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REPORT OF THE

BENTHOS ECOLOGY WORKING GROUP

Heraklion, Crete, Greece
23–25 April 1998

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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1 OPENING OF THE MEETING

The Benthos Ecology Working Group (BEWG) met in Iraklion at the Institute of Marine Biology in Crete (IMBC), Greece under the chairmanship of Dr Karel Essink.

Prof. A. Eleftheriou welcomed the group on behalf of the hosting Institute. He noted that although Greece is not a member of ICES, it held observer status which has been of great help to Greece and that IMBC will host a number of ICES meetings in coming years.

A full list of participants is given in Annex 1. Apologies were given by a number of members who are no longer able to participate in the BEWG (K. Hiskock and E. Lopez-Jamar) and from S. Smith, D. Schiedek, and K. Leonardsson who were not able to participate in the meeting. There was no representative from the ICES Secretariat at the meeting.

2 APPOINTMENT OF RAPPORTEUR

Dr Chris Smith was appointed rapporteur.

3 TERMS OF REFERENCE

The terms of reference for the 1997 meeting of the Benthos Ecology Working Group (ICES C.Res.1997/2:52) were to:

a) report on the progress on the planning of the North Sea Benthos Project;

b) assess the results of the IMPACT II project on the effects of fishing activities on the benthos;

c) report on developments in computer aids in benthic studies (taxonomic and operational);

d) provide guidance to ACME [OSPAR 1998/2:1] on quality assurance procedures for benthos studies through:

   i. review of case studies presented by members,

   ii. contributions to an inventory of national guidelines for the conduct of benthos surveys operated in different countries (within and outside the OSPAR area);

e) prepare guidelines for epifaunal sampling and epifauna community description;

f) review the ecological aspects of the introduction of *Marenzelleria* spp. in northwestern European waters;

g) debate the merits of different sampling approaches to benthos studies and new sampling devices, with a view to upgrading existing guideline;

h) provide basic recommendations on QA for sampling on hard bottom substrates [OSPAR 1998/2:1].

The terms of reference had been distributed prior to the meeting and there were no comments from the members of the group. H. Rumohr noted that the group should frame potential points for inclusion in the recommendations during the meeting.

4 ADOPTION OF THE AGENDA

Participants had received copies of the draft agenda prior to the meeting. K. Essink noted that some of the action points from the 1997 meeting belong to one or more of the Terms of Reference and others are in point 7 of the Agenda. There were no further comments and the Agenda was adopted and is attached as Annex 2.

5 REPORT ON THE 1997 ICES ANNUAL SCIENCE CONFERENCE - BALTIMORE, USA

There was no representative from the ICES Secretariat to report on the Annual Science Conference, primarily because J.R. Larsen is leaving ICES .

H. Rumohr, however, had been present at the ASC meeting and provided some information. All contributions and papers were delivered in Theme Sessions and a Mini Symposium. The Biological Oceanography Committee came to an end in the restructuring process of ICES. At its final session H. Rumohr gave a report on the history of the BOC, titled 'Twenty years of Benthic-Pelagic Coupling', ending on a high note. The new parent committee for BEWG is the Marine Habitat Committee (MHC) and A. Jarre-Teichmann from Denmark was elected as chairperson. New topics, policies and aims for the MHC are still being constructed. Working groups formerly under the BOC have now been placed under two different parent committees, with the pelagic groups going to the new Oceanography Committee and benthos, seabirds and contaminants moving to the MHC. There is on-going discussion over this division and there may be some alterations in the future.

A. Eleftheriou, also present at the ASC meeting, noted that benthos was totally absent from the plenary session (thematic areas) which was a notable occurrence. There seems to be a new cycle starting where benthos is regarded as a complication to the ecosystem and is out of favour. It would not even have been mentioned at the conference had H. Rumohr not made his presentation concerning the BOC. BEWG concurred that it would try and highlight the role of benthos in theme sessions at major meetings in future.

The report for the 1997 ICES Annual Science Conference (85th Statutory Meeting) (Baltimore, 25 September–3 October 1997) has been published.

6 REPORT ON ACME AND OTHER MEETINGS OF INTEREST

6.1 ACME Meeting

There was no representative from the ICES Secretariat to report on the ACME meeting. H. Rumohr had been present at the ACME meeting to present information on the effects of trawling, seabirds, and the pending North Sea Project. He noted that the meeting mainly dealt with the new structure. Members were referred to the ACME report for further information.

It was noted that the ACME had recognised the importance of the BEWG especially with regard to quality assurance.

6.2 ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO)

K. Essink was involved in a presentation on the dispersal and the development of populations of *Ensis americanus* and *Marenzelleria* spp. in northwestern Europe. A report on *Marenzelleria* is given later in this report.

6.3 ICES Working Group on Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT)

K. Essink reported that there was a meeting of the WGEXT running concurrently with the BEWG. A presentation was made by Essink on cockle shell extraction in the Netherlands. The amount of material removed has to balance annual production figures for shell material, in order to produce a sustainable shell extraction. Most of the shell material is fossile and amounts are not exactly known. The report was made available to BEWG and members were encouraged to look at it.

H. Rees noted that a major aim of this meeting was to produce a draft ICES Cooperative Research Report on marine aggregate extraction. Drafts of the different chapters are being considered for discussion at the meeting

6.4 Monitoring Biodiversity in the North Sea Groundfish Survey (EEC/FAIR)

H. Rees reported that a meeting on this project is currently taking place in Hirtshals, Denmark. BEWG member I. Kröncke is participating in this project. K. Essink is in contact with A. Jarre-Teichmann (Hirtshals).

6.5 ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements Related to Eutrophication Effects (SGQAE)

H. Rees chaired the 1998 SGQAE meeting. The report of that meeting is published as ICES CM 1998/ACME:3.

6.6 ICES/HELCOM Steering Group on Biological Measurements in the Baltic Sea (SGQAB)

H. Rumohr reported on a SGQAB meeting that was held in conjunction with the SGQAE in Copenhagen. SGQAB was mainly concerned with the new HELCOM Monitoring Recommendations (COMBINE) and quality assurance. Annex C-8 of the HELCOM COMBINE guidelines covering the macrobenthos recommendations was presented to the BEWG for comments (see Annex 3).

6.7 ICES/HELCOM Benthos Taxonomic Workshop (WKBT)

J.N. Jensen reported on this workshop that took place in Copenhagen in November 1997. It was agreed to have an intercalibration workshop every two years. This covers all faunal groups with participants bringing their own interesting or problematic materials. There is a maximum number of 20 participants. The possibility to cover the OSPAR area was discussed. H. Rumohr has committed to drafting a funding proposal for the next two workshops in Copenhagen. In the off-years there will be national meetings on selected topics (e.g., identification of small individuals of *Marenzelleria*).

6.8 Society of Integrative and Comparative Biology, USA

L. Watling reported on this meeting held in Boston in January 1998. While normally concerned with pure biology, there were two days on molecular phylogeny of invertebrates and on phylogenetic relationships. This is an expanding and interesting field. However, a major observation of a disturbing nature was that molecular biologists rarely use morphological information when relating their results.

6.9 Sand and Gravel Extraction

H. Rumohr reported on a German national meeting on sand and gravel extraction. New methods and approaches to monitoring were detailed. In particular, the role of abundant and rare species, working up times and economic implications of sampling were noted.

7 REPORT ON COOPERATIVE STUDIES AND OTHER STUDIES RELEVANT TO ICES (INCL. ACTION LIST OF 1997 BEWG MEETING)

7.1 Large-scale Distribution Patterns in Molluscan Assemblages off North Iceland

S. Steingrimsson reported on a study on distribution patterns of Mollusca in Icelandic waters. A total number of 42 samples were included in the analysis with a depth range between 40 and 1200 m and a latitudinal range between 66 °N and 68 °N. Around three hundred (268) different taxa (species/genera) were identified from a collection of 2916 individuals. Classification based on similarity measures indicated three major assemblages (A, B, and C), with low similarity (Bray-Curtis, 25 %), and was further demonstrated by a non-metric multidimensional scaling (MDS). The geographical distribution of the assemblages was clearly restricted by depth. In shallow coastal areas (< 100 m depth) *Arctica islandica*, *Macoma calcarea*, and *Nuculoma tenuis* were identified as indicator species (44.3 % of average abundance, assemblage A). On the continental shelf (~100–300 m depth) Nuculoma corticata, *Crenela decussata*, *Thyasira pygmaea*, and *Nuculana pernula* were the dominating species (26.5 % of average abundance, assemblage B) and further off shore (> 300 m depth) *Thyasira pygmaea*, *T. dunbari*, *T. flexuosa*, and *Dacrydium vitreum* (62.7 % of average abundance, assemblage C). Further analyses will relate the observed large-scale distribution patterns to environmental parameters associated with the samples.

7.2 Macrobenthos Variability in the Barents Sea

E. Rachor reported that the Barents Sea is subjected to strong variations in the inflow of warm Atlantic waters and in its ice coverage and the influence of cold Arctic waters. Primary production in the marginal ice zone and ice-free areas of the Barents Sea can be high, supporting not only the rich benthic communities in these areas but also, according to a simple summer model of carbon fluxes constructed after a European 'Polarstern' expedition in 1991, allowing export of

particulate organic matter into areas of low primary production, especially the permanently ice-covered regions in the North.

At several Russian Institutes, especially the Murmansk Marine Biology Institute and the Zoological Institute of St. Petersburg, there are data and materials available on the variability of zoobenthos in the Barents Sea during the past 100 years. As an INTAS project, selected materials (especially molluscs, ophiuroids, and cumaceans) have been analysed with respect to dramatic variability. Four main climatic periods could be identified: cold - before 1920; warming and warm - 1920 until the early 1960s; cold - late-1960s until mid-1980s; and warming again thereafter. All of the investigated zoobenthos groups showed shifts in their distribution patterns during these periods, with the more warm temperature adapted Atlantic-boreal species penetrating into the north and east regions of the Barents Sea (and the Arctic elements retreating) during the warm periods, while cold-adapted species spread to the south and west during/after cooling.

The cumaceans are given as an example of a taxon with a high number of Atlantic-boreal species. Accordingly, species numbers of cumaceans in the Barents Sea increased significantly during warming. The ophiuroids exhibit quite the opposite pattern, with higher species numbers during colder periods. A review of the main results of these Barents Sea studies is in preparation and will be submitted to Polar Biology for publication. Results concerning the changes in mollusc fauna were published in Russian by Y. Galkin; an English publication is in press (Ber. Polarforsch., 1998).

7.3 Joint Research Projects in the Mediterranean Sea

C. Smith reported on some of the on-going benthic studies in the Mediterranean, principally the EU-supported MAST project Mass Transfer and Ecosystem Response (MATER). This project involves over 50 institutes from 13 countries in a number of subprojects covering 3 basins in the Mediterranean. Benthic faunal studies are covered in detail in the Eastern Mediterranean by the Institute of Marine Biology Crete. Generally speaking, Mediterranean benthic studies tend to be limited and tend to be financed at the local level and are not cooperative, but are more impact-oriented.

7.4 Recovery of Kattegat Fauna after Oxygen Depletion

J.N. Jensen reported on the recovery of the benthic fauna in the Kattegat since the occurrence of a period of oxygen depletion in autumn 1988. Several stations seemed to show an increased biomass, although few of them were significant. An increased biomass and individual size through time of *Amphiura filiformis* were significant at stations situated in regions with low oxygen concentration in autumn 1988, multidimensional scaling (MDS) showed that the community has changed significantly from the end of the 1980s to the present. Several species were responsible for this change.

7.5 Macrofaunal Communities on the Dogger Bank

I. Kröncke reported on current on-going investigations at the Dogger Bank in the North Sea. Macrofaunal communities were compared with those investigated in the 1980s. The station grid, the grab and sampling were identical to those employed by Kröncke in the 1980s. Samples were taken in May 1996.

The results of the comparison can be summarized as follows:

i) a decrease of the mean abundance;

ii) a decrease of northern species, species with a wide spatial distribution in the North Sea, and species with a preference to fine sand sediments;

iii) an increase in species numbers, diversity and evenness;

iv) an increase of 'southern' species and those which prefer coarser sediments.

Most of these changes occurred especially in the northeastern part of the Dogger Bank.

The changes found might be caused by the severe winter of 1995/1996 that reduced food availability and reproduction. Also changes in the large-scale hydrological regime of the North Sea with a higher inflow of water masses through the English Channel might have affected the species distribution in the northeastern part of the Bank. In addition, higher mud contents on the whole Dogger Bank and changes in species composition especially at deep stations at the southern border of the Dogger Bank indicate increasing eutrophication of the central North Sea. Especially the northern border of the Dogger Bank is heavily fished for sandeels, effects will be discussed.

7.6 Long-term Zoobenthos Studies in the German Bight

E. Rachor reported that zoobenthos (macroinfauna) has been sampled by the Alfred-Wegener Institute (AWI) at four locations in the German Bight since the late 1960s. Increases in densitiy and biomass have been described in several papers; they have been related to increased eutrophication in the German Bight. Strong meteorological 'events', especially cold winters, are superimposed on these trends as well as the regularly occurring disturbances by heavy demersal fishing gears. Until the very cold winter of 1995/1996 there was a quite 'steady' increase in zoobenthos biomass, which is well-documented by the highest biomass values ever reported in the German Bight in 1995.

To better understand the main factors controlling long-term variability of zoobenthos, a new project is being developed as a cooperative programme of Dutch and German institutes (NEBROC). It is intended to combine the results of continued benthos sampling with those of growth ring analysis of long-lived animals (alive and sub-fossil, e.g., *Arctica islandica*, which would allow reconstruction of life conditions for more than 100 years), and with geological core analyses from the same area. It is expected that this may allow reconstruction (back-casting) of zoobenthos at least for several hundred years. From these results, correlations with the known climatic changes in the southern North Sea may be investigated.

Another perspective of long-term biological studies in the German Bight is related to the incorporation of the Biologische Anstalt Helgoland (BAH) into the Alfred Wegener Institute. Thus the long-term benthic offshore studies of the former AWI will be included in the pelagic and inshore benthic long-term programme of the BAH.

7.7 Infaunal Crash and Recovery in Gullmarsfjorden, Western Sweden

B. Tunberg reported that a widespread mass mortality of benthic organisms occurred in the deep areas of the Gullmarsfjorden on the Swedish west coast, probably caused by low oxygen levels. These severe disturbances were observed in the early 1980s, late-1980s–early 1990s and in 1997–???? Statistical analyses have indicated that these disturbances are strongly connected to cyclical changes within the infaunal communities in the Skaggerak, which have been shown to be linked to the climatic phenomenon NAO (North Atlantic Oscillation). Therefore, most likely, climatic oscillations influence not only the benthic communities of the Kattegat/Skaggerak region, but also those of 'enclosed' fjord systems. If the role of climatic variation is not considered, it may lead to incorrect conclusions of anthropogenic versus naturally generated disturbances in regulating marine biological systems.

This topic was received by BEWG with great interest, supporting a long discussion based around the urgent need for further information and data from different geographical areas. The group focused on the need to identify and understand the mechanisms of the action. A number of similar cyclical phenomena have been recognised in Germany and Sweden, in soft- and hard-bottom communities with various degrees of lag on the NAO. It was proposed that benthic community studies be linked with the NAO and become one of the action points in the terms of reference. This would help to catalyse work in this direction. It should also become the focus of a research proposal with particular emphasis on larval development and recruitment which is thought to be one of the key mechanisms.

7.8 The BioMar Project

D. Connor reported that the Life-funded BioMar programme (1992–1997) is now completed, with the final report awaiting approval from the EC before publication. The main outcomes of the project were a survey of coastal (National Parks and Wildlife Service, Dublin) and marine (Trinity College, Dublin) habitats of Ireland, which helped identify sites for designation under the EC Habitats Directive, the development of a marine biotope classification for Britain and Ireland (UK Joint Nature Conservation Committee), the development of rapid survey techniques for intertidal and subtidal marine habitats (University of Newcastle, and an inventory of European marine protected areas (AID Environment, Netherlands).

D. Connor elaborated on the biotope classification, which is a hierarchical classification now widely used in the UK and Ireland for interpretation of marine data, mapping, and nature conservation management. The classification has been distributed to 18 countries in Europe and has been incorporated into a CD-ROM information system (the *BioMar Viewer*) which was made available to BEWG members for inspection.

7.9 OSPAR and European Environment Agency Habitat Classification Initiatives (EUNIS)

D. Connor reported that an OSPAR workshop on marine habitats and species, held at Texel, Netherlands in February 1997, strongly encouraged the development of a marine habitat (biotope) classification for the OSPAR North-east Atlantic region. As a consequence, the UK will make further proposals for such a classification to the OSPAR IMPACT meeting in September 1998, together with reporting on a literature review on the ecological functioning of a number of marine habitats (e.g., kelp forests, seagrass beds).

The European Topic Centre on Nature Conservation (ETC/NC), Paris, on behalf of the European Environment Agency, is currently developing EUNIS (a European Nature Information System) which includes a European habitat classification. The marine part of this classification at present primarily reflects the BioMar classification (i.e., only covers Britain and Ireland). The ETC/NC has been encouraged to encompass marine habitats from the rest of the North-east Atlantic, the Baltic, and the Mediterranean through wider consultation.

7.10 UK Marine Nature Conservation Review

D. Connor reported that this programme, run by the Joint Nature Conservation Committee (JNCC), has now ended. Following 11 years of marine habitat surveys around Britain, over 30,000 habitat samples have been compiled in a database used to develop the BioMar biotope classification and to identify sites of high nature conservation interest. The results of the programme are currently being published in a series of volumes, each describing particular sections of coast with biotope maps.

7.11 UK Marine SACs Project

D. Connor reported that a major new Life-funded project had started in the UK (to run until 2001). Its main aim is to develop management schemes on 12 demonstration sites to be designated as Special Areas of Conservation (SACs) under the EC Habitats Directive. The project includes the development of monitoring programmes and techniques for marine habitats and species for which the UK will involve European specialists (including ICES and OSPAR), especially through a workshop to be held in October 1998.

7.12 European Species Directory (MAST Concerted Action)

D. Connor reported that a two-year programme involving collaboration between 22 institutes throughout Europe has just begun to develop a checklist of marine species for Europe. It will be published both on the world-wide web and in book form, together with a bibliography of taxonomic identification guides, a register of taxonomic experts, and a list of locations for reference collections. D. Connor encouraged the BEWG to communicate with the programme coordinator to ensure mutual benefit as ICES was already involved in taxonomic coding systems for its databases (see the 1997 BEWG Report).

7.13 Utilization of Acoustic Methods for Broad-scale Benthic Mapping

M. Robertson reported that over the last three years FRS Aberdeen has been conducting an evaluation of RoxAnn, an acoustic seabed classification system and in the process, also providing data for the MNCR initiative, throughout the Greater Minch, an area on the western coast of Scotland between Kinlochbervie (58° 26.00'N 05° 15.00'W) and Stanton Banks (56° 00.00'N 07° 33.00'W) of approximately 17,000 km^2.

Five cruises, on board the research vessel 'Clupea', were undertaken from August 1995 to July 1997 during which acoustic, video, and photographic data were collected along with infaunal and sediment sampling. The acoustic data were logged using an Apple computer loaded with MACSEA GIS software. This provided a real-time plot of the cruise tracks coloured with preliminary user-defined shades while TV and photographic images were taken using either a towed sledge or a drop-frame. Soft sediments were sampled by means of a 1/10 m^2 Day grab.

On return to the laboratory, the acoustic data were divided into three groups corresponding to the North Minch, Little Minch, and South Minch and were analysed using the SURFER and IDRISI packages. Unsupervised cluster analysis of the acoustic data from the North Minch revealed the presence of 11 clusters, 9 for the Little Minch and 4 for the South Minch, respectively. Comparisons between the ground-truthing samples and the acoustic data supported these divisions.

Both the North and South Minch regions were dominated by mud and mud/sand while the Little Minch exhibited a mixture of sediments comprised, primarily, of sand, gravel, and stones.

The epifaunal community was investigated throughout the area by the means of two video techniques from a total of 57 sites; on softer sediments, a towed epibenthic sledge was deployed, while over harder ground a drop-frame was lowered to within 1 metre of the seabed and the vessel was allowed to drift for up to thirty minutes. Still photography was carried out by means of a Hasselblad camera mounted on a square, steel tubing drop frame. Up to 20 random photographs were collected from each site by this method.

65 epifaunal species or taxa were recognised from the Greater Minch area. Echinoderms were the most numerous, accounting for 30.8 % of all those identified. Cnideria and Crustacea were common (21.5 % and 20.0 %, respectively), while Mollusca, Porifera, Annelida, Tunicata, and Echiura were also observed.

Analyses of these data identified 4 broad groupings that could be related to sediment type. **Community A** was characterised by a gravel substrate and had an epifauna dominated by the feather star *Antedon bifida*; **Community B** was characterised by the presence of a soft-mud substratum dominated by burrowing decapods, however, within this grouping three subgroups were identified and were generally characterised by small variations in sediment characteristics and by the presence of additional species such as *Asterias rubens* and *Gymangium montagui.* **Community C** occurred over mixed sediments and comprised a variable fauna; *Gymangium montagui* was the most common species while *Pagurus prideaux*, *Adamsia carciniopados*, *Myxilla incrustans*, and *Echinus esculentus* were also present in large numbers. **Community D** was found over bedrock and large boulder fields, the fauna being dominated by the echinoderms. The four broad groupings identified here were compared with recently published JNCC (UK) biotope definitions and proved to be comparable even when difficulties in defining biotopes of mixed sediments are included.

The infauna were also sampled during these cruises; samples and data are still being analysed and will be published shortly.

A final cruise was undertaken in February 1998 in the Moray Firth to assess the suitability of a high-speed ground truthing vehicle. Data are still to be analysed.

7.14 Effects of Fisheries on Deep-water Coral Reefs on the Norwegian Continental Shelf

On-going research on the *Lophelia pertusa* coral reefs was reported by Jan Helge Fossa. The high structural complexity of the *Lophelia* reefs has been documented on videos by the Norwegian State Oil Company in connection with topographic mapping of the mid-Norwegian shelf. These and other investigations show that the extent of this habitat is much larger than previously known. At present the largest documented reef is found at the Sula ridge. It is 13 km long with an average width of 250 m. Along the continental break at 300–400 m depth there seem to be large areas covered by corals. During recent years alarming reports from fishermen indicate that large areas with corals have been damaged by bottom trawling on the Norwegian shelf and along the shelf break at Storegga. The goals of the Norwegian project are to: collect new information on the natural distribution of *Lophelia*; map reported damage; develop methods for a) mapping of reefs and b) obtain documentation on the destruction of reefs. The ecological importance of the reefs as a habitat for fish will be studied by performing an experimental fishery.

BEWG concluded the discussion with the following statement:

Lophelia coral reefs are a highly structured and complex deep-water habitat associated with an exceptionally high species diversity, which are believed to take decades or even centuries to establish. Potential widespread damage by the use of mobile fishing gear to such a sensitive habitat is therefore of considerable concern. The ICES BEWG strongly endorses Dr Fossa's intention to collect scientific evidence to establish the effect of such trawling activities. The ICES Secretariat is requested to bring this issue to the attention of the ICES Working Group on Ecosystem Effects of Fishing Activities.

7.15 Macrophytobenthos in Coastal Zones of the Baltic Sea

A. Künitzer presented the final report of a study on the distribution of macroalgae in the German part of the Baltic Sea. The report had been produced by T. Meyer (Germany). The aim of the study was to develop the basis for a monitoring programme of the phytobenthos to show eutrophication effects such as changes in depth distribution of macroalgae.

For the overall mapping of macrophytes of the shallow waters at the outer eastern coast of Mecklenburg-Vorpommern, 64 transects have been recorded by an underwater video system from 1995 to 1996. In addition, 6 locations which were established as permanent transects were examined by divers who took photographs and samples of plants and sediments at the depths of 2, 4, 6, 8, and 10 metres twice a year, in spring and summer. Thus a detailed survey of the composition of macrophytes was achieved. Meadows of the eelgrass (*Zostera marina*) dominated in the upper sub-littoral where it found good conditions in the sandy substrates of the protected coastline. The deeper zones were inhabited by a community of red algae and *Mytilus edulis* which settled on the whole length of the transects. In these communities also perennial red algae occurred frequently in the zones of greater depth. In the eastern part of the examination area, especially at the eastern coast of Rügen, the frequency of stones as substrates increased. Filamentous green algae and red algae settled between 2 m and 6 m depth. as well as *Fucus vesiculosus* at certain transects. In the deeper zones annual and perennial red algae dominated. In one section, *Laminaria saccharina* could be found at depths between 8 m and 16 m.

The study forms the basis for the German monitoring programme on macrophytes in the Baltic Sea. The permanent transects will be investigated once a year. The data will be reported to HELCOM as part of the HELCOM monitoring programme.

7.16 Benthic Studies in Rijkswaterstaat (Netherlands)

K. Essink briefly reported on recent and on-going benthos studies in the Rijkswaterstaat organisation, in which his institute is involved (see Annex 4).

7.17 Monitoring Programmes

Baltic Sea

There was no report for the Swedish programme for the northern Baltic Sea.

A status report was received from M. Ceitlina on monitoring in the Gulf of Riga. It reports on the development of *Marenzelleria viridis* into a dominant component of the benthic community. For more details see Annex 5.

The Netherlands

K. Essink reported on developments in the Dutch monitoring programme. An evaluation is currently under way (for details see Annex 6). K. Essink will report further next year.

Wadden Sea

K. Essink reported that with respect to the Trilateral (German, Danish, Dutch) Monitoring and Assessment Programme of the Wadden Sea, the responsible Ministers agreed on a common list of parameters and a guideline for monitoring, implementation of which should be realised in two years' time (for details see Annex 6).

Concerning the monitoring of the Danish Wadden Sea, a message was received from P.B. Madsen. In 1997 there was a dramatic decrease of *Corophium volutator* in the Ho Bugt for reasons unknown. He has been put in touch with Dr Lauckner to try assess the possible reasons which may due to parasitic infection.

H. Rees noted that this animal has strange dynamics and has been know to exhibit population crashes.

Germany

A. Künitzer informed BEWG about the new joint federal/state monitoring programmes for the North Sea and Baltic Sea (Bund/Länder Messprogramm Nord und Ostree, BLMP), which had been agreed on by the ministries in January 1998. She presented the benthos part of the programme in the North Sea; 35 coastal stations will be sampled by four institutes one to four times per year for macrozoobenthos. In the Baltic Sea, 39 coastal and offshore stations will be sampled by three institutes one to three times per year for macrozoobenthos and once per year for phytobenthos (transect). A supporting quality assurance programme is being developed to assure the comparability of the data from these institutes. Monitoring will be carried out according to the guidelines of OSPAR and HELCOM. The data will be reported to

OSPAR and HELCOM since they form the German contribution to the monitoring programmes of OSPAR and HELCOM. The programme will be updated and harmonized each forthcoming year to keep it flexible.

The BEWG is of the opinion that long-term monitoring stations should be continued where possible.

Monitoring effects of pipeline emplacement in Belgium

J. Wittoeck reported on the research regarding the construction of two gas pipelines on the Belgian continental shelf and their impacts on the biota. A general increase has been observed for the macrofaunal density and diversity. For the epibenthos a similar increase has been observed for density and biomass. These increases may not have been caused by the pipeline, but rather by seasonal variations as are also seen at the reference stations. The study is being continued with final sampling in autumn 1998. Further details are given in Annex 7.

Monitoring sand extraction off the Dieppe

A report from M. Desprez was read by the Chairman. In the Dieppe the biological monitoring of recolonisation after sand extraction initiated in 1996 was continued in 1997 in the former dredging site where extraction activity stopped at the end of 1994. This survey confirmed the results of 1996 showing that the impact of sands deposited from overflow can be as high as the impact of dredging itself on benthic macrofauna.

7.18 Oil Pollution Studies

Bioaccumulation of oil

P. Kingston reported on a recent study of bioaccumulation of oils. The transfer of oil through three trophic levels was investigated using mussels, amphipods, and fish. Uptake and depuration of hydrocarbons in a suspension feeder, *Mytilus* and two deposit feeders, *Scrobicularia* and *Arenicola*, were determined by subjecting them to oil contamination of approximately 500 ppm for a period of three days and then allowing them to depurate over a period of 32 days. *Mytilus* tissue oil concentrations reached over 600 ppm, but dropped rapidly when the animals were placed in clean sea water to 100 ppm after 2 days and 25 ppm after 16 days. The deposit feeders did not take up oil from the sediment as readily as the suspension feeder from water. Concentrations of oil in *Arenicola* tissue peaked at 250 pm after 3 days exposure, whilst those in *Scrobicularia* reached only 180 ppm in a similar time period. Depuration was also rapid with pre-contamination levels of oil in tissue being regained after 8–16 days of the animals being placed in clean sediment.

Two radiolabelled polycyclic aromatic hydrocarbon (PAH) components of crude oil (phenanthrene and benzo[*a*]pyrene) were introduced into an experimental food chain by exposing *Mytilus* to contaminated water for three days and then feeding the contaminated tissue to amphipods (*Gammarus*) and then feeding the *Gammarus* to juvenile trout. *Mytilus* accumulated a tissue concentration of benzo[*a*]pyrene some 100 times that in the water with an approximate 10 % transferal to the amphipods and a 10 % transferal of the amphipod tissue burden to the fish. When exposed to phenanthrene, the mussels also accumulated a tissue concentration of the PAH 100 times of that in the water. Counts of the amphipod tissue indicated a 10 % transferal of radiolabelled material to the amphipods and 3 % transferal of radiolabelled material to the fish. Most of the activity in the fish was detected in the intestinal fat. Preliminary analyses of the labeled residues suggest that most of the phenanthrene had been consumed and all that was left were mostly its metabolic products.

Impact of the 'Sea Empress' oil spill

A. Rowden reported on progress in monitoring the impact of the 'Sea Empress' oil spill on macroinvertebrate communities of kelp holdfasts.

The 'Sea Empress' oil spill off the coast of south Wales, UK, provided the opportunity to test the applicability of macroinvertebrate holdfast communities of *Laminaria* kelp for detecting a putative oil contamination gradient, and to assess the immediate response of taxonomic components of the holdfast biota to oil pollution. Four zones, each comprising four sites, were sampled to reflect potentially differing levels of impact from the oil spill. At each site five holdfasts and their fauna were recovered, together with a portion of the stipe for oil content analysis. Univariate analyses of the data illustrated decreases in number of species, diversity and abundance at sites nearest the spill. Multivariate analyses indicated significant differences in the macroinvertebrate community structure between zones, with distance from spill providing the best explanation. The abundance of Crustacea, in particular Amphipoda, Polychaeta, and

Echinodermata was significantly reduced, whilst Mollusca remained relatively unaffected one month after the spill. Analysis of samples taken 3 months, 6 months, 1 year, and 2 years after the spill is yet to be completed. Thus far work has been carried out by the Benthic Ecology Research Group, Department of Biological Sciences, University of Plymouth and Plymouth Marine Laboratory.

8 THE NORTH SEA BENTHOS PROJECT

The North Sea is a relatively new ecosystem having being established only since the end of the last glaciation. Nevertheless, its faunal composition is complex having been influenced by both northern (Arctic/boreal) and southern (lusitanian) elements and even now may not have yet reached successional climax. Little is known about the periodic changes that have been shown to occur in several localities although several regional long-term studies have shown cyclical or trend-like changes in the benthos. This aspect has been recently highlighted by new information on cyclical changes in benthic community composition in the eastern North Sea (cf. Section 3.7), the causes of which are not fully understood but may be connected to the North Atlantic Oscillation (an El Niño-like effect). The North Sea benthos is also under considerable pressure from eutrophication, the effects of fishing activities, and the continuing development of the offshore oil industry.

Changes in local community structure are often difficult to relate to environmental factors because of the huge number of variables involved in reproductive success, larval development, recruitment and growth of individual species. A more large-scale holistic approach to the distribution and abundance of individuals and the communities which they comprise can often reveal long-term trends that are invisible to a more geographically focused approach.

With these considerations in mind, a plan to repeat the survey successfully carried out in 1986 using exactly the same sampling and analytical protocols, with the addition of quantitative Triple-D dredge sampling for 'mega'infauna, would provide maximum comparative information and allow the mapping of changes in distribution and trends in species composition, abundance and biomass to be determined. This is not viewed as a simple monitoring exercise. The study will provide key scientific data for a better understanding of the processes controlling the distribution of benthic infauna in the North Sea and, as was the case in the 1986 survey, will provide an information base for others studying the North Sea ecosystem, especially regarding climatological changes. It will also complement the qualitative epifaunal work that is under way as part of an EU-funded groundfish survey in the North Sea.

The lack of success in attracting funding for a new North Sea benthos survey so far was noted with regret. Most funding bodies that were approached considered the proposal to be one of monitoring which should be funded by individual countries. Despite the lack of encouragement, BEWG decided that it should continue to seek a central source of funding for the revised work programme. The information that a new North Sea survey would provide will be of great importance in interpreting changes in the North Sea environment brought about by alterations in global climatic conditions, eutrophication, and the widespread impact of bottom fishing activities.

It was proposed that the survey be carried out during the months of May to July in 2000. A small project group will be formed to organize the funding of the work and to determine the logistics of its implementation.

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

Because of its relationship with this topic, the reslts of Islandic research on effects of otter-trawling are also reviewed below.

9.1 Effects of Otter-trawling on Benthic Communities; Results of a Pilot Study

Sigmar A. Steingrimsson reported on the progress in the experimental field study on the effects of otter-trawling which commenced in 1997 (see Annex 8). A pilot study was carried out in March 1997 in order to investigate the spatial pattern of fauna and sediments within the confined study area. Sediment was muddy, with silt content on average 49.6 % by weight. The spatial distribution of the majority of species was highly patchy. However, no species exhibited a consistent gradual change in abundance across the study site, neither along the east-west axis nor the north-south axis. Ordination of the data using non-metric multidimensional scaling showed that there is a high degree of overlap among all samples, indicating that species composition and abundances were similar throughout the study area.

9.2 Results of IMPACT II (1994–1997)

M. Bergman and H. Rumohr reported on the IMPACT II project. The EU-funded research project AIR 94 1664 'The ffects of different types of fisheries on the North Sea benthic communities' studied short-term and long-term effects of bottom trawl gear on benthic invertebrates and fish as well as the relative impacts of different trawl types. The general conclusions of this report are attached as Annex 9.

During this century North Sea fisheries changed from a sailing fleet of 6000 small ships, mainly using passive gears, from 1910–1930 to a fleet dominated by beam trawlers after the 1960s. Engine power increased steeply after the introduction of the diesel engine in the second half of this century. At present the southern North Sea is trawled on average 1.5 times per year. Each passage flattens the seabed, while the top layer is disturbed to a depth of 1–8 cm.

Trawl catches consist of about similar amounts of undersized and marketable fish and several times more, non-targeted benthos. Total catches in beam trawls were on average 10 times higher than in otter trawls.

Catch efficiency for small-sized fish and benthos is far less than 10 % (< 3 % for otter trawls). Although mortality in the catch is high (< 10 % for starfish, 50–70 % for crabs and bivalves, 50–100 % for fish), they are, as a percentage of the initial density in the seabed, less than 3 %.

For all invertebrates, direct mortality mainly occurred in the trawl path due to direct contact with the gear or to availability to predators. This mortality ranged from 10–50 % for gastropods, starfish, and crabs and to even 80 % for bivalves. It revealed that 4 m and 12 m beam trawling caused comparable mortality. Only in fine sandy and silty areas did otter trawling lead to lower mortality than beam trawling.

Annual fishing mortality on the Dutch continental shelf ranged from 7–48 % of the various invertebrate populations considered.

Scavenging predators (crabs, starfish, amphipods) feed on discards and fish feed on trawl path victims. The amount of dead material produced by fisheries in the southern North Sea is estimated at 0.3 g AFDW/m^2/year for discards and 1.4 g AFDW/m^2/year for trawlfish victims. This amount accounts for less than 10 % of the annual food consumption of the main scavengers.

Long-term effects of trawling on benthic communities were found after experimental disturbances of a previously unfished site. The general opportunistic species increased in abundance, while sensitive species declined in numbers. Measures of diversity and evenness were consistently higher in unfished areas.

Almost 100 years of trawling impact has certainly restructured the benthic system of the North Sea. For the longest time span observed (1902–1986), a decline in the frequency of occurrence of bivalves can be seen, whereas scavengers and predators such as crustaceans, gastropods, and seastars have increased.

The benthic communities of the German Bight show a significant increase in biomass and a change in community structure, with a dominance of opportunistic short-lived species (r-selected) and a decrease in long-living sessile organisms (K-selected) including several bivalve species.

The observed variations in annual numbers of fish and invertebrates delivered to the Zoological Station in Den Helder, The Netherlands, was found to relate to the changes in gear and fishing effort of demersal trawlers. Otter trawlers delivered relatively more fish than invertebrates and, on average, the catch efficiency of beam trawling appeared to be an order of magnitude higher than that of otter trawling for all the species considered.

Combined with the results from other parts of the study on the direct effects of bottom fisheries on the benthos and the comparison between fished and unfished areas, it has to be concluded that the observed long-term trends in benthic communities were, to a great extent, caused by direct and indirect effects of fisheries and not solely by eutrophication, climatic factors, and/or pollution.

The IMPACT II report recommends the reduction of fishing mortality in the benthic ecosystem by reducing the trawling effort, spatial restriction of particular gears, and the development of more selective, less damaging gears. Further understanding of long-term impacts of fisheries requires more information on population dynamics of different species. Further analysis of historical data is needed. Areas closed for fisheries are necessary to provide more conclusive

evidence for long-term impacts. Fisheries policy and nature management should be combined in an integrated management strategy for the North Sea.

10 DEVELOPMENTS IN COMPUTER AIDS IN BENTHIC STUDIES (TAXONOMIC AND OPERATIONAL)

M. de Kluijver reported on the progress of the ETI CD-ROM for identification of benthic species (illustrated keys) which is under development. The CD-ROM facilitates the identification of macrobenthic organisms (1 mm and larger) in the southern North Sea (down to 100 m depth). During the past year, the existing keys were implemented in the new Linnaeus II version and keys were developed for the identification of 1000 species. At this time, pictorial keys are available for 1406 species, belonging to 14 different taxa (see Annex 10). It is expected that the total product will enable the identification of nearly 3000 species. Besides the keys, the CD-ROM will contain introductions to the different taxa, glossaries, species cards, literature links, and taxonomic sections. In addition, standard protocols for sampling and identifying benthic communities will be developed by combining existing methodologies. Reference will be made to guidelines in different ICES reports and QA systems.

11 ADVICE ON QUALITY ASSURANCE (QA) PROCEDURES FOR BENTHOS STUDIES

11.1 Quality Assurance Studies in Germany

A. Künitzer gave an overview on the 1998 work programme of the German Working Group on QA in the marine monitoring programme (Annex 11). The aim of the QA system is to assure comparability of the data obtained from different laboratories on the same determinand.

The work programme includes:

1) development of a QA management system in the laboratories (internal QA);
2) coordination of external QA activities: the organisation of 4 national taxonomic workshops on zoobenthos and phytoplankton and the organisation of national intercalibration exercises;
3) judgment and validation of analytical methods and determination methods;
4) coordination of the production/development of reference materials such as reference collections for benthic species;
5) reporting the performance and final results of these QA activities.

The development and coordination of the QA system is being financed by the German Federal Ministry of Research, Technology and Development as a pilot project and is carried out by the German Federal Environmental Agency.

A. Künitzer further reported on the results of the first national taxonomic workshop on zoobenthos within the German QA system in March 1998 in Neubroderstorf, Germany. The workshop focused on taxonomy of difficult Polychaeta families. Taxonomic experts from Germany (A. Bick) and Denmark (D. Eibye-Jacobsen) taught about 20 participants from monitoring laboratories. For each Polychaeta family, systematics, identification features, and identification literature were presented. During the workshop, species lists including synonyms were developed for the German North Sea and Baltic Sea. The conclusions drawn from the workshop were that:

1) special identification keys should be used in addition to Hartmann-Schroder (1996) for: *Marenzelleria* spp., Pholoidae, Spionidae, Cirratulidae, Ampharetidae;
2) for the determination of difficult species, identification features were compiled in tables for: *Marenzelleria* spp., *Pholoe* spp., *Spio* spp. and *Phyllodoce* spp.;
3) species lists compiled during the workshop should be used for the reporting of monitoring data;
4) small specimens can only be identified to species level if they have the following minimum size;
    - *Marenzelleria* juv.: 2 mm (for 7th segment measured from ventral including parapodia, excluding setae)
    - *Nephtys* juv.: 20 mm
    - *Nereidae* juv.: 20 mm

The Workshop developed the following recommendations:

1) A reference collection of Polychaeta of the North Sea and Baltic Sea will be built up by A. Bick at the University of Rostock, Germany.
2) Information on new identification keys and new species will be made available via the internet by the Federal Environmental Agency (UBA). Information should therefore be sent to the UBA.

The Workshop was very successful and the interest in future taxonomic workshops was strong. The participants felt that it was necessary to carry out the next workshop soon (Autumn 1998) and that it should focus on Crustacea and the level of identification precision required for different groups.

After discussion the BEWG expressed the urgent need for taxonomic expertise to assure correct identification of benthic species.

11.2 Quality Assurance in the Northern Baltic

No report was given as K. Leonardsson was not able to attend the meeting.

11.3 New Methods/Aspect of Standardisation and Quality Assurance

H. Rumohr presented the outcome of a SGQAB meeting. SGQAB discussed a new methods manual for the HELCOM monitoring programme of the Baltic Sea (COMBINE). BEWG was requested to provide review comments on Annex C-8, Macrozoobenthos, the new guidelines on how to sample zoobenthos in the Baltic. The document is given in Annex 3.

L. Watling drew attention to the problem of failure of adequate follow-up after training workshops. Furthermore, there is a problem of bad taxonomy in manuscripts submitted for publication; apparently qualified taxonomists are not regularly involved in the peer review process.

D. Connor made reference to the UK National Marine Biological QA programme in which each lab is required to participate and there is a check/recheck on an annual basis.

BEWG concluded that there is a strong need to include taxonomic expertise in QA and other procudures.

11.4 Quality Assurance Activities in ICES/OSPAR and the UK

H. Rees reported on the outcome of the ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements related to Eutrophication Effects (SGQAE) held in February 1998. There was a marked contrast between the HELCOM and OSPAR areas regarding the history of biological monitoring activities. In the former case, there has been a long-standing commitment to cooperative studies and an equally long history of QA-related work both for plankton and benthos sampling activities. In the latter case, a more disparate approach has been the norm, even for the North Sea area, with the emphasis firmly placed on national priorities for attention, rather than international collaboration. Some notable exceptions include activities associated with the ICES North Sea Benthos Survey (1986), cooperation between Nordic countries with regard to eutrophication and offshore oil-platform studies, and coordination of Wadden Sea studies under the Trilateral Monitoring Programme.

Information on QA activities within the OSPAR region was gradually coming to light through SGQAE activities, which is now represented by a somewhat wider (though still relatively poor) range of Member Countries. There has been particularly useful interaction between this group and the Baltic QA Steering Groups, as well as a number of ICES WGs approached for advice (including the BEWG).

It was agreed that the ICES Secretariat would be approached with a view to circulating the 1998 SGQAE report to BEWG members, when it becomes available.

SGQAE strongly supports the preparation of 'in-house' QA manuals (and the associated production of 'Standard Operating Procedures' (SOPs), see Section 11.5, below) as an important contribution to ensuring consistency in the generation of monitoring data by OSPAR countries. It is to be expected that such manuals (and SOPs) will be compatible with international guidelines, where available. Notable among these are the OSPAR Joint Assessment and Monitoring Programme guidelines for benthos studies, to which the BEWG had an input in 1997.

SGQAE, along with its Baltic counterpart (the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea), intends to produce general guidelines for QA of biological data (including specifications for production of QA manuals) for the OSPAR and HELCOM areas, respectively. Initially, SGQAB will seek to adapt guidelines prepared for chemical QA in the Baltic area. If successful, SGQAE will consider their suitability for the OSPAR area, and make appropriate recommendations.

SGQAE reviewed criteria for acceptance/rejection of data submitted to international monitoring programmes, recognising that, for studies of biological communities:

i) experience is generally very limited;

ii) depending on the objective of the study, and the measure under consideration, pass/fail criteria may need to be applied at varying levels of 'severity'. The multivariate nature of the output from plankton and benthos identification work provides a hint of the scope and necessity for this. A hypothetical example of the need for a pragmatic approach to the setting of pass/fail criteria would be a laboratory which persistently under-performed in tests on the identification of many rare algal species, but was consistently correct in its identification of an established list of potentially harmful species;

iii) in the absence of agreed criteria, alternative approaches—such as accreditation of laboratories or even individuals with regard to their proficiency in the identification of organisms—may be considered suitable.

An account of UK experience in the application of criteria for evaluating the quality of benthos data submitted as part of a national marine biological Analytical Quality Control (AQC) scheme is given in Annex 12.

H. Rumohr commented on the forthcoming updated publication of ICES TIMES No. 8, in which QA of sampling and laboratory procedures regarding benthos are covered. Rejection criteria for collected samples are also included.

11.5 Recommendations from BEWG

The scope for extending QA approaches to cover issues of survey objectives and sampling design was also discussed, since these will have a strong influence on any criteria set for data quality and, furthermore, may be subject to change with time.

BEWG endorsed the principle of including such considerations in the development of QA programmes.

SGQAE had sought the help of the BEWG in the compilation of an inventory of guidelines for benthos sampling (both within and beyond the ICES/OSPAR area), and a draft was produced at the meeting. Any further submissions should be forwarded to H. Rees by December 1998, i.e., in time for an up-dated version for SGQAE and BEWG meetings in 1999.

Finally, the feasibility of reviewing the content of Standard Operating Procedures (SOPs) was considered. The BEWG endorsed the idea of such a review, noting that the very act of documenting procedures imposed a discipline on sampling and analytical practices within laboratories. The value of SOPs as training and teaching aids for new laboratory recruits was also emphasised. It was recommended that members submit drafts to H. Rees by December 1998, to permit an evaluation of the degree of variability in current practices to be presented to the 1999 SGQAE and BEWG meetings (NB. Unless specifically requested, this evaluation would not attribute any observations to named laboratories or individuals.)

As an aid to those laboratories who were not presently familiar with the role of SOPs, a suggested structure for their production is given at Annex 13. This structure should not be considered as definitive: the main purpose of this exercise was to encourage responsible individuals to produce an account of field sampling and analytical practices for the benthos to their own satisfaction, i.e., which they would be happy to pass on to third parties, confident in the knowledge that the work would be conducted to an adequate and consistent standard.

12 GUIDELINES FOR EPIFAUNA SAMPLING AND EPIFAUNA COMMUNITY DESCRIPTION/ RECOMMENDATIONS ON QA FOR SAMPLING ON HARD BOTTOM SUBSTRATES

Agenda items 12 and 15 were dealt with concurrently.

The development of guidelines and QA procedures for studies of epibiota builds on the work undertaken at the 1995 and 1996 BEWG meetings, which was published as Annex 10 of the 1996 ACME report.

The BEWG formulated the following recommendations:

i) production of an ICES TIMES report, with emphasis on the most recent developments in techniques to meet various objectives of contemporary interest;

ii) identification of experts to contribute to chapter headings;

iii) production of draft text (including guidelines for a range of techniques) intersessionally, and submission of material to BEWG 1999 for review and compilation.

The proposed structure of the report is given in Annex 14.

13 REVIEW THE ECOLOGICAL ASPECTS OF THE INTRODUCTION OF *MARENZELLERIA* SPP. IN NORTHWESTERN EUROPEAN WATERS

K. Essink informed the BEWG of his participation in the meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) 25–27 March 1998 in The Hague, where the dispersal of *Marenzelleria* spp. in European coastal waters was discussed. BEWG was further informed about the recent publication of a special issue of Aquatic Ecology (Vol. 31, No. 2) containing a broad selection of taxonomic, genetic, physiological, reproductive, and ecological studies of scientists at the University of Rostock and the Institute for Baltic Sea Research, Warnemünde.

K. Essink presented an overview of the present knowledge regarding *Marenzelleria* spp. in northwestern Europe (see Annex 15). The following conclusions were drawn:

1) the identity of *Marenzelleria* in the Baltic Sea has now been established as *M. viridis*. The present populations were indicated to be located in estuaries/coastal waters of the Atlantic coast of North America;

2) animals from North Sea coastal waters and estuaries are preliminary named *M.* cf. *wireni*, genetic analysis has also demonstrated parent populations in North America;

3) on-going research by scientists at the Universities of Rostock and Maskau is aimed to further elucidate the taxonomic position of the *Marenzelleria* populations in the North Sea because *M. wireni* has been described as occurring exclusively in Arctic waters;

4) H. Rumohr mentioned the recent find of specimens of *M. viridis* and *M. cf. wireni* in the Kiel Canal, connecting the North Sea and the Baltic Sea, surprisingly, *Marenzelleria* has not yet been found in Kiel Bay;

5) *Marenzelleria* spp. have developed populations of several thousands of individuals per square metre in many estuaries and coastal habitats;

6) although negative correlations have been found between the abundance of *Marenzelleria* and abundances of original fauna, no clear evidence is available of a competitive interaction between the original fauna and the newcomer species;

7) *Marenzelleria* populations are highly productive, possibly providing food to a variety of demersal fish species;

8) it is concluded that in European waters *Marenzelleria* spp. has occupied open niches rather than outcompeted existing species.

14 MERITS OF SAMPLING APPROACHES AND NEW SAMPLING DESIGN

14.1 Analysis of Large Spatial Datasets

L. Watling reported on the analysis of large spatial datasets. With the increasing availability of ROVs, benthic camera sleds, and submersibles, there is the possibility of obtaining images of benthos which represent transects covering areas as long as 0.5 km or greater. Up until now, the only statistical techniques available to analyse these data were derivatives

of terrestrial plant communities block quadrat procedures. Unfortunately, when applied to these long transect data, such block quadrat techniques always indicate that the species were randomly distributed. Spectral analysis, as usually applied to time series, may offer data analysis techniques that will show underlying patterns in long transect data. These techniques were applied to data from transects in excess of 500 m taken in the Gulf of Maine, USA, and are reported in Annex 16.

14.2 Investigation of Scales of Variability

J.N. Jensen reported on some preliminary results of a study on spatial variability in benthic infauna from the Kattegat. The use of multidimensional scaling (MDS) has shown significant differences in the benthic community on all the spatial scales used in the study (50, 200, and 1000 m). These results suggest that the size of spatial variability has to be taken into account in temporal monitoring of benthic infauna.

In a discussion, the BEWG recognised the problem of pseudo-replication. Pseudo-replication means that data will have to be dealt with in a more sophisticated fashion (more advanced statistical analyses). Reference was made to a book by Tony Underwood.

14.3 Improvements to the Triple-D Design

M. Bergman reported on a number of modifications and proposed changes to be made to improve the functioning of the Triple-D benthic dredge. Improvements have been made to control opening and closing operations so that boat speed at deployment and retrieval does not effect sampling. Overall weight has been increased to control stability in penetration depth. Future modifications may include surface vessel-triggered opening and closing by electrical signal.

14.4 Improvements in Sampling at Sea

H. Rumohr showed an overhead of a new design of a sieve table, which is illustrated in Annex 17. Construction drawings are available from Grete Fallesen, Aarhus, Denmark. It is constructed from aluminium with a controllable spray system.

14.5 Sediment Profile Imagery

B. Tunberg inquired as to the use of sediment profile imagery (also known as SPI and REMOTS). In Sweden this system is being very aggressively marketed because of its quick and relatively easy application in environmental monitoring. The general consensus of the BEWG was that whilst providing quick information, the method should always be used in conjunction with traditional sampling technologies. It was recommended as a combination tool, not as a replacement tool.

15 ANY OTHER BUSINESS

15.1 Publications

A list of reports and documents tabled at the meeting of BEWG is given in Annex 18.

H. Rumohr noted that a new journal is being published on Biological Invasions. The new journal has already received 80 manuscripts.

A. Eleftheriou reported that the IBP Handbook 'Methods for the Study of the Marine Benthos' is to be revised and a new edition is to be printed. Drawings, photographs, and descriptions of any new devices should be submitted within a month or so.

15.2 Meetings, Symposia

A. Eleftheriou also informed BEWG that there has been an invasion of *Caulerpa taxifolia* in the Mediterranean, slowly spreading from Monaco towards the east. This has caused a great deal of concern in terms of environmental damage. An international meeting on this issue was held in Heraklion in March 1998.

A. Eleftheriou reminded the participants that the ICES Benthos Dynamics Symposium will be held 5–7 October 1998 in Crete. Topics are wide but generally concern the impact of fisheries activities on the benthos.

The 1998 ICES Annual Science Conference will be held in Lisbon, 16–22 September 1998. H. Rumohr and H. Rees will be co-conveners of Theme Session V on Recovery and Protection of Marine Habitats and Ecosystems from Natural and Anthropogenic Impacts.

The 33rd EMBS will be held in Wilhelmshaven, Germany, 7–11 September 1998. The topics are life at boundaries and life under extreme conditions.

The 8th European Ecology Congress will be held in Halkidiki, Greece, 10–23 September 1999. The congress deals with biological invasions.

A symposium/workshop on Organism Sediment Interactions will be held October 1998 at Belle Baruch Institute and the University of South Carolina, USA.

BEWG participants were reminded that such meetings play a very important role in sharing information. In recent years there has been very little support for benthic studies either financially or in terms of recruiting new scientists. A. Eleftheriou stated that he would initiate a new website, initially placed under the IMBC website, devoted to benthos. This will be connected to other relevant sites and will focus on a number of issues, including bibliographies, technical aspects, news, projects, etc.

15.3 BEWG Membership

E. Rachor inquired as to whether scientists from other disciplines could be invited to participate in the BEWG. This could be extremely important in supporting benthic studies. K. Essink replied that this was not problematic, but that prospective participants should be appointed by their national ICES delegates.

16 PLACE AND DATE OF THE NEXT MEETING

It was proposed that the 1999 meeting of the Benthos Ecology Working Group be held at the Kristineberg Marine Station, Sweden, 28 April to 1 May. The offer to host this meeting in Kristineberg was confirmed by B. Tunberg.

17 RECOMMENDATIONS AND ACTION LIST

17.1 Recommendations

At its 1999 meeting the BEWG will:

a) finalise the details of the North Sea Benthos project;

b) report on further developments in computer aids in benthic studies (taxonomic and operational);

c) debate the merits of different (new) sampling approaches to benthos studies and new sampling devices, with the aim of upgrading existing guidelines;

d) provide guidance to ACME on quality assurance procedures for benthos studies through:

   i. review of standard operating procedures (SOPs) in use in Member Countries,

   ii. further review of case studies aimed at evaluating the quality of benthos data,

   iii. finalise an inventory of national guidelines for the conduct of benthos surveys operated in different countries (within and outside the OSPAR area);

e) prepare guidelines for sampling and objective community description of epibiota (of soft sediments and hard bottom substrata), including QA matters;

f) commence an analysis of the impact of the North Atlantic Oscillations (NAO) on long-term variations of benthic population parameters in different geographical locations in the ICES area.

Justifications:

a) It is necessary to finalise the logistics of the North Sea Benthos Project that is now planned for implementation in 2000.

b) This action relates to on-going developments aimed at improving the consistency and quality of benthic data.

c) There is a need for continued debating of the pros and cons of different sampling designs and sampling methods.

d) This will continue a fruitful collaboration between the ICES/OSPAR and ICES/HELCOM QA Steering Groups and the BEWG.

e) These guidelines will build on work undertaken at recent BEWG meetings which has been reported to ACME and represents the next stage of development of TOR (e) of the 1998 BEWG meeting and the preparation of an ICES TIMES report.

f) A few benthos researchers found significant correlations in their long-term benthos datasets with the NAO Index. In order to find causal pathways, a more complete coverage of other European benthos studies is needed and connections to pelagic processes have to be established (cf. GLOBEC and CPR programmes).

17.2 Action List

1) Jan Helge Fossa to report on further results of research on deep-water *Lophelia* reefs in Norwegian waters.
2) Jan Helge Fossa to report on the development of an acoustical method for biomass estimation of kelp.
3) Gerard Duineveld to report on the OMEX project on transport from the continental shelf to the deep sea.
4) Rogier Daan to report on the Faeroes Channel project.
5) Magda Bergman to report on the REDUCE project on selectivity of fishing gears in relation to its effects on benthos.
6) Sigmar Steingrimsson to report on further results from the BIOICE project.
7) Ingrid Kröncke to report on further results of benthos studies at the Dogger Bank.
8) Ingrid Kröncke to report on sublittoral fauna of the German Wadden Sea.
9) Heye Rumohr/Paul Kingston to report on the ICES Benthos Dynamics Symposium, October 1998, Crete.
10) David Connor to provide an update on the development of monitoring techniques in the UK.
11) David Connor to report on progress on habitat classification in OSPAR framework.
12) Mario de Kluijver to report on progress regarding a CD-ROM for the identification of macrozoobenthos.
13) Karel Essink to report on the outcome of the evaluation of the Dutch macrozoobenthos monitoring programme.
14) Sigmar Steingrimsson to report on results of experimental studies on the effects of otter trawling on benthos.
15) Björn Tunberg to report on progress in analysing causal relationships in long-term-changes in benthos off the Swedish west coast.
16) Jørgen Nørrevang Jensen to report on the effect of sand extraction in the Kattegat.
17) Anita Künitzer to report on progress in the development of a QA system for the German marine monitoring programme.
18) Ashley Rowden to report on progress in studies on small-scale distributions of benthic invertebrates.
19) Doris Schiedek to report on progress in research on *Marenzelleria* spp.
20) Portuguese member(s) to report on new developments in Portuguese benthos research.
21) Spanish member to report on new developments in Spanish benthos research.
22) Hans Hillewaert to report on macrofauna in dredge spoil dumping areas.
23) Jørgen Nørrevang Jensen to report on spatial distribution of benthos.
24) Members of BEWG to submit standard operating procedures (SOPs) for benthos monitoring to Dr H. Rees by December 1998 for an evaluation of variability in content.
25) Members of BEWG to contribute to Epibiota Guidelines through Dr H. Rees, following e-mail communication.
26) Tasso Eleftheriou/Chris Smith to report on benthic studies in the Mediterranean.
27) Hubert Rees to report on the outcome of the 1999 ICES/OSPAR SGQAE meeting.
28) Ashley Rowden to report on progress on the 'Sea Empress' oil spill studies.

29) Eike Rachor or Rainer Knust to report on long-term zoobenthos studies in the southern North Sea within the NEBROC framework.

18 CLOSING OF THE MEETING

The Chairman thanked all the members for their assistance and cooperation. He thanked A. Eleftheriou for providing facilities and the dinner and C. Smith for preparation of the meeting and arrangements. This extended to N. Papadopoulou for all the behind-the-scenes arrangements and support. Thanks were also expressed for the other support staff.

A. Eleftheriou thanked the group for coming to Crete. He expressed his interest to work more actively and to be included in the action list in future.

ANNEX 1

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ANNEX 2

AGENDA

1) Opening and local organisation
2) Appointment of rapporteur
3) Terms of reference
4) Adoption of Agenda
5) Report on ICES Annual Science Conference, Baltimore, USA
6) Report on ACME and other meetings of interest
7) Report of cooperative studies and other studies relevant to ICES
   - (incl. Action List from 1997 BEWG meeting)
8) North Sea Benthos Project
9) Results of IMPACT II project on the effects of fishing activities on the benthos
10) Developments in computer aids in benthic studies (taxonomic and operational)
11) Advice on quality assurance (QA) procedures for benthos studies through:
   - review of case studies
   - inventory of national guidelines
12) Guidelines for epifaunal sampling and epifauna community description
13) Review of the ecological aspects of the introduction of *Marenzelleria* spp. in
   - NW European waters
14) Merits of sampling approaches and new sampling devices
15) Recommendations on QA for sampling on hard-bottom substrates
16) Any other business
17) Date and venue of next meeting
18) Closing of the meeting

ANNEX C-8: SOFT-BOTTOM MACROBENTHOS
(HELCOM COMBINE)

ANNEX C-8

SOFT BOTTOM MACROZOOBENTHOS

1. Introduction

The species composition of benthic communities generally depends on the substrate, depth, wave exposure and salinity etc.

Macrobenthic communities are an appropriate target for monitoring since:

a. an important component of benthic communities is formed by species which are long-lived and which therefore integrate environmental change over long periods of time;
b. they are relatively easy to sample quantitatively;
c. they are well-studied scientifically, compared with other sediment-dwelling components (e.g. meiofauna and microfauna) and taxonomic keys are available for most groups;
d. community structure responds in a predictable manner to a number of anthropogenic influences (thus, the results of changes can be interpreted with a degree of confidence);
e. there may be direct links with commercially valued resources, e.g. fish and for wintering birds (via feeding).

The so-called positive effects of nutrient enrichment/eutrophication may increase the food supply to the benthos and, therefore, may give rise to changes in species composition and numbers, increased biomass, shifts in functional groups and changes in community structure. Evident negative effects of eutrophication, as wide range anoxia, leads to impoverished benthic communities or even azoic bottoms.

This guideline is based on the old HELCOM guideline (HELCOM, 1988) as well as on the new OSPARCOM Guidelines for JAMP (OSPARCOM 1997). Much information exists on methodology for benthos investigations. The most relevant reports are those by Rumohr (1990), which deals largely with methodology for the collection and treatment of samples of the soft-bottom macrofauna, and by Rees *et al.* (1991), which focuses on the monitoring of benthic communities around point-source discharges. The latter also deals more generally with the role of benthos studies in investigations of human impact and includes guidance on approaches for the sampling of different substrate types.

Both reports refer to a range of earlier documents which are of value in the planning and conduct of marine benthos sampling programmes. The most valuable of these is that by Holme and McIntyre (1984) which is a standard reference for anyone working in this field. Guidelines which have been published since the two sets of ICES guidelines (i.e. Rumohr 1990 and Rees *et al* 1991) include Gray *et al.* (1992) concerning approaches to marine pollution assessment and which provides practical examples of applying the PRIMER ('Plymouth Routines in Multivariate Ecological Research') package for univariate, graphical and multivariate data analyses.

2. Purpose

The monitoring of benthic communities is carried out for, *inter alia*, the following purposes:

a. to monitor the spatial variability in species composition and biomass within the maritime area resulting from anthropogenic nutrient inputs;
b. to monitor temporal trends in species composition and biomass within the maritime area (at a timescale of years) in order to assess whether changes can be related to temporal trends in nutrient inputs;
c. to support the development and implementation of a common procedure for the identification of the status of the benthic communities;
d. to understand the relationship between nutrient concentrations and temporal trends in species/community characteristics.

3. Sampling strategy

Sample sites should be representative of the whole monitoring area and therefore, characteristic habitat structures and substrates must be sampled. Prior to temporal trend analysis, checks must be made to ensure that sample sites are inhabited by a homogenous benthic community rather than non-comparable, heterogeneous benthic communities.

Establishment of the baseline community structure and variability at the site under consideration is important. Sample points must be spread out over the extent of the habitat studied to ensure an adequate consideration of spatial variation. It cannot be assumed that one point is representative of the habitat as a whole. When measuring anthropogenically induced change a control reference site is required for each test site. It is important that similar habitats are selected for comparison.

Guidance on the design and implementation of field sampling programmes around waste discharges (Rees *et al.*, 1991) may usefully be applied to eutrophication-related studies. The strategy comprises five stages, as follows:

Stage 1: desk study;
Stage 2: planning a sampling programme;
Stage 3: analysis and interpretation of data;
Stage 4: rationalisation of sampling design for regular monitoring;
Stage 5: establishment of routine.

4. Ship-board routines

4.1 Sampling

Sampling on shallow stations (70 m or less) should preferably be conducted during the daytime, since some benthic species have semipelagic activity during the night.

The following information should be recorded in the field:
- type of positioning system and its accuracy;
- whether or not a buoy was used;
- whether or not the ship was anchored;
- the time of day;
- the weather conditions and state of the sea during sampling;
- a description of the sediment, including:

i. surface colour and colour change with depth (as a possible indicator of redox state);
ii. depth of the oxygenated surface layer
iii. smell (H_2S);
iv. a description of sediment type, including important notes, e.g., the occurrence of concretions, loose algae, etc.

- the type and specification of the sampler.

Near-bottom temperature, salinity and oxygen have to be measured. If more than one sample is taken at a station, the depth range of samples should be recorded. An estimate of the volume of sediment retained should be made for each samples taken, as a measure of sampler efficiency. Criteria for rejection of samples collected by grabs are given by Rees *et al.* (1991) and in the QA part of this guideline.

The widely applied 0.1 m^2 Van Veen grab should be used as the standard gear for benthic macrofauna sampling in the Baltic Sea, because of its very good reliability and simplicity of handling at sea. The emptied grab should weigh about 25-35 kg when used for fine grain size and up to 80 kg in sandy bottoms. In order to reduce the shock wave caused by lowering the grab, the windows on the upper side shall cover an area as large as possible, in practice around 60% of its upper surface. The windows shall be covered with metal gauze of 0. 5 x 0. 5 mm mesh size.

There may be cases where the use of other gear with smaller sampling area is advisable, e.g. if the fauna is very dense and uniform. When other gears than the standard grab are employed, intercalibrations have to be done on a regional basis and on specific sediments on which these samplers will be used. When a change of gear is intended, it is recommended to sample parallel with both gears for a period of 3-5 years.

Precautions that must be taken when using the grab:

- The settling down and the closing of the grab must be done as gently as possible. Winch operation should be standardized (complete stop and slow lowering (< 0.5 m/s) for the last few meters). This will reduce the shock wave and the risk of sediment loss as a result of lifting the grab before completed closure;
- The wire angle must be kept as small as possible to ensure that the grab is set down and lifted up vertically.

If, as often happens on sandy bottom or erosion sediments, less than 5 l of sediment is collected, the sample should be regarded as not quantitative, and a new sample should be taken after loading the grab with an extra weight. This may as much as double the effective sampling depth of the grab. If less than 5 l of sediment is still collected, the sample may be used, but the low sample volume should be stressed when results are given (Dybern *et al.* 1976). The evidence of this problem may be different in different parts of the Baltic Sea, depending on, e.g., how deep in the sediment the species live.

The choice of sample size and number of samples is always a compromise between the need for statistical accuracy and the effort which can be put into the study. One way to do this is to calculate an index of precision. The ratio of standard error to arithmetic mean may be used (Elliott, 1983), i.e. ($\bar{x}$ = arithmetic mean, s = standard deviation, n = number of samples). A reasonable error would probably be 0.2 ± 20%.

$$D = \frac{1}{\bar{x}}\sqrt{\frac{s^2}{n}} \qquad (D \leq 0.2)$$

On the representative stations, at least 3 to 5 samples should be taken, depending on area and species composition, to enable the investigator to reach a certain level of precision by sorting as many samples as necessary. The same procedure is strongly recommended for all other benthos stations unless another sampling strategy (area sampling) is employed in national/coastal monitoring programmes.

Each laboratory shall carefully check the exact sampling area of its grab in order to make possible a correct calculation of the number of individuals per square metre.

4.2 Sieving

The standard sieve for the Baltic Monitoring Programme shall be of metal gauze (stainless steel, brass or bronze) and have a mesh size of 1.0 x 1.0 mm. In order to collect quantitatively developmental stages of the macrofauna and abundant smaller species it is, however, recommended to use an additional sieve with mesh size of 0.5 x 0.5 mm. This sieve must have the same material as the 1 mm sieve. The mesh size of the sieves has to be checked from time to time for damage and wear.

Attention must be paid to the following points:

- Each sample must be sieved, stored and documented separately;
- The volume of each unsieved sample must be measured. This can be done by grading the container or by using a ruler;
- The grab has to be emptied into a container and should be brought portion by portion onto the sieve as a sediment-water suspension. The use of sprinklers and hand-operated douches to suspend the sample is recommended. Very stiff clay can be gently fragmented by hand. Between the pourings the sieve must be cleaned to avoid clogging and thus to ensure an equal mesh size during the whole sieving procedure;
- The sieving of the sample has to be done carefully in order to avoid damage of fragile animals. Therefore, a direct jet of water against the sieve should be avoided;
- Visible fragile animals, e.g. some polychaetes, shall be hand-picked during the sieving; stones and big shells should be picked out to avoid the grinding effect;
- All residues retained on the sieves should be carefully flushed off the sieves with water from below. Spoons and other tools for sample transfer should be applied carefully. The minor residues in the sieve should be transferred with water;
- When the 0.5 x 0.5 mm sieve is used, the 0.5 and 1.0 mm sieve fractions must be kept separate throughout all further processing;
- Fixed samples should never be sieved.

4.3 Other sampling methods

Dredge hauls are a valuable complement to grab samples, since mobile as well as large but comparatively rare species are more easily caught by dredging. Dredging is not a quantitative sampling method, but can be useful for qualitative sampling with a five-point scale of abundance. Standardized dredging should always be used when van Veen grabs are likely without fauna, if not done on a routine basis at every sampling. When done so, a visual documentation by video or photography is recommended. Video control and track plotting of dredging actions is recommended as that is the only suitable way of estimating the dredge effort. Descriptions of suitable dredges can be found in Holme & McIntyre (1984) and Bergman & van Santbrink (1994).

In areas where the burrowing depth of the fauna are beyond the penetration depth of the grabs (or that type of gear cannot be used), core samplers may be advisable to use, provided that their efficiency has been satisfactorily proven by intercalibrations to the standard grab.

Photographic and video and records are recommended as a complement to traditional sampling methods. Sediment profile imaging (see e.g. Rhoads and Germano, 1982) may provide a useful means for rapid surveys and classification of sediment structure and bioturbation depth. Side-scan sonar images will provide information on bottom topography and substrate type, which can be useful in the planning of benthos monitoring programmes or in the interpretation of the data. Images should be 'ground-truth' by underwater video recording and/or grab sampling of sediments. (Rumohr, 1995)

4.4 Fixation

The hand-picked animals and the sieving residue shall be fixed in buffered 4% formaldehyde solution (1 part 40% formaldehyde solution and 9 parts water). All necessary measures should be taken to avoid health damage by formalin. For buffering, 100 g of hexamethylenetetramine (Hexamine = Urotropin) shall be used per 1 dm^3 of 40% formaldehyde. Sodiumtetraborate (= Borax) in excess may also be used.

5. Laboratory routines

5.1 Staining

In special cases, i.e. samples from sandy bottoms, it may be advisable to stain the 1 mm sieve samples to facilitate the sorting process. However, in some cases staining may cause problems with species determination.

The staining shall be done before sorting by:

- wash the sample free from the preservation fluid by using a sieve with a mesh size smaller than 0.5 X 0.5 mm;
- allowing the sieve to stand in Rose Bengal stain (1 g/dm^3 of tap water + 5 g of phenol for adjustments to pH 4-5) for 20 minutes with the sample well covered.

However, Rose Bengal (1 g/dm^3 of 40% formaldehyde) may be added already to the fixation fluid.

5.2 Splitting of samples

Splitting ~~or~~ and pooling of samples is not allowed under normal circumstances. Instead of splitting use a smaller core sample obtained using a standardized method, which should be fully documented.

5.3 Sorting

Small portions of the unsorted material shall be put on a 0.5 mm mesh size sieve and washed with tap water, so that sorters are not exposed to formalin vapour. Sorting should always be done using magnification aid (magnification lamp, stereo-microscope). Any finer fraction (< 1 mm) should always be sorted under a stereo-microscope.

Broken animals shall only be counted as individuals by their heads (e.g. polychaetes) or hinges of bivalves with adhering pieces of tissue.

5.4 Biomass determination

Samples should be stored for at least three months before weighing. The biomass shall be determined as dry weight and ash-free dry weight.

The biomass determination shall be carried out for each taxon separately.

All polychaetes should be removed from the tubes, other methods have to be explicitly stated (e.g. for large numbers of polychaetes).

The dry weight shall be estimated after drying the formalin material at 60°C to constant weight (for 12-24 hours, or an even longer time, depending on the thickness of the material).

5.5 Supporting measurements

The use of ash-free dry weight is recommended in routine programmes, because it is the most accurate measure of biomass (Rumohr et al., 1987; Duineveld and Witte, 1987). Ash-free dry weight should be determined after measuring dry weight. It is measured after incineration at 500-520° C in an oven until weight constancy is reached, depending on sample and object size. The temperature of the oven should be checked with a calibrated thermometer, because there may be considerable temperature gradients (up to 50° C) in a muffle furnace. Caution is advised to avoid exceeding a certain temperature (> 550°), at which a sudden loss of weight may occur owing to the formation of CaO from the skeletal material of many invertebrates ($CaCO_3$). This can reduce the weight of the mineral fraction by 44%. Such decomposition occurs very abruptly and within a small temperature interval (Winberg, 1971).

Before weighing, the samples must be kept in a desiccator, while cooling down to room temperature after oven drying or removal from the muffle furnace.

As a simple measure of grain size distribution for the upper 5cm the following sieves should be used: 63μm, 125 μm, 250 μm, 500 μm, 1000 μm and 2000 μm together with weight loss on ignition (500° C - 520° C), total organic carbon and pigments (recommended).

6. Recommendations for Quality Assurance

Most of the recommendation given here are based on the outcome of two ICES/HELCOM workshops of the Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea (ICES, 1994; ICES, 1996).

6.1 General remarks

Experienced and well-trained personnel is a prime basis for maintaining quality standards on a high level. Allocation of resources for proper training and education of field and laboratory personnel is important.

Ring tests and intercalibration exercises at least on a regional basis should be undertaken regularly basis and be obligatory for institutions delivering data to HELCOM. They should be

open to all institutions including private industry. Technicians who carry out the actual procedures rather than managing scientists should take part in the exercises.

Exact positioning and correct depths when sampling should be noted in the protocols to avoid comparisons between samples taken at different localities (although noted as the same station in the protocols). If exact positioning due to weather or technical problems is impossible, then fix station work to the correct depth.

Track-plotting during sampling (especially when dredging) is highly recommended, since it both gives information on the size of the area sampled and, if the track-plots are saved, after some time they can provide a detailed depth map of the station.

The number of steps in the sampling and sieving procedures must be kept as small as possible.

Decks hoses are not suited for washing subtle benthos samples. Washing samples on sieves by hand in water-filled containers is recommended as the most gentle way of washing samples.

The use of large sieves is encouraged because:
- the risk of clogging is kept low;
- on sandy bottoms so much sand might be collected that small sieves are filled or even overfilled;
- they reduce the risk of spilling when transferring samples from containers/buckets to the sieves.

Only suspended matter must reach the sieves. The use of water jets directly onto the sieving nets is forbidden.

Rejection criteria for samples are that the samples should be rejected if:

- less than 5 litres is obtained (van Veen, for Haps less than 15 cm penetration);
- incomplete closure is noted;
- obvious uneven bite is noted;
- spillage during transferring of samples is observed;
- samples clearly deviate from the other samples (they should be kept though, but another sample should be taken to replace this in calculating the mean for the station).

If samples are sorted alive, care should be taken to avoid predation within the sample.

It is advisable to stain the samples to facilitate sorting, if this does not hamper species identification.

6.2 Control routines

To check whether animals are lost when sieving because of using too high water pressure, an extra 1 mm sieve should be placed below the main sieve which should be checked for the number of animals found there after sieving the sample.

The sorting efficiency of the personnel sorting the samples should be checked by an experienced technician. At least 5 % of the samples should be checked for sorting efficiency. Also the species determination should be checked in the same way.

All data lists must be proof-read after input to the computer, before usage. Any spread sheet can be proof-read by the computer with a Sound Card, so you do not need two persons to do it.

One way to check the quality of numbers in the database is to compare individual mean weights. If they are abnormally high or low, the figures need verification.

6.3 Taxonomy

Lists of taxonomic literature in use should be reported with the data.

Regional taxonomical workshops should be held on a regular basis and be attended by every laboratory.

A checklist of species in the area should be developed, distributed to the participating laboratories and updated regularly. [This should be a task of the planned taxonomic workshop in Roskilde, Denmark, in November 1997.]

If the dry weight and ash-free dry weight are determined by drying-burning, an extra sample should be taken and kept preserved unsorted for some years as a reference, in order, for example, to be able to go back to check for the presence of new species.

It is ~~advisable~~ indispensable, even with routine samplings, to place some specimens of each taxon under museum curatorship to make later taxonomic checks possible. ("Voucher Specimens")

6.4 In-house Quality Assurance

All laboratories should develop programmes for in-house QA, including the appliance of a quality assurance manual.

Signed protocols should be obligatory for all steps in the analyses.

Taxonomic accreditation of the persons responsible at the laboratories (as in Britain) is recommended. Training should be offered by institutions having the expertise.

7. Reporting requirements

Reporting formats need to be developed which will allow the exchange and evaluation both of the raw data and of all relevant ancillary information. Such formats must be readily usable by both the data centres and the originators of the data. Data for the common pool will have to be submitted via the national data centres in order for them to keep in touch with progress of the work, including the availability of data from each Contracting Party. This procedure should help to guarantee data quality, since the national data centres will be ultimately responsible for the timely submission of completed data sets to the common pool. Reporting formats have to be developed.

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ANNEX 4

SUMMARY REPORT ON RIJKSWATERSTAAT BENTHOS PROJECTS

To:
ICES Benthos Ecology Working Group

Meeting 23-24 April 1998

Heraklion, Crete, Greece

From:
Dr. Karel Essink
Date:
April 16, 1998
Subject:
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Appemdices:
-
Number:
RIKZ/OS-98.605x
Project
ICES*ICES

Summary report on benthos projects within RIJKSWATERSTAAT (NL)

by Karel Essink

1. Risk Analysis of Coastal Nourishment techniques (RIACON)

A study was carried out in 1994-1996 to assess the effects of shoreface nourishment and of subaquaeous marine sand extraction on benthic communities. This study was undertaken by research institutes in Denmark, Germany, The Netherlands, Belgium and Spain, and was co-sponsored by the Commission of the European Communities (contract MAS2-CT94-0084). The project was co-ordinated by the National Institute for Coastal and Marine Management/RIKZ in the Netherlands.

Effects of nourishment of the foreshore and beach were studied in Denmark (Torsminde), Germany (Norderney), Netherlands (Terschelling), Bellllgium (De Haan) and Costa Daurada (Spain). Effects of subaquaeous marine sand extraction were studied off Torsminde (DK), Terschelling (NL) and Costa Daurada (ES).

1.1. Shoreface nourishment in the North Sea

Direct effects of nourishment (250,000-2,600,000 m^3) were short-term loss of species abundance and biomass due to burial by a 1-3 m thick body of sand. Only a moderate development of opportunistic species was observed, viz. *Scolelepis squamata* at the beach nourishment at Norderney.
For most of the macrozoobenthos species. Abundance and biomass had largely recovered already ca. 1 year after completion of the nourishment. Long living species, such as bivalves (e.g. *Spisula subtruncata, Donax vittatus*) and sea urchins (*Echinocardium cordatum*) showed a much slower recovery. For these species recovery may take 2-5 years.
In view of the rather fast recovery of the benthos the risk to demersal coastal fish due to loss of feeding grounds is considered negligible unless the spatial scale of shoreface nourissshments is much larger than the four cases studied.
Diving ducks, such as the common scoter (*Melanitta nigra*) , experience a more serious risk in case that in nourishment operations beds of *Spisula* spp. will become buried.

1.2. Beach nourishment in the Mediterranean Sea.

Beach nourishment may lead to increased sedimentation in the foreshore. Seagrass beds of *Posidonia oceanica* were founmd to be very sensitive: shoot mortality, decline of vegetated area. In case of light sedimentation seagrass rhizomes are able to counteract burial by invreasing their vertical growth rate up to 2-3 cm per year.
The recovery potential of *Posidonia oceanica* after burial by sediment is considered very low. Therefore, seagrass beds and their intrinsic ecological functions (e.g. feeding ground and habitat of commercially exploited species) are at risk.

1.3. Effects of subaquaeous sand extraction

In the North Sea borrow sites caused species dabundance and biomass to decrease. The polychaete *Spio filicornis* showed a quick opportunistic response of increasing abundance. Recovery of the benthic abundances and biomass proceeded rather fast (wiithin one year), except for longer living bivalve species and sea urchins. The latter species were still rare ca. 2 years after sand extraction.

Observations made around the borrow site at Costa Daurada show that no direct effect of sand extraction on nearby seagrass beds are likely to occur as long as a distance of 1-2 km is observed.
Shortly after extraction a dramatic development of opportunistic species (*Capitella capitata, Malacoceros* sp.) was observed. An important loss of the locally exploited mollusc *Callista chione* was observed. Recovery of these populations may take several years.

1.4. References

BIRKLUND J., H. TOXVIG & C. LAUSTRUP (1996). RIACON Risk analysis of coastal nourishment techniques and subaqueous sand extraction for the coastal marine benthoc community. Evaluation of the nourishment and sand extraction off Torsminde, Denmark. Danish Coastal Authority, in cooperation with Water Quality Institute (VKI).

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LE ROY, D., S. DEGRAER, K. MERGAERT, I. DOBBELAERE, M. VINCX & P. VANHAECKE (1996). Risk of shoreface nourishment for the coastal marine benthic community. Evaluation of the nourishment of De Haan, Belgium. ECOLAS N.V., Antwerp.

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VAN DALFSEN, J.A. & K. ESSINK (1997). Risk analysis of coastal nourihment techniques in The Netherlands. Part A. The ecological effects of shoreface nourishment of the island of Terschelling, Part B. The ecological effects of subaqueous sand extraction North of the island of Terschelling, Part C. Literature references. Rijkswaterstaat, National Institute for Coastal & Marine Management/RIKZ, Den Haag. Report Nr. RIKZ-97.022.

2. Recovery of macrozoobenthos in a sand borrow site.

At the location of the subaqueous sand extraction North of Terschelling, used for shoreface nourishment (see above), an extra survey of the sebed morphology and macrozoobenthos was made in the fall of 1997. This project (RIACON*2) was commissioned by Rijkswaterstaat, North Sea Directorate because of its interest to obtain better insight into the recoovery process of the macrozoobenthic community after sand extraction.
This project will be concluded in 1998.

3. Effect of temporary sand extraction pits on macrozoobenthos.

Official Dutch policy does not allow marine sand extraction landward of the 20 m depth contour in the North Sea coastal zone.
In 1996 an experimental deep pit was dredged NE of IJmuiden, the sand being used to start a local beach nourishment. The extra sand necessary for the nourishment was borrowed from the approach channel (IJ-geul) to the port of IJmuiden, dumped in the pit and transported onto the beach by

a stationary suction dredger 'PINPOINT'. After completion of the beach nourishment, the pit was filled again.
The effects on abundance and biomass of macxrozoobenthos are being studies by repeated surveys at and around the area of the temporary borrow pit. This study is commissioned by Rijkswaterstaat, North-Holland Directorate, and carried out and co-ordinated bij the National Institute for Coastal & Marine Management/RIKZ.
This study will be concluded in the beginning of 1999.

4. Ecological effects of large scale sand extractions.

Large scale sand extractions are foreseen in relation to a number of potential coastal plans in The Netherlands, such as:

- enlargement of port of Rotterdam ("Maasvlakte-2') - ca. 800 x 10^9 m^3
- land from the sea off Hook of Holland-The Hague - ca. 550 x 10^9 m^3
- airport off the coast - ca. 750 x 10^9 m^3

For the extraction of the amount of sand needed, it is estimated that 10 years of borrowing of 0.1 -0.2 x 10^9 m^3 annually is necessary.

The study, which is mainly a desk and simulation study considers at least three scenario's for sand extraction:

1. **borrowing from deep pits** .
   A case study will be undertaken in the area of the 'Loswal-Noord' dredge spoil dumping ground near Hook of Holland.
2. **shallow borrowing from large areas.**
3. **enlargement of coastal shipping lanes.**

The effects that will be focussed on are 1) effects on water circulation patterns, 2) effects on transport of silt and sand, 3) ecological effects in the water column as well as in and on the seabed.

Reports will be finalized during 1998 to support policy decisions by the Dutch Government.

5. Extraction of shells

Since long, a few hundred thousand m^3 of shells is being extracted annually from Dutch coastal waters, the major part of which comes from the Dutch Wadden Sea. The majority of the shells fished consists of cockles (*Cerastoderma edule*). *Spisula* spp., *Macoma balthica* and various other species constitute the rest. A non defined proportion consists of fossil shells from Eemien or even Pliocene and Eocene periods.
An environmental impact study was done considering the effecst of shell fishing on 1) geomorphology and erosion, and 2) ecology (increased turbidity, disturbamce of seals and birds.

A new policy was of sustainable shell extyraction was formulated. This means that the average amount of shells to be fished annually has to

balance the long-term annual calcimass production by bivalves in the Dutch coastal waters. To obtain an estimate of mean annual natural calcimass production in the Dutch coastal waters existing data sets of *Cerastoderma edule* and *Spisula* spp. (some covering decades, some only a few years long) were analysed. From these data amounts becoming available for fishermen ('net' production) were calculated (Table 1).
In new licences for shell fishing these 'net' production estimates will be used to define the amount of shell that are allowed to be fished.

Table 1. Estimated 'net' annual production of shells (m^3) in different Dutch coastal waters (From: RWS, 1998a,b)

Water system	Cockles	Spisula
Wadden Sea	132.000	-
Wadden Sea coast	-	137.000
Holland coast	-	121.000
Voordelta	2.000	102.000
Eastern Scheldt	78.000	12.000
Western Scheldt	5.000	2.000
Total:	217.000	374.000

References:

RWS, 1998a. Draft-National Policy for Shell Extraction (Landelijke Nota Schelpenwinning). Ministry for Transport, Public Works and Water Management, Directorate-General for Public Works and Water Management (in prep.) (in Dutch)

RWS, 1998b. Draft-Environmental Impact Study Shell Extraction (Concept MER Schelpenwinning). Ministry for Transport, Public Works and Water Management, Directorate-General for Public Works and Water Management (in prep.) (in Dutch)

ANNEX 5

STATUS REPORT ON MACROZOOBENTHOS INVESTIGATIONS IN LATVIA

Status Report on Macrozoobenthos Investigations

Report to ICES Benthos Ecology Working Group,
Heraklion, Crete, Greece,
23-25 April 1998

by Maija Ceitlina

Introduction

The investigations of soft bottom macrozoobenthos have been carried out in several reseach institutions of Latvia . Regular sampling in a system of monitoring was started at the end of 1970s. In Eastern Gotland Basin the investigations have been occasional. In the Gulf of Riga mapping is carried out on a regular basis, the station net covers almost the whole area of the Gulf (16330 km^2). Therefore, a characterization of benthofauna can be given for various depths and regions with different level of eutrophication.

Monitoring in the Gulf of Riga

The Gulf of Riga is considered as a highly eutrophied water basin. Therefore, particular attention is paid to studies of macrozoobenthos in the coastal zone in the southern part of the Gulf . Here, four largest rivers of Latvia flow into the Gulf. In this part of Latvia, the human population density and industrial activities are also the highest.
In the southern part of the Gulf macrozoobenthos is sampled at 8-13 stations 1-3 times every year in a depth of 10-13 m. The species composition, abundance and biomass of macrozoobenthos (wet and dry weight) are determined. The relationships between quantitative and qualitative benthos parameters with the trophic state of respective region are investigated.

Besides the coastal zone, 10-14 stations are situated in the deeper part of the Gulf in the depth of 20 - 55 m. The central part stations are mainly 40 m deep, as this is the most characteristic depth there. Here, the quantitative and qualitative parameters of the community are influenced by depth, type of sediments and inflows from the Baltic proper.

The sampling and treatment of samples are carried out according to HELCOM recommendations. The present grab in use is a new type of Van Veen grab with 0.1 m^2 surface area. The obtained data are stored in PARADOX type database.

Some Results

The long-term monitoring of macrozoobenthos in the Gulf of Riga allows to evaluate the effect both of natural and anthropogenic factors. In the coastal zone considerable changes in the species composition were observed during the last decade, viz. a drastic decrease of amphipod abundance and a significant increase of polychaete abundance. A recently introduced alien species *Marenzelleria viridis* played an important role in the changing of the species composition. This polychaete appeared in the Gulf of Riga less than 10 years ago having very low abundances then. At present, this species is found at every station, often being the dominant one. Probably *M.viridis* is competing with some local species and replacing it in its habitats. This problem requires further investigations, as well as the relations of long-term changes of macrozoobenthos and the eutrophication of the Gulf of Riga.

Some recent publications

At the ECSA-27/BMB-15 Symposium held in Mariehamn, Åland, Finland, June 1997 the following presentations on benthic research in Latvian/Estonian waters were given.

G. Martin: Distribution of phytobenthos biomass in the Gulf of Riga (1984-1991)

H. Cederwall & V. Jermakovs: Growth and production of some important macrofauna species in the Gulf of Riga, incl. comparisons wiith other areas.

N. Kautsky, G. Martin, A. Mäkinen, M. Borgiel, P. Vahteri & J. Rissanen: Structure of phytobenthic plant and animal communities in the Gulf of Riga.

These manuscripts were submitted to the journal Aquatic Ecology (Kluwer Academic Publishers) for publication in the Proceedings of the Symposium.

ANNEX 6

DEVELOPMENTS IN THE DUTCH BIOLGICAL MONITORING PROGRAMME AND THE TRILATERAL MONITORING AND ASSESSMENT PROGRAMME (TMAP) FOR THE WADDEN SEA

To:
ICES Benthos Ecology Working Group

Meeting 23-24 April 1998

Heraklion, Crete, Greece

From:
Dr. Karel Essink
Date:
April 16, 1998
Subject:
Biological Monitoring Programme
Telephone (direct):
+31.50.5331.373

Appemdices:
-
Number:
RIKZ/OS-98.606x
Project
ICES*ICES

Developments in the Dutch Biological Monitoring Programme and the Trilateral Monitoring and Assessment Program (TMAP) for the Wadden Sea

by Karel Essink

1. Dutch Biological Monitoring Programme

In 1996 the first steps were set in the process of evaluating the on-going biological monitoring programme in coastal and marine waters of the Netherlands. This programme includes monitoring of phytoplankton, microzooplankton, macrozoobenthos, seagrass beds, saltmarshes, breeding birds, high water counts of waders, ducks, geese and gulls, airborne counts of seabirds and sea mammels. This monitoring programme is coordinated by the National Institute for Coastal and Marine Management/RIKZ.

The evaluation covers the following steps:

1. Documentation and motivation of those parameters in the programme that are included because of national or international obligations.
2. Documentation of the other parameters measured, and especially of the argumentation for selecting these parameters and for applying the present monitoring strategy.
3. Inventory of the information needs of the various users (higher and lower governmental bodies and organisations).
4. Analysis of the merits and shortcomings of the present programme.

Steps 1 and 2 were carried out in 1996. Interviews relating to step 3 are currently done with various categories of users.

For step 4 multivariate statistics are being used to analyse data sets. The porpose of this approach is to obtain insight in the statistical power of the present monitoring programme to reveal trends or changes in the measured parameter values. A second objective of statistical data analysis is to explore possibilities for reducing the monitoring effort, however without loss of essential information.
So far, in step 4 data on breeding birds in SW Netherlands and data on abundance of a selection of phytoplankton species in the North Sea (Dutch Continental Shelf) have been statistically treated. Data on macrozoobenthos will be treated later in 1998.

2. Trilateral Monitoring and Assessment Program (TMAP) for the Wadden Sea

In 1982 a Ministerial agreement between Denmark, Germany and the Netherlands was made regarding the protection of the international Wadden Sea area.
In an early stage is was recognized that an integrated monitoring programme, involving measurement of physical, chemical and biological variables and of humas use, was essential to facilitate a proper management of the area. Much effort was put into the formulation of ecological targets, taking into account nature's needs as well as those of man. Workshops of international specialists were held to review existing monitoring programmes and to advise on measuring strategies, methodology and organisation of future monitoring in the Wadden Sea.
In October 1997, the newly developed Trilateral Monitoring and Assessment Program (TMAP) was adopted by the Trilateral Ministers Conference held in Stade, Germany. Implementation of this programme and its set of 'common parameters' and guidelines (TMAG, 1997) should take place stepwise within 2 years time.

Reference:

TMAG, 1997. Trilateral Monitoring and Assessment Group. TMAP Manual. The Trilateral Monitoring and Assessment Program (TMAP). Working Document. Common Wadden Sea Secretariat, Wilhelmshaven.

ANNEX 7

ENVIRONMENTAL IMPACT STUDY IN THE FRAMEWORK OF THE CONSTRUCTION OF THE GAS PIPELINE INTERCONNECTOR ON THE BELGIAN CONTINENTAL SHELF

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Agricultural Research Centre Gent, Sea Fisheries Department,
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Introduction :

New pipelines crossing the Belgian Continental Shelf gave rise to new sampling and monitoring programmes. The Interconnector gas pipeline crosses the Southern North Sea from Bacton (United Kingdom) to Zeebrugge (Belgium). At some places (e.g. shipping lanes) the pipeline was buried and stabilised in the bottom. But most of the time it was installed into a presweeped corridor of about 10 metres width on the sea floor bed. The completion of all construction activities was scheduled for the Interconnector pipeline for the end of August '97. The system is designed for a long-term operational life of 50 years.
Three periods of sampling will be carried out : before the installation (t_0), immediately after (t_1) and one year following the execution of the construction works (t_2). All samples were taken from the research vessel 'Belgica' by means of a 0.1 m^2 Van Veen grab (macrobenthos) and a small meshed 8 meter beam trawl with a 22 mm mesh size at the cod-end (epibenthos & fish).

Preliminary results : (after 2 campaigns)

a) Interconnector

In 1997, samples were taken along the trajectory of the Interconnector gas pipeline and at some reference stations across the Belgian coastal waters of the North Sea to assess the environmental impact of such an installation on the benthic and fish communities in the area. Density and species composition of the macro- and epibenthos as well as the fish populations were studied. Furthermore sediment characteristics were determined for each sampled station along the pipeline trajectory.

- First campaign – period prior to the installation (t_0) (spring '97):

The sediments of all sampled stations along the pipeline (H4-H8 & 435) were characterised by a median grain size varying between 305 and 438 µm, therefor, according to the Wenthworth scale, cataloguing it under a medium coarse sediment type. Two stations (H4 & 435) showed also a large fraction of gravel (resp. 16 and 20 %). The mud content never exceeded 3 % .
A significant gradient in median grain size was recorded from the coastal area to the open sea. The stations near the coast were characterised by a low median grain size, while the highest values were noted at the offshore stations.

A total of 62 macrobenthos species was found along the pipeline track, half of them polychaetes, with a total mean density of 264 ind./m². The most common ones were the species from the genus *Nephtys* (*N. cirrosa* and *N.* species (juveniles)). Other frequently occurring species were *Ophelia limacina*, *Glycera* species and *Scoloplos armiger*. In one station (H5) however there was a dominance of crustaceans, mainly amphipods (*Bathyporeia* species, *Urothoe brevicornis* and *Pariambus typicus*). Diversity (Shannon-Wiener index) increased linearly along the pipeline track.

The epibenthos communities ranged from 302 ind./10^5m² to 5,879 ind./10^5m² and were dominated by *Ophiura* species, with very high densities in the vicinity of the Belgian Sand Banks. Other important species were *Asterias rubens*, *Crangon crangon* and *Pagurus bernhardus*. Density and biomass values indicated a decrease along the pipeline track from the coastal stations towards the open sea.

The fish densities ranged from 1616 ind./10^5m² to 5,409 ind./10^5m². The most common ones were *Limanda limanda*, *Merlangius merlangus* and *Trachurus vipera*.

- Second campaign – period immediately following the pipe laying (t_1) (autumn '97):

The sediment samples, taken along the pipeline, showed higher median grain sizes in comparison with the first campaign. The gradient in median grain size, as described in spring '97, was still present.

In total 89 macrobenthos species were observed, with a total mean density of 423.3 ind./m². The different communities were dominated either by polychaetes or exceptionally by crustaceans. A comparison was made with the situation before the installation of the pipeline (t_0) showing an enriched macrobenthos population.

The epibenthos communities ranged from 655 ind./10^5m² to 47,915 ind./10^5m² and were dominated by brittle stars (*Ophiura* species), with very high densities near and in the vicinity of the Thornton and Goote Sand Banks. The flying crabs (*Liocarcinus holsatus*) represented the highest biomass in the epibenthic communities, except in the offshore areas. A general increase in density and biomass was recorded at all sampled sites in comparison with the first campaign in spring '97 (t_0). The biomass values indicated a downward trend along the pipeline track from the coastal stations towards the offshore sampling stations.

The fish densities ranged from 1612 ind./10^5m² to 8,505 ind./10^5m². The most common species were *Pomatoschistus* species, *Limanda limanda* and *Trachurus vipera*.

This second report must, similar to the first one, be considered as a further basis for final comparison with results from the third survey, which will be carried out about one year after the completion of the pipeline.

Discussion :

Although we observed a slight change in sediment composition and a general increase in density and diversity in the macrobenthic communities, we can not be certain whether the pipeline was the cause of this all. Probably not, because the same phenomena were noticed at the different stations. Normally we would expect a decrease in densities and diversity, if we consider the possible damage or disturbances caused by the instalment of the pipeline. But we found the opposite. A likely explanation could be that our sampling strategy was not accurate enough to assess such a local disturbance.
In fact we can not say for certain whether our samples were taken in the near vicinity of the pipeline. Our ship did not posses the means for detecting or visualising the exact position of the pipeline on the seafloor. Another point to consider is that while we were taking the four

replicates with the Van Veen grab the boot drifted away from the initial position. So, that is why we think that the higher densities of the biota are probably the result of seasonal variations, rather than being caused by the pipeline. This is also observed in nearly all our biomonitoring sites. The fact that the macrobenthos populations taken from both periods showed considerable similarities with each other supports that theory.
In autumn of this year the last sampling campaign will take place along the pipeline stations, one year after the pipe was constructed. Again all the samples will be processed and densities and biomass will be determined of the biota.

Figure 1. –Interconnector- Positions of sampling stations for macrobenthos research.

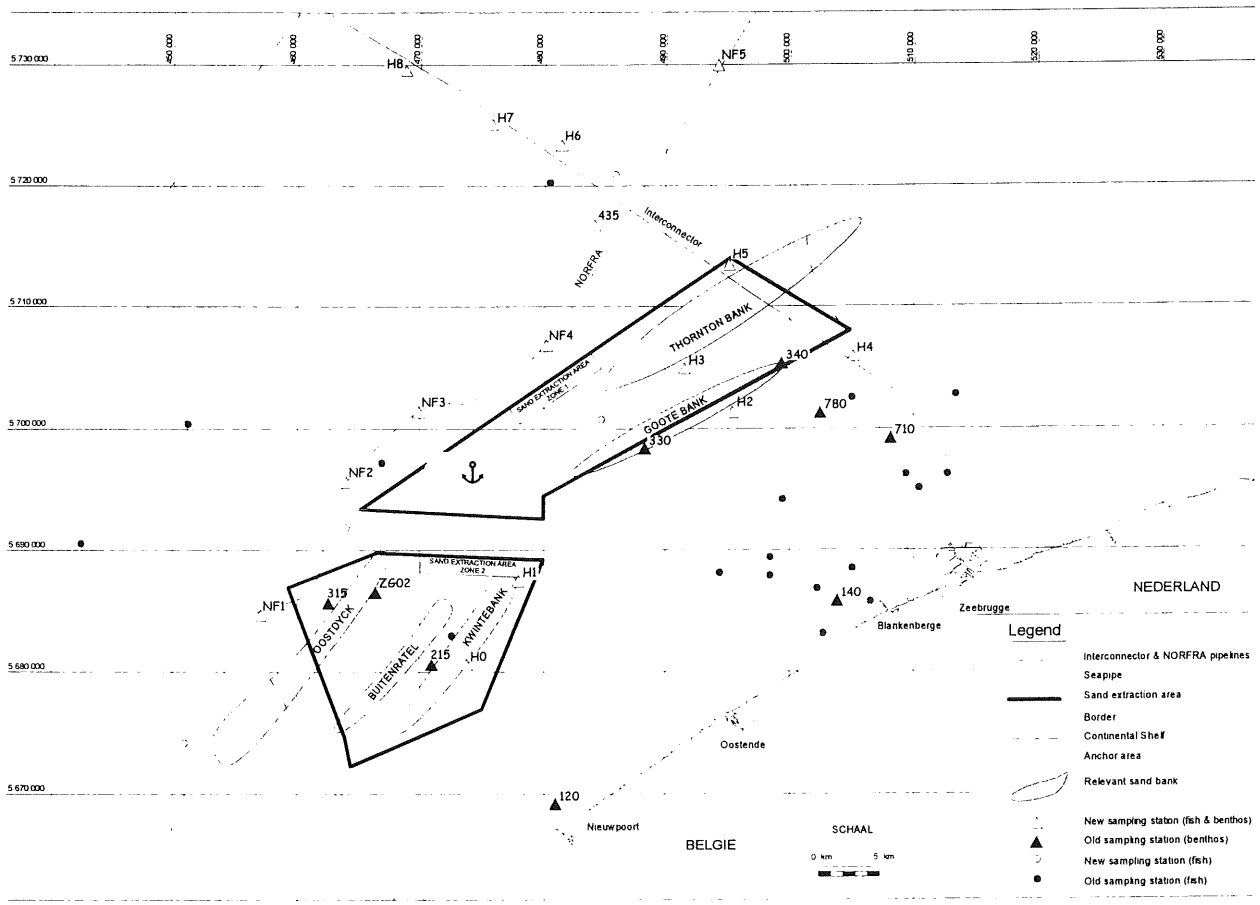


Figure 2. Sediment characteristics Interconnector t_0 and t_1.

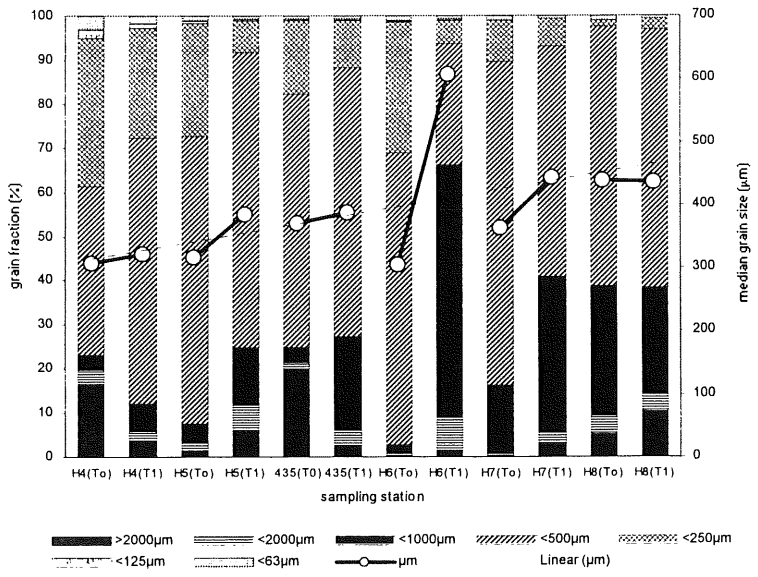


Figure 3. Density macrobenthos period before (To) and after (T1) the installation

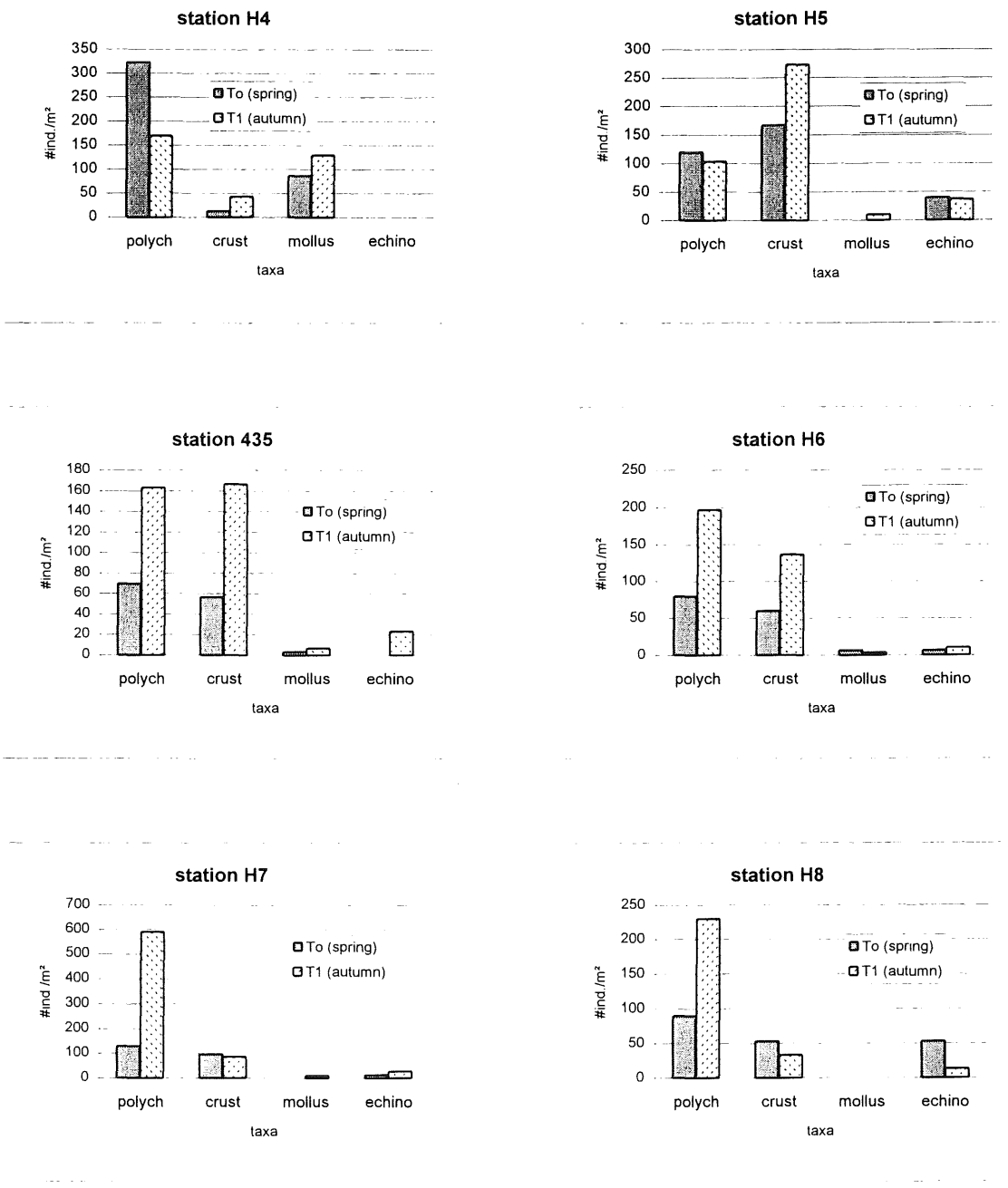


Figure 4. Density macrobenthos reference stations

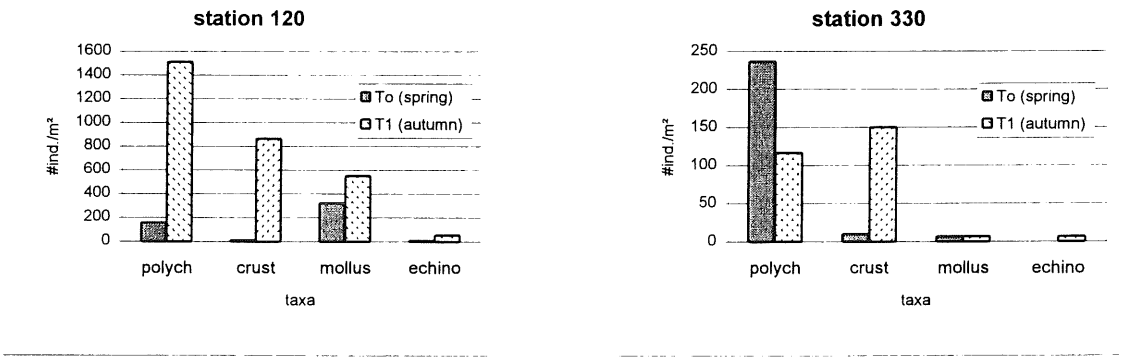


Figure 5. Number of macrobenthos species; before (To) and after (T1) the installation of the Interconnector pipeline

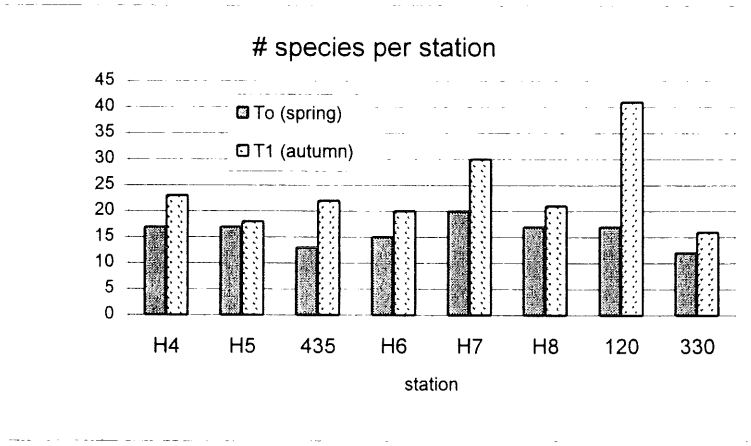
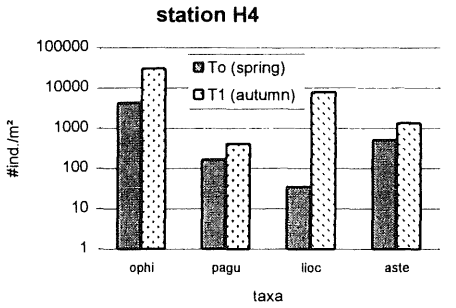
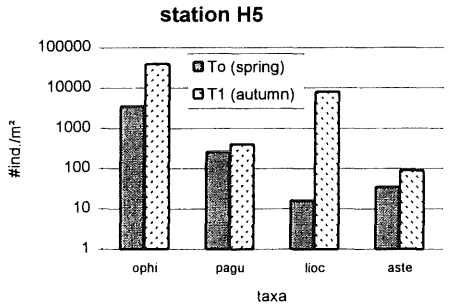
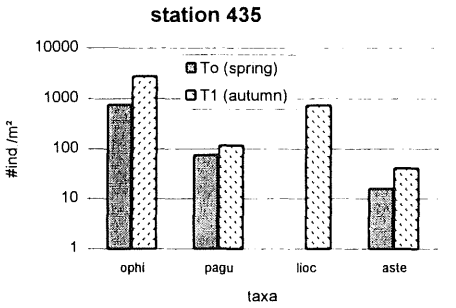
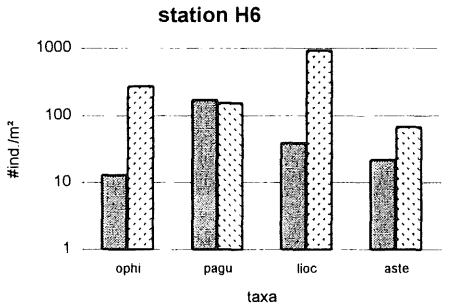


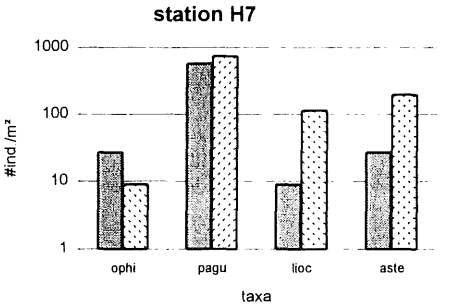
Figure 6. Density of the most common epibenthos species (Ophiura spec., Pagurus bernhardus, Liocarcinus holsatus and Asterias rubens) along the pipeline.











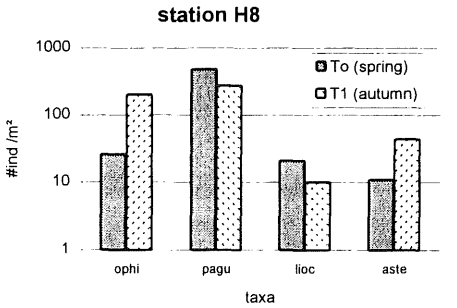
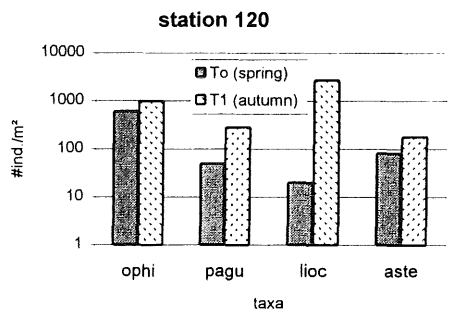
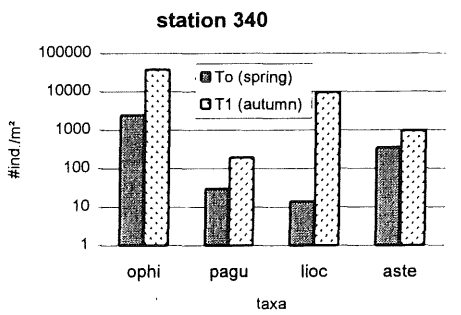


Figure 7. Density epibenthos species in reference stations





ANNEX 8

EFFECTS OF OTTER-TRAWLING ON BENTHIC COMMUNITIES: RESULTS OF A STUDY

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In 1997 the Marine Research Institute in Reykjavík initiated a field experimental study on the short term and the longer term effects of otter-trawling on macrobenthic communities and sediment properties. For many years, prior to the experiment, the study area has been closed for ground fish trawling, and a side-scan sonar survey found no evidence of disturbance by fishing activities in the area.

A pilot study was carried out in March 1997 (Figure 1) in order to investigate the spatial pattern of fauna and sediments within the study area. The depth range within the study area was from 30 to 33 meters. Sediment was muddy with silt content on average 49,6% by weight, and in 80% of samples it varied from 45 to 55% (Figure 2). The fauna was dominated by two species, *Myriochele oculata* and *Macoma calcarea* (42% and 32% by numbers, respectively), other species were less abundant (26% of the total). The spatial distribution of majority of species was highly patchy. However, autocorrelation on the data has not yet been carried out in order to investigate the spatial patterns further. No species exhibited gradual change in abundance across the study site, neither along the east-west axis or the south-north axis (Figure 3). Results from cluster analysis revealed high similarity among samples. Ordination of the data using non-metric multi-dimensional scaling showed that there is a high degree overlap among all samples, indicating that species composition and abundances were similar throughout the study area (Figure 4).

To investigate the effects of trawling on benthos and sediment characteristics, eight transects were laid out within the study area (Figure 5). In July 1997, four of these transects were trawled 10 times while the other four remained undisturbed. From each transect, samples for fauna (with grab and sledge) and sediments were collected in July, immediately after trawling, August and in January this year. This experimental design allows investigation on the short and longer-term effects of trawling on the abundance, biomass and composition of fauna as well as on the sediment characteristics.

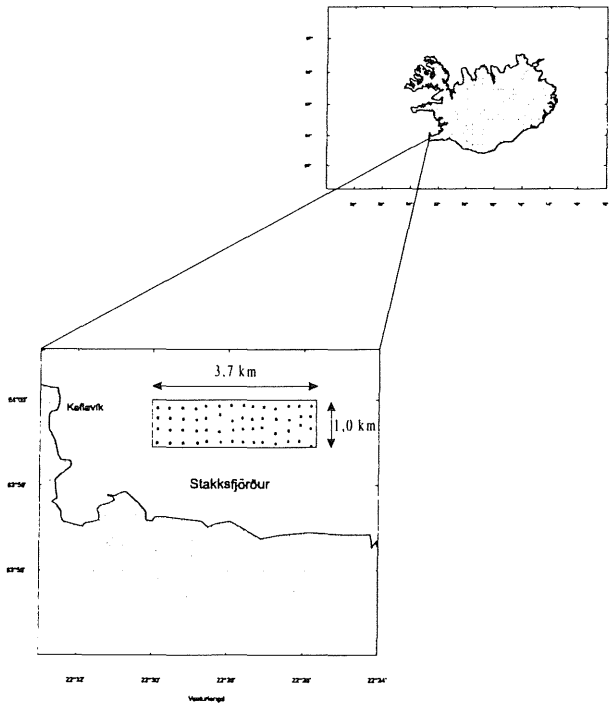

Figure 1. The study area (1,0 km x 3,7 km) in Stakksfjörður (Faxaflói Bay, SW Iceland). Locations of the 55 sampling stations in the study area (dots), sampled with Haps corer (0,013m^2).

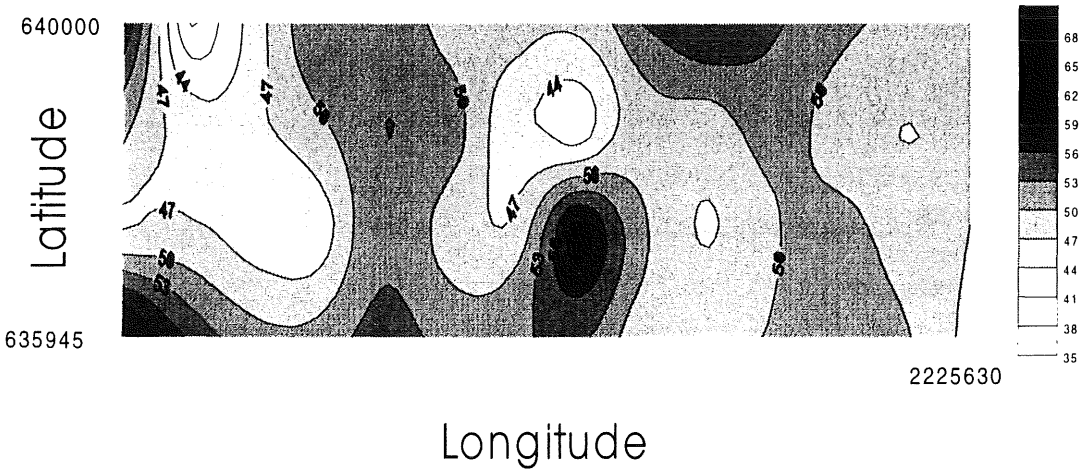

Figure 2. The study area in Stakksfjörður. Contour plot of silt contents (% by weight) of the sediments within the study area.

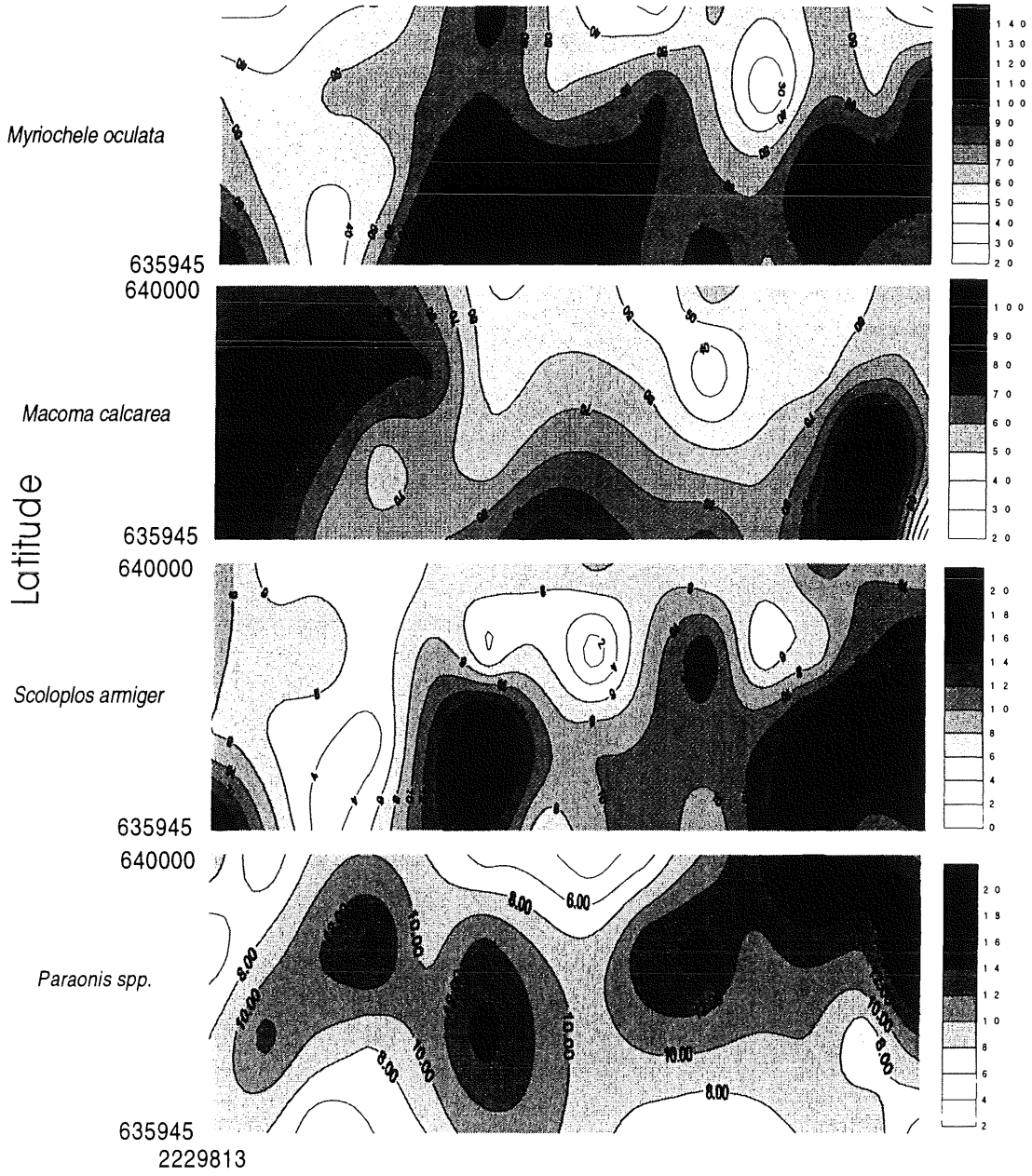

Figure 3. The study area in Stakksfjörður. Contour plots of abundance of the most common species within the study area (individuals / 0,013 m^2).

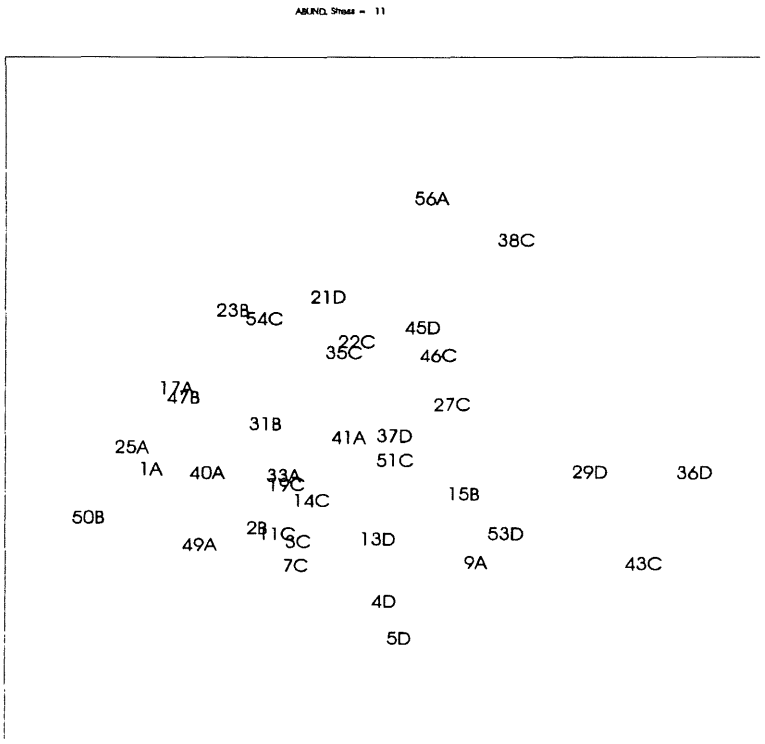

Figure 4. Non-metric multi-dimensional scaling (MDS) of samples taken during the pilot study. Labelling of samples indicate the position within the study area; numbers increase from west to east; letters in alphabetical order from south to north (see Figure 1).

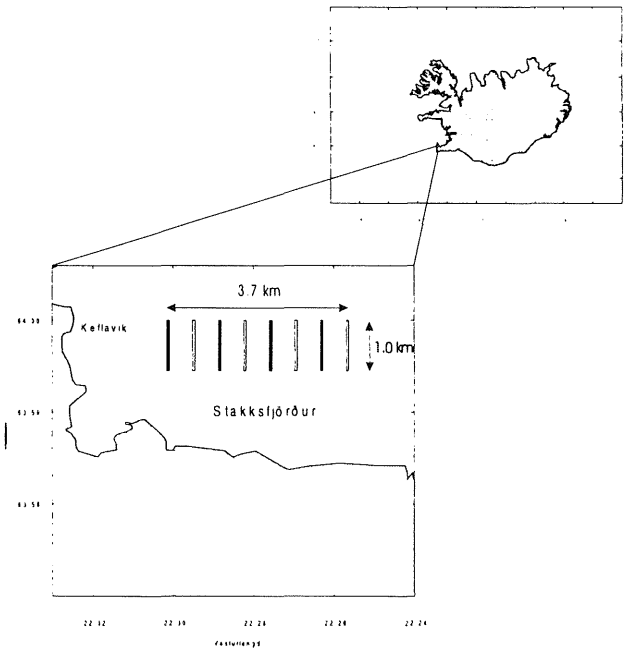

Figure 5. The experimental setup in Stakksfjörður. Trawling with an otter-trawl was carried out in four transects (black) and four transects were left undisturbed by trawling (white).

ANNEX 9

THE IMPACT II PROJECT: SUMMARY AND CONCLUSIONS

The EU funded research project AIR 94 1664 "The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystem" was set up to investigate the short-term and long-term effects of bottom trawl gear on benthic invertebrates and fish. As a follow-up to the IMPACT I (FAR MA 2-549) project an extensive study of the relative physical and biological effects of different trawl types on the benthic ecosystem was executed at different sites in the southern North Sea and Irish Sea. The effects of fisheries upon scavengers was assessed, while the long-term impacts were studied by comparing fished and unfished areas and by collating nine different long-term data sets which might indicate possible changes in the marine ecosystem during the last decades and the last century.

An historical review of fishing fleets and gears used in the study area was made, being a clear indication of the rapid development from a large sailing fleet at the end of the previous century towards a smaller but much more efficient engine powered beam and otter trawl fleet nowadays. An inventory was made of the present numbers of Belgian, Dutch, German, Irish and UK fishing vessels active in the North Sea and Irish Sea. The gears in use per vessel size class in the different fleets is described, indicating that beam trawling is the most important fishery in Belgium and the Netherlands, while for England and Wales otter trawling is the most significant fishing method. The distribution of the fishing effort of the different fleets and gears is given for the North Sea.

The physical impact of the fleets on the seafloor was determined by direct pressure measurements, side scan sonar observations, RoxAnn surveys, sediment profile imaging (REMOTS/SPI) and video and stills photography.

Trawling programs to further study the effects on benthic communities and to compare the impact of the different gear types were carried out in the southern North Sea and the Irish Sea. The catch efficiency of the different gears, and the mortality both of the discards and of organisms in the trawl path was assessed. A comparison was made between the impact of the 4m beam trawl rigged with chain matrices or with tickler chains, the 12m beam trawl and the otter trawl. Before, and after, experimental trawling both in- and epifauna were sampled using various pieces of equipment including; box corers, Van Veen grabs, Day grabs, 3m beam trawls, and the specially developed Triple-D dredge.

The responses to trawling of sub-surface scavengers was investigated both in the field and the laboratory. Repeated trawling over the same fishing strip, the use of baited traps, video and stills camera observations, and stomach content analyses all hinted at a very active response of possible scavengers to fishing activities. Using the results of the field surveys, and the outcome of feeding experiments under controlled conditions in the laboratory, the importance of fisheries as food source for selected scavenging species was assessed. A comparison was made between these effects in the southern North Sea and the Irish Sea.

To assess the longer term impact of fisheries at three study sites (Loch Gareloch, Firth of Clyde, Scotland; Iron Man/41 Fathom Fast in the Irish Sea, and West Gamma in the North Sea), areas disturbed by fishing were compared with undisturbed areas. In Loch Gareloch, the effect of experimental fishing was measurable. At the other two sites a difference in the benthic fauna was detected between these areas.

The long term trends in demersal fish and benthic invertebrates was assessed by analyzing seven different data sets. On average, the relative species composition appeared to have changed in the research area. Almost all benthic communities show a significant increase in biomass and a change in community structure with a shift towards dominance by opportunistic short-lived species and a decrease in long-living sessile organisms such as bivalves. A model describing fishing types and efforts implied that between 1947 and 1981, bottom fisheries has a considerable impact on the marine ecosystem by reducing several demersal fish and benthic invertebrate species to very low

levels of abundance. Especially during the last decades not all data series show expected trends. This and possible other causes for the observed changes, e.g. climate change and eutrophication are discussed.

The actual impact of the different gears used in the southern North Sea was estimated by-combining the fishing efforts, the estimated mortalities and the actual distribution of a number of selected species.

The project was undertaken by the following contractors:

01 Netherlands Institute for Fisheries Research (RIVO-DLO), P.O. Box 68, 1970 AB IJmuiden, The Netherlands
02 Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands
03 Institut für Meereskunde (IfM), Düsternbrooker Weg 20, D-24105 Kiel, Germany
04 Alfred-Wegener Institut für Polar- und Meeresforschung (AWI), P.O. Box 120161, D-27515 Bremerhaven, Germany
05 Rijksstation voor Zeevisserij (RSZV), Ankerstraat 1, B-8400 Oostende, Belgium
06 Rijkswaterstaat - North Sea Directorate (RWS-DNZ), P.O. Box 5807, 2280 HV Rijswijk, The Netherlands
07 Netherlands Institute of Ecology - Centre for Estuarine and Coastal Ecology (NIOO-CEMO), P.O. Box 140, 4400 AC Yerseke, The Netherlands
08 Fisheries Research Services, Marine Laboratory Aberdeen (an executive of the Scottish Office) formerly known as Marine Laboratory (MLA-SOAEFD), P.O. Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland (UK)
09 Ministry of Agriculture, Fisheries and Food (MAFF), CEFAS Conwy Laboratory, Bernarth Road, Conwy, North Wales LL32 8UB (UK)
09[a] University of Wales (UWB), Bangor, Wales (UK)
10 Bundesforschungsanstalt für Fischerei - Institut für Seefischerei (BFA-ISH), Palmaille 9, D-22767 Hamburg, Germany
11 Martin Ryan Marine Science Institute (MRI), University College Galway, IR-Galway, Ireland
11[a] Fisheries Research Centre (FRC), Abbotstown, Dublin 15, Ireland

The University of Wales (UWB), Bangor, Wales (UK) and the Fisheries Research Centre (FRC), Dublin, Ireland acted as subcontractors.

CONCLUSIONS[1]

- Fishing has been an important industry since the beginning of this century. The high numbers of sailing fishing vessels and steam trawlers demonstrate that in the early 1900s the North Sea was already intensely fished. The fishery at that time mainly used passive fishing gears but trawl nets were already in use by steam trawlers and larger sailing vessels. Technological advances have led to an increase in the impact, with the introduction of the diesel engine, otter trawls able to fish rough grounds, the beam trawl and modern navigation equipment, as the main steps (3.1).
- Beam trawls are the most common demersal fishing gears in Belgium, the Netherlands and Germany at present. Otter trawling has a minor importance and its use is still decreasing. For the UK and Ireland the otter trawl is the most frequently used fishing gear. In the U.K. however, beam trawling has gained an increasing importance over recent years (3.2).
- The pressure exerted by a beam trawl on the sea bed is relatively low and does not increase considerably with the size of the gear. The reason is that the higher weight of the larger gears is compensated by larger contact surfaces and higher towing speeds, leading to a greater vertical lift (3.3).

[1] Between ( ) the chapter to which the conclusions refer.

- Trawls leave visible marks on the sea floor. Depending on the local circumstances these marks will disappear in a period of 37 hours (beam trawl in an area with fine sediments and exposed to tidal currents) to 18 months (otter trawl on a muddy sediment in a very sheltered area) (3.3).
- The passage of towed demersal fishing gears flattens the contours on the sediment surface. Former studies estimate the penetration depth of a beam trawl as 1 to 8 cm, depending on sediment characteristics and rigging of the gear. Due to the passage of the trawl over the seabed the smaller sediment particles are suspended, but they settle out within hours (3.3).
- The catch efficiency of beam trawls was generally low (0-10%) for small sized fish and invertebrate species. In otter trawls, the catch efficiencies for invertebrates were even lower than 3%. Only in beam trawls the largest length classes of starfish, hermits and seamouse were caught with efficiencies higher than 10% (3.4).
- In North Sea flatfish beam and otter trawls, the by-catch by weight of flatfish (mostly dominated by dab and plaice) was at least as high as the marketable catch. The by-catch of invertebrates (dominated by starfish, heart urchins, crabs) was several times the amount of marketable fish. The by-catch by weight of roundfish was relatively low (< 5% of the total catch) (3.4).
- In the Irish Sea *Nephrops* studies, the by-catch by weight of roundfish (mainly juvenile whiting) was roughly similar to the amount of marketable prawns. The by-catch of non-target invertebrates was relatively low (< 5% of the total catch) and dominated by crustaceans and molluscs. However, the recent implementation of legislation governing the insertion of square mesh panels in *Nephrops* nets will increase the quantity of fish escaping from the net, and thus reduce the quantities of juvenile whiting discarded (3.4).

  The catch efficiency for invertebrates did not differ between 4m and 12m beam trawls both rigged with tickler chains. In 4m beam trawls with tickler chains, more marketable fish and invertebrates (by weight) were caught than in 4m beam trawls rigged with a chain matrix. The total catch by weight in 12m beam trawls was several times higher than in otter trawls: for marketable fish at least seven times, for all discards more than ten times (3.4).

  Mortality of discards from flatfish beam trawls was species-dependent and varied for invertebrates from < 10% of the individuals caught (starfish, brittlestars) to almost 90% (the bivalve *Arctica islandica*), with most crustaceans showing intermediate values (about 50-70%). Discarded fish showed mortalities ranging from 50 to 100% (flatfish), from 80 to 100% (roundfish), with 100% mortalities for gadoids (3.5).

  For the majority of fish and invertebrate species, no clear differences were found in discard mortalities between the different trawls tested (3.5).

  Despite the high mortality of discarded small fish and most invertebrate species, this mortality is still very low (a few %) when expressed as percentage of the initial density of these animals on the seabed. This is due to the low catch efficiency of the commercial trawl for these species which mostly pass through the meshes or do not even enter the net. For all invertebrate species, direct mortality mainly occurred in the trawl path, possibly as a result of direct physical damage inflicted by the passage of the trawl or indirectly from disturbance and subsequent predation (3.5).

  Total direct mortality of invertebrates (both discard mortality and mortality in the trawl path as % of initial density) varied for various species of gastropods, starfish, small and medium sized crustaceans, and annelid worms from 10 to 50%. For a number of bivalves species, mortalities were found of 30-80%. Fragile or superficial living species showed high mortalities, robust or deeply burrowing species low or even no mortalities. In general, small sized species and specimens showed relatively low total mortalities (3.5).

  Otter trawling in silty areas caused less total direct mortality in many burrowing invertebrate species as compared to beam trawling; otter trawls apparently penetrate less deeply into the seabed. Differences in total direct mortalities of benthic fauna due to trawling with 4m and 12m beam trawls were generally not obvious. For some species, total direct mortality for 4m beam trawls with tickler chains was slightly higher than for 4m beam trawls with chain matrices, probably because chain matrices penetrate less deeply into the sediment (3.5).

- In silty sediments in the North Sea a trend was found for higher total direct mortalities of invertebrates due to beam trawling than in sandy areas. This points to a deeper penetration of beam trawls into a softer seabed (3.5).
- The species-poor and biomass-poor fauna at the offshore station in the Irish Sea illustrates the possible impact of a longterm, high *Nephrops* trawling effort leading to a species composition that is adapted to regular fishing disturbance (3.5 and 3.7).
- Benthic scavengers and predators feed both on fisheries discards and on animals damaged in trawl tracks. The responses of scavengers to carrion varies between different sites depending on environmental and physical factors (3.6).
- In some trawled areas there is opportunistic feeding by a number of predatory species on scavenging species attracted by the disturbance effect. Scavengers can increase their food intake when migrating into and foraging in trawled areas and also alter dietry composition in response to trawling (3.6).
- Competition for fisheries discards between benthic scavengers sometimes becomes intense and can affect feeding success (3.6).
- In the North Sea the annual amount of carrion produced by fishing activities accounts for a maximum of 10% of annual food consumption by scavenger populations (3.6).
- Experimental disturbance of a previously unfished site showed clear long term effects on both epi- and infauna. Comparison of fished and protected sites within fishing grounds also showed clear differences, suggesting that fishing disturbance has significant long term effects on benthic communities (3.7).
- Comparison of the two Irish Sea sites showed an increasing effect of fishing with greater fishing intensity. At the heavily fished site the fauna already acclimated to intense fishing disturbance and no short term effects could be detected with the sampling methods used (3.7).
- In general, opportunistic (small size, fast reproducing) species increased in abundance while sensitive (large size, fragile) species declined in numbers due to trawling disturbance. Longer term disturbance effects on epifauna were less easy to quantify, and results were contradictory for some species. The results from the Loch Gareloch study did, however, suggest that fragile sessile species such as *Metridium senile* are adversely affected by trawling disturbance. The ability of mobile scavengers to migrate in and out of disturbed areas makes the detection of trawling effects on these species difficult (3.7).
- Measures of diversity and evenness were consistently higher in unfished areas when compared to adjacent disturbed areas (3.7).
- Results from the Loch Gareloch study suggest that in sheltered muddy sites, recovery following disturbance may take over 18 months. In regularly fished area, communities may never fully recover before being redisturbed (3.7).
- Almost 100 years of trawling impact have certainly re-structured the benthic system. For the longest time span observed (1902-1986), a decline in the frequency of occurrence of bivalves can be seen, whereas scavengers and predators such as crustaceans, gastropods and sea stars have increased (3.8).
- The observed variation in annual numbers of fish and invertebrates delivered to the Zoological Station in Den Helder, The Netherlands, were found to be related to the changes in gear and fishing effort of demersal trawlers. Otter trawlers delivered relatively more fish than invertebrates and, on average, the catch efficiency of beam trawling appeared to be an order of magnitude higher than that of otter trawling for all species considered (3.8).
- The benthic communities in the German Bight show a significant increase in biomass and a change in community structure with a dominance of opportunistic short-lived species (r-selected) and a decrease of long-living sessile organisms (K-selected) like several bivalve species (3.8).
- Combined with the results from other chapters on the direct effects of bottom fisheries on the benthos and the comparison between fished and unfished areas, it has to be concluded that the observed long term trends in benthic communities were to a great extent caused by the direct

and indirect effects of fisheries and not solely by eutrophication, climatic fluctuations and/or pollution (3.8).
In the Dutch sector in 1994, the 12m beam trawl fishery was the dominant type of trawling offshore, with an average frequency of 1.23. The average frequency of the 4m beam trawl fishery with ticklers was 0.13 mainly in the coastal zone, that of 4m beam trawl fishery with chain matrices was 0.01 exclusively in the southernmost areas, and that of the otter trawl fishery was 0.06 (4.1).
The annual fishing mortality in the larger sized invertebrate populations varied from 7 to 48% due to trawl fisheries in the Dutch sector in 1994, with half the number of species showing values of > 25%. The 12m beam trawl fisheries caused higher fishing mortalities than 4m beam trawl and otter trawl fisheries. Only in species restricted to the coastal zone, where 4m beam trawl fishery is much more intensive than in offshore areas, fishing mortalities due to this fishery were relatively higher and might even exceed that due to the 12m beam trawl fishery (4.1).

RECOMMENDATIONS FROM THIS STUDY

Mortality in invertebrate populations due to commercial trawl fisheries depends on (i) the spatial distributions of species and trawling effort of the different fleets, and (ii) the total direct mortality estimate. Management measures to reduce this fishing mortality have to be centred on reduction of trawling effort, on spatial restriction (e.g. zonation) of a particular trawling effort and on reduction of the direct mortality rate (e.g. alternative gear design)
The use of sampling gears suitable for specific fractions of the benthic fauna in monitoring studies of invertebrate populations in the North Sea, will provide more appropriate data for the analysis of long term changes.Traditional gears such as boxcorers and grab samplers are appropriate for small sized in- and epifauna, fine meshed small beam trawls for fish and larger epifauna, and the Triple-D benthos dredge for larger sized in- and epifauna in sandy sediments. More attention should be devoted to the development of appropriate sampling gears for other types of sediments like stony and (very) silty areas.
To understand the long term impact on the occurrence of individual species, more information on population dynamics of these species (effects on recruitment and size distribution, recovery time, succession patterns, etc.) should be collected.
The extraction of more detailed information on the long term effects from the presented and other historical data series should be continued.

GENERAL RECOMMENDATIONS

Studies on the direct effects of fishing in areas which have been continually trawled in the last decades are inconclusive. Rare and long-lived species may already have disappeared, while the relatively resistant species may predominate present-day fauna. More conclusive evidence for the long-term effects of beam trawling on the benthic ecosystem can only be obtained by studying relatively large areas closed to fisheries for many years.
Research should be encouraged to reduce the destruction of potentially valuable undersized fish, of benthos and of habitats. Alternative fishing methods should be developed.
Studies on commonly overlooked parts of the benthic fauna, i.e. large and rare in- and epifauna that may be vulnerable to fisheries, should be encouraged.
For future studies examining the effects of fishing more detailed information on the distribution of fishing effort in time and space is needed. It should be considered to equip all vessels with "black boxes" to independently register their fishing activities.
The development and application of indirect methods to estimate fishing intensity (marks in the shells of bivalves, lost arms of echinoderms) should be encouraged.
Fisheries management should not only be based on management of fish stocks with commercial value, but also on ecosystem management.

ANNEX 10

SPECIES NUMBERS FOR PARTICULAR TAXONOMIC GROUPS CONTAINED ON THE ETI CD-ROM ON MACROZOOBENTHOS OF THE NORTH SEA

Taxonomic Group	In pictorial Key	Expected
Mollusca	341	500
Brachiopoda	9	9
Crustacea	349	600
Seaspiders	-	19
Polychaeta	154	570
Nemertini	42	42
Algae	-	450
Pisces	-	100
Tunicates	34	34
Echinoderms	61	61
Sponges	62	62
Bryozoa	192	192
Anthozoa	40	40
Phoronida	5	5
Entoprocta	33	33
Hydrozoa	83	150
Cephalopoda	1	1
Total	1046	2868

ANNEX 11

WORK PROGRAMME OF THE BLMP WORKING GROUP ON QUALITY ASSURANCE FOR 1998
PART: BIOLOGY

1. Development of a quality assurance management system in BLMP-laboratories
   - requirements through international norms and guidelines *(SOPs, EN 45001,.....)*
   - national and international regulations on accreditation and certification
   - documentation of methods *(written documentation, video)*

2. Coordination of external QA-activities
   - information on QA-meetings, QA-workshops, QA activities
   - national taxonomic workshops
     - zoobenthos workshop (polychaeta), March 1998
     - (zoobenthos workshop (crustacea), October 1998)
     - phytoplankton workshop (small flagellates), April 1998
     - phytoplankton workshop (toxic algae), October 1998
   - national intercalibration exercises
     - phytoplankton: 1. ringtest on species determination via photos; 2. ringtest with cultured phytoplankton; 3. ringtest with natural phytoplankton (spring sample), 4. ringtest with natural phytoplankton (autumn sample), 5. ringtest with chl.a.
     - zoobenthos: 1. ringtest on species determination; 2. intercomparison of sample determination; 3. seagoing intercomparison exercise; 4. ringtest with natural zoobenthos sample.

3. Judgement and validation of analytical and determination methods
   - development of basic criteria for an assessment of analytical methods *(precision, accuracy)*
   - requirements for reporting formats for biological data including QA-information

4. Coordination of the production/development of reference material *(reference collection, photos,.....)*
5. Reports on the results of QA-activities within the BLMP

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ANNEX 12

UK EXPERIENCE IN THE APPLICATION OF CRITERIA FOR EVALUATING THE QUALITY OF BENTHOS DATA SUBMITTED AS PART OF A NATIONAL MARINE BIOLOGICAL AQC SCHEME

The national marine biological AQC scheme involved the independent re-analysis of samples collected and analysed by individual laboratories, as part of their routine work. The criteria were:

a) extraction efficiency

   i. total taxa to within ± 10 % or ± 2 taxa (whichever is greater) after re-analysis;

   ii. total individuals to be within ± 10 % or ± 2 individuals (whichever is greater) after re-analysis;

b) total wet-weight biomass to be within ± 20 % of the re-analysed value;

c) Bray-Curtis similarity with the re-analysed sample should be _90 %;

d) the % silt/clay fraction to be within ± 10 % of the mean of the results from all laboratories.

An overall pass/fail flag was arrived at using the outcome from analyses of three submitted samples from each laboratory during 1996/1997. Laboratories were, for the purposes of this exercise, considered to have returned an acceptable performance if they passed six of the nine exercises. (Pending resolution of some difficulties with biomass determinations, they were excluded from consideration.)

The results showed that 84ÿ% of the comparisons were within the target for identification of taxa, 82 % for densities, and 72 % for the Bray-Curtis comparison. (There was about a 70 % failure rate for the biomass standard, and procedures are under review.) The net score resulted in only eight (of sixteen) laboratories passing. For determination of % silt/clay, all but one (of fifteen) laboratories passed, and indeed they could also have passed a more restrictive standard of ± 5 %, which would seem more realistic.

An attempt to evaluate the acceptability of laboratory performances, based upon their success in identifying species of ecological relevance or commercial importance, was also noted. However, further work is required in order to reduce the element of subjectivity in the selection of appropriate species.

For measurements based on direct registration (e.g., hard-bottom community studies), it seemed more realistic to achieve acceptance/rejection criteria on the basis of repeatability tests, defined compliance to other in-house QA routines, and routines for certifying that field taxonomists hold defined levels of qualifications. Overall, it was clear that more work is required in this area, and SGQAE would seek further advice from the relevant specialist WGs in the future.

Conclusions arising from the full range of QA activities under this scheme in the period 1996/1997, which involved the participation of about 25 UK laboratories, are as follows :

1) overall laboratory performance was relatively good but inconsistent;
2) particle size analyses showed high consistency within laboratories, but systematic differences between them, associated with the methods used (especially laser-sizing versus wet-sieving);
3) biomass estimates for individual species were variable between laboratories, and indicated the need for adoption of a standardised approach and a reporting format;
4) the importance of developing 'in-house' reference collections of identified species was highlighted;
5) taxonomic problems predictably recurred with certain groups, e.g., small molluscs, syllids and certain amphipod groups, indicating the need for more targeted ring tests;
6) extraction efficiency during sample sorting was generally good for the number of individuals present but, in some instances, was unacceptably poor in accounting for the numbers of taxa present;

7) there was still some inconsistency in the approach to handling headless and partial specimens, indicating the requirement for a written protocol;

8) the failure of some laboratories to submit results on time, though often reflecting a resource problem, can impede overall progress of the scheme, and required corrective action;

9) the practice of some regulatory laboratories to sub-contract analyses to commercial consultants can, inevitably, lead to complications in any 'certification' schemes currently under consideration;

10) tests involving re-analysis of samples taken from the areas of operation of individual laboratories, rather than tests of competency based on material from many sources, were favoured by a number of participants, especially those with only a limited geographical area of responsibility.

ANNEX 13

PROPOSED CONTENT OF A STANDARD OPERATING PROCEDURE (SOP)

(Modified from DIN EN 45001, Chapter 5.4.3.)

In general line with the requirements of the international standard DIN EN 45001, procedures/methods are recommended which are published as international, regional, or national standards.

Regarding procedures/methods which are not standardised, it is recommended to give a description of operational procedures which should include the following subjects:

a) scope of procedures used;

b) description of the study target;

c) variable to be determined;

d) equipment necessary, reference materials (e.g., voucher specimens), taxonomic literature used;

e) specification of working conditions required for effective sampling;

f) description of procedure/method with respect to the following aspects

   i. sampling and sample treatment, labeling, handling, transport and storage of samples, preparation for laboratory analysis,

   ii. instrument control and calibration,

   iii. recording of data,

   iv. safety aspects;

g) criteria to adopt or reject results/measurements;

h) data to be recorded and methods for their analysis;

i) assessment of uncertainty of measurements.

ANNEX 14

PROPOSED STRUCTURE FOR A DOCUMENT ON GUIDELINES FOR STUDIES OF EPIBIOTA

1 To identify the role and importance of the epibiota in the marine ecosystem

General introduction and justification for epifauna studies, including:

- broad definition of 'epibiota'
- ecosystem function

2 To identify the main objectives of epibiota studies

These may include:

- establishment of trophic and other links with commercial fish/shellfish species
- environmental quality assessment
- conservation
- fundamental research, including experimental and behavioural studies

NB: The methodology to be used will largely depend on the objectives of study.

3 To advise on sampling design to meet various objectives

Important issues will include:

- scale of sampling
- environmental heterogeneity
- capacity of the sampling gear to meet the requirements of different sampling designs
- replication
- frequency of sampling in time
- position-fixing

4 To identify critical environmental factors which determine the structure of epibiota assemblages and to advise on appropriate methods for describing habitat types

Critical environmental factors may include:

- substratum type
- height (intertidal)
- depth (subtidal)
- current speed and wave action/exposure
- turbidity
- salinity/temperature
- biological zone

Methods for describing habitat types will include:

- acoustic methods
- underwater photography/video
- direct sampling (grabs/cores/suction samplers etc.)

5 To evaluate and recommend standard epibiota sampling methods and procedures across the range of habitats likely to be encountered

Examples include:

- GIS systems
- acoustic methods (if sufficiently precise and in association with 'groundtruth' sampling)
- direct observations/sample collecting: shallow water and intertidal
- underwater photography (ROVs, drop cameras, diver-held cameras, towed video/camera sledges, trawl-mounted cameras)
- trawls/dredges: potentially a wide range of choices, with varying levels of uncertainty in sampling efficiency

NB: Sampling may need to take account of temporal changes on a diurnal, seasonal, and annual time-scale (e.g., as a result of behavioural patterns, recruitment processes, seasonal growth and/or mortality).

An example of approaches to matching techniques against different objectives is given in Table A14.1.

6 To propose consistent means for objectively identifying assemblage types

This will need to consider:

- the degree to which samples collected by various means truly reflect epibiota distributions at the sea bed
- the role of multivariate classification techniques as descriptive aids
- current European Environment Agency and OSPAR initiatives for community classification

NB: Some epibiota studies may only involve the sampling of single species, or small groups of species, rather than entire assemblages, depending on the objectives of the study.

7 To consider the current status of aids for identification and quantification of the epibiota, for work at sea and in the laboratory

These will include:

- image analysis systems both for identification and quantification of species
- data banks of photographs as identification aids
- computer-aided taxonomy
- inventories of species occurrences

8 To advise on quality assurance of epibiota studies

This should be integrated across 2–7 above, i.e., applied to:

- survey design
- survey techniques
- laboratory processing
- data collation
- data analysis/interpretation

ANNEX 15

ON THE DISPERSAL, IDENTITY, AND ECOLOGY OF *MARENZELLERIA* SPP. (POLYCHAETA: SPIONIDAE) IN NORTHWESTERN EUROPE

To
ICES Benthos Ecology Working Group

Meeting of April 23-25 , 1998

Heraklion, Crete, Greece

From
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Date
17-04-1998
Subject
Marenzelleria in NW Europe
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Appendices
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Number
RIKZ/OS-89.608x
Project
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On the dispersal, identity and ecology of Marenzelleria spp. (Polychaeta: Spionidae) in NW Europe.

by Karel Essink

1. INTRODUCTION

Transport by means of tanker ballast water is considered one of the main vectors for intercontinental dispersal of various marine organisms. This means of transport has been assumed to have caused the transfer of many species, e.g. the North American jack-knife clam *Ensis americanus* (Syn.: *E. directus)* and the *Marenzelleria* spp. polychaetes across the North Atlantic to the North Sea and Baltic Sea (cf. VON COSEL et al., 1982; ESSINK & KLEEF, 1988; BASTROP et al., 1997).
In this document an overview will be given of the dispersal of the immigrant *Marenzelleria* in NW European coastal waters. Its systematic identity will be explained. In addition, some information will be given on the development of local populations.

2. FIRST RECORDS

The first records of the North American spionid polychaete *Marenzelleria* are from 1982 (Forth Estuary, Scotland - McLUSKY et al., 1993) and 1993 (Ems estuary, The Netherlands - ESSINK & KLEEF, 1988). These records were, and still are, considered to represent independent introductions on opposite sides of the North Sea (ESSINK & KLEEF, 1993). On the basis of the time sequence of the various first records in North Sea coastal waters and estuaries as well as in the Baltic Sea, tentative routes of dispersal were constructed (Fig. 1 in ESSINK & KLEEF, 1993), the Forth estuary being the starting point for dispersal along the Scottish and English coasts of the North Sea, and the Ems estuary being the starting point for dispersal along Dutch, German and Danish coasts and even along the coasts of the Baltic Sea. So far, all populations discovered around the North Sea and in the Baltic Sea were described as *Marenzelleria viridis* (Verrill, 1873).

3. THE IDENTITY OF MARENZELLERIA IN NW EUROPE

Within the framework of a broadly orientated research program (for overview of results see ESSINK & SCHÖTTLER, 1997) German scientists tried to explain certain differences observed between Baltic Sea (e.g. Darss-Zingst Bodden) and North Sea (Ems estuary, Weser estuary) populations. They demonstrated morphological (BICK & ZETTLER, 1997) as well as reproductional (BOCHERT, 1997) differences between these populations. Comparative genetic investigations applying allozyme electrophoresis and DNA-sequencing gave conclusive evidence of two different species of *Marenzelleria* being present in NW Europe (BASTROP et al., 1997). The North Sea populations were described as *Marenzelleria* cf. *wireni*, and the Baltic Sea populations as *Marenzelleria* cf. *viridis*. Parent populations of both species were identified in several estuarine and coastal waters of NW America. In addition to this, there exists the possibility that the observations of *M.* cf. *wireni* in North Sea estuaries and coastal waters are due to range expansion of either arctic populations and/or a cryptic North Sea population (for details see BASTROP et al., 1997).
Some doubts remain, however, as to the correct identification of the specimens from the North Sea and also from Atlantic North America. Are we really dealing with *Marenzelleria wireni* Augener, which was originally described as a species from polar waters of the Northern hemisphere (see (BICK & ZETTLER, 1997). At present, this matter is under co-operative investigation by scientists from the Rostock and Moskau universities (D. Schiedek, pers. comm.)

4. DISPERSAL IN NW EUROPE

With the knowledge now available, the tentative dispersal map once suggested by ESSINK & KLEEF (1993) has to be changed (Fig. 1). Now, at least three independent sites of introduction have to be considered:

1. *M.* cf. *wireni*	Forth Estuary, Scotland	(1982)
2. *M.* cf. *wireni*	Ems Estuary, The Netherlands	(1983)
3. *M.* cf. *viridis*	Darss-Zingst Bodden, Germany	(1985)

Along the western North Sea shores, no further records of *M.* cf. *wireni* have been reported since 1987 (cf. ENO et al, 1997). On the eastern shores of the North Sea, *M.* cf. *wireni* dispersed further southward to the coastal waters of SW Netherlands and the Western Scheldt estuary (J. Craeymeersch, pers. comm; YSEBAERT et al, 1997). In the Baltic Sea, during the 1990s, *M.* cf. *viridis* expanded its range to the North along the Swedish east coast (S. Smith, pers. comm.; ANONYMOUS, 1997).

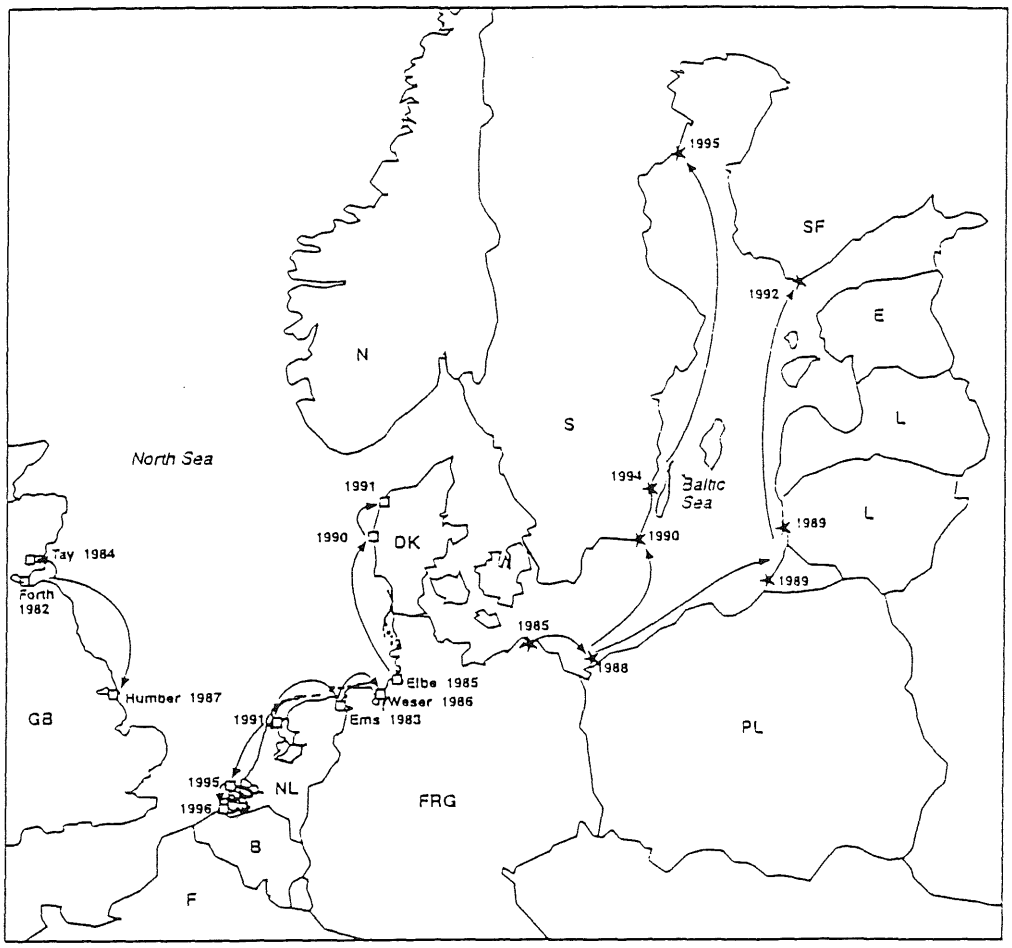

Fig. 1. *Dispersal routes of Marenzelleria cf. wireni (North Sea) and Marenzelleria cf. viridis (Baltic Sea). Adapted from ESSINK & KLEEF (1993) + additional information.*

5. POPULATIONS IN THE NETHERLANDS

After the first find of *M. cf. wireni* in the Ems estuary a significant population developed in the Dollard, a brackish embayment in the inner part of the Ems estuary (ESSINK & KLEEF, 1993; ESSINK et al., 1998). In sandy silt sediments a 2-3000 individuals occur per m^2. Muddy sediments high in the intertidal zone seem to act as a nursery area; here, 130,000 juveniles per m^2 were found (ESSINK & KLEEF, 1993).

Other intertidal as well as shallow subtidal populations, viz. in the Dutch Wadden Sea and in the waters of SW Netherlands, were less successful. Here, densities were observed of 150 ind.m^{-2} at the most. One exception is the population at Balgzand intertidal flats (western Dutch Wadden Sea), where in 1997-1998 c. 2000 ind. per m^2 were present (Table 1).

Table 1. *Populations of Marenzelleria cf. wireni in The Netherlands with year of first record and maximum density observed since. Ad. - adults; juv. - juveniles. [s]) - sublittoral occurrence.*

Population	Year	Density (N m^{-2})	Source
Ems estuary/Dollard	1983	ad.: 2-3,000 juv.: 130,000	ESSINK & KLEEF, 1993
Wadden Sea/Groningen	1994	52	RWS*
Wadden Sea/Piet Scheve	1994	145	RWS*
West.Wadden Sea[s]	1994	117	RWS*
Wadden Sea/Balgzand	1989	2155	R. Dekker (unpubl.)
Voordelta[s]	1995	40	J. Craeymeersch (unpubl)
Western Scheldt[s]	1996	p.m.	YSEBAERT et al , 1997
Rotterdam Waterway	1997	67	J. Craeymeersch (unpubl)

RWS* - data from Rijkswaterstaat Biological Monitoring Programme

6. DEVELOPMENT OF THE DOLLARD POPULATION

After its first appearance in the Ems estuary in 1983, *M. cf. wireni* showed a dramatic development, attaining a biomass of 8-16 grams ash-free dry weight (AFDW) m^{-2} in the years 1989-1994 (ESSINK et al., 1998). This alien species caused a major turnover of the local macrozoobenthic community (Table 2) . Before its introduction (1977-82) polychaetes made up only 24% of the total biomass, and bivalves were dominant with 64%. After the establishment of *M. cf. wireni* (1986-94), polychaetes took a 58% share,

leaving the bivalves with no more than 25%. In the Dollard, polychaetes have been taking over indeed (cf. REISE, 1982).
Juvenile plaice (*Pleuronectes platessa*) and flounder (*Platichtys flesus*) were found to exploit the new food source, although the amphipod *Corophium volutator* remained their staple diet (ESSINK & KLEEF, 1993).

Table 2. *Average contribution (%) of three major taxa to the total biomass at three transects in the Dollard before (1977-82) and after (1986-94) the successful establishment of Marenzelleria cf. wireni. From: Essink et al. (1998)*

	1977-82	1986-94
Bivalves	64	25
Polychaetes	24	58
Crustaceans	12	17

7. DISCUSSION

7.1. Dispersal

In the North Sea, northward expansion from the Ems estuary, and southward expansion from the Forth estuary can easily be explained by assuming larval transport to be mediated by the net counter-clockwise water circulation patterns existing in the North Sea. In contrast to this, an expansion of *M. cf. wireni* from the Ems estuary in westward direction along the Dutch shores is not very likely because of the eastward residual water transport patterns inside the Dutch Wadden Sea. Along the coast, however, a westward transport of water, and therefore of pelagic larvae, is very well possible. This was made plausible for the case of dispersal of the American jack-knife clam *Ensis directus* (= *E. americanus*) (ESSINK, 1985). Ship mediated transport, however, can not be excluded. As a matter of fact, there have been regular transports of seed mussels (*Mytilus edulis*) fished in the eastern Dutch Wadden Sea that were seeded on culture lots in the westernmost part. Moreover, ship loads of cultured mussels are transported from the Dutch Wadden Sea to the SW Netherlands (Eastern Scheldt) to be cleansed and marketed.
In the Baltic Sea, also a counter-clockwise water circulation pattern exists (cf. ANONYMUS, 1997) which to a large extent may be held responsible for dispersal of *M. cf. viridis* within the Baltic Sea.

7.2. Impact on the indigenous benthic community

During the years 1989-1994, in the Dollard a negative correlation was found between the biomass of *M. cf. wireni* and that of *Nereis* spp., suggesting a competitive interaction between these two polychaete species. A similar negative correlation was reported by ATKINS et al. (1987). As *Marenzelleria* is able to perform as a filter-feeder as well as a deposit-feeder (DAUER et al., 1981), competition for food and for space may be the acting process. The correctness, however, of this suggestion will be dependent on the outcome of relevant experiments to be carried out.
In the Darss-Zingst Bodden, where mean annual abundance reached values of several 10,000s of individuals per m^2 , no evidence for a decrease in the abundance or biomass of nereids was found (ZETTLER, 1996).

The main reason for the successful development of *M. cf. wireni* in the Dollard may be ability of this animal to utilise a hitherto not exploited food source. After all, the total macrozoobenthic biomass in the Dollard increased from 10-15 g AFDW m^{-2} before the introduction of *M. cf. wireni*, to 15-25 g AFDW m^{-2} thereafter. This poses some question marks at the concept of a food resources limited carrying capacity in ecosystems. An explanation may be the assumption of a still empty niche being available and taken by the newcomer *M. cf. wireni*.
The availability of an open niche is also argued with respect to the establishment of *M. cf. viridis* in the Baltic Sea (ZETTLER, 1996, 1997). An additional factor of importance may be that the post-glacial recolonization of the Baltic Sea by benthic species appears to be still not completed (LEPPÄKOSKI, 1984), providing an benthic species assemblage with spaces open to immigrants such as *Marenzelleria*.

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ANNEX 16

METHODS OF ANALYSIS OF LONG TRANSECT DATA IN BENTHOS STUDIES

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Introduction

With the advent of bottom camera sleds and submersibles, the possibility of obtaining spatial information for megafaunal species has dramatically increased. As with many endeavours, the methods of analysis of these large data sets has not kept pace with the ability to obtain the data. Most transect-based statistics, while dealing with quadrat data, are usually tested on rather short transect lengths, of fewer than 100 quadrats generally. In our laboratory we have been investigating methods of transect analysis, and some of the results will be reported here.

Methods of Data Procurement

Two long transects from the bottom of the Gulf of Maine will be detailed. For both, an external video camera was mounted to the submersible *Clelia*. When on the bottom, the submersible was turned to face into the prevailing current and then was driven on a steady course at a speed over the ground of approx. 0.5 knots for 45 to 60 minutes. Speed over the bottom needed to be slow enough to allow visual identification of the fauna in the fields of view, but was also somewhat variable owing to the physics of driving an non-streamlined heavy object over the sea bottom.

Quadrat size was held constant by using the concept of field of view. That is, the videotape was stopped and all objects of interest were counted from the bottom of the view on the monitor out to a predefined horizon (usually near the edge of the lighted area, or about 3/4ths of the view on the monitor). The tape was then advanced until the objects at the predefined horizon just disappeared off the monitor. Each field of view was contiguous with the following one, and because of the angle at which the camera was generally mounted, was also slightly trapezoidal. For purposes of the analysis in this paper, the area of the field of view is unimportant (although needs to be held constant), but the length of the field of view outward from the sub needed to be calculated. This was done by using laser beams mounted a fixed distance apart on the camera such that they were visible in the video image.

Two studies were conducted in the Gulf of Maine. In 1993, the sea pen, *Pennatula aculeata*, was the object of study. A series of dives were made on the SW flank of Jeffreys Bank, NW Gulf of Maine (lat & long, depth). Only the results from sea pen Dive 134 will be reported here. In 1995, the large cerianthid (tube about 8 cm diameter and protruding up to 15 cm above the sediment surface), *Cerianthus borealis*, was studied in the area of Cashes Basin, central Gulf of Maine (lat & long, depth). Results from cerianthid Dive 341 will be reported here.

For the sea pen study the camera was mounted on the front lower frame of the submersible and the resulting field of view was approximately 0.5 m in depth (from bottom to top of view on monitor). In contrast, because of the much larger size of the cerianthids, the pan-and-tilt camera had to be used. It was set at a fixed focus encompassing a field 1.2 m in depth (distance away from submersible). A total of 1094 contiguous fields of view, encompassing a transect of approximately 550 m, were recorded during the sea pen Dive 134 while 470 fields of view, encompassing 560 m were recorded during the cerianthid Dive 341.

Data Analysis

It must be emphasized first, that the methods discussed here are suitable for investigating patterns of distribution of species within a defined community. that is, when patterns change

with faunal boundaries, the type of statistics used in this paper are no longer appropriate. Questions of interest include: (1) are individuals of a species distributed randomly within the community or are they aggregated or dispersed? (2) If there is any deviation from non-randomness, what is the distribution pattern, that is, is there a characteristic patch size?

The most commonly, and certainly the earliest methods used involved counts of individuals within randomly placed quadrats (summarized well in Grieg-Smith 1983). Most of the quadrat methods involve a relatively small number of quadrats and do not require the quadrats to be contiguous. More recently, methods have been developed to analyze the distributions of individuals in quadrats arranged contiguously along a transect (summarized in Ludwig & Reynolds 1988). Again, the number of quadrats used is generally small, often less than 100. Of course, for all methods the size as well as the number of quadrats has to be chosen so as to produce values on which the statistical algorithms can operate.

Three general measures of dispersion were calculated using formulae and programs provided by Ludwig and Reynolds (1988). These were:

a. the Index of Dispersion (ID), or variance to mean ratio, which should be near 1 for random patterns, 0 for maximum uniformity, and n (total no. individuals in all samples) for maximum clumping.

b. the Index of Clumping (IC), which = ID-1, and is near 0 for random patterns, -1 for max. uniformity, and n-1 for max. clumping.

c. Green's Index (GI), which = IC/n-1, and is near 0 for randomness, -1/(n-1) for max. uniformity, and 1 for max. clumping.

Block quadrat methods, as outlined by Ludwig & Reynolds have been used in one marine benthic study, that of Malatesta et al (1992). In this method sampling units are combined into ever larger units, and the variance of the counts in the blocks computed. As the combination of blocks works to homogenize the sample counts the variance will drop. Patch sizes then are estimated fromblock sizes producing the largest variances. The most popular of the block quadrats measures is Hill's TTLQV (two term local quadrat variance). None of the block measures have been adequately studied to be able to determine their behaviour under long transect conditions with complex underlying patterns.

Counts from contiguous quadrats can also be thought of as digitalized spectra and can therefore be analyzed by common spectral techniques such as Fourier analysis. Descriptions of the techniques can be found in Diggle (1990) and Dunstan (1993). Computer programs offering time series methods include SYSTAT 7 (for Windows or Mac), as well as several other similar statistical packages, and some of the graphing software (e.g. the transform add-ons for Sigma-Plot from Jandel Scientific). Routines in C++ available in the "Numerical Recipes" series were also used in our lab and combined into an overall spatial analysis program.

Results

A. Dive 134, distribution of *Pennatula aculeata.*

Indices of dispersion were determined to be as follows:

ID: 0.734
IC: -0.265
GI: -0.00024

These values suggest that this species, as sampled along this transect, is more or less random in its distribution. Similarly, when block quadrat methods were used, there was a continuous rise in variance to a block size of 60-66 (120-132 fields of view), after which the variance slowly decreased until the analysis was stopped at a block size of 80.

Spectral analysis methods produced a somewhat different result. While the raw sea pen counts do indeed look random, some form of pattern begins to emerge when the data are smoothed. Many smoothing techniques are available, and two have been tried on these data. The first smoothing method was to compute a 10-cell, then a 15-cell running mean. The raw data and the 10-cell running mean for Dive 134 are shown in Figure 1. Also computed was a sequential series of smoothings, referred to as the 4253H filter (devised by Tukey and elaborated by Velleman & Hoagland 1981). In this case the data series are smoothed first using the median values of a sliding window 4 fields of view in length, then the resulting series is smoothed using the median values of a 2 field of view window, then 5 and 3 fields of view, followed finally by a wieghted means window of size 3 with the weights 1,2,1. All smoothings resulted in the same Fourier components being of largest size, and so only the 10-cell and 15-cell running mean results are shown in the table below. Only the harmonics for the 15 largest magnitudes are given. Fourier analysis showed strong peaks at wavelengths of 146, 114, 341, and 78 fields of view (73 m, 57 m, 171 m, and 39 m, respectively).

Harmonic	Magnitude		Periodogram		Frequency	Wavelength
	10-cell	15-cell	10-cell	15-cell		(fields of view)
8	0.361	0.357	42.382	41.555	0.00684	146.2
10	0.343	0.336	38.393	36.846	0.00879	113.7
4	0.333	0.334	36.076	36.392	0.00293	341.3
14	0.26	0.253	22.052	20.852	0.0127	78.7
17	0.179	0.168	10.439	9.19	0.01563	63.9
11	0.166	0.161	9.007	8.434	0.00977	102.3
26	0.164	0.146	8.736	6.924	0.02441	40.9
3	0.161	0.162	8.425	8.52	0.00195	512.8
21	0.161	0.151	8.463	7.407	0.01953	51.2
5	0.156	0.154	7.95	7.712	0.00391	255.7
35	0.156	0.123	7.941	4.918	0.0332	30.1
15	0.152	0.148	7.572	7.165	0.01367	73.1
12	0.147	0.146	7.07	6.93	0.01074	93.1
13	0.145	0.14	6.807	6.404	0.01172	85.3
18	0.134	0.126	5.895	5.213	0.0166	60.2

Another spectral method, that might indicate a repeated pattern of some fixed dimension in the data, is autocorrelation analysis. In this case, the data sequence is correlated with itself, with the correlation values being re-calculated as the data are shifted by one unit (in this case, by one field of view). A plot, or table, of the correlation coefficients, termed a correlogram, can be examined for peak values. Significant values will exceed +/- {2/sqrt(n)}, or 0.0873 for this transect. Significant positive and negative lags from the autocorrelation analysis are given in the table below.

Table of significant values for r(k), sea pen data, Clelia Dive 134, 1093 quadrats. Lags are in fields of view. Significant values of *r* will exceed +/- {2/sqrt(n)} = 0.0873

lag	r	lag	r
1	0.3391	50	-0.0879
2	0.2478	168	-0.0906
3	0.1680	185	-0.0942
4	0.1638	198	-0.0920
5	0.1629	228	-0.1123
6	0.1429	496	-0.1132
7	0.1297	497	-0.0938
8	0.1253	507	-0.1255
9	0.0928	508	-0.1002
11	0.0899	509	-0.1172
12	0.1007	510	-0.1484
13	0.0898	511	-0.0894
18	0.0987	517	-0.0903
19	0.1175	519	-0.1030
121	0.0891	520	-0.0870
298	0.0968	521	-0.0991
299	0.1431	523	-0.1087
301	0.0939		
310	0.1064		
311	0.1165		
312	0.1206		
313	0.0918		
318	0.1280		

Significant positive lags occur in the range of 1-20 fields of view (median of 10, equal to about 5 m), and 298-318 fields of view (149-159 m). There is also a group of significant negative lags in the range of 496-523 fields of view (248-261 m). The positive values are in the range of wavelengths isolated by the Fourier analysis.

B. Dive 341, *Cerianthus borealis*

Indices of dispersion were determined to be as follows:

ID: 0.961
IC: -0.039
GI: -0.000083

As with the sea pen data, these values suggest that the cerianthids are randomly distributed. The block quadrat method, TTLQV, also suggested there was no pattern in the data, as the variance rose steadily, reaching a very high value until the analysis was stopped at a block size of 80 (160 fields of view).

Autocorrelation analysis of this data set showed continuously decreasing autocorrelation values, indicating the series was non-stationary. Transformation by first order differencing was used to make the series stationary. This was followed in one analysis by smoothing using a 10-cell running mean. These results are presented below. When the series is differenced, the Fourier analysis results in three wavelengths which are larger than most -- 11, 28, 23, and 12 fields of view, representing patch sizes of approximately 13-14 m and 27-34 m.

transformed by 1st order differencing

Harmonic	Magnitude	Periodogram	Frequency	Wavelength
24	0.214	3.739	0.08984	11.1
10	0.201	3.289	0.03516	28.4
12	0.159	2.067	0.04297	23.2
22	0.155	1.961	0.08203	12.1

When the series is transformed using first order differencing, then smoothed using a 10-cell running mean, Fourier analysis produces an output in which the smaller wavelengths no longer are important, as seen in the table below. In fact, the only wavelength of comparable size to that where smoothing was not used, is that for 28 fields of view.

transformed by 1st order differencing
followed by 10-cell running mean smoothing

Index	Magnitude	Periodogram	Frequency	Wavelength
10	0.163	2.157	0.03516	28.4
7	0.121	1.195	0.02344	42.6
12	0.114	1.054	0.04297	23.2
4	0.092	0.693	0.01172	85.3

Discussion

This analysis, while preliminary, has shown that the standard quadrat techniques used for short transects, or for a relatively small number of randomly placed quadrats, are generally not of much use for long transect studies. While this study has not examined spectral methods in terms of statistical significance testing, the methods employed os far suggest that spectral techniques might be useful in delineating meso-scale patterns of benthic megafaunal species. It is also concluded that much more information needs to be obtained with bottom camera sleds, ROVs, or submersibles, so that these kinds of patterns can be detected.

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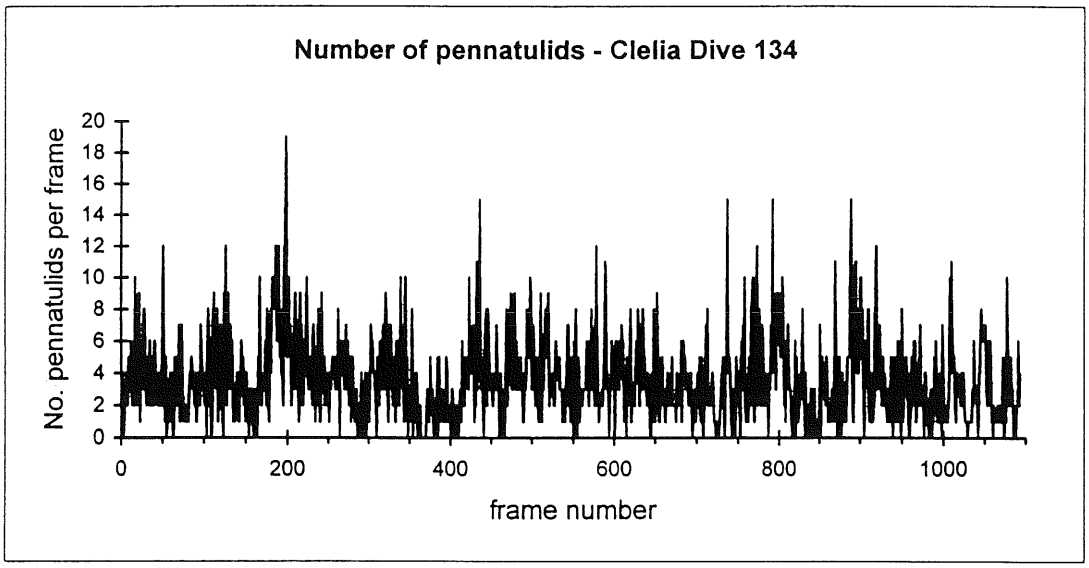


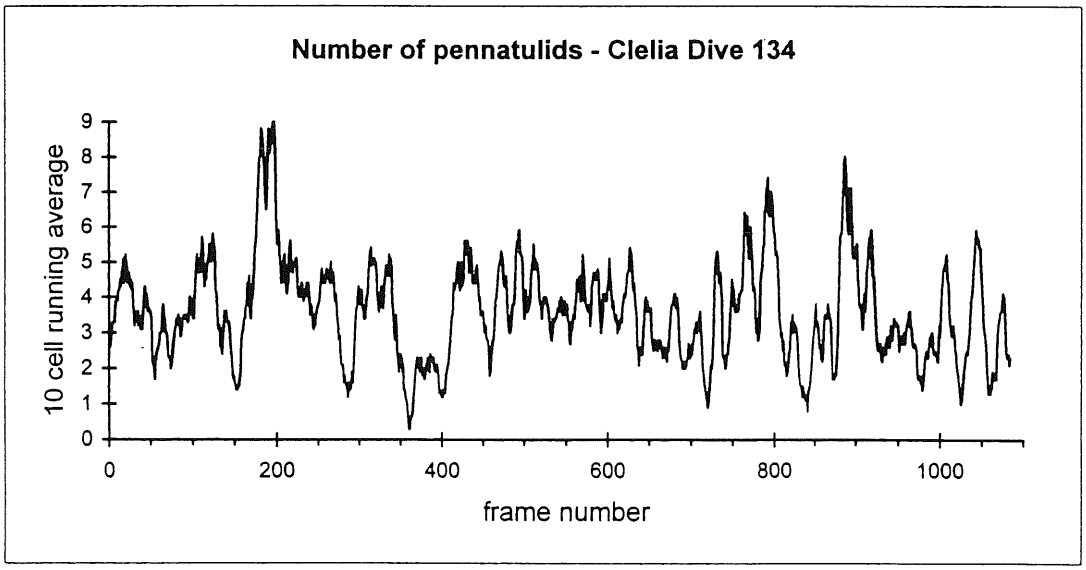


Figure 1.

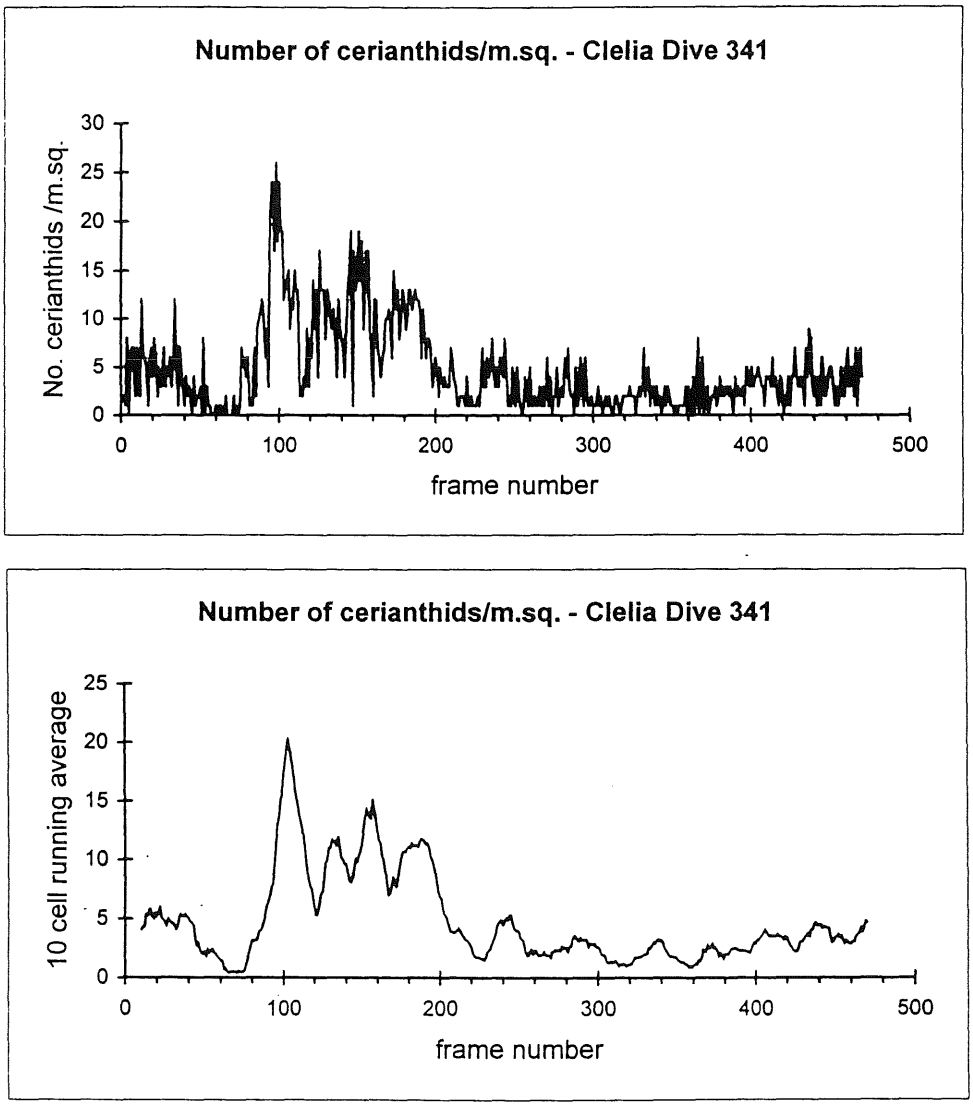
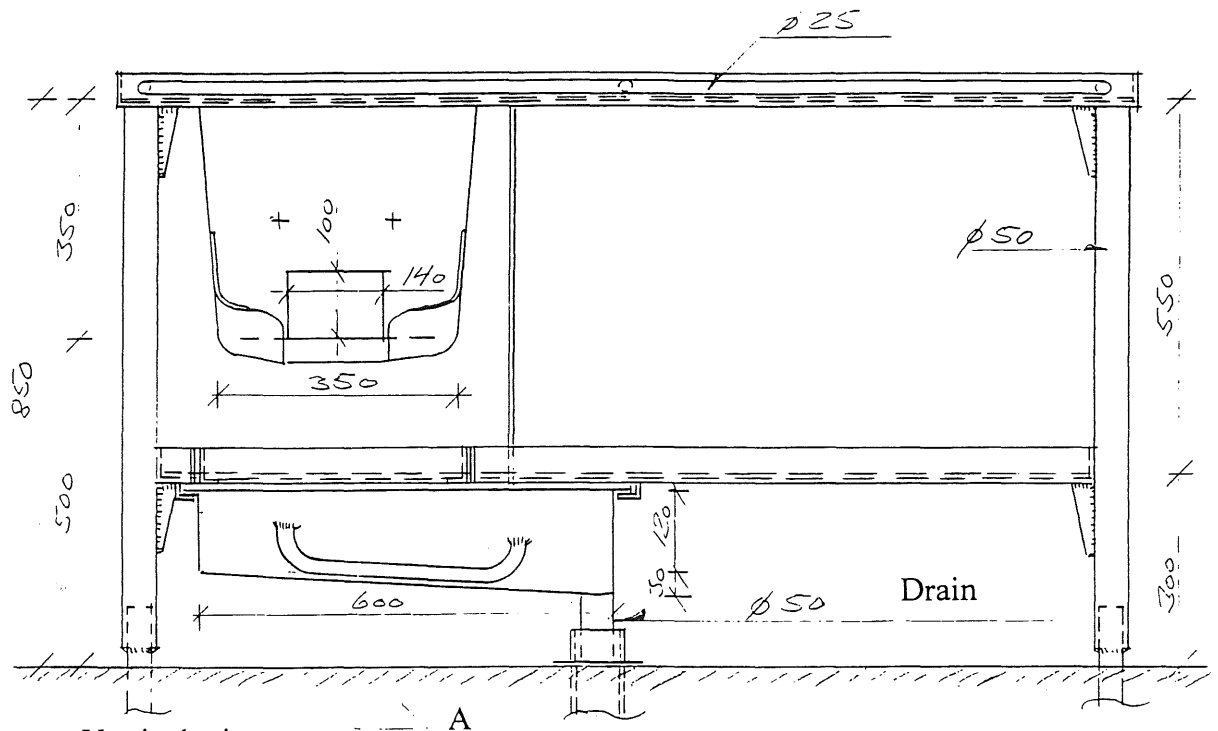

Number of cerianthids/m.sq. - Clelia Dive 341
No. cerianthids /m.sq.
30
25
20
15
10
5
0
0
100
200
300
400
500
frame number
Number of cerianthids/m.sq. - Clelia Dive 341
10 cell running average
25
20
15
10
5
0
0
100
200
300
400
500
frame number

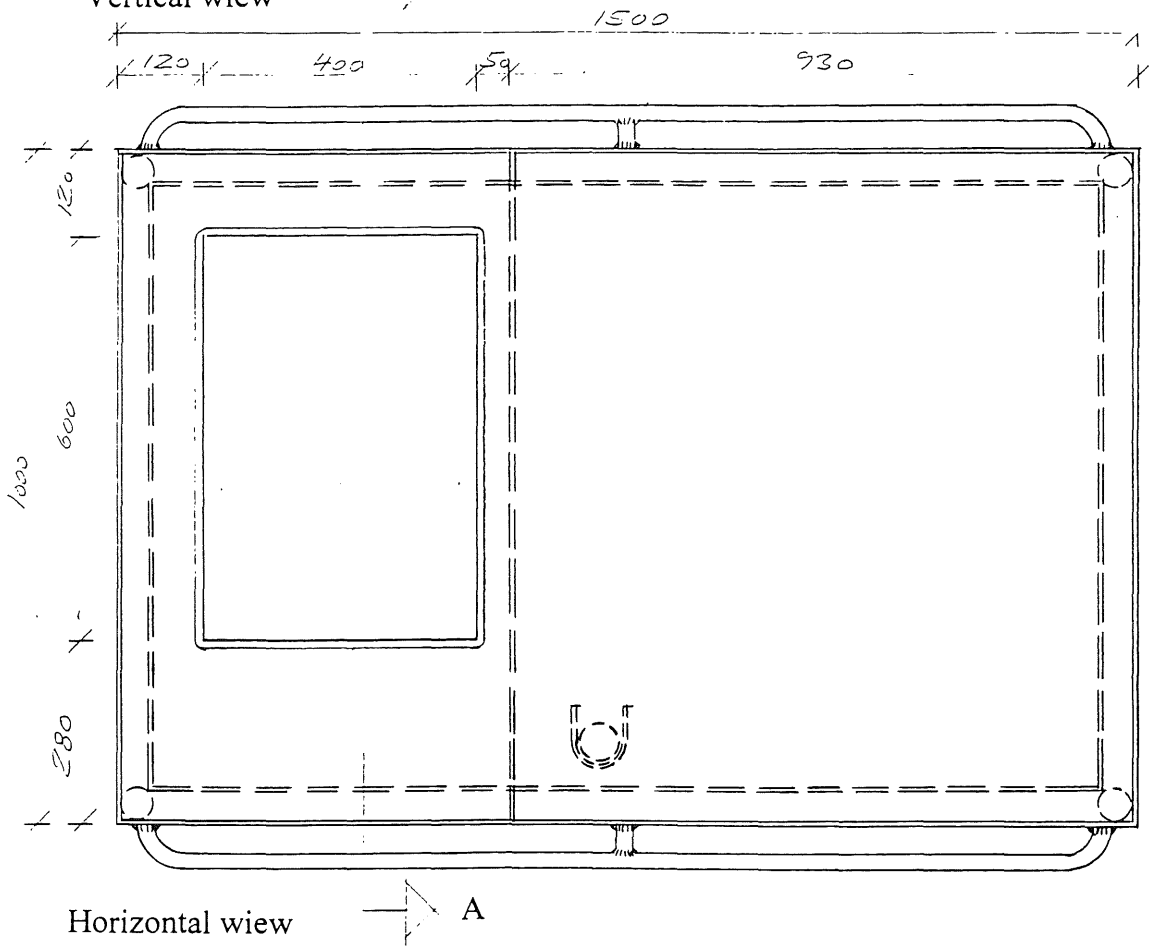
Figure 2.

ANNEX 17

CONSTRUCTION DIAGRAMS OF THE AARHUS SIEVING TABLE

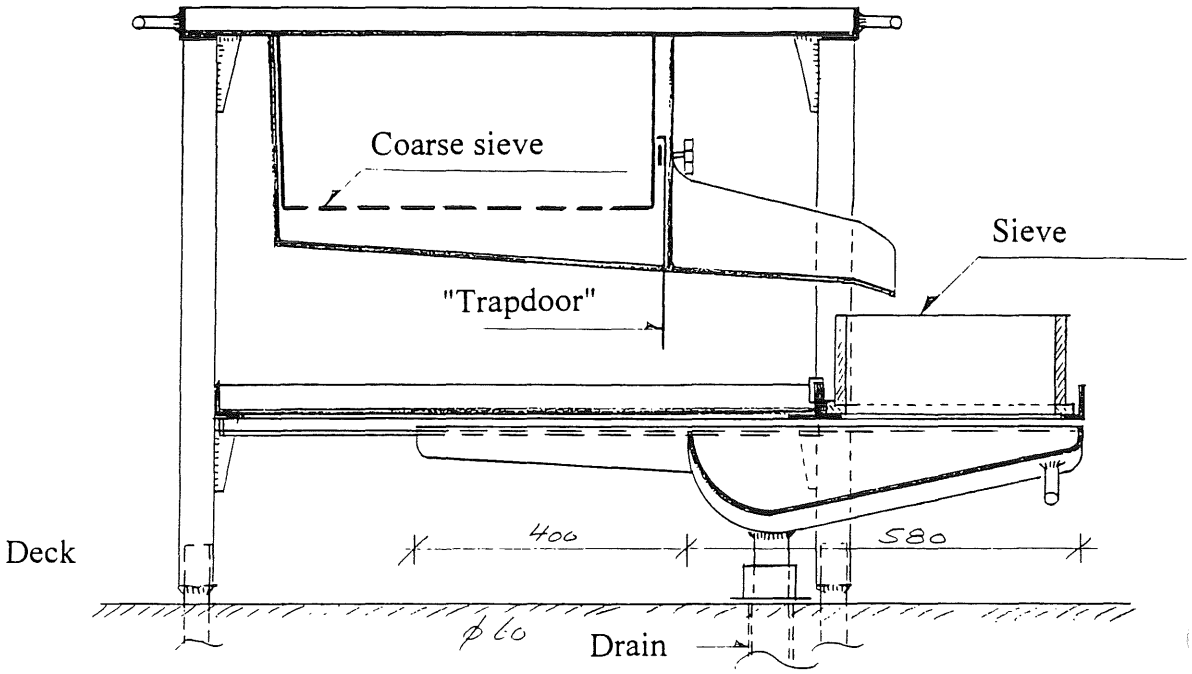


Vertical wiew



Horizontal wiew

Plan



Cut A-A

NOTE:
All components are made of saltwater resistent aluminium, excl. removeable coarse sieve and trapdoor in washbasin - these components are made of stainless acidproof steel.
Sheets + = 6 mm
Profiles 50 x 50 x 6 mm
All measures in mm
Measure 1:10

ANNEX 18

WORKING DOCUMENTS PRESENTED AT THE MEETING

LINDEBOOM, H.J., & S.D. DE GROOT. (Eds.) 1998. IMPACT II. The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems. NIOZ-Rapport 1998-1. RIVO-DLO Report C003/98.

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