as much as possible, and estimates of biomass per species were made, either by direct determination of ashfree dry weight or by conversion of wet weight to ashfree dry weight.

The execution of this Rijkswaterstaat monitoring programme is commissioned to the Netherlands Institute of Sea Research (Texel, NL). In 1994 a report was produced on the data obtained in 1991-1993; also for some stations a comparison was given with data collected previously (DUINEVELD & BELGERS, 1994). Only little signifant changes in density of single species could be demonstrated.

2. SAMPLING STRATEGY

In a study on sampling design of monitoring programmes for marine benthos Mr. Jaap van der Meer of the Netherlands Institute of Sea Research (Texel, NL) made a comparison between the use of fixed versus randomly selected stations. In this study the statistical power of univariate analysis of variance was also considered.

Office Haren
P.O. Box 207, 9750 AE Haren, The Netherlands
Visiting address Kerklaan 30

Telephone +31 50 331331
Telefax +31 50 340772

Accessible with buslines 51, 53 and 59 from the Groningen station

Van der Meer demonstrated that a sampling design with stations that are randomly selected each year will reveal a larger variance and a smaller statistical power than a sampling design in which stations are chosen randomly the first year and are revisited in succeeding years. A third sampling design with fixed non-ramdomly selected stations, will yield the largest statistical power, but will give biased estimates of the year-to-year changes in abundance of species (VAN DER MEER, 1994)
The statistical power analysis was presented in a previous meeting of the Benthic Ecology Working Group by Mr. Johan Craeymeersch.
As a practical approach for trendmonitoring of changes in marine benthos Van der Meer suggests 1) to sample at randomly selected stations, 2) to revisit these stations in succeeding sampling campaigns, and 3) to make little sampling effort at each station.

3. REDESIGN OF SAMPLING PROGRAMME.

The above considerations made us to change the sampling design of the monitoring programme for macrozoobenthos in the Dutch part of the North Sea in order to increase the statistical power.
The original design consisted of 25 stations, partly located along transects perpendicular to the coastline (Fig. 1). At each station 5 samples were taken with a 0.068 m^2 box corer.
Because of existing knowledge on the structure of the North Sea benthic fauna as obtained through the ICES North Sea Benthos Survey of 1986 (*e.g.* KÜNITZER *et al.*, 1992) and MILZON-BENTHOS surveys by Rijkswaterstaat North Sea Directorate, a stratified sampling design was developed. Four subregions were identified, *viz.* coastal zone, offshore, Oyster ground and Dogger bank. In addition to the 25 existing stations, in each subregions stations were chosen *quasi* randomly, *i.e.* in stead of a really randomly chosen station a most nearby station was chosen that had been sampled before in ICES-NSBS or MILZON-BENTHOS. Additional to the 25 existing stations 75 stations were distributed over the four subregions according to their differences in surface area. In the 'coastal zone', however, some extra stations were chosen to increase the statistical power. At each station only one 0.068 m^2 box core sample will be taken from May 1995 onwards.
The distribution of sampling stations over the four subregions of the Dutch sector of the North Sea is presented in Table 1 and Fig. 2.

Table 1. Distribution of sampling stations over subregions of the Dutch sector of the North Sea.

Subregion	No. of stations
Coastal zone	~~7~~ 15
Offshore	42
Oyster ground	36
Dogger bank	~~15~~ 7

4. REFERENCES.

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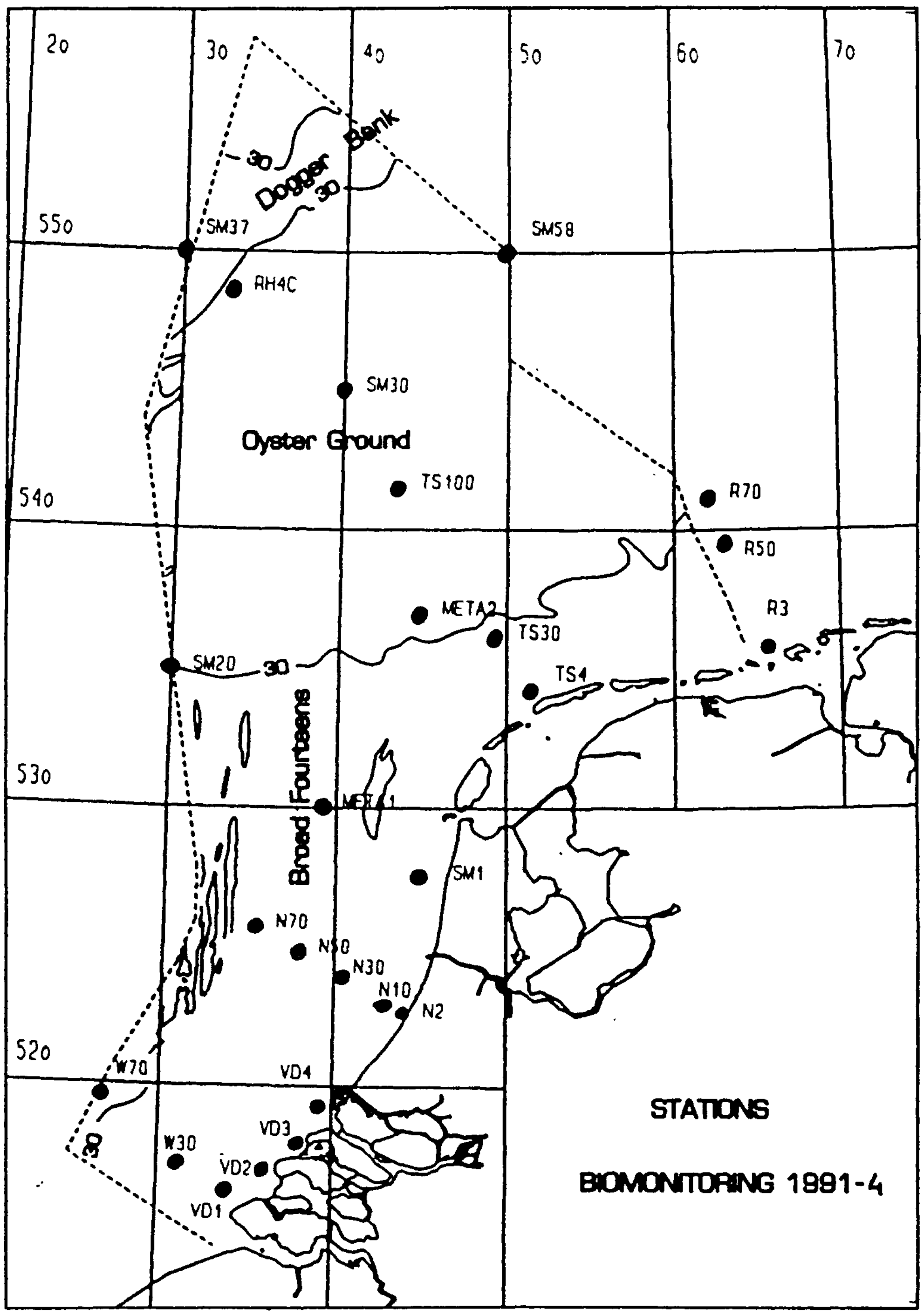


Fig. 1. Position of sampling stations for macrozoobenthos in 1991-94.

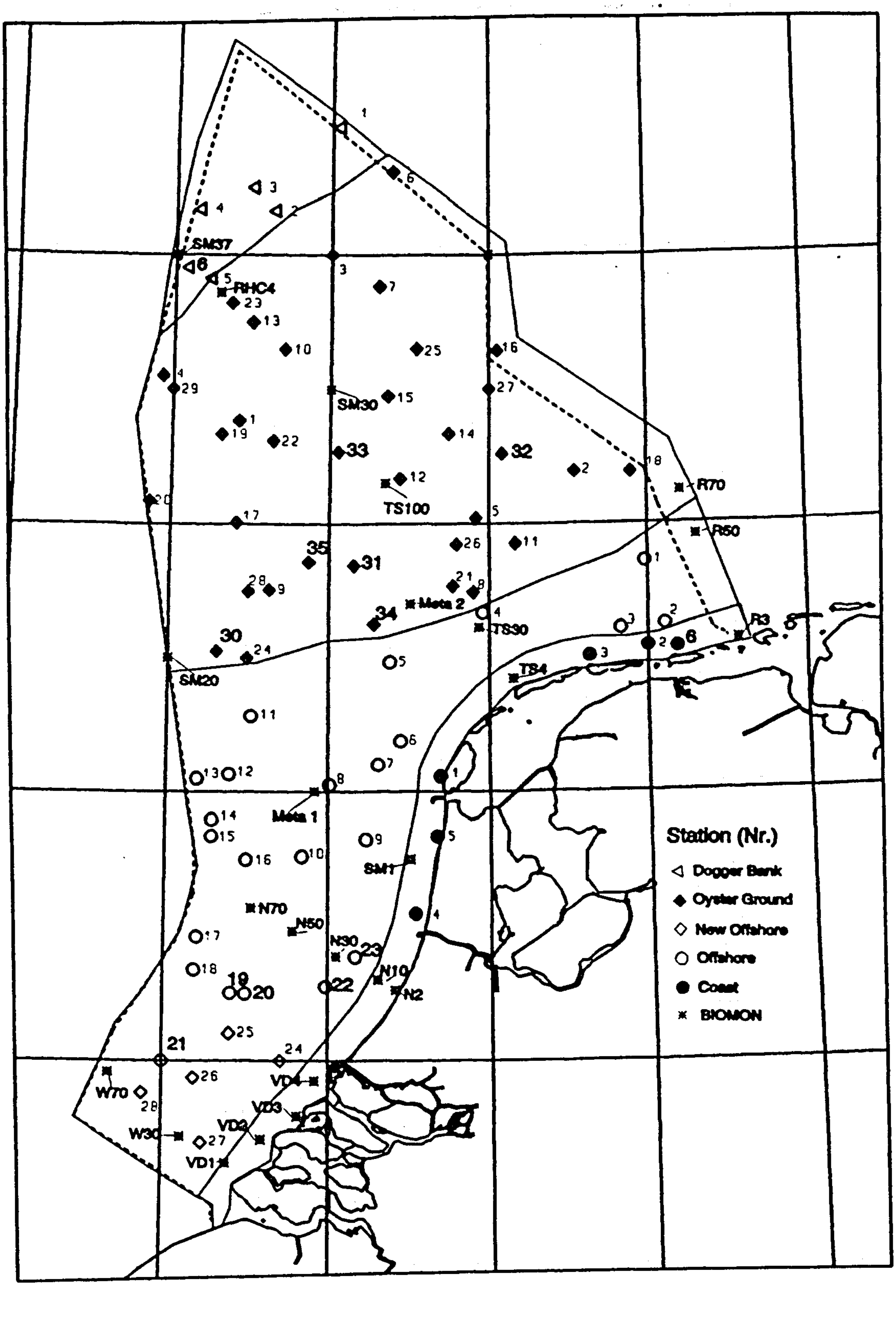


Fig. 2. Position of sampling stations for macrozoobenthos in 1995.

Impact of biodeposition on macrofaunal communities in intertidal sandflats

Ingrid Kröncke

Senckenberg Institute, Schleusenstr. 39a, 26382 Wilhelmshaven, FRG

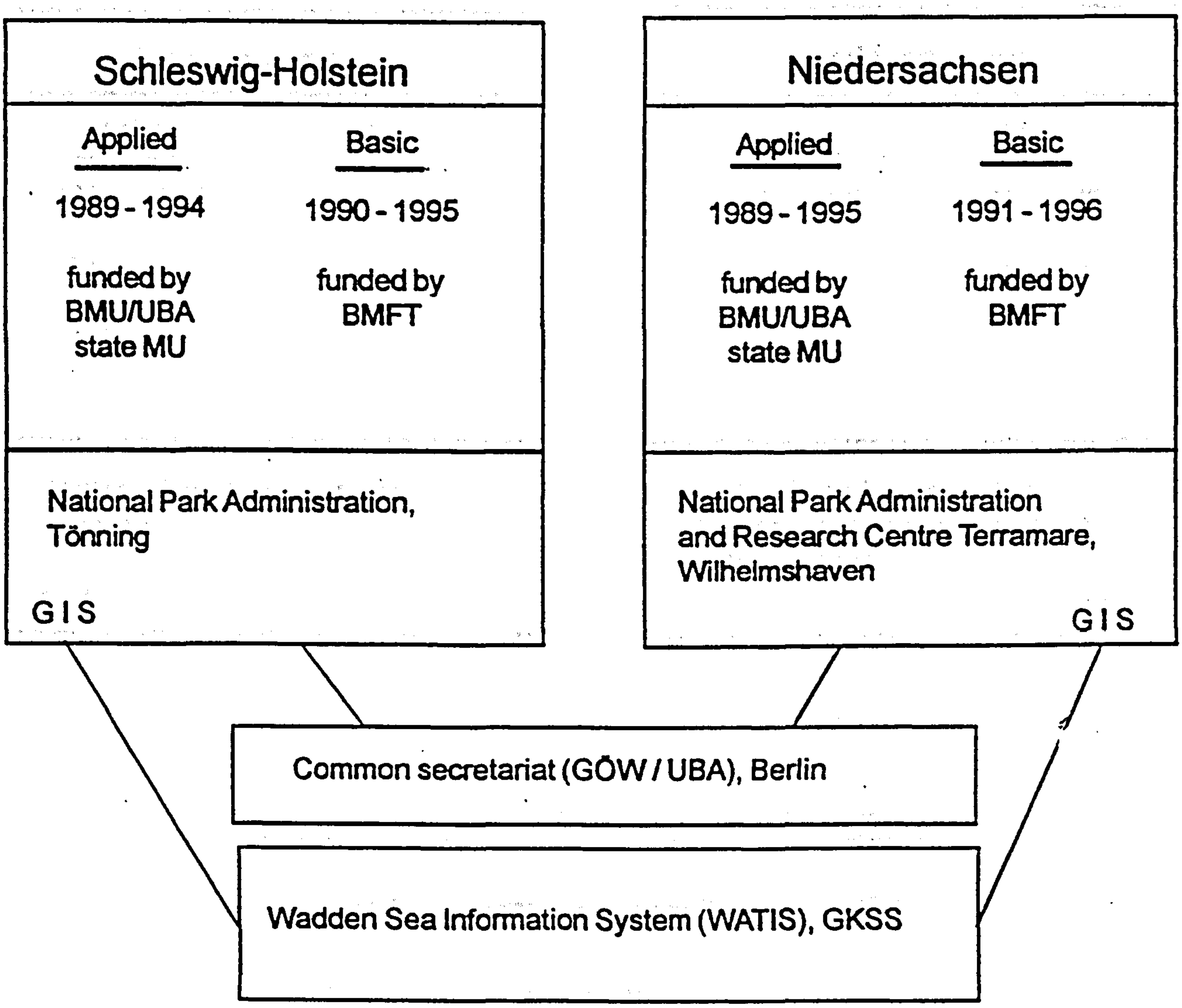
Area of investigation is the back barrier tidal flat system behind the East Frisian Island of Spiekeroog. Due to erosion by the ebb current a plume of biodeposits extends from an area of diffuse mussel beds (*Mytilus edulis*) towards the adjacent sandy sediments. This plume represents a gradient of decreasing concentrations of organic material. 6 sampling points were installed to analyse effects on benthos communities. The distance between the points extends 50 m. The macrofauna was sampled within sampling areas of 0.25 m^2.

The macrofaunal communities differed along the transect. In the mussel patches oligochaetes dominated, whereas along the transect deposit feeding polychaetes increased, finally ending in the communities of the sand flats. Within an interdisciplinary approach the changes in the communities will be discussed in the framework of organic carbon contents of sediments and interspecific relationships.

After an extending cover of green algae during summer and a cold winter, the mussels were almost completely eliminated from the back barrier tidal flat. Nevertheless sampling went on in order to investigate the 'regeneration' of the macrofaunal communities along the transect under a decreasing input of biodeposits.

Ecosystem Research in the Wadden Sea

Goals:
- understanding of interactions between nature and man
- scientific background for conservation policies
- developments of criteria for long-term surveillance



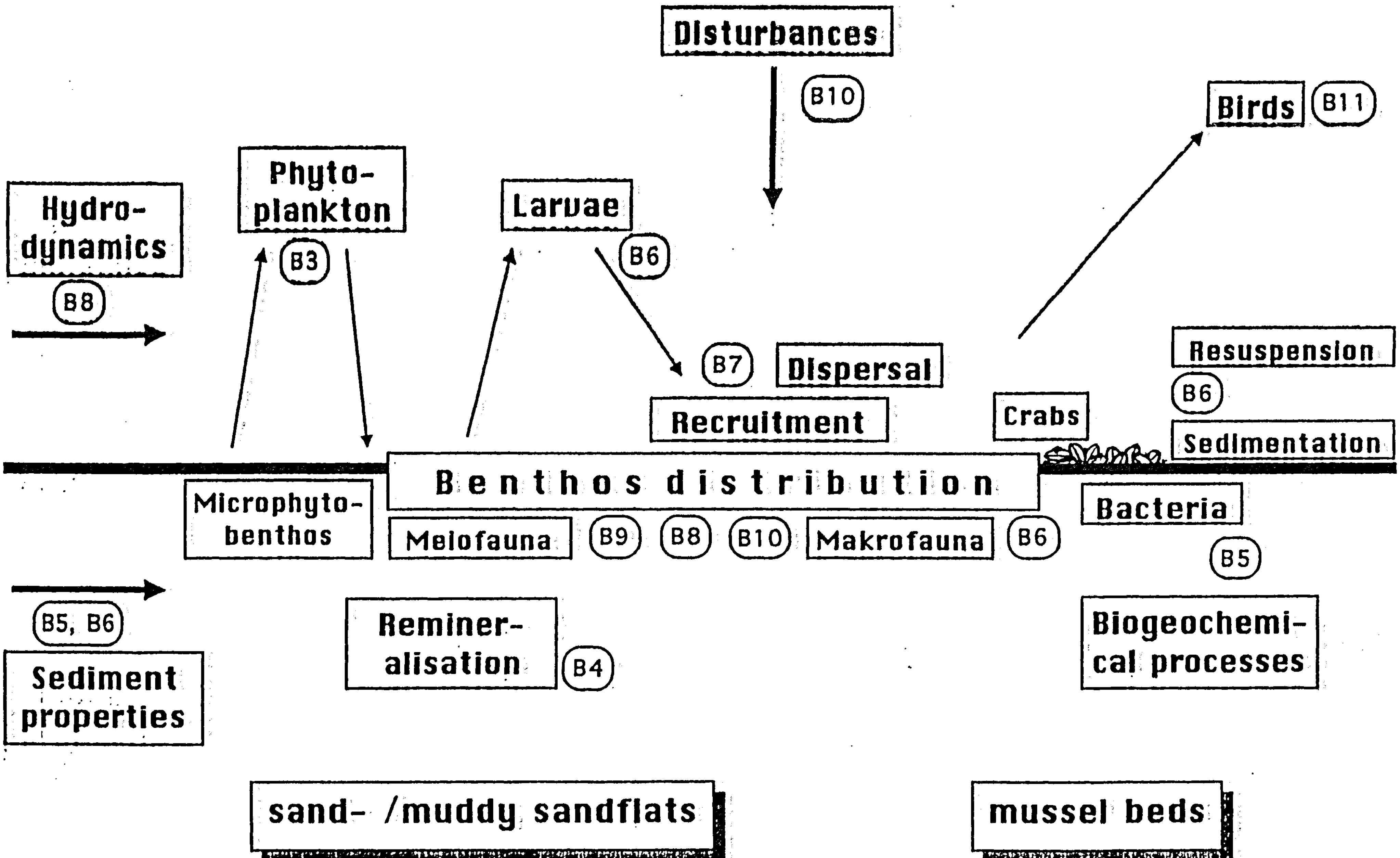
Ecosystem research in the Wadden Sea

Lower Saxony, Basic Research Part

ELAWAT: Resilience of the Wadden Sea ecosystem

hypothesis: The spatial and temporal dynamic of patches in the Wadden Sea facilitates resilience of the ecosystem.

resilience: ability of a system to restore its structure following a disturbance



ELAWAT - scheme of investigated parameters and processes, respective project numbers are given.

Long term studies in *Abra alba* community of the English Channel and Southern North Sea

Dr J-M Dewarumez

Data has been collected by Dr J-C Dauvin from stations at Pierre Noire and of the River Murlaix off Brittany, Dr B Eikaim from the Bay os Seine in the Central English Channel and Dr J-M Dewarumez from Grovelines in the Southern North Sea.

Statistical analysis was undertaken by Dr F Ibanez, Dr J-M Fromentin, Dr A Lepretre and Dr P Carpentier.

Four stations, instigated from the COST 647 project, were chosen for long term study since 1978. This report discusses data from samples collected between 1979 and 1982.

Initially a monospecific study based on the mollusc *Abra alba* was undertaken comparing the evolution of the population established on each site. These data were then compared with climatic data, particularly temperature. A relation between temperature and density was apparent but other factors were involved. The *Abra alba* community at the Grovelines station was particulaly well correlated with temperature, low abundaces ocurring after colder than average winters. This pattern was reflected in the Brittany and Bay of Seine sites with adelay of one or two years.

A multi-specific study based on the Grovelines data has been undertaken. The density data produced from this station indicate a 7 year cycle. During the period covered in this report two maximal levels were noted in 1979-80 and 1986-87. The species involved in these maximal years varied; in the former *Lanice conchelega, Pectinaria koreni* and *Mya truncata* were responsible whereas in the latter, *Spiophanes bombyx, Macoma balthica Ensis directus* and *Lanice concelega* caused the increase. In the intermediate years (1982-83 and 1989-90) when the winters were warmer *Abra alba* remained doiminant.

It is therefore assumed that climatic events may have considerable evolutionary effects on marine benthic communities. The more northerly Grovelines site appears to react faster than the more southerly stations. We assume that local events eg pollution in the Bay of Seine and oilspills off Brittany may nmask evolutionary effects linked to climatic change.

Macrofauna long-term studies in a subtidal habitat off Norderney (East Frisia, Germany) from 1978 until 1994

I. The late winter samples

Zeiss, Bernd & Kröncke, Ingrid
Forschungsinstitut Senckenberg, Abteilung für Meeresforschung
Schleusenstr. 39a, D-26382 Wilhelmshaven

Abstract

Macrofaunal samples were collected regularly during spring time from 1978 to 1994 in the subtidal zone off Norderney, one of the East Frisian barrier islands. The field work was carried out from a research vessel by means of a 0.2 m^2 van-Veen grab at five sites with water depths of 10-20 m. Abundance, biomass and species composition were analysed by means of cluster analysis and multidimensional scaling. The resulting patterns are discussed in terms of human impact and varying climatic conditions. Species survival is severely impaired by cold winters, whereas storms and hot summers have a minor impact. Mild climatic conditions and eutrophication are positively correlated with total biomass since 1989. In addition to environmental factors community is influenced by interspecific relationships including competition.

Further results of studies on the distribution and population dynamics and on bioturbative activity of macrozoobenthos in the Pomeranian Bight (Southern Baltic Sea).

Martin Powilleit[1], Jan Kube[1], Jerzy Maslowski[2], and Jan Warzocha[3]

1: Institut for Baltic Sea Research (IOW), Seestrasse 15, D-18119 Warnemünde, Germany

2: Academy of Agriculture, Szczecin, Poland

3: Sea Fisheries Institute, Gdynia, Poland

Up to six cruises, in a study (TRUMP) directed at evaluating the impact of input material from the river Odra on the distribution and on activity of the macrozoobenthos in the Pomeranian Bight (Southern Baltic Sea), were performed the last two years. A minimum of three bottom samples were taken at 34 locations using a box corer (0.0225 m2) and a Van-Veen grab (0.1 m2). Samples were sieved with 0.5 and 1mm mesh size, respectively. Abundance and biomass of each species were analysed following the HELCOM-guidelines. The programmes PREDABAN (Prena 1990) and PRIMER (Clarke & Warwick) were used for data analysis. Further data were collected on the population structure of the most dominant species in the study area and on sediment characteristics.

The total number of benthic species is 45 (about 15-25 per sampling location). Nine of these species have an occurence of more than 88% (one of them is Marenzelleria viridis) which indicates a homogeneous structed community. A multi-dimensional scaling analyses (MDS) of the species reveals four different assemblages according to different ecological habitats.

A cluster analysis of abundances suggests five different subareas of the Bight having different macrozoobenthos assemblages:

- the south western, estuarine zone is strongly influenced by the outflow of river Odra and the Greifswalder Bodden;
- the shallow Oderbank region with "poor" sand (very low organic content), including some stations in the eastern part of Pomeranian Bight;
- the area with "rich" sand, which covers central and eastern parts of the Bight;
- the deeper channel region in the north western part of the bight, which is connected to the southern part of the Arkona-Basin; and,
- the transition zone between the estuarine and the deeper north western part of Pomeranian Bight.

For each of these subareas we choose representative stations for further detailed macrofauna-, sediment- and bioturbation analyses/measurements.

Distribution pattern of single species allowed to find out the factors controlling their distribution. Highest macrofauna biomasses (100-150g AFDW/m^2) were found in the estuarine region near the river mouth with suspension feeders as being dominants. Pronounced gradients in macrofauna- and ATP-biomass exists from this coastal zone to outer parts of Pomeranian Bight with macrofauna biomasses of only 10-20g AFDW/m^2. Sediment characteristics are more or less equally distributed all over the Bight. The nutrition value of the near bottom water is considered to be the most important factor controlling macrofaunal distribution.

A first comparison of historical macrofauna data obtained by Loewe in the late fiftieth (Loewe 1963) shows some changes in distribution pattern. Species which are very sensitive against oxygen depletions like Cerastoderma lamarki, and Bathyporeia pilosa are nowadays restricted to the central and eastern parts of the investigation area whereas they were distributed all over the Bight in the late fiftieth.

In late summer 1994 a strong thermal stratification of the water column in a large area of Pomeranian Bight resulted in a drastic oxygen depletion and hydrogen sulfide release. These causes a mass mortality of either all macrobenthic species or at least a reduction of biomass and abundance in the south western part of the Bight. Until now the effect of these catastrophic event can still be seen on several locations and will be monitored in future cruises.

To determine the bioturbative exchange of dissolved substances at the sediment-water interface we performed tracer experiments with sediment cores in the laboratory. We used bromide as an inert tracer for dissolved substances. By means of a multi-box, non-steady state, diffusion model we simulated exchange coefficients on the basis of tracer concentrations in the water column (initial and final values), vertical profiles of tracer concentrations in the pore water, and the porosity of single sediment layers. Model calculations are based on Fick`s first law of diffusion adapted to sediments. An "effective sediment diffusion coefficient" (Deff.) of the active benthic community was compared to an "molecular sediment diffusion coefficient" (Ds.) excluding all fauna. The ratio Kbio (Deff/Ds.) was finally calculated to quantify the increase of the diffusive flux due to the benthic community (e.g. Powilleit et al. 1994; Forster et al. 1995). Values of Kbio was highest, i.e. 23.7, at the coastal station GB2 with the dominant species Marenzelleria viridis, Nereis diversicolor and Mya arenaria in the sediment cores. At station H48 in the outer sandy part of the investigation area, with the dominant species Macoma balthica, Marenzelleria viridis and Nereis diversicolor, we calculated a medium Kbio of 17.5 and at station 39 on the Odrabank a Kbio of 7.1 , with medium sized Mya arenaria as being dominants. Generally high transport rates in coastal regions are connected with the occurence of either one of the large polychaetes or of large specimen of Mya arenaria. The transport mechanisms involved in these tracer transports are siphon movements, crawling of bivalves through shell contractions, and irrigation activity and burrow building by polychaetes. Comparing these transport rates with literature data from other coastal areas our data, especially the one from coastal stations, are high.

Literature:

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A report submitted to the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries, 1995.

THE EFFECTS OF MARINE GRAVEL EXTRACTION ON THE MACROBENTHOS: AN OFFSHORE EXPERIMENTAL STUDY.

A J Kenny and H L Rees

MAFF, Directorate of Fisheries Research
Fisheries Laboratory
Burnham-on-Crouch, Essex, UK.

Introduction

During the 1960s concern was expressed over the potential impact of marine gravel extraction on the macrofauna and the effect this would have on commercial fisheries. At that time the Ministry of Agriculture, Fisheries and Food (MAFF) began a programme of research at the Burnham-on-Crouch Laboratory in collaboration with colleagues at Lowestoft to determine the impact of dredging on the feeding and spawning grounds of economically important fin-fish species, such as the sand eel (*Ammodytes ammodytes*; MAFF, 1981). Research was also directed towards understanding how the sea-bed sediments were altered after dredging and how persistent these changes would be (Shelton and Rolfe, 1972; Dickson and Lee, 1972; Millner *et al.*, 1977 and Lees, 1990). However, due to difficulties of sampling coarse sediments and uncertainties over the location, timing and magnitude of dredging, they were unable to quantify accurately the initial impacts and subsequent processes of macrobenthic recolonisation.

In October, 1990 a study, jointly sponsored by the Crown Estate Commissioners (CEC) and MAFF, was given the task of quantifying the impacts of commercial aggregate dredging and examining the rates and types of recolonisation post-dredging.

Preliminary results of that study indicated that whilst the dominant species recolonised quickly (i.e. within 8 months after dredging) the biomass remained significantly lower than its pre-dredged state (Kenny and Rees, 1994), suggesting possible long-term effects on the community structure.

This report presents the physical and biological findings some 2 years after dredging.

Methods

Following an extensive survey off North Norfolk a small area of sea-bed gravel (500 metres by 270 metres) was selected for experimental dredging (Figure 1a). The site was dredged over a 5 day period by a modern 'H' class suction-trailer dredger. A total of 52,000 tonnes of commercial coarse aggregate was removed, representing about 70% of the total surface area of the experimental site.

A reference site (1 mile distant) was also selected, having similar physical and biological characteristics to the dredged (treatment) site.

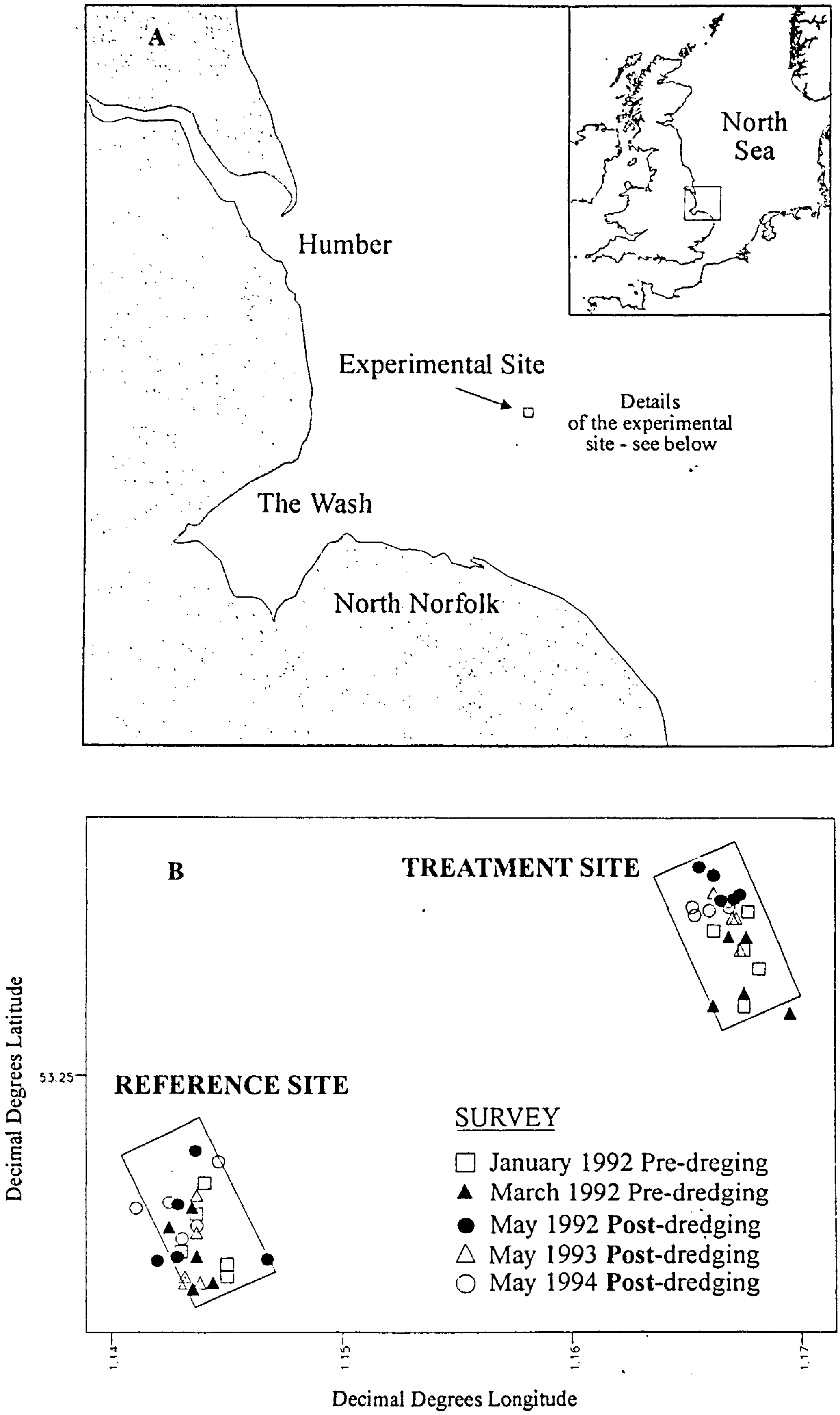


Figure 1. Experimental reference and treatment sites showing the position of Hamon grab samples taken pre- and post-dredging.

Samples of the sediment were obtained using a Hamon grab (see Holme and McIntyre, 1984) and were processed in the field and laboratory according to the procedures given in Kenny and Rees (1994). Grab samples were located at random within the confines of the 'treatment' and 'reference' boxes both before and after dredging (Figure 1b).

Sediment sub-samples (approximately 0.5 litre) were analysed for their particle size distributions according to the Udden-Wentworth Phi classification, where Phi=$-\log_2 d$ and d is the particle size diameter in millimetres, following the procedures given in Kenny and Rees (1994).

Physical images of the sea-bed (sonographs) at the treatment site were obtained pre- and post-dredging using a dual frequency EG&G side-scan sonar.

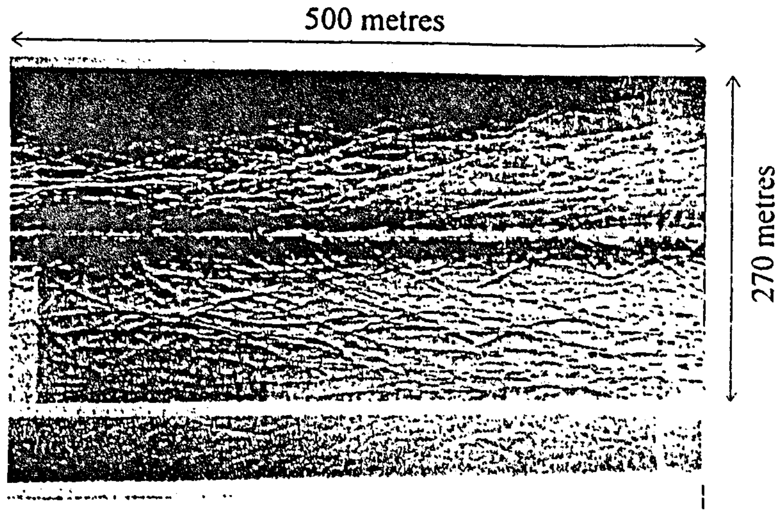
Results and Discussion

Physical observations

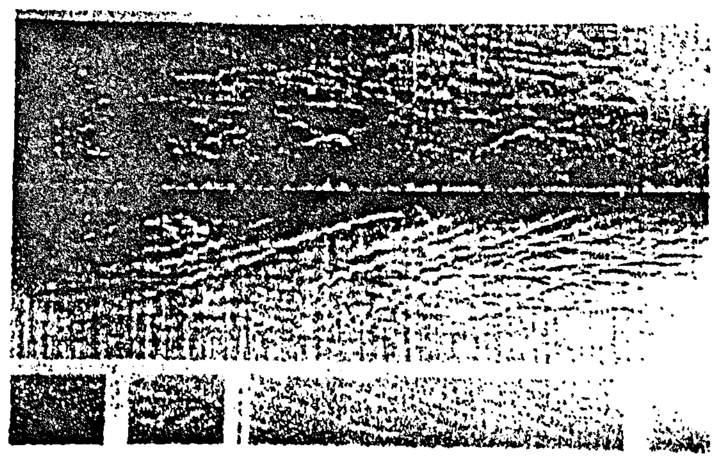
Side-scan sonar records and underwater pictures of the sea-bed provided a physical overview of the sediments both before and after dredging. The sea-bed at the treatment site pre-dredging consisted of a uniform gravelly sediment with an even surface profile. However, after dredging it was apparent that the drag-head had created well defined furrows measuring about 1 to 2 metres wide and about 0.3 to 0.5 metres deep, covering a large proportion of the dredged box (Plate 1a). In addition, photographs of the sea-bed at the treatment site in May, 1992 (2 weeks after dredging) revealed the presence of sand ripples along the base of the dredge tracks (Kenny and Rees, 1994). Underwater video images of these sand ripples taken over a complete tidal cycle showed that the sand ripples changed direction in accordance with the prevailing tidal conditions (i.e. the flood and ebb tides). This indicates that the sand in newly formed dredged tracks is subject to tidal transport and may, in part, account for the noticeable absence of epifauna on exposed gravels in the dredge tracks.

During the May, 1992 survey it was estimated by SCUBA divers that the sea-bed had been lowered by nearly 2 metres in areas where the drag-head had followed the same path several times. By May, 1993 (1 year after dredging) it was apparent that the dredge tracks could no longer be distinguished using underwater cameras. However, the physical effects on the sea-bed remained identifiable using the side-scan sonar (Plate 1b). The weathering of dredge tracks may have been due to increased wave action over the winter months which, combined with the prevailing tidal currents, would serve to increase sediment transport at that time. By May, 1994 (2 years after dredging) the dredged furrows were further eroded and remained only just visible as distinct features using side-scan sonar (Plate 1c).

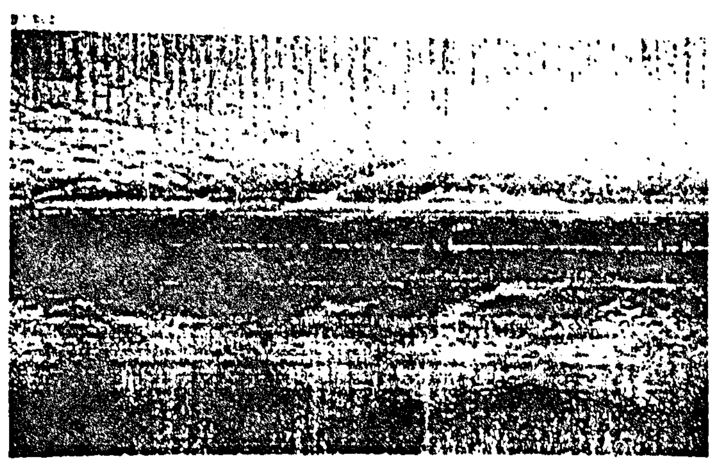
Static particle size distributions at the reference and treatment sites in March, 1992 (before dredging) were very similar (Figure 2), exhibiting the same proportions of sand and gravel and both having a distinctive mode at about 0.18 mm (fine sand). However, the sediment characteristics at the treatment site post-dredging are much more variable (in time) than those the reference site which remained relatively



a. December 1992 (8 months post-dredging).

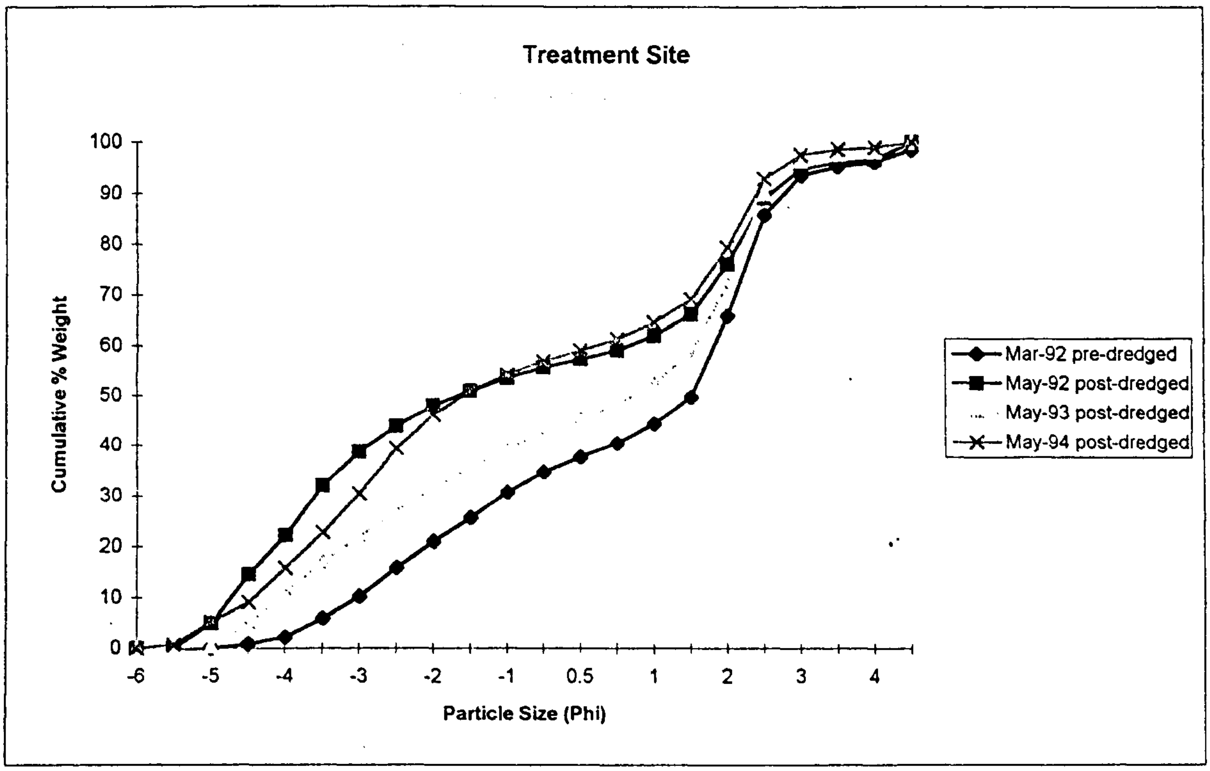


b. May 1993 (12 months post-dredging).



c. May 1994 (24 months post-dredging).

Plate 1. Side-scan sonographs of the sea-bed at the treatment site post-dredging (a-c), showing the disappearance of dredge tracks with time.



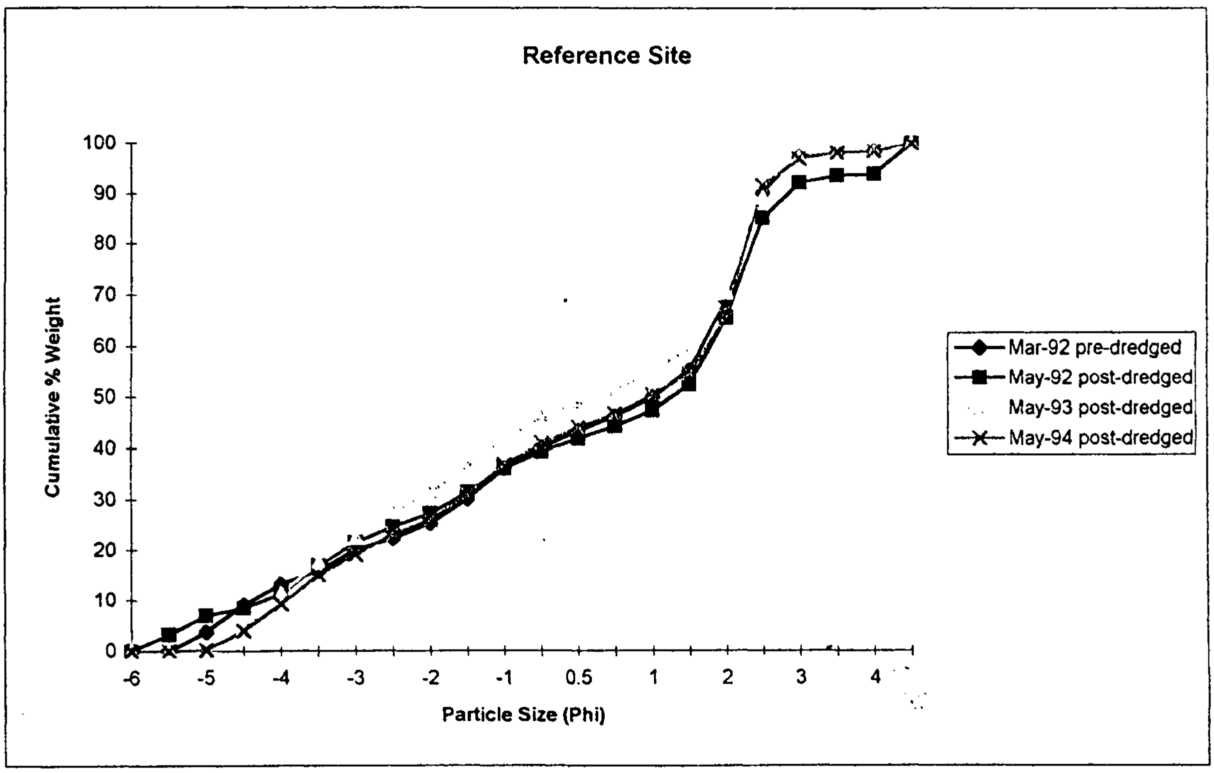


Figure 2. Average particle size distributions determined from 5 Hamon grab samples taken pre- and post-dredging at the reference and treatment sites.

constant. At the treatment site there has been a tendency towards an increase in the proportion of coarse sediment (>2 mm). This may, in part, be explained by the presence of a gravel 'rich' layer which was identified at the treatment site before dredging, using a vibrocore, between 0.05 and 0.7 metres deep. The action of suction-trailer dredging would therefore have resulted in the exposure of this gravel 'rich' layer which may account for the increased gravel content at the treatment site post-dredging.

In conclusion, dredging has transformed a relatively even, uniform and stable sea-bed into a sea-bed characterised by furrows and ridges subject to increased sediment transport which has led to a significant erosion of the dredge tracks.

Biological observations

Derived mean densities of all taxa at the treatment and reference sites is shown in Figure 3a. Mean densities at the treatment site in January and March, 1992 (pre-dredging) were 3833.4 and 591.4 individuals $0.25m^{-2}$, respectively, whereas in May, 1992 (immediately post-dredging) this had fallen significantly to 34.4 individuals $0.25m^{-2}$. However, a significant increase was observed during the first 12 months following dredging with densities increasing from 34.4 to 447.4 individuals $0.25m^{-2}$ in May, 1992 and May, 1993, respectively. Densities at the treatment site in May, 1994 remained relatively constant at 424.6 individuals $0.25m^{-2}$. Although the densities at the treatment site some 2 years after dredging remain significantly lower that at the reference site they have nevertheless returned to their pre-dredged levels.

The average number of species recorded from 5 Hamon grab samples taken at the treatment and reference sites pre- and post-dredging is shown in Figure 3b. The reference site exhibited an almost constant number of species (about 35) during the 29 month sampling period. By contrast at the treatment site a significant reduction in the average number of species, from 38 to 13, had occurred immediately post-dredging. However, during the 12 month post-dredging period, between May, 1992 and May, 1993, a significant two fold increase was observed from 13 to 25 species. The number of taxa at the treatment site 12 months after dredging was not significantly different from the reference site or the treatment site in its pre-dredged state.

The number of taxa continued to increase, albeit more slowly, between May, 1993 and May, 1994, increasing from 25 to 30 taxa. Overall, this suggests that the greatest period of recolonisation had taken place during the months immediately following dredging. Indeed, during the first 12 months after dredging some 67% of the of taxa present before dredging had recolonised.

Trends in biomass at each site pre- and post-dredging are in general agreement with those for taxa and abundance (Figure 3c). Immediately post-dredging the biomass was reduced dramatically from 22g (ash free dry weight) m^{-2} to 0.2 g (AFDW) m^{-2}, in March and May, 1992, respectively. However, the biomass increased only slightly during the first 12 months after dredging from 0.2 g (AFDW) m^{-2} to 1.5 g (AFDW) m^{-2}. Between May, 1993 and May, 1994 the biomass at the treatment site had fallen from 1.5 g (AFDW) m^{-2} to 0.7 g (AFDW) m^{-2}, respectively. At the reference site over

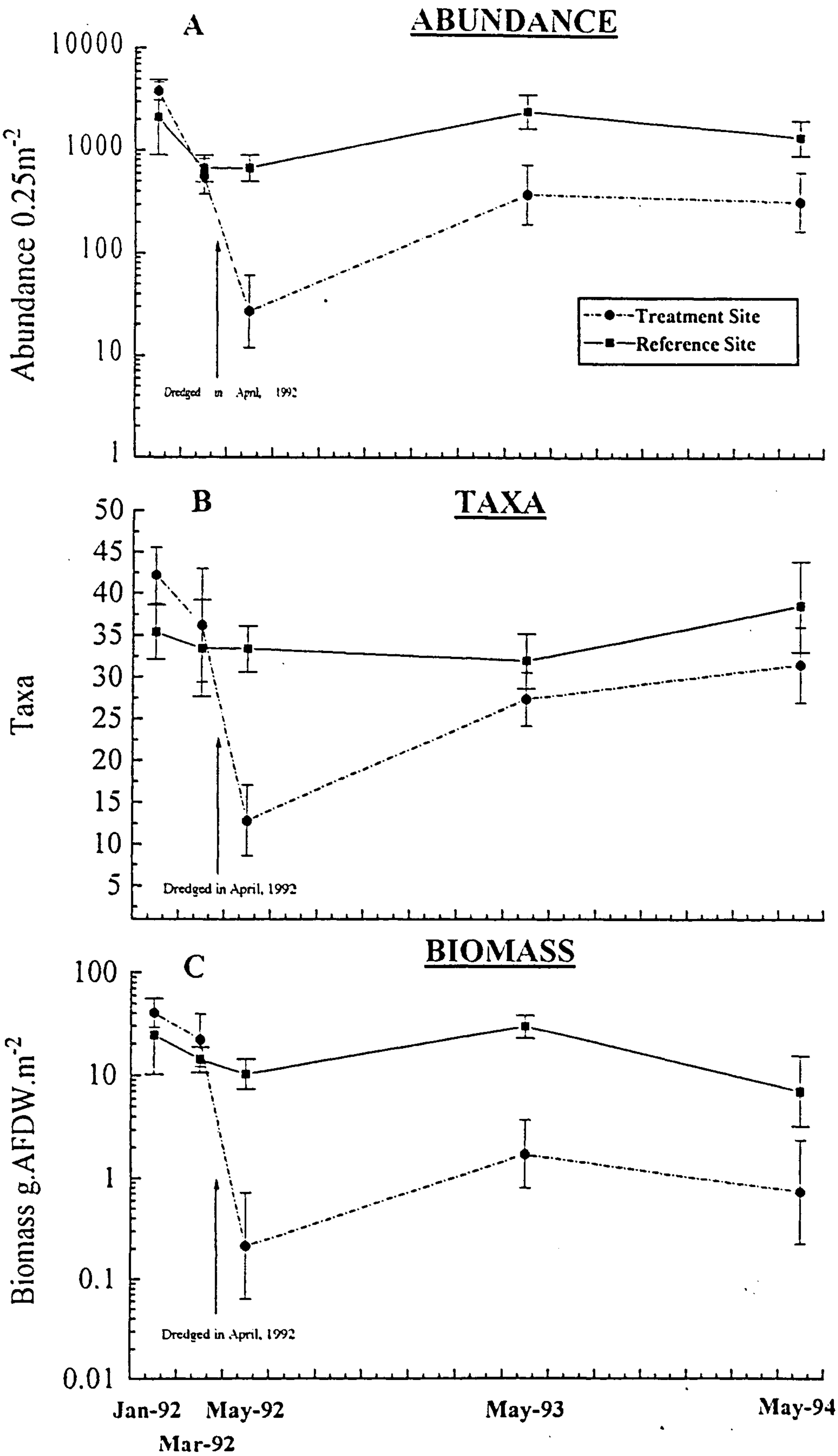


Figure 3. Plots of abundance, taxa and biomass determined from 5 Hamon grab samples taken at the reference and treatment sites pre- and post-dredging. January and March, 1992 samples were taken before dredging, whilst May, 1992, 1993 and 1994 samples were taken after dredging. Error bars represent 95% confidence limits.

the same post-dredging period the biomass remained significantly greater ranging between 10 and 30 g (AFDW) m^{-2}.

Although the biomass at the treatment site some 2 years after dredging remains significantly lower than its pre-dredged state, the difference between the treatment and reference site biomass has become less significant owing to a greater fall in the biomass at the reference site relative to the treatment site between May, 1993 and May, 1994.

The top 16 species ranked according to their percentage mean dominance (% MD), from samples taken pre- and post-dredging at the treatment and reference sites is given in Table 1. The advantage of ranking the species in terms of % MD is that any change in the dominance or type of species within the community caused by dredging can easily be identified. Table 1 clearly shows that the overall complement of the dominant species remained similar both before and after dredging, although the average species abundance and biomass was dramatically reduced.

It is apparent from the output of non-metric multi-dimensional scaling (MDS) that the reference site samples have been grouped with the treatment site samples taken in March, 1992 (pre-dredged), indicating that both sites were biologically similar before dredging (Figure 4). In addition there was very little variation between the samples at the reference site during the 2 year survey period between May, 1992 and May, 1994. However, at the treatment site the samples taken immediately after dredging (May, 1992) are clearly separated to the left of the main cluster and also display an increase in the distance (biological dis-similarity) between each other. Samples taken 12 months after dredging in May, 1993 indicate that there is a shift in the composition and abundance of fauna back towards the pre-dredged state, that is towards recovery. However, samples taken in May, 1994 (some 2 years after dredging), rather than showing a further shift towards the pre-dredged state have remained clustered with the May, 1993 samples.

In conclusion, evidence from side-scan sonar records and underwater cameras indicate a considerable amount of sediment transport had occurred during the first two winters following dredging such that the once well-defined dredge tracks had become infilled with sand and gravel. There is no evidence of any change in the composition of the dominant species after dredging which may have been expected due to the increased amount of sediment transport. However, the substantially reduced biomass at the treatment site some 2 years after dredging is thought to be directly related to sediment disturbance maintaining the community at a stage dominated by newly settled individuals with small individual body size and low biomass.

It may be predicted that a return to the pre-dredged physical state of stability would therefore contribute greatly to an increase in the community biomass. If the physical instability of the environment were to persist then, clearly, the community would unlikely ever return to its pre-dredged state.

The consequence of a persistent and much reduced biomass following commercial dredging will clearly depend on its 'value' to higher trophic groups and on its

Jan-92 — Treatment Site (Pre-dredged)

Species	% M.D.
Dendrodoa grossularia	51.28
Balanus crenatus	42.39
Amphipoda	1.74
Sabellaria spinulosa	0.74
Lanice conchilega	0.71
Pisidia longicornis	0.32
Aonides paucibranchiata	0.30
Nebalia bipes	0.30
Pholoe minuta	0.29
Syllis cornuta	0.27
Harmothoe impar	0.22
Spio martinensis	0.22
Maldanidae	0.12
Poecilochaetus serpens	0.11
Nephtys sp	0.11
Molgula occulta	0.08
Av. Abundance	**3833.4**

Mar-92 — Treatment Site (Pre-dredged)

Species	% M.D.
Balanus crenatus	53.60
Dendrodoa grossularia	26.92
Amphipoda	4.80
Sabellaria spinulosa	1.62
Pisisdia longicornis	1.45
Syllis cornuta	1.15
Poecilochaetus serpens	0.98
Lanice conchilega	0.95
Pholoe minuta	0.91
Maldanidae	0.74
Aonides paucibranchiata	0.71
Spio martinensis	0.54
Nephtys sp	0.41
Glycera lapidum	0.41
Caulleriella sp	0.41
Harmothoe impar	0.41
Av. Abundance	**591.4**

May-92 — Treatment Site (Post-dredged)

Species	% M.D.
Dendrodoa grossularia	29.65
Balanus crenatus	25.58
Amphipoda	15.12
Pisisdia longicornis	6.40
Poecilochaetus serpens	2.91
Pholoe minuta	2.33
Nebalia bipes	2.33
Spio martinensis	1.74
Mysella bidentata	1.74
Aonides paucibranchiata	1.74
Maldanidae	1.74
Syllis cornuta	1.16
Ophiura albida	1.16
Lanice conchilega	1.16
Lumbrinereis gracilis	1.16
Sabellaria spinulosa	1.16
Av. Abundance	**34.4**

May-93 — Treatment Site (Post-dredged)

Species	% M.D.
Dendrodoa grossularia	71.21
Balanus crenatus	14.84
Amphipoda	4.74
Sabellaria spinulosa	4.11
Molgula occulta	0.54
Pisidia longicornis	0.49
Syllis cornuta	0.36
Spio martinensis	0.31
Pholoe minuta	0.27
Poecilochaetus serpens	0.27
Lumbrinereis gracilis	0.27
Maldanidae	0.27
Cumacea	0.27
Glycera lapidum	0.22
Nephtys sp	0.22
Pomatoceros lamarcki	0.22
Av. Abundance	**447.4**

May-94 — Treatment Site (Post-dredged)

Species	% M.D.
Dendrodoa grossularia	48.56
Balanus crenatus	28.92
Amphipoda	10.65
Spiophanes bombyx	2.17
Sabellaria spinulosa	0.94
Caulleriella sp	0.89
Poecilochaetus serpens	0.89
Polycirrus medusa	0.80
Pholoe minuta	0.71
Aonides paucibranchiata	0.66
Syllis cornuta	0.61
Spio martinensis	0.47
Molgula occulta	0.42
Glycera lapidum	0.33
Nebalia bipes	0.33
Exogone niadina	0.33
Av. Abundance	**424.6**

Jan-92 — Reference Site

Species	% M.D.
Balanus crenatus	81.22
Dendrodoa grossularia	59.30
Pisidia longicornis	1.42
Amphipoda	1.23
Sabellaria spinulosa	0.58
Lanice conchilega	0.43
Pholoe minuta	0.42
Syllis cornuta	0.26
Aonides paucibranchiata	0.26
Spio martinensis	0.22
Nebalia bipes	0.19
Harmothoe impar	0.12
Maldanidae	0.11
Crepidula fornicata	0.11
Leptochiton asellus	0.10
Nephtys sp	0.10
Av. Abundance	**1893**

Mar-92 — Reference Site

Species	% M.D.
Balanus crenatus	53.79
Dendrodoa grossularia	31.15
Amphipoda	3.55
Lanice conchilega	1.53
Pisidia longicornis	1.50
Pholoe minuta	1.12
Syllis cornuta	1.06
Sabellaria spinulosa	1.00
Aonides paucibranchiata	0.68
Leptochiton asellus	0.50
Spio martinensis	0.44
Harmothoe impar	0.41
Nebalia bipes	0.41
Maldanidae	0.38
Nephtys sp	0.29
Crepidula fornicata	0.29
Av. Abundance	**681.2**

May-92 — Reference Site

Species	% M.D.
Balanus crenatus	51.17
Dendrodoa grossularia	33.32
Amphipoda	5.18
Sabellaria spinulosa	1.76
Pholoe minuta	1.53
Lanice conchilega	0.93
Syllis cornuta	0.84
Pisidia longicornis	0.69
Leptochiton asellus	0.67
Aonides paucibranchiata	0.64
Spio martinensis	0.52
Lumbrinereis gracilis	0.32
Nephtys sp	0.29
Maldanidae	0.29
Caulleriella sp	0.29
Pomatoceros lamarcki	0.20
Av. Abundance	**691.4**

May-93 — Reference Site

Species	% M.D.
Dendrodoa grossularia	51.56
Balanus crenatus	44.17
Sabellaria spinulosa	1.22
Amphipoda	1.19
Pholoe minuta	0.21
Leptochiton asellus	0.17
Syllis cornuta	0.16
Pisidia longicornis	0.15
Maldanidae	0.14
Nemertea	0.13
Lanice conchilega	0.09
Anomia ephippium	0.08
Molgula occulta	0.08
Aonides paucibranchiata	0.08
Nephtys sp	0.07
Lumbrinereis gracilis	0.07
Av. Abundance	**2611.4**

May-94 — Reference Site

Species	% M.D.
Dendrodoa grossularia	86.17
Balanus crenatus	3.21
Amphipoda	3.03
Sabellaria spinulosa	0.82
Pisidia longicornis	0.65
Syllis cornuta	0.55
Pholoe minuta	0.55
Spio martinensis	0.47
Polycirus medusa	0.47
Leptochiton asellus	0.43
Exogone niadina	0.32
Molgula occulta	0.30
Spiophanes bombyx	0.27
Aonides paucibranchiata	0.27
Maldanidae	0.27
Nemertea	0.25
Av. Abundance	**1456.4**

Table 1. The top 16 species ranked by % mean abundance (%M.D.) at the Treatment and Reference sites pre- and post dredging.

Macrofauna ABUNDANCE >1 mm (stress = 0.19)

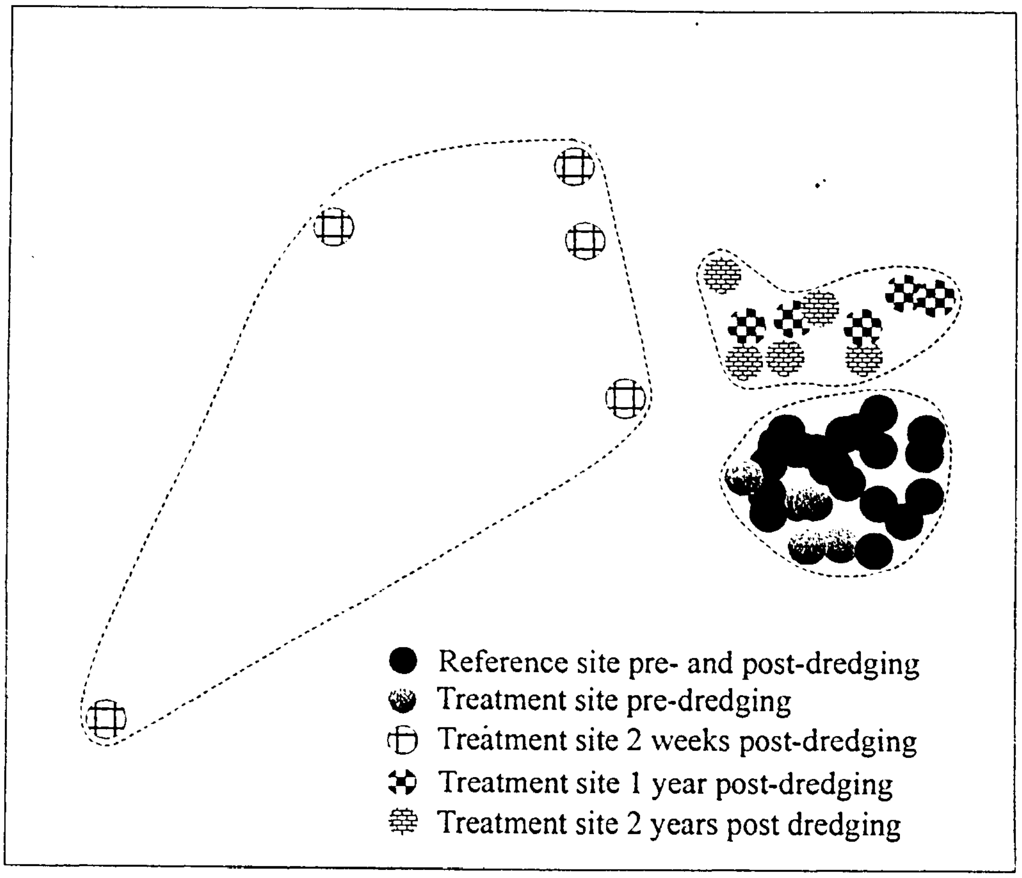


Figure 4. Non-metric multi-dimensional scaling (MDS) performed on the Bray-Curtis species similarities following double-root transformation.

turnover (i.e. productive importance). This is the subject of on-going research and will be reported at a later date.

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Long-term faunal changes: an analysis of by-catch data

J.A. Craeymeersch[1], A.D. Rijnsdorp[2], J. Buijs[1], P. van Leeuwen[2]

1. Netherlands Institute of Ecology, Centre for Estuarine and Marine Ecology, Yerseke
2. Netherlands Institute for Fisheries Research, IJmuiden

Introduction

Since 1969 the Netherlands Institute for Fisheries Research (RIVO-DLO) performes once or twice a year a bottom trawl survey (Tridens Sole Net Survey) in the Dutch, German and Danish continental waters. In Autumn and, for some years, in Spring, several trawls has been made along 14 transects (figure 1). During these surveys also benthic species were identified and counted. Of following species records were considered reliable: *Acanthocardia echinata, Neptunea antiqua, Arctica islandica, Aporrhais pespelecani, Buccinum undatum, Liocarcinus puber, Hyas areneus, Corystes cassivelaunus, Pagurus bernhardus, Nephrops norvegicus, Carcinus maenas, Liocarcinus holsatus, Ophiotrix fragilis, Echinoidea* indet., *Astropecten irregularis, Ophiuroidea* indet., *Asterias rubens, Alcyonium digitatum, Aphrodita aculeata.* TWINSPAN analyses based on the densities of these species showed a similar structuring of the area covered as described by Dyer et al. (1983) and Duineveld et al. (1991): a shallower, coastal area, influenced by the English Channel inflow, and deeper areas influenced by Atlantic water.

The analysis presented here was supported by BEON, a co-operation of dutch institutes and institutions for Policy Linked Ecological Research in the North Sea and Wadden Sea.

Material and methods

The Autumn data of the period 1974-1991 were analyzed following two approaches.

First, the data of each transect were analyzed for changes in the dominance structure by canonical correspondence analysis (CCA). The resulting ordination diagrams express the patterns of variation in species composition, and the major relations between the species/stations and each of the given external variables. Variables used were: position (X- and Y-coordinates), depth, year, winter temperature (average of the two preceeding years) and fishing intensity (mean number of fishing hours per ICES quadrant in the year in question and the two preceeding years). Partial canonical correspondence analyses were used to partial out the effects of one or more covariables, and to relate the residual variation to the variable(s) we were specifically interested in (e.g. year as external variable, and position and depth as covariables to test for trends in time). Whether the samples were significantly related to one or more variables was tested by a Monte Carlo permutation test.

Secondly, all data of each species were analyzed by two types of analysis of variance. Two-way analyses of variance were performed using year and transect as categorical variables. Multiple analyses of variance were done using year as categorical variable and depth, winter temperature or fishing intensity as continuous variables.

Results

community analysis

The external variables used could account for 9.4-36.4% of the total variance. On 8 transects, species composition showed changes along the transect, mostly relating to a depth gradient. Figure 2 shows a typical example of the CCA ordination plots (Esbjerg transect). In this figure, external variables are represented by vectors. The length of a vector is a measure of how much the species distributions differ along that variable. Important variables therefore tend to be represented by longer vectors than less important ones. Vectors pointing in roughly the same direction indicate a high positive correlation between these variables. Vectors crossing at right angles indicate nearly zero correlation, and vectors pointing in roughly opposite direction indicate a highly negative correlation (e.g. X-coordinate and depth). The species and sites are positioned as points in the CCA diagram. For clearness' sake species and sites are showed in separate plots. Projecting the species position on the external vectors points approximately to the ranking along that variable. Thus *Astropecten irregularis* mainly occur in the deeper part of the Esbjerg transect.
Partial CCA results showed a significant trend in time on the transects Esbjerg, Helgoland, Klaverbank and Holmanground. Fishing intensity should have influenced the species composition on the transects Helgoland and Klaverbank.

analysis of variance

Density of all species except *Carcinus maenas, Alcyonium digitatum, Aphrodita aculeata* and *Astropecten irregularis* showed changes in time. For most species there is an interaction between time and transect, and the differences among transects are larger than the differences among years.
Fluctuations in winter temperature seem to have influenced the density of the echinoderms (sea urchins and brittle stars). Fluctuations in fishing intensity should only have influenced the density and/or distribution of starfish.

Discussion

In the period 1974-1991 major changes in species composition, density and dominance structure due to changes in fishing intensity obviously only occurred on the transects Klaverbank and Helgoland.

In the ordination diagrams of both transects (figure 3 and 4) *Alcyonium digitatum* is situated opposite to the fishing intensity axis. On the Klaverbank transect the species was only found in 1974, 1978 and 1983, on the Helgoland transect only once in 1974. More information is needed to check whether the species has always been rare, or if it really disappeared.

The species *Arctica islandica* is known to be influenced by fisheries (Rumohr & Krost, 1991; Klein & Witbaard, 1993). But, on the Helgoland transect *Arctica islandica* is situated oppositie to the fishing intensity axis, while on the Klaverbank transect it is situated along this axis. The number of specimen found clearly decreased in both areas (figure 5). The positive correlation between fishing intensity and the number of quahogs on the Klaverbank area is due to the large decrease of fishing intensity in the early eighties (figure 6; ICES quadrant 36F3 and 35F4). How well is our estimation of fishing intensity? We probably need a better parameter to express the fishing intensity, taking into account e.g. the changes in beam length and, thus, in the disturbed area per hour fishing. Moreover, there might been large differences in fishing intensity within an ICES qudrant (Rijnsdorp et al., 1994). But there is no information on fishing intensity on a smaller scale than ICES quadrants.

Remains the question whether the density of starfish has been influenced by fishing intensity or not. On the Holmanground and Klaverbank transects *Asterias rubens* is situated in the centre of the ordination diagrams, an indication of the indifferent nature with regard to the main gradients. But, at least in one ICES quadrant 33F4 (near Scheveningen) more starfish were found from 1985 onwards, corresponding with an increased fishing intensity (figure 7).

The fact that the temporal fluctuations in fishing intensity in adjacent ICES quadrant can be very different, certainly influenced the ordination analysis. At the Scheveningen transect for instance, the difference between ICES quadrants 33F3 and 33F4 resulted in a positive correlation between position and fishing intensity.

The results presented here are a first analysis of the data. We hope to find time to look into more detail within the near future. In doing so, we should focus on changes within each ICES quadrant, as this is the scale of the fishery statistics.

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Figure 1: Location of transects
Figure 2: Canonical correspondence analysis (Esbjerg transect). Ordination plots: samples and external variables (top), species and external variables (bottom)
Figure 3: Canonical correspondence analysis (Klaverbank transect). Ordination plots: samples and external variables (top), species and external variables (bottom)
Figure 4: Canonical correspondence analysis (Helgoland transect). Ordination plots: samples and external variables (top), species and external variables (bottom)
Figure 5: Plot of time against numbers of Arctica islandica (left), and time against residuals of a regression of numbers against depth and position (right)
Figure 6: Fishing intensity in the ICES quadrants 36F3, 35F4 (Klaverbank) and 37F7 (Helgoland)
Figure 7: Plot of time against fishing intensity (left) and numbers of starfish (right) in ICES quadrant 33F4 (off Scheveningen)
Figure 8: Fishing intensity in the ICES quadrants 33F3 and 33F4 (Scheveningen transect)

Abbreviations in figures:

X-utm: position (X-coordinate)
Y-utm: position (Y-coordinate)
depth in: depth
Year: year
Winterj2: winter temperature
Visuur3: fishing intensity

ALCYDIGI: Alcyonium digitatum
ARCTISLA: Arctica islandica
ASTERUBE: Asterias rubens

Figure 1

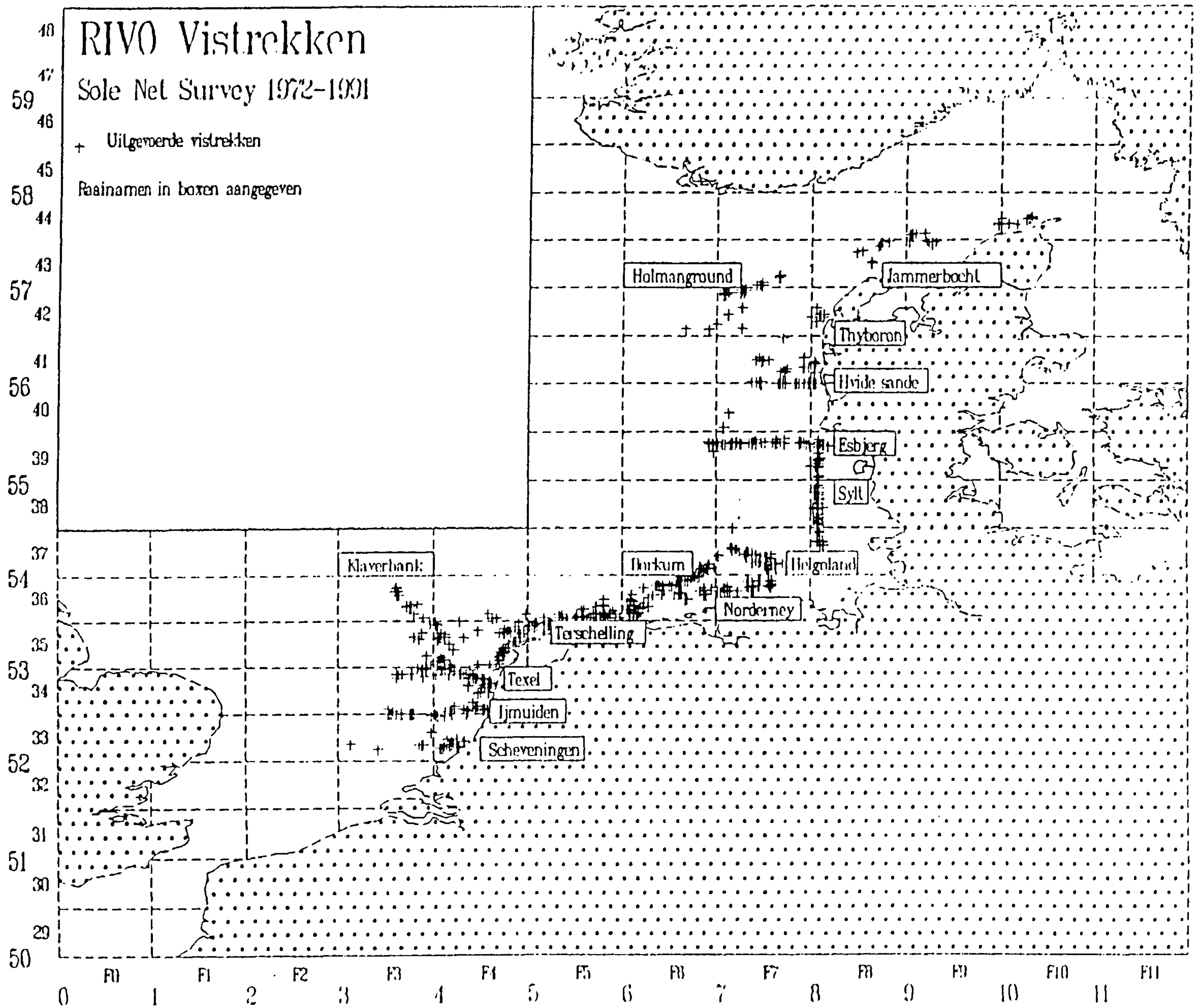
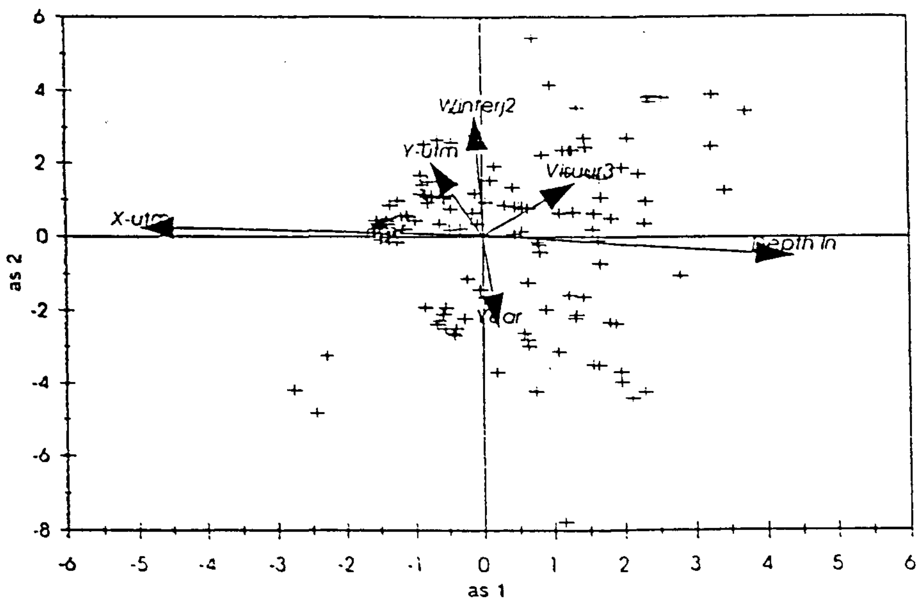

RIVO Vistrekken
Sole Net Survey 1972-1991
Uitgevoerde vistrekken
Holmanground
Jammerbocht
Thyboron
Hvide sande
Esbjerg
Sylt
Klaverbank
Borkum
Helgoland
Norderney
Terschelling
Texel
Ijmuiden
Scheveningen

Figure 2



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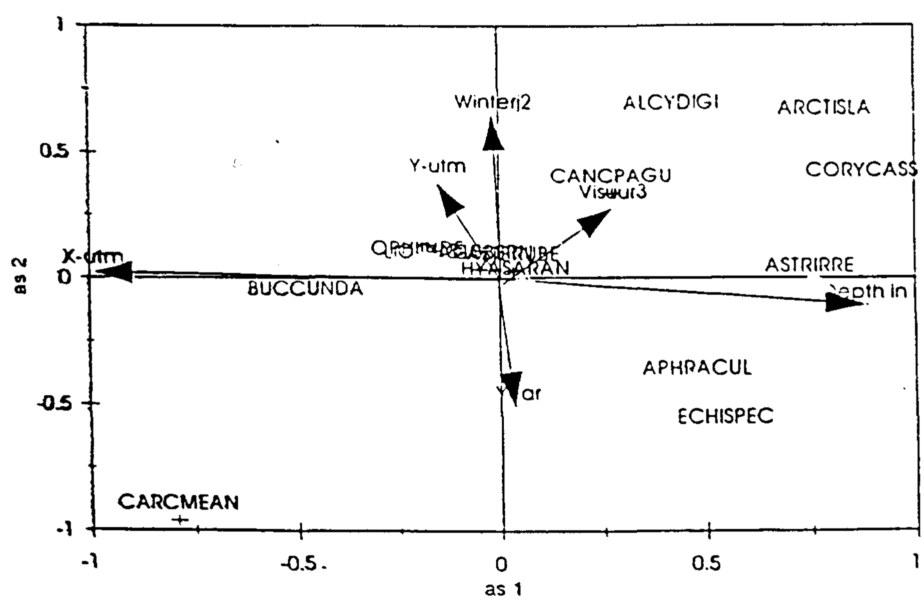
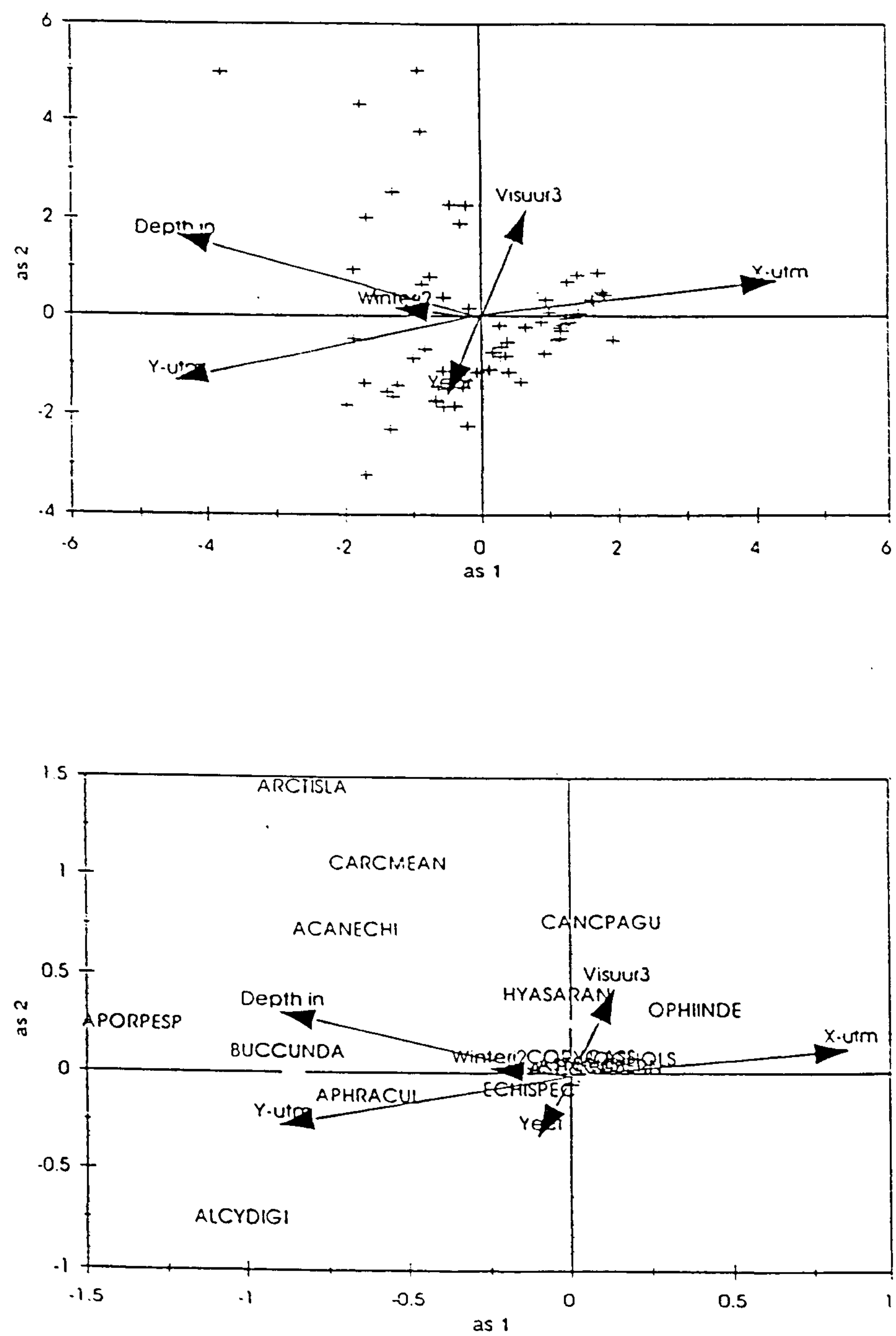
Y-utm



Winterj2
ALCYDIGI
ARCTISLA
Y-utm
CANCPAGU
CORYCASS
HYASARAN
ASTRIRRE
BUCCUNDA
APHRACUL
ECHISPEC
CARCMEAN
as 2
as 1

Figure 3


Visuur3
Depth in
X-utm
as 1
as 2
ARCTISLA
CARCMEAN
ACANECHI
CANCPAGU
Visuur3
HYASARAN
OPHIINDE
Depth in
APORPESP
BUCCUNDA
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ALCYDIGI
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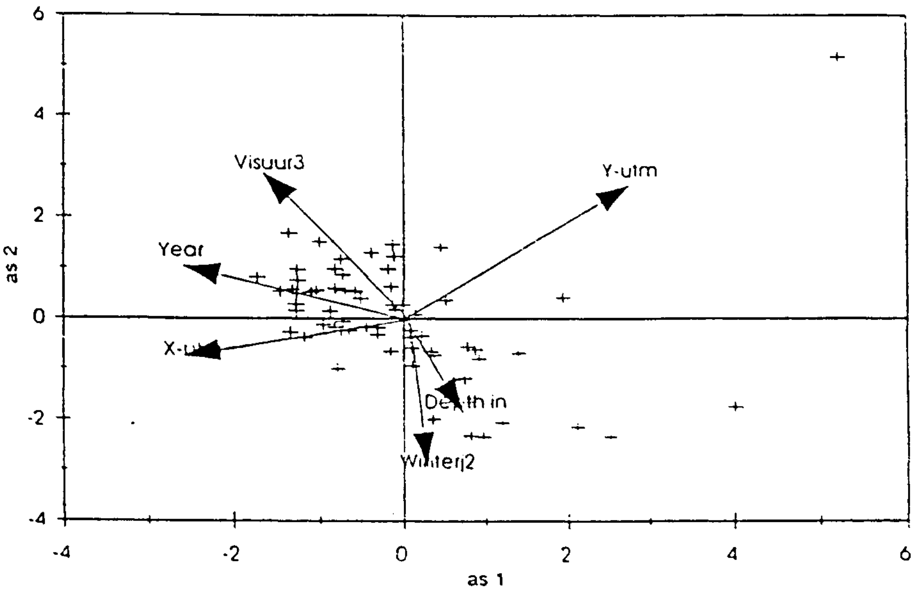
Figure 4



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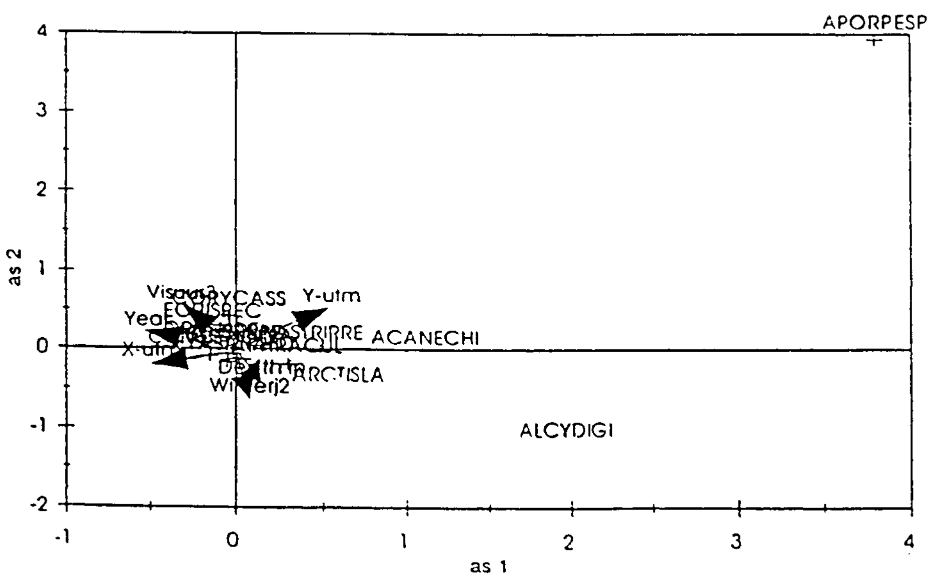

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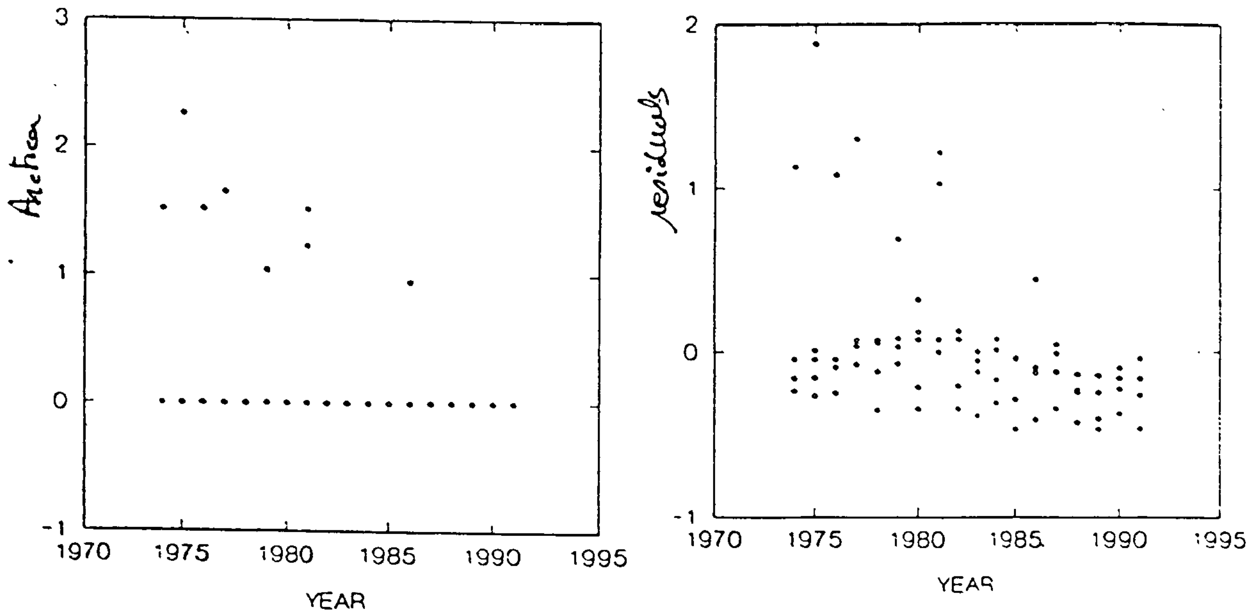
Y-utm
ACANECHI
ARCTISLA
ALCYDIGI

Figure 5

Klaverbank



Helgoland

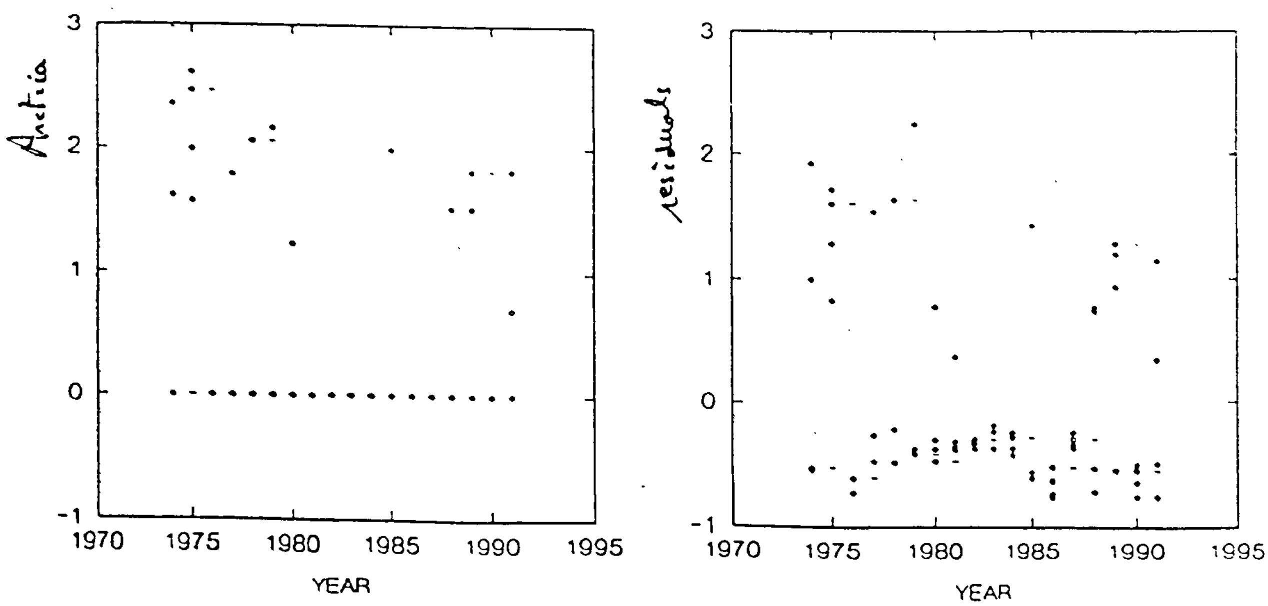
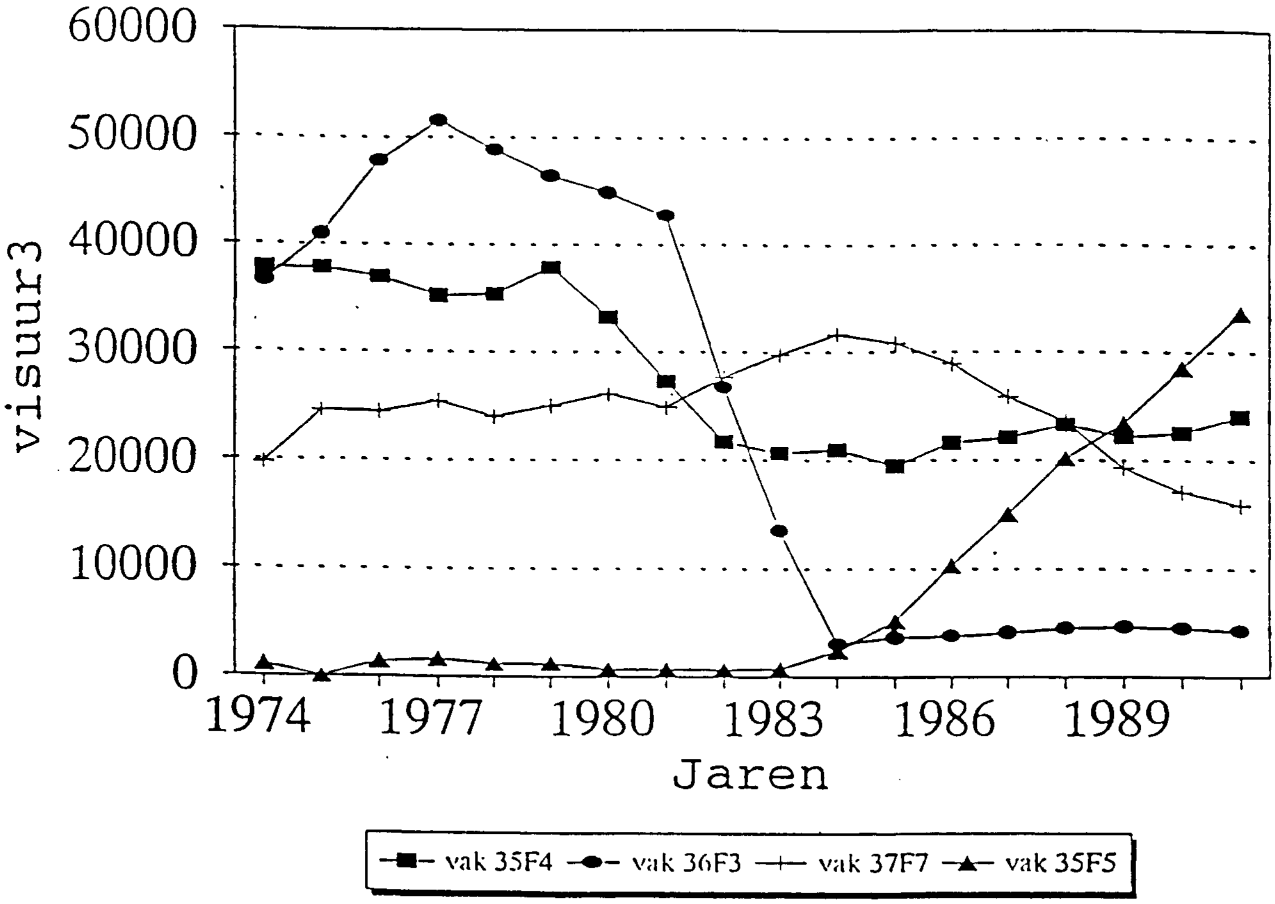


Figure 6



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Jaren
vak 35F4
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vak 37F7
vak 35F5

Figure 7

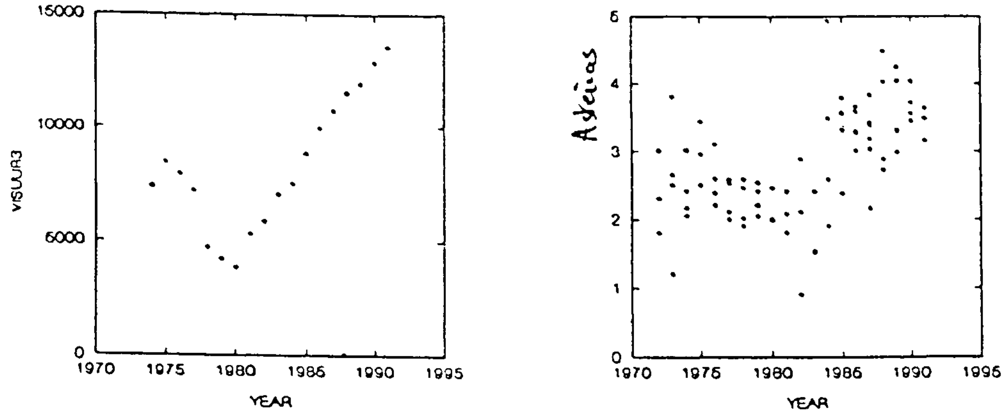
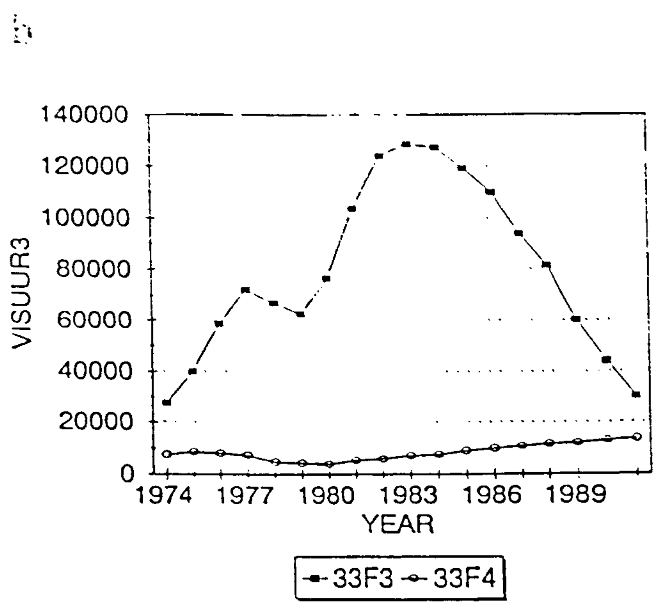


Figure 8



INDICATOR SPECIES SENSITIVE TO PHYSICAL DISTURBANCE

1 Introduction

In addressing the continuing request for a list of indicator species, the Working Group has reviewed the earlier BEWG report as well as the report of the 1994 Working Group on the Ecosystem Effects of Fishing Activities. We have accepted the definitions and characteristics of vulnerable species established in these earlier reports, but have organized some of the information in a slightly different manner so as to produce a set of criteria that might be broadly applicable within the ICES area. Further, we prefer the use of the term "sensitive" rather than "vulnerable" to describe species that may be affected in some way by physical disturbances. Of special note here, however, we have considered not only the direct effects on individuals that is the central theme of the definition of vulnerability in the 1994 report, but have also extended our discussion to characteristics that might lead to local extinction of a species given sufficiently intensive repetition of the physical disturbance.

No list of indicator species is currently drawn up; however, using the criteria outlined in this report it should be possible to make for each habitat within each biogeographic province a list of the most likely sensitive species. (Some species were proposed in the 1994 Working Group Report; most will be accepted as "vulnerable" after application of the criteria outlined below.) A complication that must be dealt with, is that for most regions of interest the seabed has been trawled for so many years that it is difficult to know which species are absent because of their sensitivity to physical disturbance or because of some other habitat requirement that is not met in that region. It is likely that those species which are present in these heavily trawled areas are those which have survived and therefore are not very vulnerable to physical disturbances, at least at the population level. We also believe that many of the most sensitive species, and consequently, the species whose absence is most likely to be indicative of physical disturbance, are small invertebrates about which, unfortunately, little is known. It must be noted that the single most important block to the preparation of such a list is the lack of natural history information for most species.

2 Characteristics of species that would make them vulnerable.

Whether a species is sensitive to the effects of physical disturbance is dependent on several aspects of its life style and life history. These characteristics must be viewed in a hierarchical manner, however, as it is possible for individuals of a species to be damaged, killed, or removed locally, but the regional population can produce sufficient new recruits that the species will have the capability of recovering from the disturbance.

To assess this capability, effects of physical disturbance on benthic species are arranged into two main categories, direct effects on individuals, and long term effects on the population of a species. Obviously, if there are no direct effects on individuals, the long term population effects are unimportant. On the other hand, if individuals are impacted in some way, then criteria at the population level must be invoked in order to determine finally if a species is sensitive to physical disturbances.

To complete the assessment of sensitivity, one also needs to know the effect on a species of disturbance frequency, and the proportion of the area occupied by the species that is disturbed. For example, some species may suffer severe physical damage from a single disturbance event and have very limited recolonization ability. Other species may be able to repair physical damage after one disturbance event, but do not have the energetic capability to do so several times. Still other species may suffer severe physical damage from repeated disturbances, but the undisturbed part of the population is capable of producing sufficient propagules to recolonize the disturbed area following the cessation of disturbance.

A Direct Effects on Individuals

damage to body of the individual. Species with very fragile bodies are most likely to be killed on contact with the agent of disturbance, or with sediment particles being moved by this agent. Examples include polychaetes such as cirratulids and terebellids as well as some echinderms such as *Echinocardium.*

damage to burrow dwelling. Species which maintain complex, shallow burrows, and expend considerable energy doing so, may consume energy by having to repeatedly excavate the burrow. A few species are also known to house their young in the burrow; these species will suffer losses of young as well as adults. Examples include various amphipods and polychaetes.

removal of individuals from their burrow or tube. Species which continuously make small incremental changes to their burrow as they grow often lose their ability to vigorously burrow as they age. If individuals of these species are removed from their burrow by the agent of the physical disturbance, it is unlikely that they will be able to re-burrow. e.g., *Mya.*

damage to tubes. Species which make a single tube over their life-time will be unable to replace one destroyed by a physical disturbance. Animals whose tubes are damaged or destroyed are liable to increased predation. e.g., polychaetes such as *Pectinaria.*

removal of individuals from the substratum. Species which are attached to the substratum by structures which are easily broken will be readily removed by most agents of physical disturbance, e.g., sponges, bryozoans, hydroids.

damage to shells. Breakage of shells increases the species vulnerability to predators, e.g. *Arctica.*

clogging of feeding structures. Resuspension of bottom muds can coat or clog feeding structures of species living in water with low suspended particle concentrations resulting in starvation and eventual death of individuals, e.g., bryozoans, *Glycymeris.*

burial of individuals by resuspended sediment. Many small species may be unable to burrow upward through several centimeters of sediment deposited following a resuspension event or thrown up into mounds by fishing or dredging gear. Such species may die from increased exposure to H2S or lack of porewater oxygen. Examples might include small mud-dwelling polychaetes confined to tubes and requiring a connection to the surface to maintain oxygenated water flow.

B Population Characteristics of Sensitive Species.

Species whose individuals suffer direct impacts of physical disturbance may be capable of local recovery due to sufficiently rapid growth or recruitment potential. On a population level, however, a species may be vulnerable to local extinction if its life history includes one or more of the following features:

low growth rate

low regenerative capability

low fecundity or infrequent recruitment

low mobility of reproductive propagules

specialized housing of juveniles

loss of specialized habitat, e.g., commensal losing their host

narrow substrate tolerance.

Examples:

The direct effects on individuals and population characteristics can be combined to produce some examples of most likely sensitive species.

Severe damage to body of the individual and *low fecundity*: such a species, after losing much or all of the body mass would be unlikely to recover within a considerable time, e.g., *Paragorgia arborea.*

Removal of individuals from the substratum and *narrow substrate tolerance*: such species would only recolonize the type of habitat that is being repeatedly disturbed, and, given frequent removals, the species would eventually be so reduced that a breeding population would not be large enough to maintain itself, e.g, *Neptunea antiqua, Aporrhais pes-pelicani.*

3 Characteristics of Species Not Vulnerable:

In contrast, many species may suffer some direct effects from physical disturbance, but long term effects on the populations of these species are unlikely because they exhibit some or all of the following characteristics:

highly mobile
freely burrowing, as in *Capitella*
rapid burrowing capability, as in some bivalves
wide tolerance to natural disturbance
high densities
rapid reproduction & high fecundity

"r" species

4 Species taking advantage of disturbed bottoms

One additional category of possible indicator species are those that are capable of taking advantage of the results of physical disturbance. Most of these species are highly mobile, have strongly developed chemosensory capabilities, are a capable of rapidly consuming soft tissues. High densities of scavengers are representative of this category.

5 Recommendation

There are very likely many species that are sensitive to the effects of physical disturbance of the benthic habitat. Before the degree of sensitivity can be assessed, some indication of the intensity and frequency of disturbance needs to be given. Further, it may be necessary to examine the recolonization of areas newly closed to fishing in order to know which species have historically been lost due to long term effects of physical disturbance.

6 Literature

No additional literature beyond the 1994 report was considered.

METHODS FOR STUDYING HARD BOTTOM SUBSTRATES

Prepared by D Connor, Joint Nature Conservation Committee, UK

1 Introduction

This report provides a brief account of methods available to study marine benthic communities which occur on hard substrata. Hard substrata are taken to be habitats of bedrock, boulder, stable cobble and pebble, artificial substrata and biogenic reefs, such as *Mytilus edulis* and *Modiolus modiolus* beds, on which epibiota communities develop, either in the littoral or sublittoral zone. This definition excludes sediment substrata which hold infaunal communities (but may develop epibiota communities if sufficiently stable), including mobile shingle which may have little associated biota. Habitats of mixed hard and soft substrata occur which are difficult to sample for their infauna and might best be considered here.

Previously within the ICES BEWG most attention has been directed towards studies of soft bottom substrata, the predominant habitat over most offshore areas and in some coastal areas. In many countries however hard substrata form a major component of coastal areas and are consequently subject to many of the pressures of coastal activities, such as coastal defences, urban and industrial development, mineral extraction, coastal quarrying, fishing, chemical contamination, eutrophication, waste dumping and oil pollution. Rocky habitats often hold much intrinsic appeal both for their scenery and the wealth of marine life associated with them.

Although the ecology of littoral rocky habitats is generally well studied, that for sublittoral rock, and particularly for offshore rock, is relatively poorly understood. There remains much to be learned about the basic nature and distribution of rocky communities; also very little monitoring occurs in comparison to that done for littoral and sublittoral sediments.

2 The nature of rocky habitats

The communities of rocky habitats exhibit a very high degree of heterogeneity, dependent on local conditions, particularly height up the shore (due to desiccation) or depth into the sublittoral (due to light attenuation, temperature, wave disturbance), exposure to wave action and currents, salinity, temperature, topography, geology and the effects of suspended sediment or siltation. In addition biological interactions of predation, competition and chance recruitment play their role in community structure. The effect of this is often to yield a very high variety of communities in an area, often changing markedly over a few metres, compared with a much smaller range of sediment communities which typically cover larger expanses of shore or seabed. Such complexity in rocky habitats presents difficulties in both ecological monitoring and monitoring for man-induced change, and may in part explain why so little is undertaken.

On the shore and in the shallow kelp-dominated infralittoral zone one or several species may typically dominate (numerically or by space) community structure; however in the deeper animal-dominated circalittoral zone communities tend to comprise a wide variety of species and present a much patchier community structure; this too can make effective monitoring difficult to establish.

3 Sampling rocky habitats - general principles

As with sediment studies the methods adopted need to be appropriate to the end requirements of the study. Consequently methods, equipment and resources required for mapping habitats differ considerably from those for detailed description of habitats or for monitoring studies. The scale of the study, be it local, national or international also has a marked effect on the techniques employed and the level of detail appropriate, as does the focus of the study on species distribution and dynamics, community description, productivity and so on. It has not been possible in this brief review to consider all the potential types of hard substrata sampling to suite every requirement. An attempt is made here to give general guidance of the types of method applicable to baseline resource surveys and to monitoring, as these are likely to be of most interest to ICES.

The general strategy for sampling should be similar to both littoral and sublittoral rocky habitats, although the specific methods adopted will differ according to the logistics of sampling in each zone.

Since rocky habitats by definition support epibiotic communities, they are visible by eye and sampling can typically be undertaken in a non-destructive *in situ* manner, rather than the infaunal sampling of sediments which requires removal of samples to the laboratory for analysis. For some studies removal of samples (destructive sampling) may however be appropriate.

Quantitative sampling is difficult as many species are colonial in nature (and thus cannot be counted), are difficult to count (e.g. stands of filamentous algae) or adhere as a crust over the rock (and so cannot be collected or counted). More effective assessment of quantity for such species is given by estimates of percentage cover. An integration of such percentage cover estimates with a log10 based quantitative abundance scale for species which can be counted is provided in Hiscock (1990). Fully quantitative sampling with removal of the entire sample from the rock to determine biomass is little undertaken (e.g. Christie 1980).

In the sublittoral use of Scuba diving enables detailed recording and sampling to be made, particularly important in description of the community and monitoring. Use of remotely operated video (ROV) cameras offers advantages in depth and time available underwater, not requiring diving expertise and providing a permanent record of the site. However for species identification remote video is able to pick up only the larger species at a site, amounting to only about 50% of the macrobenthic species present (R.H.F. Holt, pers. comm.). It is consequently unsuitable for detailed description of the habitat and for certain types of monitoring.

Monitoring for man-induced change requires previous knowledge of the nature of the community and its natural variability. Such basic information is lacking for the majority of rocky habitats, making the design of monitoring programmes critical to ensure they effectively answer the aims of the study. Such monitoring should therefore include sufficient study to establish natural variation at the site or parallel monitoring of a reference site which must be of comparable nature.

4 Baseline resource studies

Mapping of biotopes (i.e. habitats and their associated communities). Rapid identification of the key biological features which define each community, combined with knowledge of the extent of the physical habitat can be used to provide maps of the resource without recourse to detailed and time consuming programmes for sampling of species. Such an approach requires a pre-established biotope classification such as that currently being developed for the British Isles (Connor 1994, Connor *et al.* in press). For littoral habitats Richards, Bunker & Foster-Smith (in prep.) have developed a technique using aerial photographs to define polygons of similar physical habitat which are then ground-truthed by field surveyors. The data are fed into a Geographical Information System (GIS) to provide maps and allow for spatial analysis of the data. In the sublittoral, a similar approach can be achieved through acoustic survey of the seabed (such as using the RoxAnn system) and ground-truthing with ROV cameras (e.g. Davies & Southeran 1995).

Description of biotopes - main species only. In the sublittoral ROVs can be used to give a general description of the community, although only the largest conspicuous species can be identified accurately (typically those at least 10 cm in size), accounting for only up to 50% of the macrobenthic species present. ROVs can be used to great depths and have fewer time restrictions compared with divers; they are often used when diving expertise is unavailable.

Description of biotopes - all conspicuous species. In situ recording by experienced field ecologists to identify all conspicuous species present in a defined habitat can be achieved through search over a wide area of the habitat to ensure widely dispersed species are recorded. Diving techniques are used for the sublittoral zone. This approach is adopted for the Marine Nature Conservation Review, a major resource survey for the whole coast of Great Britain (Hiscock ed. in prep.). For more restricted surveys specific quadrat or transect approaches may be appropriate to provide more quantitative data for some studies.

5 Monitoring studies

Monitoring requires repeat surveys of the same location at set time intervals. Marking of such sample sites is important to ensure return to the exact location, because of marked spatial variation in community structure over short distances. Epibiota communities lend themselves to photographic monitoring techniques as well as monitoring by *in situ* recording. Stereo photography techniques for sublittoral rocky monitoring have been developed by Lundalv (1971, 1976) and used for many years in Sweden. Recent advances in computer-aided image analysis allow direct comparison of photographic images with time (e.g. Fowler ?1993 for monitoring growth if individual specimens of slow-growing sponges and seafans).

Point source monitoring. Transects away from the source of contamination with sampling at regular intervals along one or more transects can be used but are subject to difficulties in interpretation. Heterogeneity of the rocky habitats is likely such that sample points along the transect are likely to be in different communities and hence not comparable; also samples within quadrats may not be representative of the wider area due to spatial variation.

Long term change (trend) monitoring - ecological or man-induced Establishment of the baseline community structure and variability at the site under consideration is important. Sample points need to be spread out over the extent of the habitat studied to ensure adequate account of spatial variation is considered, rather than assuming one point is representative of the habitat as a whole. If measuring man-induced change than a control or reference site is required for each test site. It is critical here that like habitats are selected for comparison.

6 Parallels with sediment sampling

For consistency of approach it is important to use similar strategies for sampling both rock and sediment habitats. However the differing nature of the two habitat types leads to marked differences in techniques used, as does the logistics of sampling in littoral and sublittoral environments. For rocky habitats there is generally more emphasis on *in situ* recording and photographic techniques. For a table providing a broad comparison of approaches applicable to rock and sediment habitatssee Annex 12. It is not comprehensive as other techniques may be equally valid to use.

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TABLE 1

	Littoral		Sublittoral	
Detail	**Rock**	**Sediment**	**Rock**	**Sediment**
Baseline resource sampling:				
Mapping - habitat and biotope type	Aerial photography, OS maps, & rapid field survey	Aerial photography, OS maps, & field survey with *in situ* identification (dig over sediment)	Acoustic survey (RoxAnn) + Video (ROV) ground-truthing	Acoustic survey (RoxAnn) + towed video
Describe biotopes - main species only	Rapid *in situ* recording	*In situ* identification (dig over sediment)	Rapid *in situ* recording by diver Video (ROV)	Remote sampling - identification on boat Diver observations of epibiota
Describe biotopes - all conspicuous species	*In situ* recording	Coring - samples worked up in lab	*In situ* recording by diver	Remote sampling - samples workid up in lab
Monitoring/surveillance:				
Monitoring	Fixed transects or positions Quadrats Photography	Replicate samples on grid Regular sampling programme	Fixed transects or positions Quadrats Photography	Replicate samples on grid Regular sampling programme

NORTH SEA BENTHOS SURVEY PROPOSAL

1 Introduction

In 1986 the ICES Benthos Ecology Working Group performed a synoptic mapping of the North Sea benthos, the so-called North Sea Benthos Survey. In the 1994 meeting of this group it was proposed to undertake a new synoptic survey should be performed. However, the group agreed that the survey should not be a repeat of the 1986 survey, in which the benthic infauna was studied, but should focus on studying the epifauna and large infauna.

The outcome of the 1986 survey showed clear patterns in biomass, diversity and species distributions within the North Sea. These patterns seemed closely linked to the grain size distribution in combination with depth. Certain infauna assemblages could be identified but before these can be extrapolated to the entire benthic fauna more knowledge should be gathered about the larger infauna and epifauna, a category which was not adequately sampled in 1986.

By focussing on epifauna and large infauna, of which very little is known up to now, a new and more complete picture of the North Sea benthos will arise. Furthermore, as these two functional groups are highly sensitive to physical disturbance of the seabed, for example by bottom trawl fisheries, the results can form the basis for evaluating the effects of fisheries. The epifauna, because of their relatively large large size and there life style (being generally motile and living on, or near, the surface of the sediment) make up a large proportion of the food for demersal fish. Finally the results of this survey combined with the results of the 1986 survey will form the basis for the classification and mapping of the benthic habitats within the North Sea and will provide detailed information on the biodiversity of the North Sea benthos.

2 Objectives

The following objectives should be met by the 2nd North Sea Benthos Survey:

- To give, by taking into account both the benthic infauna (1986), the epifauna and large infauna, a complete picture of the distribution of all benthic species and assemblages and of the benthic biodiversity in the North Sea.

- To classify, characterize and map the benthic habitats in the North Sea.

- To assess the relationship between the distribution and diversity of the North Sea benthos and the major physical and chemical parameters of the North Sea system, as far as the information is available.

- To explore the effects of bottom trawl fisheries by correlating the distribution of sensitive benthic species or assemblages with fisheries intensities.

- To provide information on benthic species sensitive to fisheries as a basis for defining areas to be closed for fisheries.

- To provide infauna samples which can be compared with the 1986 survey. A secondary objective would be the following:

- To provide sampled material which can be used for further investigations, eg contaminants in epifauna (contact to the Joint Assessment and Monitoring Programme of OSPARCOM), TBT imposex. Additional samples can be taken for chemical investigations at each station.

3 Area

The survey should cover the whole North Sea including the English Channel, Skagerrak and the Kattegatt which is the area covered by region II of the Quality Status Report 2000. It might be expanded to adjacent areas. Within the North Sea the station grid of the 1986 survey should be sampled.

4 Ship

Sampling should be done preferebly within one survey with one large vessel and as many experts identifying the epifauna directly on board as possible. This would a) increase the statistical precision of the sampling and analysis, b) eliminating the need for intercalibration exercises, c) reduce the equipment costs, and d) reduce the net traveling requirment by avioding the need to take numerous boats to the area.

If this approach is not possible, ships may be available from NL (Pelagica), D (Senckenberg, Heincke, Victor Hensen), F, UK and possibly N.

5 Participants

The coordinator of the survey will be Paul Kingston.

The following institutes will participate:

UK	: Aberdeen Institute of Offshore Engineering
	MAFF (?)
	SOAFD (only ship time and analysis of sediment samples)
D	: Senckenberg Institut
	AWI (?)
	BAH (ship only)
F	: Marine Station Wimereux
	Roscoff, Dinard, Museum of Paris (western English Channel)
DK	: National Environmental Research Institute (?)
NL	: NIOZ
	Delta Institute
	Rijks Water Staat
N	: University of Oslo or NIVA (?)
B	: University of Gent (?)
	Fisheries Research Station Ostende

S : Kristineberg Marine Center (?)

6 Sampling equipment

The epifauna and large infauna on soft sediment will be sampled by the dredge Triple D with the aim to get a standardized mapping of the large infauna. The Triple D was especially developed to obtain quantitative samples of large infauna organisms which cannot be sufficiently sampled by grab or trawl.

The epifauna on gravel will be sampled by the Rallier du Baty dredge (does not take infauna) which takes a sample over a large distance. No subsampling is planned.

A video camera will be attached to the Triple D to check the sampling process.

Video pictures of the Epifauna will be taken at each station by ROV.

RoxAnn sediment mapping will be ru throughout the cruise.

7 Sampling strategy

The same grid of stations as in the 1986 survey will be sampled for epifauna and large infauna, including those stations which could not be sampled for any reason. Additional stations can be added for special environmental areas.

Only one dredge sample will be taken per station.

In addition, at each station of the 1986 survey infauna samples should be taken with the same type of grab and same number of samples as in 1986. These samples should be stored and might be analysed at a later stage. From Dutch benthos monitoring in the North Sea it is at present not evident that changes have been occurred in the infauna of the southern North Sea since 1986. No information is available on the development of the benthos in the northern North Sea. Changes could occur in the species distribution due to climatic, anthropogenic or natural changes. Therefore the sampling of the infauna should be repeated at all stations.

The whole area of the English Channel will be sampled taking the gradients between east and west and between coastal and offshore areas in account.

The positions of the Stations in the Norwegian Deep, Skagerrak and Kattegatt should be determined by Norway, Danmark and Sweden.

8 Taxonomy

Specialists for each taxonomic group are needed. Each taxonomist should decide, if the identification can be done on board or must be done in the lab. For at least five taxonomic groups specialists are needed:

- hydrozoa
- bryozoa (lab work)
- porifera (determination on board & lab)

- anthozoa
- ascidia

For four taxonomic groups specialists might be needed only with special problems:

- Crustacea
- Mollusca
- Echinodermata
- Polychaeta

9 Data analysis

The statistical analysis of the data will be done by Netherlands Institute of Ecology.

10 Publication

The final results of the survey will be published as an ICES report and in the *ICES Journal of Marine Science*

11 Timing

First the outline of the survey should be presented to ICES for approval by ACME.

Second a proposal for funding should be submitted to the EEC by the end of this summer. The proposal should include the possibility for an extension of the survey to the 'Celtic Seas', Faroe Islands or other OSPAR areas. The proposal will include the costs for

- shiptime (2 months)
- database development
- equipment
- taxonomists
- survey travelling and workshops

COMPUTER AIDED TAXONOMY

Keeping up to date on identification of species is essential to the interpretation of field data. However, identification keys are spread over a still growing body of literature, and updates cannot be released regularly. In addition, new keys are provided by specialist at workshops on particular taxa (e.g. ECSA Polychaete Workshop), and these keys are not widely circulated. Thus, many scientists and institutions use different keys hampering comparisons between different studies. Moreover, building up the necessary expertise in identification of the specimens is time consuming, and the number of specialists is limited.

Therefore, the working group considered at their last meeting the feasibility of producing identification sheets to achieve standardization of identification and faster update of keys. The group concluded that a traditional approach would be too expensive and that emerging computer-aided techniques might provide a practicable alternative.

At their meeting this year, a subgroup (D. Basford, D. Connor, J. Craeymeersch, H. Hillewaert, E. López Jamar, A. Norrevang) made a list of desirable attributes for such identification programs:

- the program should not restrict the order in which characters can be used
- the program should advise on the most suitable characters for use at any stage of an identification
- the program should use probabilistic identification methods
- the program should give an overview of all characters used
- the program should be capable of restricting identification on a geographical basis
- the program should allow flexible display of illustrations (e.g. simultaneouly displaying illustrations of (part of) several species)
- the program should include information on the species' distribution and ecology, and important references
- the program should keep track of the species identified before by that person and warn if the species was new for that person
- it should be possible to add notes to the species' information
- the program should be easy to update

Certain of these features are only met when the program is based on a matrix of characters which are described for each species. The group therefore encourages the production of such data matrices. But it will take several years before such matrices exist for all benthic taxa of the North Sea, the group also encourages the production of computerized dichotomous identifcation keys (storing existing keys). In that case the program should allow backtracking (reconsideration of previous choises).

The production of identification programs based on data matrices can only be done by specialists. But the working group can help in providing

- digitized photos

- information on the distribution and ecology of species
- testing new keys.

A suitable database should be produced capable of invetorying a) stored images b) location of reference material and c) any other relevant ecological information.

The production of dichotomous keys could be done by less experienced scientists or technicians. Updates of these keys should be based on a data matrix. But most, if not all, of the institutes do not have staff available to do the job. If suitable computerized keys should become available working group members should assess them and report their findings (see action list item 3). If 'in house' key are to be produced additional funds will have to be found to employ people for this task.

Most of the existing programs (see list below) are DOS-based, and are therefore less user fiendly, but releases for Windows are imminent. The list with desirable attributes will be send to the programmers, and they will be asked to include these attributes in their programs. Members of the group will stay in contact to exchange information and to evaluate programs.

The following list of programs for interactive identification and information was compiled by M J Dallmitz of CSIRO division of Entomology, Box 1700, Canberra ACT 2601, Australia. Tel +61 6 246 4075; Fax +61 6 246 4000; Email: Internet delta @ ento.csiro.au.

Programs for Interactive Identification and Information Retrieval

ASKATAXA

This program used to access synoptic keys produced with the program package PC-TAXON (DOS version 2.6; Windows version planned). For information on the program package or on currently available demonstration keys and trial version of ASKATAXA, please contact:

Fred Rhoades, Biology Department, Western Washington University, Bellingham, WA 98226, USA. Phone: +1 206 733 9149, Fax: +1 206 650 3148, Email: fredr@henson.cc.wwu.edu

CABIKEY

Ian White, CAB International, Wallingford, Oxon OX10 8DE, UK. Phone: +44 491 83 2111, Fax: +44 491 83 3508

FLORA

Eirene Williams, Seale-Hayne Dept of Land Use, University of Plymouth, Newton Abbot, Devon TQ12 6NQ, UK. Fax: +44 626 32 5605

IdentifyIt, LINNAEUS II

ETI, University of Amsterdam, Mauritskade 61, NL 1092 AD Amsterdam, The Netherlands. Fax: +31 20 525 7238, Email: info@eti.bio.eva.nl

INTKEY

Shareware, for MS-DOS/Windows. Available (with several data sets) by gopher or anonymous ftp from the following Internet hosts.

muse.bio.cornell.edu (directory: /pub/delta)
spider.ento.csiro.au (directory: /delta)

Mike Dallwitz, CSIRO Division of Entomology, GPO Box 1700, Canberra ACT 2601, Australia. Fax: +61 6 246 4000, Email: md@ento.csiro.au

MEKA

Christopher Meacham, MEACHAM@VIOLET.BERKELEY.EDU, Museum Informatics Project, 501 Banway Building, Univ. of California, Berkeley, CA 94720 USA

ONLINE

Richard J. Pankhurst, Royal Botanic Garden, Edinburgh EH3 5LR, UK. Fax: +44 31 552 0382, Email: rjp@castle.ed.ac.uk

TAXASOFT

Interactive identification directly from DELTA format and Binary format.
ddproc.exe for DOS available from the DELTA gopher/ftp sites (see under INTKEY).
Eric Gouda, Jungfrau 107, NL-3524 WJ Utrecht, The Netherlands. Email: gouda@cc.ruu.nl

TAXY

Executables for Apple Macintosh, Sun SPARC, SGI, and IBM PCs are available at d2.com in directory pub/taxy. Source code is available upon request.
Nathan Wilson. Phone: +1 310 314 2939, Email: nathan@d2.com

PLATO

Christine Leon, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, England

POLLY

Trevor Whiffin, Department of Botany, La Trobe University, Bundoora, Vic 3083, Australia

XID

Richard Old, XID Services, Inc., Post Office Box 272, Pullman, WA 99163, USA. Phone/Fax: (509) 332-2989. Price: US$330.00 (XID Authoring System 2.1).

XPER

Jacques Lebbe, Service de Me'decine Nucle'aire, Ho^pital Broussais, 93 rue Didot, 75014 Paris, France

ICES Benthos Ecology Working Group
Kaldbak, Faroes, May 1995

Working document

Report on the effects of the *Aegean Sea* oil spill on the subtidal macroinfaunal communities

S. Parra, E. López-Jamar and A.V. Dorrío

Instituto Español de Oceanografía

Centro Oceanográfico de La Coruña, Apdo. 130, 15080 La Coruña, Spain

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. In this report we provide some new results on the evolution of the communities after the spill in the affected area, and the overall consequences on the subtidal benthos are discussed.

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 every two months (Fig. 1). Details on sampling protocols and laboratory methods are given in the previous BEWG reports.

Data on temporal variation of the community prior to the oil-spill were available in Stations C1 and C3 in La Coruña Bay. This has permitted to compare the changes after the accident with the natural variation of the community at these sites. In these stations a matrix of similarities between observations was constructed based on the Bray–Curtis similarity coeficient calculated on fourth root transformed abundances. A multi-dimensional scaling analysis (MDS) based on the ranked Bray–Curtis similarity matrix was performed to obtain an ordination of the successive obvervations (Field *et al.*, 1982; Clarke, 1993). In these two stations abundance of the most important species after the spill were compared with the corresponding average values from the three year-period before the oil-spill (1990–1992), and changes were expressed as the percent of deviation from this mean.

RESULTS AND DISCUSSION

General characteristics of the communities

Station C3, located in the inner area of La Coruña Bay, has a sediment composed of well sorted, fine sand with a relatively low organic content. The dominant species are the polychaetes *Paradoneis armata, Spio decoratus* and *Magellona alleni*, and the bivalve *Tellina fabula.* Station C1, located inside the harbour area of La Coruña Bay, has a poorly sorted sediment composed mostly of silt with a high organic matter content. The dominant species in this station are the bivalve *Thyasira flexuosa*, the oligochaete *Tubificoides* sp., and the polychaetes *Chaetozone* sp. and *Capitella capitata*. These two macroinfaunal assemblages are described in more detail in the 1994 BEWG report and in López–Jamar and Mejuto (1985).

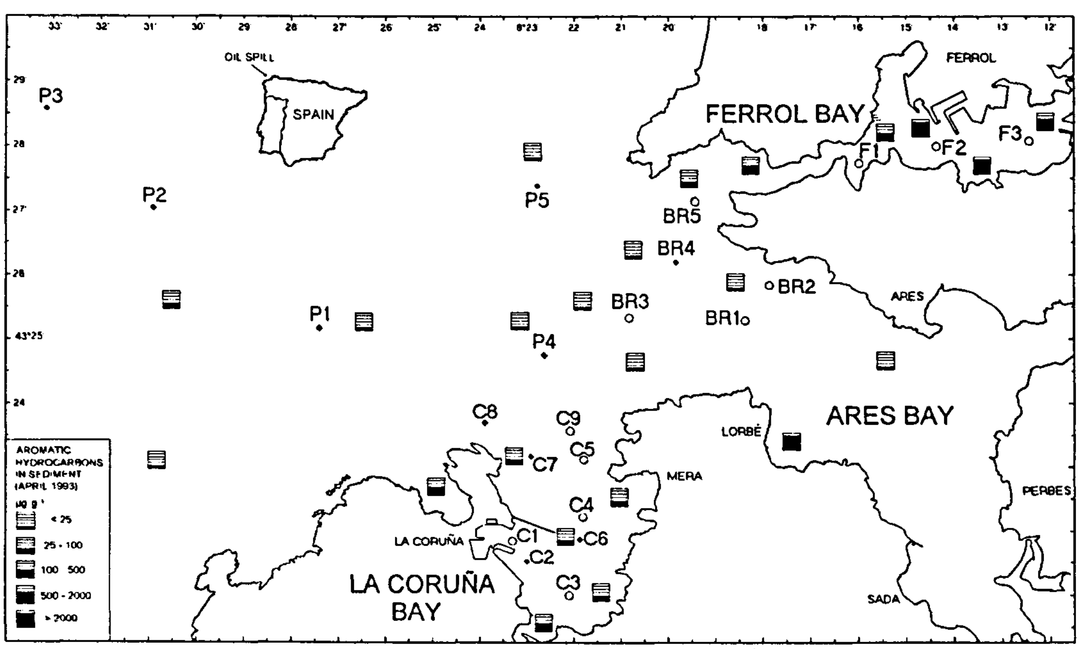

Fig. 1. Location of the sampling stations and hydrocarbon levels in the sediment in April 1993. Open dots: stations sampled monthly; solid dots: stations sampled only once.

Stations C4, C5 and C9, located in the middle and outer area of La Coruña Bay, have a sediment composed of well sorted, fine sand with a low organic matter content. Stations BR1 and BR2 are located in the outer Ares Bay, Station BR5 in the outer Ferrol Bay, and Station BR3 in the continental shelf off the three bays (Fig. 1). The sediment of these four stations is composed of fine to medium sand with a very low organic content. Station F1, located in the middle area of Ferrol Bay, has a sediment composed of silt with a high proportion of shell debris. Organic matter content is from moderate to high. Station F2, located in the middle Ferrol bay, and Station F3, located in the inner bay, have a silty sediment with a high organic matter content. The infaunal dominants of these stations were listed in the 1994 BEWG report.

Distribution of hydrocarbons in the sediment

The distribution of hydrocarbon levels in the sediment four months after the oil–spill is shown in Fig. 1. Relatively high values were recorded in the entire study area; the highest levels ocurred in Lorbé (not sampled for infauna) and in the inner Ferrol Bay. Table I indicates average values of hydrocarbons in the area during 1993 (González & Nunes, 1994). The Ría de Ferrol has the highest concentrations, although a decreasing trend is evident. The sediments of Ría de La Coruña had a relatively high concentration throughout 1993, whereas in the continental shelf the hydrocarbon levels were lower initially, but increased in July and specially in November. Although the "theoretical" temporal evolution of hydrocarbon concentration in sediments after an oil–spill should display a gradual decrease with time, this was not the case in several areas, where an irregular pattern or even an increasing trend may be present. 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).

Table I. Concentration of aromatic hydrocarbons in sediment in 1993 ($\mu g \cdot g^{-1}$). Data from González & Nunes (1994).

	April	July	September	November
Continental shelf				
Average	**18.7**	**42.3**	**143**	**528**
Maximum	23	69	393	1485
Minimum	16	12	11	9
Ría de Ferrol				
Average	**2908**	**2493**	**797**	**931**
Maximum	12800	7770	2030	2460
Minimum	277	198	90	144
Ría de La Coruña				
Average	**98**	**336**	**237**	**257**
Maximum	184	600	562	811
Minimum	34	138	54	44

Effects on the macroinfauna

In order to compare the changes induced by the oil–spill with the natural variation of the communities, we have considered first the effect of the spill on the macroinfauna of Stations C1 and C3, where information on the temporal variation prior to the spill was available. For this purpose we have used data from a three year–period before the spill. Although the community structure of both Stations C1 and C3 did not change drastically after the spill, some effects are evident. The ordination of the observations obtained by the MDS separates the pre– and the post–spill periods in both stations (Figs. 2). In Station C1 the post–spill samples (January 1993 to November 1994) are grouped quite distinctly separated from the pre–spill ones. In Station C3, this separation is not as clear as in Station C1, although both groups are still discernible. In Station C3 the post–spill samples show a wider scattering, indicating that temporal changes of the community were relatively fast.

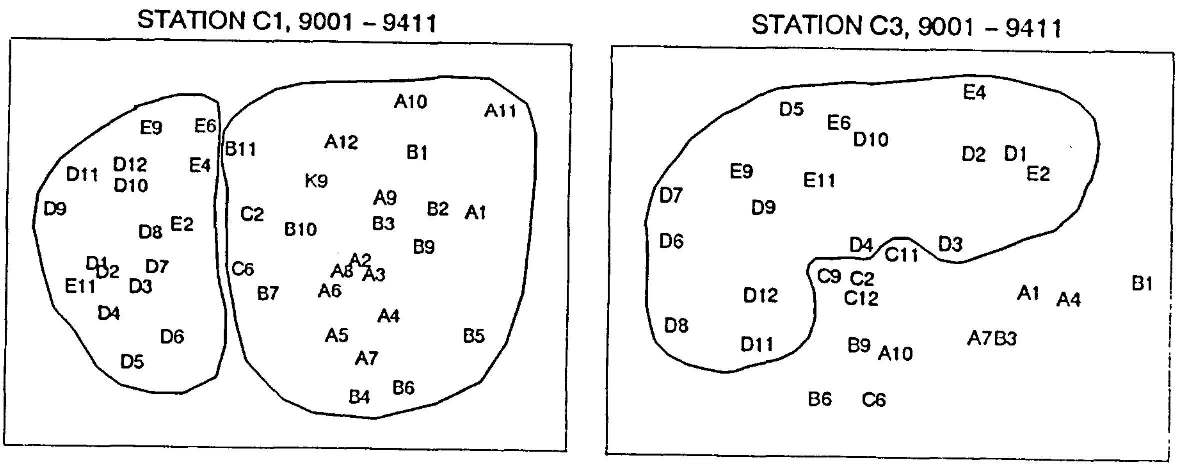

Fig. 2. MDS ordination of observations in Stations C1 and C3 (Ría de La Coruña) in the period 1990–1994; stress in C1 = 0.193; stress in C3 = 0.233. A: 1990, B: 1991, C: 1992, D: 1993, E: 1994. Numbers correspond to months.

These changes in the community structure of Stations C1 and C3 are mainly due to: (1) a high mortality of the more sensitive species during the first months after the spill; and (2): an increase in the abundance of opportunistic species. In Station C3 there was a clear decrease of species richness since January 1993 in most of the samples (Fig. 3 A). This decrease does not happen in Station C1, probably because of a better adaptation of the community to chronic pollution. The organisms more adversely afected by the spill in Station C3 were the amphipods; they were relatively abundant in the pre–spill period, but decreased significantly during 1993 and the first half of 1994. In this station other species showed important decreases after the spill, such as *Magelona alleni*, *Chaetozone* sp., *Mediomastus fragilis* and *Notomastus latericeus* (Fig. 3 C–F). In Station C1 the species that seem to be more afected are the bivalves *Abra alba* and *Abra nitida*, having densities much lower than usual during 1993 and 1994 (Fig. 3 G–H).

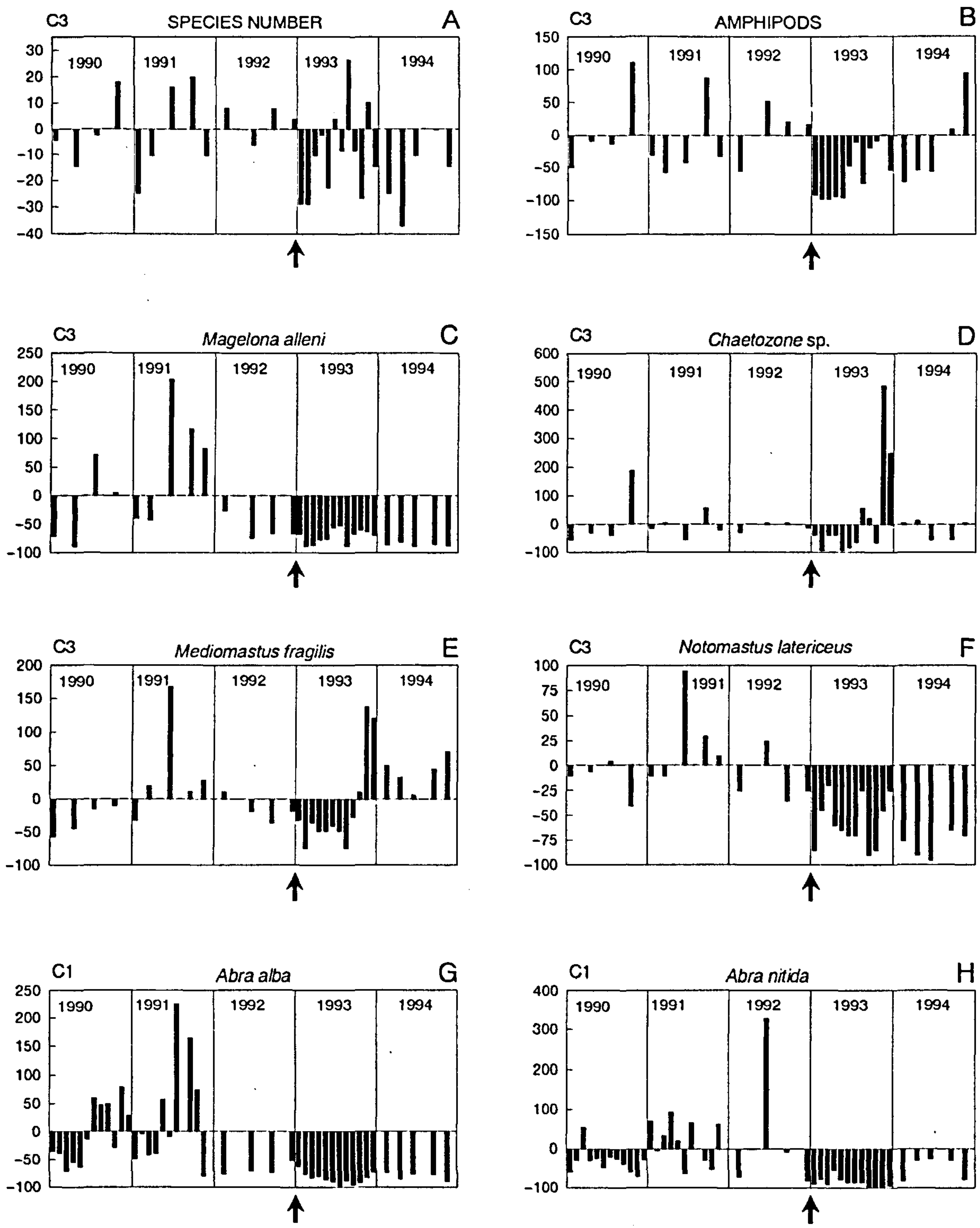

Fig. 3. Temporal variation of species number in Station C3 (A), and of several taxa whose abundance decreased after the oil spill in Stations C1 and C3. Y axis: percentage of deviation from average values during the pre-spill period (1990–1992). Arrow indicates the date of the oil-spill.

On the other hand, several species displayed very important increases in their abundance after the oil-spill. The highest abundance increase occurred in the small spionid polychaete *Pseudopolydora* cf. *paucibranchiata*, whose density reached as much as $20 \cdot 10^3$ % in Station C3 and $8 \cdot 10^3$ % in Station C1 several months after the spill. Abundance of this species rapidly decreased after these maxima, reaching normal values again (Fig. 4 A-B). The polychaete *Capitella capitata* shows a similar pattern in both Stations C1 and C3, although its increase was not as spectacular. In Station C1, *C. capitata* densities remained very high during most of 1993 (Fig. 4 C-D). The polychaetes *Notomastus latericeus* and *Ophiodromus flexuosus* also experienced relatively high increases in their densities in Station C1. In the case of *N. latericeus*, high densities were present almost constantly during 1993 and 1994. Oppossingly, a fact somewhat surprising is that *N. latericeus* seemed to be negatively affected by the spill in Station C3 (see Fig. 3 F).

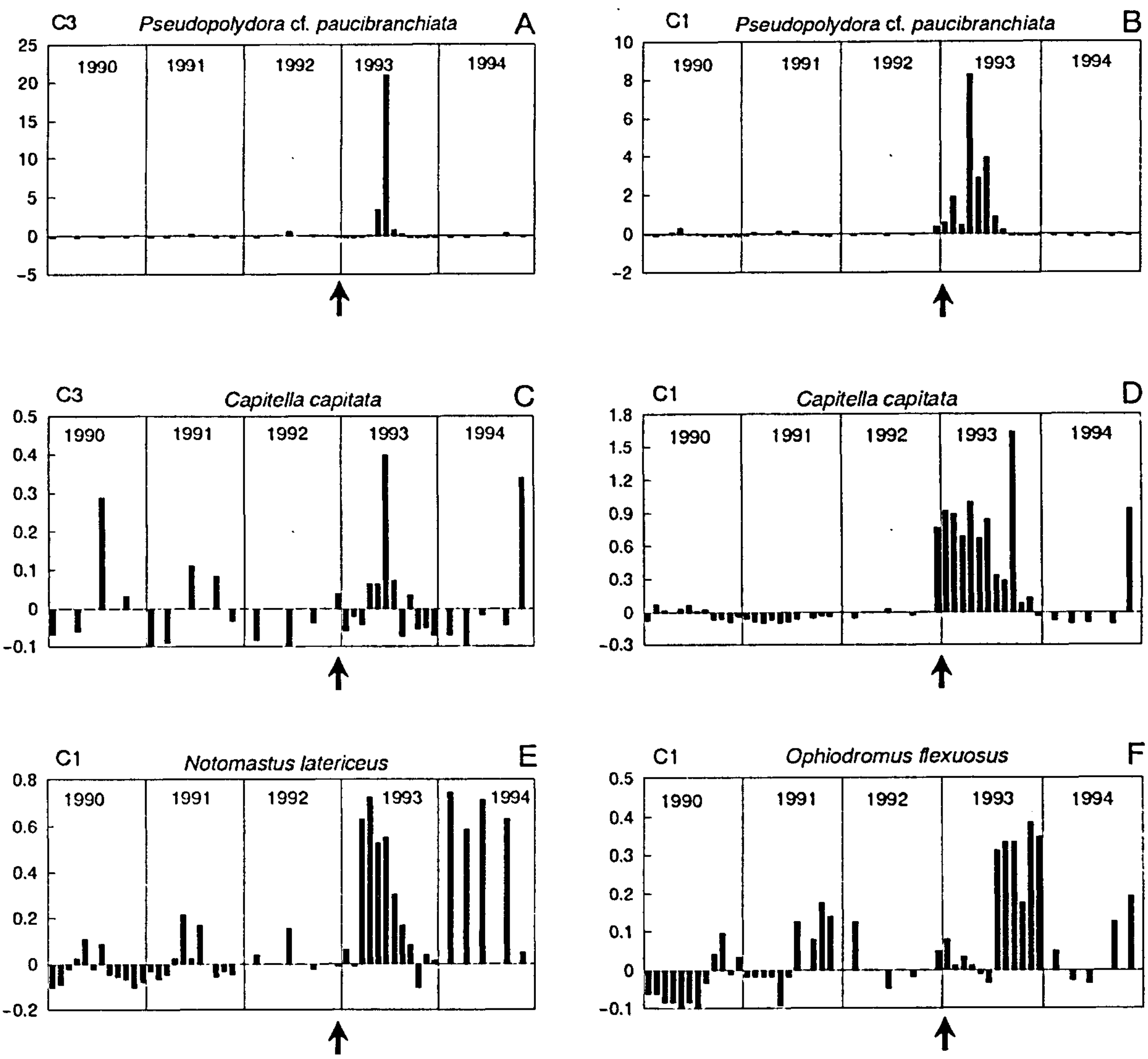

Fig. 4. Temporal variation of several species whose abundance increased after the oil-spill in Stations C1 and C3. Y axis: percentage of deviation (divided by 10^3) from average values of the pre-spill period (1990-1992). Arrow indicates the date of the oil-spill.

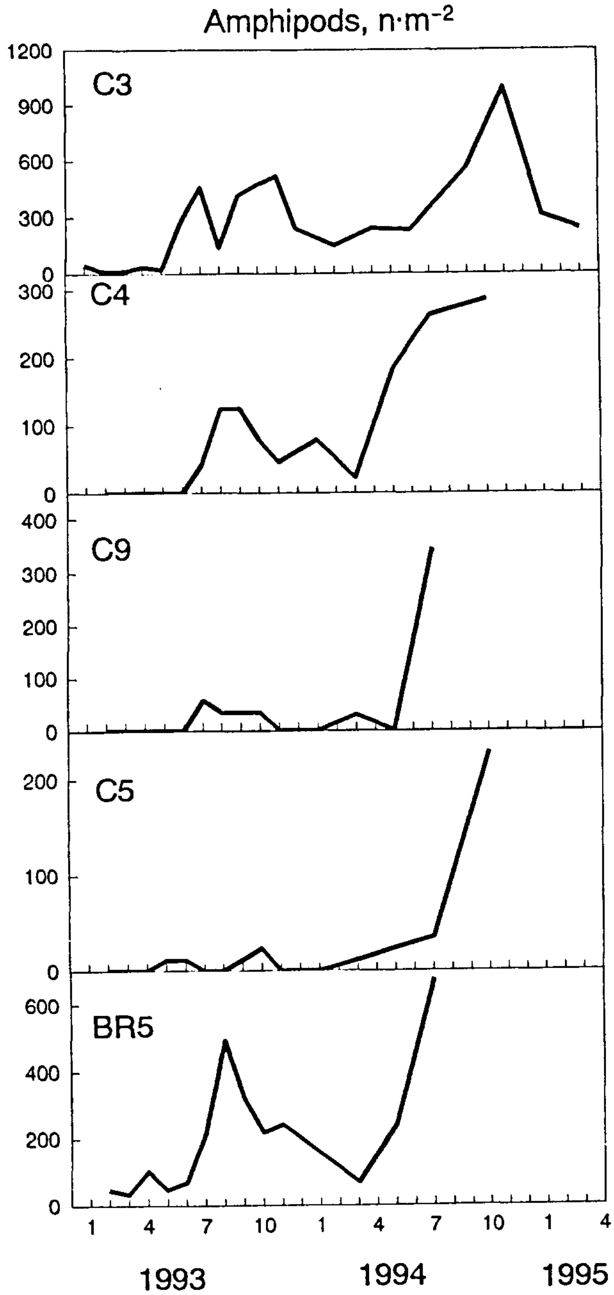

Fig. 5. Temporal variation of amphipods after the oil–spill in several sampling stations.

In the stations where no information was available before the spill, the interpretation of the results is more difficult. However, we tried to evaluate the effects of the spill by comparing the temporal variation of these stations with the changes that occurred in Stations C1 and C3. An increasing trend of the abundance of amphipods during the first months after the spill is quite evident in Stations C4, C9, C5 and BR5 (Fig. 5), suggesting that this group was severely affected in these stations. The sharp increase of abundance of opportunists (*Capitella capitata*, *Pseudopolydora* cf. *paucibranchiata*) several months after the grounding is also clear in other stations (Fig. 6). However, in some of these stations there is a second peak in 1994, and thus the relation between the proliferation of opportunists and the spill cannot be established in these stations.

Studies on the effects of the *Aegean Sea* oil–spill on the benthic communities will continue at least during 1995. However, at this stage we can conclude that the general consequences on the subtidal benthos were not catastrophic, and that after two years, most of the communities have almost recovered their normal structure prior to the spill.

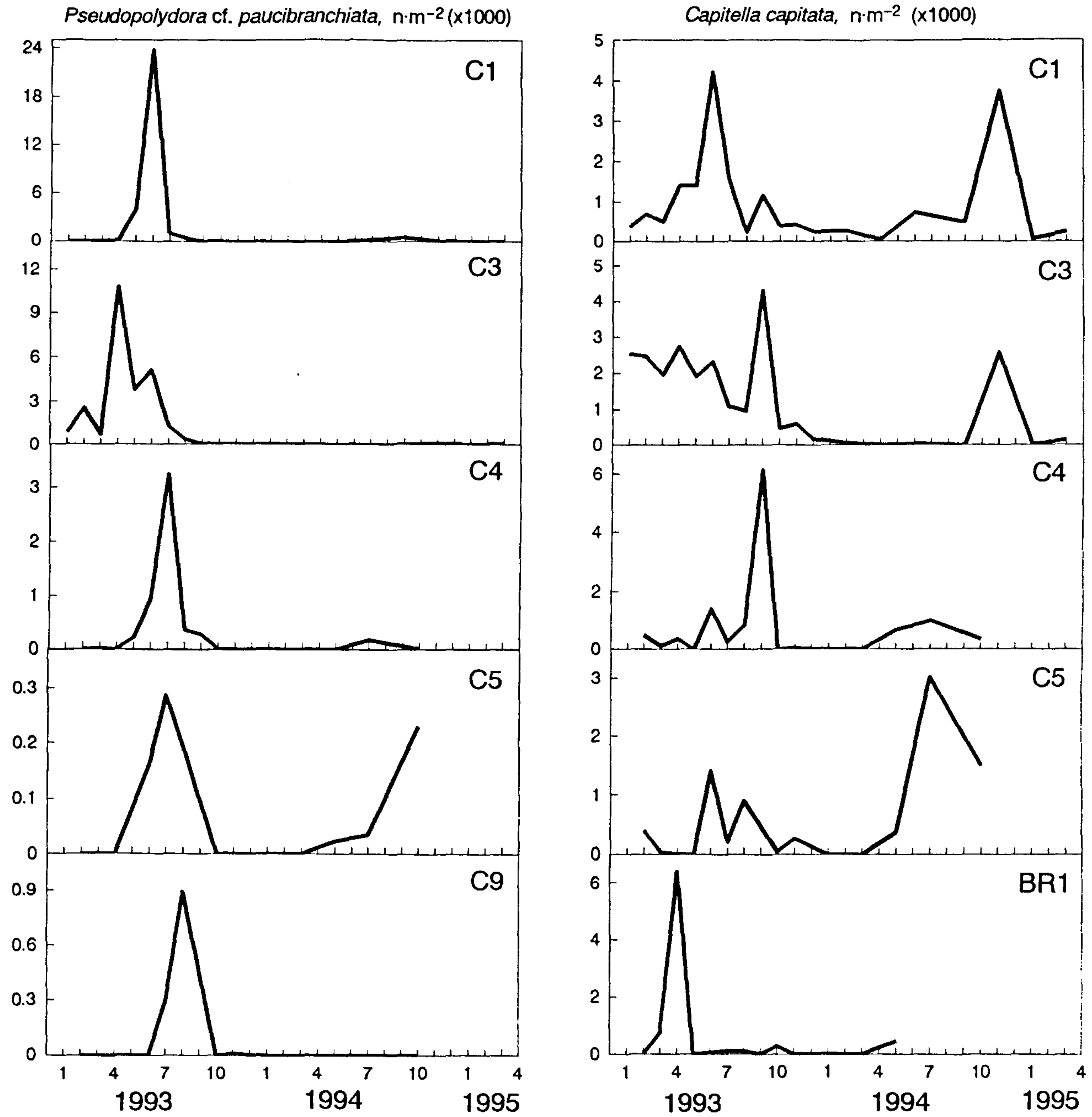

Fig. 6. Temporal variation of *Pseudopolydora* cf. *paucibranchiata* and *Capitella capitata* after the oil-spill in several sampling stations.

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Field, J.G., K.R. Clarke & R.M. Warwick. 1982. A practical strategy for analysing multispecies distribution patterns. *Mar. Ecol. Prog. Ser.* 8: 37–52.

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Benthos Ecology Working Group 1995
Working document

Benthos database structure

This description of a benthos database serves two purposes:

1) It should form the basis for the data reporting protocol to be applied during the 1996 North Sea Benthos Survey

2) The description will define the benthos data base (potentially) to be established at the ICES Secretariat

The description is generic, i.e. it contains no assumptions concerning the computer software or hardware that will process and store the data. The principle is that the structure should be so general that it can be implemented on any computer platform.

In contrast to, for instance the BEDMAN database (see the last page of this annex), this proposal describes two databases: One for *sampling* data (sampling position, number of individuals found, etc.), and one for *species codes* data (systematic name, synonyms, codes, etc).

The *sampling* data base will have this structure:

Hierarchy links:
- Cruise
- Station
- Sample
- Species

Horizontal links:
- Person
- Comment

The *species codes* data base will have a simple list structure

There are three data types:

NUMX: Integer, length X
NUMX.Y: Real, total length X, the decimal part of length Y
CHARX: Character, length X

Sampling data base

Cruise record			
Field	Type	Possible values	Description
CRIDE	CHAR10	User defined	Cruise identifier
CRDES	CHAR4	COKEY	Cruise description
CRLAB	CHAR4	Database	Laboratory/Institute conducting cruise
SHIPC	CHAR2	Database	Ship code
NUMST	NUM2	0..99	Number of stations sampled during cruise
FIDAY	CHAR8	0..99999999	First day of sampling
LADAY	CHAR8	0..99999999	Last day of sampling
CRSCI	CHAR4	PEKEY	Scientist responsible for cruise
DASCI	CHAR4	PEKEY	Scientist responsible for data handling
CRKEY	CHAR4	User defined	Cruise key

Station record			
Field	Type	Possible values	Description
STIDE	CHAR10	User defined	Station identifier
SDATE	CHAR8	0..99999999	Sampling date (YYMMDD)
STIME	NUM4	0..2359	Sampling time (HHMM)
LATDG	NUM3	-90..+90	Latitude degrees
LATMI	NUM2	0..59	Latitude minutes
LATMF	NUM2	0..99	Latitude decimal minutes
LONDG	NUM4	-179..+179	Longitude degrees
LONMI	NUM2	0..59	Longitude minutes
LONMI	NUM2	0..99	Longitude decimal minutes
WADEP	NUM4	0..9999	
NUMSA	NUM2	0..99	Number of samples taken at station
STKEY	CHAR4	User defined	Station key
CRKEY	CHAR4	User defined	Cruise key

Sample record			
Field	Type	Possible values	Description
SAIDE	CHAR10	User defined	Sample identifier
SDETY	CHAR4	Database	Sampling device type
SDEAR	NUM5.1	0..9999.9	Sampling device area (cm2)
NUMSP	NUM4	0..9999	Number of different species identified in sample
SLIST	CHAR5	MCSCO (Marine Conservation Society Species Directory Code), RUBIN (RUBIN code), SYSNA (systematic name) SPKEY (species key)	Species code system applied
SAKEY	CHAR4	User defined	Sample key
STKEY	CHAR4	User defined	Station key
CRKEY	CHAR4	User defined	Cruise key

Species record (data reporting)			
Field	Type	Possible values	Description
SNAME	CHAR65	Database	Species name, according to SLIST
NUIND	NUM4	1..9999	Number of individuals found in sample
BIOMW	NUM7.3	0..9999.999	Weight of biomass in sample
BIOMB	CHAR1	'D', 'W'	Basis for BIOMW (wet weight or dry weight)
SAKEY	CHAR4	User defined	Sample key
STKEY	CHAR4	User defined	Station key
CRKEY	CHAR4	User defined	Cruise key

Person record			
Field	Type	Possible values	Description
PNAME	CHAR65	User defined	Person name
PELAB	CHAR4	Data base	Laboratory
PEKEY	CHAR4	User defined	Person key

Comment record			
Field	Type	Possible values	Description
COTXT	CHAR65	User defined	Comment text
COKEY	CHAR4	User defined	Comment key

BEDMAN (BEnthic Data MANagement)
update May 1995

J.A. Craeymeersch & J. Buijs

Surveys included

1) the ICES BEWG North Sea Benthos Survey (1986)
2) stations in the northern North Sea lying on an extrapolated ICES grid (1980-1985)
3) surveys in the Voordelta (coastal region from the Belgian border to the Rotterdam harbour in the north) (1984-1988)
4) an inventory of the spatial distribution of the zoobenthos on the Dutch Continental Shelf (MILZON) (1988-1993)
5) monitoring program of Rijkswaterstaat on the Dutch Continental Shelf (1990-1993) (incl. NSTF-MMP)
6) monitoring program of Rijkswaterstaat in the estuarine area of the rivers Rhine, Meuse and Scheldt (1990-1993)
7) monitoring program to evaluate the effects of a land reclamation scheme, designed to extend Rotterdam harbour (1988-1990)
8) Norwegian NSTF data (NIVA) (1990-1991)
9) Norwegian NSTF data (Institute of Marine Research, Bergen) (1990-1991)
10) German monitoring program (1987-1990) (incl. NSTF-MMP)
11) NSTF data of Scottish coast and Shetland (1990)
12) NSTF data of the UK North Sea coast and offshore (1991)
13) Swedish west coast benthic program (including NSTF stations) (1985-1991)
14) surveys for Norwegian oil fields (1981-1990)
15) Grevelingen (SW Netherlands) (1982-1989)
16) Westerschelde (SW Netherlands) (1978-1990)
17) Doggerbank (data NIOZ) (1986-1987)

Database structure

The file BEDMAN2.DB has been split up in three files, respectively storing information on 1) numbers and density, 2) biomass and 3) length/age of some molluscs. The file BEDMAN9.DB has been included in the biomass file.

In these files, the 'species identification number' has been replaced with a 'name identification number'. Thus, the original names given by the researchers can be stored (although not yet done for the data included in the past). The file SPEC_TOT.DB now contains following fields:

Name id	name identification number
Species id	species identification number
Name	latin name
Author	author who first described the species
Biblio	bibliographic citations
Remarks	s = species consists of several species; d = there are two or more species with the same name
Literature	references
MCSSD-No	Marine Conservation Society Species Directory code
Rubin code	Rubin code

Thus, synonyms have a different 'name id' but the same 'species id'. The file SYNONYM.DB is now included in SPEC_TOT.DB. We hope to fill in al blanks (author, etc.) within the next year. For the species included in BEDMAN5.DB the 'species id' is identical to the 'name id'.