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REPORT OF THE

Benthos Ecology Working Group

Tromsø, Norway
24–27 April 2002

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 at Akvaplan-NIVA in the Polar Environmental Centre in Tromsø, Norway. The group was welcomed by the Chair, K. Essink, and by the resident scientist, S. Dahle.

The list of 28 participants for the meeting is appended as Annex 1. Regretfully, H. Rees (UK) could not be present due to illness.

2 APPOINTMENT OF THE RAPPORTEUR

Two rapporteurs were appointed, Mike Robertson and Hans Hillewaert. A contribution from every participant to drafting the text of the report was, as ever, greatly appreciated.

3 TERMS OF REFERENCE

The terms of reference (ToR) for the 2001 meeting of the Benthos Ecology Working Group (C.Res. 2001/2E07) were to:

a) produce a final draft of guidelines for epibenthos sampling and community description with a view to publication in the *ICES Techniques in Marine Environmental Sciences* (TIMES) series;
b) report on the progress in the North Sea Benthos Survey, including first results of data analysis;
c) review studies in northern seas in comparison with, e.g., the Baltic Sea and North Sea, with a view to gaining insights into ecosystem functioning, human impacts, criteria for ecosystem health, and gaps in knowledge;
d) develop possible Theme Sessions for 2003 and 2004, focusing on the role of benthic communities as indicators of marine environmental quality;
e) review further needs for quality assurance in benthic monitoring and research;
f) provide for the Working Group on Beam Trawl Surveys, a list of infaunal and epibenthic invertebrate species or higher taxa that can be monitored with a beam trawl and allow identification of ecosystem changes in the communities present in the area covered by the beam trawl surveys;
g) review studies under way on ecological quality objectives for the North Sea with regard to:
    i) nutrients and eutrophication effects; and
    ii) benthic communities;
h) consider the variability in some reference sites in benthic monitoring programmes with a view to developing a better understanding of the observed variability.

An additional request had been received from the Chair of the Advisory Committee on Ecosystems (ACE) to assess the benthic invertebrates as included in a draft OSPAR Priority List of Threatened and Declining Species and Habitats, and the data relating to them. This subject was, together with ToR (g), placed under agenda item 13.

The Chair noted that BEWG will report by 13 May 2002 for the attention of the Marine Habitat and Oceanography Committees and ACME.

4 ADOPTION OF THE AGENDA

The agenda was reviewed and duly adopted. It can be found at Annex 2.

5 REPORT ON ICES MEETINGS AND OTHER MEETINGS OF INTEREST

5.1 Report on the ICES Annual Science Conference (Oslo, Norway, 2001)

H. Rumohr reported on the ICES 2001Annual Science Conference (Oslo) and the ICES Annual Report for 2001. He stated that this meeting had become rather elitist and may now exclude younger scientists as they possibly could not afford to attend. K. Essink also observed that in certain theme sessions little time was allocated for presentations and discussions, thus not serving the goal of scientific debate.

The report of this meeting is now available as ICES Annual Report for 2001, Part 1 (February 2002).

5.2 Marine Habitat Committee, Oslo 2001

K. Essink gave a short account of the meeting of the Marine Habitat Committee, which met during the Annual Science Conference in Oslo, with Dr Paul Keizer (Canada) as Chair. Reference: ICES Annual Report for 2001, Part 2 (Feb. 2002).

The reports of the 2001 working group meetings were reviewed. For the BEWG it was noted that all terms of reference had adequately been addressed in the report. Many and difficult questions had been referred to this Group. The final formulation of the terms of reference was done before presentation for approval at the Consultative Committee. Two terms of reference were added, one request from the Working Group on Beam Trawl Surveys (WGBEAM) and one from ACME to respond to a request from OSPAR concerning matters of Ecological Quality Objectives for benthic communities.

There was a widespread complaint with regard to Delegates' failures to properly nominate working group members and remove members from working group lists.

5.3 Report of the ICES Advisory Committee on Ecosystems, 2001 (Coop. Res. Rep. 249)

Reference was made to the *ICES Cooperative Research Report*, No. 249, the 2001 report of the Advisory Committee on Ecosystems.

5.4 SGQAE/SGQAB meeting, 19–22 February 2002, Copenhagen

H. Rumohr reported that the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (SGQAE) deals with the North Sea while the ICES/HELCOM Steering Group on Quality Assurance of Biological Measurements in the Baltic Sea (SGQAB) addresses the Baltic. Workshops and ring tests have been organised. The OSPAR/ICES guidelines on quality assurance for biological measurements have been finalised and are ready to be adopted by OSPAR. Further to this, H. Rumohr's questionnaire on the adoption of QA throughout European Institutes had received 32 replies. The results from this will be published in the near future. It was also noted that all AQC reports will be available on the ICES website some time during May 2002.

5.5 Working Group on Marine Habitat Mapping (WGMHM)

H. Rumohr informed BEWG about the Working Group on Marine Habitat Mapping (WGMHM) meeting held in San Sebastian from 2–5 April 2002, with the next meeting scheduled to be held in New Jersey (USA). National reports were presented and it was decided to standardise the format of these reports. The EUNIS classification system was also considered and debated. Mr David Connor was put forward as the new Chair of WGMHM.

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

K. Essink spoke briefly on the report from the Working Group on Introductions and Transfers of Marine Organisms (WGITMO) meeting held in Göteborg, Sweden, 20–22 March 2002.

WGITMO is preparing an *ICES Cooperative Research Report* "Directory of Dispersal Vectors of Exotic Species". An advisory report was prepared on the predatory gastropod *Rapana venosa.* This snail has been found recently also in southern Brittany.

The native North American polychaete *Marenzelleria* cf. *viridis,* known in Swedish waters since 1990, continues to move north and in 2001 was found as far north as off Luleå in the Bothnian Bay. The species has been recorded in the southern part of the Öresund, however, in quite low densities. Its distribution thus covers localities from the entire Baltic coastline of Sweden. No records are known at the Swedish west coast.

H. Rumohr added that no records of this species are known from high salinity areas such as Kiel Bay and Mecklenburg Bay.

5.7 Working Group on the Effect of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) meeting

J. van Dalfsen and H. Hillewaert, who participated in the meeting of the WGEXT in Boulogne-sur-Mer, France, 9–13 April 2002, reported the following to BEWG:

- Members of WGEXT reported on the status of marine extraction, development of seabed resource mapping, legal frameworks and approaches to environmental impact assessments in the various participating countries.

- The Working Group reviewed a draft form for submitting regional data through the Internet. The submission form will be trailed in reporting data to WGEXT.

- Comments on a revised ICES Code of Practice for the Commercial Extraction of Marine Sediments (including minerals and aggregates) and guidelines for the preparation of an Environmental Impact Assessment evaluating the effects of seabed aggregate extraction on the marine environment were reviewed and the new Code was approved.

- The Group discussed the application of risk assessment methods as a tool for the management of marine sediment extraction.

- Procedures were reviewed for dealing with international transboundary issues arising from the extraction of marine aggregates. A set of preliminary guidelines was produced.

- Work was commenced on scoping the necessary coverage and content of a new *ICES Cooperative Research Report.*

5.8 6th Conference of Parties to the Convention on Biological Diversity

K. Essink made reference to the 6th Conference of Parties to the Convention on Biological Diversity (COP6-CBD), held in The Hague, the Netherlands, April 2000. In conjunction with this conference two one-day symposia were held under the titles “Biodiversity in agricultural landscapes” and “Biodiversity – driving force of life”. In the latter symposium presentations were given on stability in ecosystems, alien species in marine ecosystems, DIVERSITAS: an international framework for biodiversity research, and the Global Biodiversity Information Facility (GBIF). Further information on GBIF can be found at http://www.gbif.org.

5.9 ICES Marine Data Management Working Group, 17–19 April, Helsinki

E. vanden Berghe reported on the ICES Working Group on Marine Data Management (WGMDM) meeting held in Helsinki, 17–19 April 2002. Three meetings were held in tandem.

The WGMDM group of ICES met from 17–19 April in Helsinki, Finland. Two more meetings were organised at the same location: the Study Group for XML (SGXML), a joint group of ICES and IOC/IODE, from 15–16 April; and the Group of Experts on Technical Aspects of Data Exchange (GE/TADE), a working group of the IOC/IODE. All three meetings were hosted by the Finnish Institute of Marine Research. In view of the large overlap between the three groups, both in terms of scope and in terms of membership, members of each of the three groups were invited to attend all three meetings.

5.9.1 SGXML

This group is chaired jointly by Anthony Isenor of the Bedford Institute of Oceanography, Canada, and Bob Gelfeld of the National Oceanographic Data Centre, USA. The objectives of this group are to evaluate XML as a tool for oceanographic data exchange. Two main activities will be undertaken by members of this group:

- creating a standard dictionary of oceanographic parameter names. Some of the parameters include taxonomic names (like densities of species). The taxonomic names will be matched to those available in ITIS;
- creating a Document Type Definition for specific types of oceanographic data. Biogeographic data will be part of this pilot project.

5.9.2 WGMDM

WGMDM is chaired by Anthony Isenor. The main discussions during the meeting centred on the guidelines for data management that WGMDM has been developing. It was felt that these guidelines were not adequately publicised, and hence not widely enough known and applied. A number of practical solutions to this problem were suggested, like links on the websites of partner institutions.

Part of the guidelines relate to the use of a taxonomic coding system. The members of the group felt that the Interagency Taxonomic Information System (ITIS) would provide a good working list. It is a very extensive list of well-documented names (more than 300,000 names are included), which is growing rapidly. ITIS is not a project, but a joint activity of important institutions, and as such is not likely to disappear very soon, unlike a temporary project. NODC is the founding partner in this activity, and can make sure that the needs for marine databases are adequately covered.

The North Sea Benthos Project was presented, as being an activity of the Benthos Ecology Working Group of ICES.

5.9.3 GE/TADE

The GE/TADE meeting was chaired by Greg Reed, from the IOC/IODE Secretariat. The objective of the group is to provide a forum to discuss data exchange between different data centers of the IODE Network (WDC, RNODC, NODC, DNA…), and to develop and make available guidelines for best practice of data management. The main tasks for the GE/TADE members will be to: Review guidelines – some are out of date;

- Make an annotated inventory of relevant publications; identify gaps;
- Work towards a pilot project for distributed access to marine data and information; pilot = temperature/salinity profiles;
- Continue work on MEDI (Marine Environmental Data and Information referral system); this is a metadata system that is relevant also to BEWG.**REPORT OF COOPERATIVE STUDIES AND OTHER STUDIES RELEVANT TO ICES**

6.1 Cooperative studies

6.1.1 Study Group on Mapping the Occurrence of Cold-Water Corals

A report was received from Jan Helge Fosså on the Study Group on Mapping the Occurrence of Cold-Water Corals (SGCOR) discussing cold-water corals (a.o. *Lophelia pertusa*) in Irish and Norwegian waters.

It was generally believed that, as hard surfaces such as pipelines had been observed to be recolonised, the status of these hard corals was generally good. However, G. Duineveld commented that he had not seen any recruitment on a frame laid out on the seabed, suggesting that there were different settlement rates in different areas.

H. Rumohr reported evidence of fishing damage off Ireland and France. T. Brattegard observed that, in Norwegian waters, there would always be a pool of undamaged sites to "reseed" any damaged areas as there existed naturally protected areas which kept fishing boats out.

6.1.2 Effects of extraction of marine sediments on the marine ecosystem (Coop. Res. Rep. 247)

Reference was made to the *ICES Cooperative Research Report* No. 247, produced by the members of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT).

6.2 Benthos and fisheries

6.2.1 *Spisula*: habitat preferences, surveys, fishery

J. Craeymeersch presented work conducted in the Dutch coastal waters since 1995 by the Centre for Shellfish Research (CSO) of the Netherlands Institute for Fisheries (RIVO). The work focuses on the distribution, density, biomass and stocks of *S. subtruncata.* This species is of commercial interest (landings: 25–40 mil. kg) and an important food source for diving ducks (eider, scoter). But the results also include data on another 30 species as well (bivalves, echinoderms, crustaceans). Every spring (April–June) about 800–1000 stations are sampled following a stratified sampling strategy. Strata are based on the known or expected density of *S. subtruncata*. Samples are mainly taken with a trawled dredge, sampling the upper centimetres of the sediment. This dredge has specifically been designed by CSO for sampling bivalves living on or in the upper centimetres of the sediment. The data show large temporal and spatial fluctuations, mainly due to differences in recruitment. Only limited data are available on the impact of fisheries. Landings mostly are a small fraction of the total adult stock, but in years with low stocks (1999–2000) fisheries removed a third to a half of the adult stock. In 1999, fisheries concentrated in a small area near Texel. Landing statistics showed that about 36 % of the adult stock was removed. However, a survey by NIOZ/Alterra in mid-June showed a decline of 70 %. This might be due to additional mortality caused by shellfish fisheries but also due to beam trawling for sole.

In the past year, the monitoring data have been used to model the probability of occurrence of this species. Presence/absence has been linked by logistic regression to sedimentological features (median grain size, silt content, shell percentage; data NITG), depth distribution (data RIKZ), and salinity (modelled data by Delft Hydraulics). Overall about 60 % of the data were correctly predicted. There are, however, some areas where the model results did not correspond with the observed data. It is expected that the inclusion of hydrodynamical features (current velocities, bottom shear stress) and geomorphological information will improve the prediction model.

L. Watling asked what effects fishing gear have in reducing (smoothing) local topography. Would this interfere with the settlement process? Flume studies may be of some use. S. Dahle asked whether recruitment could come from outside or from within the study area. H. Rumohr commented that heavy fishing in Dutch waters may have an effect on *Spisula* settlement rates in German waters. We must think on a wider scale when considering problems such as recruitment. I. Kröncke observed that local hydrography would have a considerable influence.

6.2.2 Outcome of EU PESCA project

H. Rumohr reported on the finalized PESCA Project in the North Sea. The investigations of this project aimed at a sustainable basis for a controlled *Spisula solida* fishery in German waters. Associated with this programme was the investigation of the distribution and population dynamics of *Ensis directus*, a new but very abundant component of the subtidal fauna in German coastal waters. The fishery on this species was nevertheless forbidden after the beginning of this project. *Ensis* is the dominant (in abundance) bivalve species on the fine sand station in the German Bight. The *Spisula solida* populations and catches dropped considerably after high catches in the early 1990s both in German and Dutch waters. Right now profitable catches were only made in Danish waters (Hornsrev) and in the deeper subtidal. H. Rumohr presented length/width and growth data on *Ensis* and showed a video demonstrating their abundant distribution in the habitat and other autecological features.

He further demonstrated with stomach data from drowned black scoters (*Melanitta nigra*) from the Pomeranian Bay (Western Baltic) that the common size spectrum of this bivalve is well separated from the minimum size of commercial landings.

He also illustrated the function and operation of a hydraulic dredge with images and video. Due to lacking commercial catches in German waters, questions relating to the damage and survival of by-catch and at the bottom remained unanswered. The physical disturbance and the duration of visible track of *Spisula* dredging was rated low in the sandy high energy environment of Amrum-Bank based on multiple video-inspections.

J. Craeymeersch asked whether dominance was occurring more to the seaward side. H. Rumohr replied that *Spisula solida* does occur in deeper waters. The observed disturbance of sediment has disappeared after 2 to 3 tidal cycles. M. Zettler asked if damaged *Spisula* were only found in the catch or if they also occurred in the sea. H. Rumohr replied that damaged animals occur in all catches. M. Zettler asked what percentage was damaged by fishing. According to H. Rumohr, there are differences between beam trawls and suction dredges.

K. Essink asked what is feeding on *Ensis*. The answer was that scoters are opportunistic feeders, but no *Ensis* have been found in their stomachs so far. J. Craeymeersch then commented that *Ensis* up to 12 cm have been found in Eider Duck stomachs.

6.2.3 Effects of fishing gear on the benthos

L. Watling briefly reported on ongoing U.S. studies on impacts of fishing gear on the benthos in the laboratories primarily of the University of Maine (L. Watling) and the University of Rhode Island (J. Collie). Of particular note is the publication of the draft report of the National Academy of Sciences (NAS), National Research Council on the "Effects of trawling on marine benthos". This publication resulted from consultations of a panel of scientists, fishing industry representatives, and policy analysts with scientists, industry representatives, and non-governmental organization representatives. In general, the panel has substantiated conclusions presented in the scientific literature that trawling has strong effects on the structural complexity of benthic communities and that trawling should be limited in its extent. The draft of this publication is available on the NAS website, http://www.nap.edu/catalog/10323.html.

6.2.4 Effects of the non-native red king crab *Paralithodes camtschaticus* on *Chlamys islandica* beds

L. Lindal Jørgensen informed the Working Group on the possible effects of the introduced red king crab *Paralithodes camtschaticus* on beds of the commercially fished scallop *Chlamys islandica*. This non-native species is migrating westwards along the coast of northern Norway. The question posed is if predation from the king crab could control or eradicate scallop beds along the Finnmark coast.

A more detailed account of the project is given in Annex 3.

T. Brattegard wondered if there are any reasons why the crabs are moving west. According to L. Lindal Jørgensen the crabs spread into the current and therefore follow egg distribution. However, they have spread in all directions, depending on the depth. H. Rumohr asked why they were leaving the White Sea but not the Kamchatka area. The speaker replied that crab populations are not fully adapted to warmer areas. The White Sea animals are not the same genetically as those around Kamchatka. Distributions are not fulfilled in the Barents Sea and migration could proceed as far south as Spain if the animals have the correct genetic makeup. However, there are no real answers as to why the crabs are migrating. L. Watling asked whether there is an active fishery in Norwegian waters. L. Lindal Jorgensen confirmed this but said it is tightly controlled. S. Dahle added that this animal is a migrant from Russian waters and has caused considerable political argument between Russia and Norway. The crab is now filling up its natural niche. However, the population is now peaking in Russian waters but not in Norwegian. The estimate in Norwegian waters is currently about 1.5 million adults but many more juveniles. Biomass is not known. G. Duineveld wondered whether we know enough about the scallop. Do King Crabs really have an impact on them? L. Lindal Jorgensen replied that crab aggregation behaviour does have an effect on populations. Research is still ongoing into the effects of non-aggregated animals. L. Watling stated that the statistical design of the experimental work looks good, however the animal lives in an aggregated way. This causes problems as you have to follow a highly mobile predator. The speaker agreed and said that this aspect is under consideration and the use of sledges and camera systems should help solve the problem.

6.3 Benthos of soft sediments

6.3.1 North Sea epifauna sampling by FRS in 2001

M. Robertson informed the meeting that in July/August and November 2001, FRS Marine Laboratory, Aberdeen had commenced a sampling programme in the North Sea and to the north and west of the Orkney and Shetland Isles. Although the primary objective of this project was not aimed at quantifying benthic invertebrate community structure but was concerned with estimating secondary productivity, community data will become available as the work progresses. Sampling was undertaken during the third and fourth quarter IBTS cruises. At each of the 43 stations considered here and after a standard half-hour GOV trawl haul was completed, a two metre beam trawl was deployed for five minutes and up to 0.5 m^2 of sediment was collected by means of a 0.25 m^2 box corer or 0.1 m^2 Day grab. Subsamples for sediment particle size analysis and cores for meiofaunal investigations were also collected from each site while data for salinity and temperature were logged by CTD.

Most of the epifaunal vertebrates and invertebrates caught in the beam trawl were identified to species onboard the research vessel and as far as possible, animals were counted, measured and weighed. All others were preserved in 5 % formal-saline and returned to the laboratory for analysis. The material from the box corers or grabs was washed over a 0.25 m^2 mesh using Gardline autosievers. All sediments retained in the sieve were preserved in buffered formal-saline and also returned to the laboratory.

A very preliminary analysis of epifaunal abundance data agreed with descriptions from previously published studies showing higher species diversity and number in the northern sector of the North Sea. Numbers of individuals per station were highest to the far north and south of the study area. The top twenty species recorded were dominated by ophiuroids and echinoids with *Strongylocentrotus droebachiensis*, *Ophiura albida* and *Brissopsis lyrifera* recording the highest numbers, while the crustacean *Crangon allmanni* was also well represented. Multivariate cluster analysis of all the epifauna recorded (presence/absence transformed) identified seven main groupings which generally followed the distributions described by Zühlke (2001). To date, no work has been carried out on the infaunal material collected although multi-sieving of each sample to obtain a minimum of five size classes will commence as soon as possible.

References

Zühlke, R. 2001. Monitoring Biodiversity of the Epibenthos and Demersal Fish in the North Sea and Skagerak. Monitoring Report 2001 to the Commission of the European Community. Project 98/021.

6.3.2 Macrobenthic community structure on the Belgian Continental Shelf

G. Van Hoey talked about the macrobenthic community structure on the Belgian Continental Shelf (BCS) (see Annex 4). The macrobenthic research on the BCS can be divided into two main periods. First there was an intensive investigation in the 1970s, where the BCS was divided into three zones: a coastal zone with a set of species- and density-poor communities; a species- and density-rich transition zone; and a species-rich and density-poor open sea zone (Govaere *et al*., 1980). The 740 samples of the 1990s give a clear picture of the macrobenthic communities on the different sandbank systems. After (re)analysing these samples with different multivariate techniques, ten distinct groups were distinguished. Five of these groups differ drastically in species composition and habitat and are considered to represent four macrobenthic communities:

(1) The species- and density-rich *Abra alba – Mysella bidentata* community;

(2) The less diverse *Nephtys cirrosa* community;

(3) The *Ophelia limacina – Glycera lapidum* community, characterized by low densities and diversity;

(4) The *Eurydice pulchra – Scolelepis squamata* community, which occurs on the upper sandy beach zone.

Of course, these macrobenthic communities are not isolated from each other and five specific transitional species associations were found. The spatial distribution of the four communities seems to be correlated mainly with depth and granulometry (e.g., median grain size and mud content).

E. Rachor asked if *Fabulina fabula, Abra alba* and *Amphiura filiformis* were found in the *Nephtys* community. The speaker said that the bivalves mainly occur in the transitional communities, and that *A. filiformis* is not present.

Ingrid Kröncke commented that there was very good small-scale data. Were there any environmental data associated with this, such as pigments? G. Van Hoey said there was no pigment data available although temperature, salinity and sediment particle size data have been collected.

6.3.3 Progress in Friese Front studies

G. Duineveld gave a short account of the further results from the Friese Front studies. H. Rumohr asked whether the area is impacted by beam trawl vessels and if they produce sediment clouds. G. Duineveld confirmed that it is a traditional fishing area. They do make clouds but so do other fishing methods. Michael Zettler wondered how one can be sure that the growth rings are indeed annual. Duineveld replied that growth is hard to prove. You need to carry out stable isotope / temperature analysis as was done with *Arctica*. B. Tunberg asked how sampling for *Upogebia* was done. Duineveld said they used grabs. Animals are found at around 40 cm depth in the summer but may be at 1 metre into the sediment in the winter.

6.3.4 Recovery of benthos from sand extraction

J. van Dalfsen reported on the follow up of the “Punaise” Project.

In the winter of 1996, beach nourishment was executed at the central Dutch coast near Heemskerk/Wijk aan Zee, using a temporary borrow pit located in front of the beach at a depth of 7 m. After the beach nourishment was completed, the pit was refilled with sand from deeper waters. Between 1996 and 1998 the benthic community was monitored in order to study the ecological recovery of the area after the borrow pit was refilled with sands. It was concluded that after fifteen months the benthic fauna had largely recovered but differences between the former borrow pit and its surroundings were still present in terms of community structure, density and biomass. In 2001, a final survey was undertaken to investigate the long-term recovery process. The results of this survey showed that four years after completion of the dredging activities the former borrow pit area could not be distinguished any more from the surrounding area. The benthic community had recovered completely and showed great resemblance to the community present at the baseline survey in 1996, before the dredging. It was concluded that in a highly dynamic environment such as this the top layer of sediment recovers within about one year, but it will take fours years to have a complete recovery of the benthic community. A report (in Dutch) is available.

E. Rachor asked whether there were differences in animal feeding types between crests and gullies. J. van Dalfsen said there are no molluscs on the crests. However, there are more species and higher densities in the troughs. It is hoped to look at the mega ripples next year. L. Watling wanted to know whether there was evidence for small-scale hydrodynamics sorting phytoplankton into the troughs which could cause aggregation of animals. Van Dalfsen confirmed that this does happen. Data have been collected by another Institute.

References

van Dalfsen, J.A., Duyts, O.W.M, and Storm, B. 1999. Effecten op de bodemfauna van het gebruik van een tijdelijke zandwin/overslagput in de kustzone ter hoogte van Heemskerk. Punaise*2. Koeman en Bijkerk, Rapport 99–13.

van Dalfsen, J.A. and Lewis, B.W.E. 2001. Punaise*3. Lange-termijn effecten op de bodemfauna van een tijdelijke zandwin/overslagput in de kustzone ter hoogte van Heemskerk. TNO-rapport R 2001/494.

6.3.5 Recent drastic changes in the soft-bottom macrofauna assemblages above the halocline in the Gulf of Gdansk (southern Baltic proper)

J. Warzocha reported on the ongoing project in the Gulf of Gdansk (southern Baltic Proper), which aimed to describe relations between anthropogenic pressure and macrobenthic assemblages. Quantitative samples with van Veen grab and Niemistö corer were collected from the muddy bottom at the depths between 30 m and 110 m in 2000 and 2001. The data on the composition, abundance and biomass of macrofauna obtained in 2000/2001 were compared with survey data from the 1980s. The preliminary comparisons showed the drastic reduction in number of species, abundance and biomass of macrofauna above the halocline. The distinct changes were noted in the depth range of 30–60 m in the western part of the Gulf. Some species, e.g., *Saduria entomon*, *Pontoporeia femorata,* vanished entirely and the abundance and biomass of *Macoma balthica* decreased significantly. The observed changes in the structure of macrofaunal assemblages are most probably related to the oxygen deficiencies and occurrence of hydrogen sulphide observed since 1995. The last significant inflows of oxygenated waters, which renewed water in the Gulf of Gdansk, were noted in 1993 and 1994. The worst oxygen conditions in the Gulf were recorded in autumn 1999.

H. Rumohr asked whether there are any changes in the nutrient load of the Vistula. J. Warzocha said he hoped that the situation in the Baltic will improve. Nutrient levels have generally decreased lately due to the economic situation. However, the nutrient pool in the sediments is immense. Shallower areas have shown improvements.

K. Essink wondered whether there was any evidence for effects on fishes. J. Warzocha said it is possible. Small crustaceans, which are an important source for fish feeding, have disappeared. G. Duineveld inquired about meiofaunal samples. J. Warzocha said samples have been collected but there are no results as yet.

6.3.6 Benthic research in Northern France

J.-M. Dewarumez informed the Group about a study of benthic macrofauna in the southern North Sea and the Eastern Channel.

This study was initiated in 2001. Its first step during 2001 was exploratory. The aim was to determine the specific composition, density and biomass of macrofauna at different scales of observation. The area investigated for the smallest scale was the coastal Eastern Channel, where three sites were sampled with a 3-m beam trawl during winter and spring 2001: in front of the Canche estuary (13 stations), Boulogne (3 stations) and the bay of Wissant (3 stations). 29 species of macrofauna were sampled: molluscs (12 species), crustaceans (12 species) and echinoderms (5 species). At the medium scale, six stations were sampled with an otter trawl in the Dover Strait during a CGFS cruise of IFREMER in October 2001. 23 species were sampled. The dominant groups were also molluscs (10 species) and crustaceans (9 species). At the large scale, the southern North Sea was sampled on 46 stations with an otter trawl in March 2001 during an IBTS cruise of IFREMER. 47 species were sampled: crustaceans (18 species), molluscs (15 species) and echinoderms (14 species).

In 2002, the sampling was performed only in the North Sea during the IBTS cruise of IFREMER in February. 75 stations were sampled with an otter trawl. 75 species of macrofauna were identified: crustaceans (26 species), molluscs (25 species including 6 cephalopods), echinoderms (16 species), polychaetes (4 species) and 4 other species. 21 stations of macrobenthos were also sampled along two transects (North-South and West-East).

J.-M. Dewarumez also informed the BEWG of the spreading and distribution of *Ensis directus* on the French coast of the North Sea and in the Eastern Channel, ten years after its first record in French waters. A more detailed account is given in Annex 5.

6.3.7 Benthic studies in Ferrol Bay, NW Spain

S. Parra gave an account of studies in NW Spain. Benthic samples for the study of sediment parameters and the infaunal subtidal community were collected at 35 stations in Ferrol Bay, Northwest Spain. Additionally, benthic samples were collected from October 1999 to August 2000 in order to study the temporal changes at three benthic stations, two to study the infaunal subtidal community and one for the study of sedimentary variables.

In the distribution of the sedimentary types, four large areas were noted: 1) an internal harbour zone, where sediments are muddy with very high organic content; 2) a medium zone, where sediments are muddy or sandy with high organic content; 3) the channel, with medium or coarse sands and low organic content; and 4) an external area of the bay, with fine sands and a low organic content.

When looking at the temporal variation of the sediment characteristics, only slight variations could be observed in the mean diameter of the sediment in Station 2, which is situated in the medium part of the bay.

In the spatial distribution, five groups or infaunal subtidal communities have been identified in Ferrol Bay:

- Group A, situated in the internal harbour zone, with very muddy sediments from the harbour, with very high organic content. It shows an impoverished infaunal community dominated by the oligochaete *Tubificoides* sp.

- Group B, situated in the internal zone of the bay, in the harbour or close to it, in sandy sediments with very high organic content. The main species are the polychaetes *Paradoneis lyra* and *Prionospio fallax* and the bivalve mollusc *Thyasira flexuosa*.

- Group C, situated at stations in the middle of the bay, in sediments that vary from mud to fine sand. The organic content is very high in all stations and the characteristic species are the polychaetes *Paradoneis lyra*, *Ampharete finmarchica* and *Monticellina dorsobranchialis*.

- Group D occupies sediments of medium to coarse sand in the channel with low organic content. The infaunal species that dominate the group are amphipods and tanaid crustaceans.

- Group E, situated in fine sands, with low to moderate organic content, is located in the outside part of the bay. The main species of the group are the polychaete *Spio decoratus* and unspecified Nemertina.

The infaunal community of Station 3 does not show a clear pattern of temporal variation; its specific composition remains relatively stable, although some species show moderate seasonal variations, e.g., *Monticellina dorsobranchialis*, *Prionospio fallax* and *Abra nitida*. In Station 20, the pattern of variation is more pronounced, with an increase in abundance in summer and autumn, both in the total abundance in some species (e.g., *Paradoneis armata* and *Magelona filiformis*) reaching large temporal variations in some of them (e.g., in *Spio decoratus*).

A full account of this study is given in Annex 6.

E. Rachor mentioned the very high levels for organic carbon in the sediments, also in the outer bay. S. Parra acknowledged that they are very high in the harbour area which is very muddy. M. Zettler wanted to know about the fresh water input into the system. S. Parra said that river input is very low. There are no data on salinity.

6.3.8 Benthic monitoring 1998–2001 at the Basque coast (N. Spain)

The Department of Oceanography and Marine Environment of AZTI has developed a monitoring programme for the environmental assessment of the Basque Coast. This programme is supported by the Environmental Department of the Basque Government; it aims to assess and control the state of the contamination in the littoral zone and the estuaries and its evolution.

The monitoring programme started at the end of 1994, studying water, sediments, organisms and benthic communities. A total of 45 sampling stations are defined: 17 in 12 estuaries and 15 in the littoral zone. The variables studied each winter in soft-bottom benthic communities are: identification at species level, density, biomass, trophic groups, structural parameters (diversity, evenness), and biotic index. In estuaries there are both intertidal and subtidal samples; the littoral stations are placed at 30-m depth bottoms.

The percentage of Annelida has been increasing since 1995 and, consequently, there is a reduction in the presence of Mollusca and Arthropoda. The total number of phyla and species identified has been decreasing from 1996. Some of the effects of the environmental conditions on benthic communities can be detected by assessment of a Biotic Coefficient (see also Annex 7).

By means of a Redundancy Analysis (RDA), with a Monte Carlo permutation, the relationships between environmental variables, pollutants and biological composition are studied, explaining the distribution of benthic communities.

K. Essink asked whether agricultural runoffs are important. A. Borja answered that they are not important here; most pollution comes from the cities. J. Craeymeersch wanted to know how it is possible to differentiate between stress due to pollution and stress due to natural disturbance. A. Borja said the Biological Index is a good method for distinguishing between these.

6.3.9 Benthic research and monitoring at the Smithsonian Institution

B. Tunberg informed the meeting about the Smithsonian Marine Station. It was established in the Fort Pierce inlet area in 1999, but has been active in the Indian River Lagoon for about 25 years. The overall mission of the Marine Station is to support and conduct scholarly research in the marine sciences, including collection, documentation and preservation of south Florida's marine biodiversity and ecosystems, as well as education, training, and public service. Specific research emphases are: 1) to analyse the systematics and biogeography of major groups of marine organisms in the Floridian coastal zone, focusing on issues of biodiversity; 2) to determine the evolutionary patterns, ecological significance and physiological mechanisms of life histories of marine organisms; and 3) to investigate the complex interactions of marine organisms and the community structure of the diverse and productive habitats of south Florida. Web address: sms.si.edu (where the Indian River Species Inventory can also be found).

The Marine Station will now also be the centre for the ecological assessment of the Indian River Lagoon system, which will include the set-up of an extensive monitoring programme where the benthic component will dominate. These studies will be performed in cooperation with different local, regional and state agencies, primarily the Florida Marine Research Institute (FMRI) in St. Petersburg. Close cooperation has also been established with NASA (through Dr Grant Gilmore). New techniques and approaches will be tested in the Fort Pierce inlet area through the NASA connection. Other very important partners here are the Smithsonian Environmental Research Centre, Chesapeake Bay (through Dr Anson Hines) and the entire Smithsonian Marine Science Network (see next paragraph).

The Smithsonian Institution operates a unique network of coastal laboratories and long-term marine research sites in the western Atlantic Ocean that extends along the east coast of North and Central America, bridging the Panamanian isthmus from the Caribbean Sea to the Pacific Ocean. The Smithsonian Institution Marine Science Network provides unparalleled access to, and research support for, Atlantic Ocean and Atlantic shore ecosystems.

This network is uniquely positioned to monitor long-term change at its four component sites. It has an extensive array of programmes (including scientific diving) and addresses many of the most pressing environmental issues in marine ecosystems, including: biological invasions, eutrophication, harmful species and parasites, plankton blooms and red tides, linkages among coastal ecosystems, global warming including sea-level rise, NAO, El Niño/La Niña, UV radiation impacts, habitat destruction, fisheries impacts, ecology of key habitats (estuaries, coral reefs, mangroves, sea grasses, wetlands) and biodiversity inventories.

More information on the Smithsonian Marine Science Network is available from Michael Lang (langm@si.edu) and/or the website www.si.edu/marinescience.

6.3.10 Other U.S. benthic studies

L. Watling informed BEWG of the following projects and studies.

North Atlantic Project - Under the direction of Dr Cliff Cunningham, Biology Department, Duke University, the U.S. National Science Foundation has funded a Research Network Coordination project, tentatively entitled the "North Atlantic Project" whose aim is to investigate the historical biogeography of the colder waters of the North Atlantic Ocean. The Steering Committee for this project met in Wrightsville Beach, North Carolina, in April 2002, with the objective of planning the first of five annual meetings where data will be brought together regarding distribution and phylogeny of species that occur on both sides of the North Atlantic.

Census of Marine Life - The Sloan Foundation of New York is promoting the idea of making a Census of Marine Life and has funded the planning process for a pilot study in the Gulf of Maine. The objective of the census is to obtain detailed information on the distribution and abundance of animals and plants in the local region. Several meetings have been held and proposals prepared for carrying out this census. The primary problem at present is identifying a funding agency willing to spend the required amount of money to census even a part of the total fauna in shallow to deep waters of the Gulf of Maine. The Census, however, is viewed as an important continuation of studies that have been conducted under the auspices of BIOFAR and BIOICE.

Deep Sea Coral Studies - Deep-dwelling corals, especially gorgonians off the east coast of North America, have been discovered to be of interest for the scientific community. To date, no large reefs of the scleractinian, *Lophelia pertusa*, have been discovered in the northern part of the U.S. and Canada eastern coast. In August 2001 a meeting on deep-water corals was held in Halifax, Nova Scotia. Publications summarizing the research presented have been published by the Nova Scotia Museum and in the journal Hydrobiologia. Two graduate students at Dalhousie University, Halifax, are producing theses on the distribution and ecology of deep-water corals off the east coast of Canada, and L. Watling and P.J. Auster are compiling historical records of deep-water corals off the U.S. east coast. In addition, the latter two investigators, along with K. Eckelbarger and S.C. France, have a longer-term project to investigate the distribution and ecology of gorgonians in the Gulf of Maine area.

6.3.11 Danish Marine Monitoring

A. Josefsen (by correspondence) informed the BEWG of the Danish Marine Monitoring Programme.

Danish monitoring of fauna and benthic macrophytes is concentrated in the Danish fjords (actually bays and lagoons) and the Danish inner waters (Kattegat, the Belts, Øresund and SW Baltic Sea). In the fjords, monitored by the local counties, macrofauna is monitored using a Haps-sampler in 22 grid areas with approximately 50 stations in each fjord. One sample is taken at each station once a year, typically in April–June.

In the inner Danish waters, mainly monitored by the Danish Environmental Research Institute (NERI), macrofauna is monitored at ~ 26 single stations sampled with 5–10 Haps replicates, also once a year in the first half of the year. These stations are distributed "evenly" within the territory from the border between the Skagerak and Kattegat in the north to the Arkona Basin in the Baltic in the southeast. So, each year ~1300 haps-samples are taken in the Danish programme and analysed for species composition, abundance and biomass (ww and/or dw) of each species. All data are stored in the NERI database.

Benthic macrophytes (coverage and species composition) are monitored along transects in many of the fjords. In the "open sea" (Kattegat mainly) macroalgal species composition and coverage are monitored on what are called "stone reefs" i.e., principally aggregations of boulders.

The Danish monitoring programme is presently being revised and from 2004 on it will be complemented with spatially extensive surveys every sixth year to meet the demands from the EU Habitats Directive.

With regard to the North Sea area, there is little monitoring taking place by Danish authorities. There is, however, monitoring of fauna and sediment in connection with the oil drilling activities, performed by private companies (i.e., DHI, the Danish Hydrological Institute).

On Greenland, benthic macrofauna is monitored in the Nalunaaq and Saqqa fjords (southern Greenland). Here, macrofauna is monitored on 15 stations (together with contaminants, metals) for the effect of gold mining (spoils of crushed rock). This monitoring (so far only a baseline in 2001) is performed by NERI.

6.3.12 Estonian Marine Monitoring

J. Kotta (by correspondence) informed BEWG of the very recent decision that the Estonian Marine Monitoring Programme in the Baltic will be continued. This programme has a focus on coastal waters and hotspot areas; phytobenthos communities including zoobenthos are being monitored.

The ministry responsible, however, cut back on travel money and insisted on participation in HELCOM activities only, meaning no more possibilities to take part in the work of BEWG. As there is not a very active group on benthic invertebrates in the Baltic, cessation of contact with the ICES BEWG is considered with great regret.

6.4 Benthos of rocky substrates

6.4.1 Long-term monitoring of rocky bottom biotopes using image analysis

F. Beuchel gave an account of temporal variations and succession of a macrobenthic community from rocky-bottom localities on Svalbard and Northern Norway. They are investigated by analysis of long time series of photographs of permanently marked underwater areas. An extensive abstract can be found in Annex 8.

6.5 Assessment of marine quality

6.5.1 A proposal for the use of benthos in ecological quality objectives: the development of a Marine Biotic Index

A. Borja informed BEWG that new European regulations (see Directive Proposal 2000/60/EC) emphasise the importance of biological indicators. In order to establish the ecological quality of European coasts and estuaries, Borja *et al.* (2000) developed a marine Biotic Index (BI). This index explores the response of soft-bottom communities to natural and man-induced changes in water quality, integrating long-term environmental conditions.

For the development of this Biotic Index, the soft-bottom macrofauna is divided into five groups, according to their sensitivity to an increasing stress (i.e., increasing organic matter enrichment); from species very sensitive to organic enrichment and present under unpolluted conditions (initial state), to first-order opportunistic species (pronounced unbalanced situations). In this BI, more than 1,500 taxa have been classified. These species are representative of the most important soft-bottom communities present in European estuarine and coastal systems. The list of species, an Excel tool for the calculation of the BI and a program to calculate and represent the BI are available, upon request, from aborja@pas.azti.es or in the near future from AZTI's web page (http://www.azti.es/.

The BI has been used in the Atlantic (North Sea; UK, French and Spanish coasts), a transitional area between the Atlantic and the Mediterranean (in the south of Spain), as well as in the Mediterranean (Spanish and Greek coasts). It is independent of the pollution source, e.g., drilling cuts, outfalls (submarine or otherwise), heavy metals, marinas and civil works (dikes, sewerage works…). On the other hand, the BI varies only little throughout the year. Hence, samples obtained at different times of the year can be compared, provided that there are no major changes in the source of the pollution. It is useful to apply the BI to the comparison of the ecological quality of the soft-bottom benthos, before and after a stress episode; and it is useful also to identify spatial trends and gradients, related to the hydrodynamic and dilution processes.

H. Rumohr wanted to test the index in areas such as the Baltic and see if the concept is working both in fully marine and brackish waters. A. Borja agreed. The index has so far been tested in estuaries and checks continue.

G. Duineveld asked what is implied by "pollution". A. Borja said it applies to all types of disturbance, also dredging, sewage, civil works. Not all species react to different pollution types the same way.

T. Brattegard wondered if the index had been checked against others such as that of John Gray. A. Borja replied that the newly described index is similar to those of Gray and Rosenberg and seems to work all right. T. Brattegard then remarked that the index number hides a lot of information. It is difficult to see what is actually occurring in the field, *viz*. in the benthic community.

L. Watling thought the same problems as with ABC curves were applicable in that the results can be misleading, as was shown by, e.g., Dauer *et al.* (1993). Field data were often diametrically opposed to the results from various indices. K. Essink noted that it is good to continue testing the index in as many environments as possible.

L. Watling suggested to perform a sensitivity analysis, e.g., by removal of certain sets of species (especially rare species) and then rerun the index.

G. Duineveld wondered how the index would deal with species from unpolluted areas, situated along a gradient from freshwater to marine. S. Dahle acknowledged that the index could help to simplify interpretation of species lists. We know that benthic communities react to a variety of environmental factors, but how do we distinguish between natural gradients and effects caused by true pollution/contamination. To what extent do these contaminants build up in the biota and what effects are seen? A. Borja said he calculated the relationship between concentrations of contaminants and looked at the effects in the biota. K. Essink noted that we can use indices like these because they reduce the information to a simple figure; this is useful for management purposes. But we also need the extra information on what is actually causing the observed effect. We need more explanatory data.

J. Craeymeersch remarked that there does not seem to be any testing of biotic stress. A. Borja replied that natural movements of sand have been tested and have been integrated with the index. J. Craeymeersch said it would have been useful to also test non-polluted areas. A. Borja agreed and also noted that the classification of species into ecological groups was taken generally from the literature. On this J. Craeymeersch replied that a major revision is required, as he had observed some obvious mistakes.

References

Borja, A., Franco, J., and Pérez, V. 2000. A Marine Biotic Index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin, 40: 1100–1114 .

Dauer, D.M., Luckenbach, M.W., and Rodi, Jr., A.J. 1993. Abundance biomass comparison (ABC method): effects of an estuarine gradient, anoxic/hypoxic events and contaminated sediments. Marine Biology, 116: 507–518.

6.5.2 Ecological monitoring of anthropogenic perturbations of the sea

H. Hillewaert gave an account of difficulties that may arise in the monitoring of effects of anthropogenic perturbations on the Belgian Continental Shelf.

H. Rumohr asked whether the sieving technique was changed. H. Hillewaert answered that samples are still fixed at sea and returned to the laboratory for sieving; he did not want to change methods after twenty years of sampling. Ten replicates are collected per station;sieving all these on board becomes too time consuming and expensive. H. Rumohr remarked that this method is unique in Europe and wondered whether systematic errors were looked for. H. Hillewaert replied that comparisons between Dutch and Belgian data have been done, but not in great detail. G. Duineveld was struck by the high variance between seasons and years. H. Hillewaert then noted that catch rate of a beam trawl is variable. It is qualitative rather than quantitative.

6.5.3 BEAST

J. van Dalfsen gave an account of the development of BEAST, a Benthic Evaluation and Assessment System.

In 2001, this project had started to integrate present knowledge and site-specific information on sediment, geomorphology and morphodynamics in order to understand and predict the possible environmental impacts of different human activities. This should lead to the development of a tool to support the management of different human activities on the Dutch Continental Shelf that might affect the seabed. Using GIS, ecotope maps are being produced on a scale that is applicable for detailed Environmental Impact Assessment studies. First results of field research indicate small but distinct differences in the benthic community that can be related to relatively small morphological features.

6.5.4 Ecological assessment and biodiversity of the Indian River Lagoon, Eastern Florida

B. Tunberg talked about ecological assessments in Eastern Florida. The Indian River Lagoon (IRL) is North America’s most diverse estuary. This complex, dynamic and variable system is 156 miles (250 km) long and makes up 40 % of Florida’s east coast. More than 2,200 animal species are found in this region. Seven species of seagrasses also occur here. The lagoon is located in the zone where tropical and temperate climates meet, and the fauna and flora include tropical, subtropical and temperate species. Large parts of the bottoms of the IRL system are covered with sea grass meadows, sand- and mud-flats. Extensive mangrove forests as well as salt marshes are found throughout the IRL. The hydrology existing in any one segment of the Lagoon is dependent on a complex relationship between saline waters entering the IRL through inlets connected to the Atlantic Ocean, and freshwater discharges to the Lagoon from streams, creeks, canals and diffuse runoff. These features result in a water body which is extremely sensitive to the amount and timing of freshwater discharge to it, the pollutant load carried into it by the freshwater discharges, and salt water tidal exchange through ocean inlets. To predict the long-term cumulative impacts from watershed alterations and pollutant loads to the Lagoon, knowledge of how the natural Lagoon system functions is an absolute necessity.

Other and complicating features in the IRL system are the numerous mosquito-control impoundments. A mosquito-control impoundment is simply a marsh or mangrove swamp that has been totally or partially enclosed with an earthen dike. A perimeter ditch (borrow ditch) parallels the dike on the marsh side and marks the area where the material for the dike construction was excavated. Impoundment allows the marsh to be flooded during the mosquito-reproducing season thus preventing oviposition.

In addition, there are the nearby sandy beaches of the barrier island, the extensive waters and sandy plains of the Continental Shelf and, at the edge of the Shelf, the Florida South Current, a component of the Gulf Stream System. Extensive deep-water coral reefs (*Oculina*) are also found in this region. These very sensitive and ecologically important reefs (the tropical equivalent to the North Atlantic *Lophelia* reefs) have been severely damaged over the years from trawling activities, in spite of trawling restriction efforts. Further measures and studies are necessary to protect these reefs.

B Tunberg is cooperating with NASA scientists. They want to use space tech autonomous vehicles (AUVs) for application in the sea. Really high-tech bottom-penetrating sonar has been developed (synthetic aperture sonar).

T. Brattegard informed the group that Iceland has operational AUVs. H. Hillewaert noted that AUVs have been used experimentally to map seagrass beds in the SUMARE project.

H. Rumohr remarked that there is a large variety of novel methodologies available along with the adagium "here is the answer, where is the (scientific) question?" B. Tunberg replied that we should be open-minded to the use of any new high-tech gear. It can stimulate new research.

6.5.5 Environmental effects arising from marine aggregate extraction

H. Rees (by correspondence) informed BEWG of an investigation of the potential for cumulative environmental effects arising from marine aggregate extraction.

This is a four-year study being conducted by CEFAS on behalf of the Department of the Environment, Food and Rural Affairs (DEFRA). The final report is due for completion at the end of April 2002. The objective of the study is to distinguish natural changes from dredging-induced changes to allow scientific evaluation to be made regarding the continued acceptability of multiple extraction activities. Research on cumulative effects represents a major departure from research on individual impacts of dredging in that it aims to evaluate the interaction of events separated in time and in space.

In an initial assessment of the scope for such cumulative effects, a review of historical data was undertaken, focusing on the dredging intensity and extent, and the performance of local fisheries. Interviews were conducted with key fishers fishing within the east of the Isle of Wight region, central English Channel. Fishers were invited to provide an overview of their fishing activities including the location of fishing effort and discuss the extent that aggregate extraction has impinged on this activity.

It was also necessary to conduct new, carefully targeted sampling regimes to cover appropriate spatial scales and especially to establish the stability of any observed effects over time. Regional-scale surveys of the benthos and sediments were conducted in the southern North Sea and central English Channel. Surveys were also designed to examine the nature of impacts on the benthos arising from marine aggregate extraction. The first of these surveys was conducted in 1999 to investigate the effect of different levels of dredging intensity on macrofaunal assemblages. Samples from intensively dredged sediments differed from undredged sites due to significant reductions ($p<0.05$) in numbers of species, biomass, species richness and diversity. Intermediate values of all calculated univariate measures were also observed in areas of reduced dredging intensity. Populations of the polychaete *Sabellaria spinulosa* were found to be particularly susceptible to dredging disturbance. This is in contrast to *Balanus* juveniles which were observed to be more numerous in intensively dredged sediments compared with elsewhere, suggesting that some settlement of this taxon occurs even during times of extraction.

Further studies conducted in 2000 were designed to investigate the nature and footprint of biological effects arising from marine aggregate extraction. Two transects of stations located at increasing distance from active centres of dredging activity in the central English Channel were sampled for macrofauna and sediments using a 0.1 m^2 Hamon grab. Both transects were aligned along the approximate direction of the prevailing tidal currents. A total of 394 macrobenthic species were recorded from 31 samples.

Univariate and graphical measures of community structure suggest that at the locations investigated the effects of marine aggregate extraction (both trailer and static dredging) are confined to within 1 km of the centre of intensive dredging. Multivariate methods appear to be more sensitive and show a clear gradient of change with increasing distance away from extraction activity extending beyond the margins of the extraction sites.

A further output of the study has been the development of generic guidelines for undertaking studies to investigate the potential for cumulative environmental effects arising as a consequence of marine aggregate extraction. The guidelines are presented in the final report together with guidance on the circumstances under which cumulative effects studies may become necessary in other areas.

7 GUIDELINES FOR EPIBENTHOS SAMPLING AND COMMUNITY DESCRIPTION

Unfortunately, H. Rees was not available to guide the final phase of this product of the BEWG. A subgroup was set up to try to finalise the latest draft of this guidelines report. Several text additions were made, but some more input is required (by correspondence). The report is fairly well written but requires compilation and editing.

In plenary, the BEWG agreed that the new draft should be sent to H. Rees for completion or, if he is not available, to L. Watling who is willing to finish the editing of the report. At this point, it was proposed and agreed that the author of this intended TIMES report should be H. Rees, with other BEWG contributors being mentioned in a footnote.

H. Rumohr informed the BEWG of the progress of the new 3rd edition of the IBP Handbook on Benthos Methods by McIntyre *et al*. No conflicts between these two publications are foreseen.

A recommendation to publish this report in the ICES TIMES series is contained in Annex 15.

8 NORTH SEA BENTHOS PROJECT

The objective of this NSBP project is to bring together data on macrobenthos distribution in the North Sea in 2002/2001, and to allow a comparison with the results of the 1986 North Sea Benthos Survey. A first NSBP workshop was organised in Oostende, from 28–29 January 2002. The main topics of this meeting were to evaluate the information available to the project, to discuss protocols for data exchange, and to agree on data structures and conditions of release of data. A full report on this meeting is appended to this report (Annex 9).

The progress made since the Oostende workshop was presented by the NSBP data manager, E. Vanden Berghe.

Data were expected from:

- Germany: AWI/Senckenberg, Bundesanstalt für Gewässerkunde/ Koblenz
- Netherlands: Rijkswaterstaat/RIKZ, NIOZ
- Belgium: Sea Fisheries Department and Ghent University
- France: Station Marine de Wimereux
- UK: CEFAS
- Norway: Akvaplan-nivaAdditional data would become available from FRS Marine Laboratory, Aberdeen (through M. Robertson). Data from AWI were not yet available; it was agreed that species lists will be sent in early May.

During the meeting, more data were pledged from:

- Doggerbank (Wintershal/TNO through J. van Dalfsen and F. Gosselck)
- German Bight (through H. Rumohr)Norway (through S. Cochrane)P. Kingston (by correspondence) informed BEWG that the UK Department of Trade and Industry-funded Strategic Environmental Assessment (SEA) programme in the North Sea went ahead last year. This survey, carried out between April and June 2001, specifically addressed pockmarks and offshore shallow (<20 m) sand areas including sandbanks and the shallow parts of the Dogger Bank, and comprised geophysical and biological sampling. A separate sampling survey was done over crests of the Norfolk Banks using a shallow-draught vessel. Seabed sampling was carried out using a Van Veen grab (sandbank and Dogger Bank areas) and a Calvert box corer (in pockmark areas). Also video and still photographs were obtained in all three survey areas. The project is run by the Geotek consultancy (contact: Quentin Hugget). Information on the SEA programme is available at the website www.habitats-directive.org/sea2/index.cgi

It was agreed that remaining data should be submitted as soon as possible; taxonomic lists should be sent to E. Vanden Berghe not later than the end of June.

Since January 2002, further efforts were made to integrate the taxonomic lists from the different constituent data sets. The consolidated taxonomic list now has 1493 names, corresponding with 1429 taxa. This list will be circulated well before the next workshop (September; see below) amongst the members of the NSBP team.

Two main problems are apparent from the data:

1) Since no special cruises could be organised, the NSBP has to rely on data that were collected in the framework of independent national projects. This has resulted in a very uneven geographical coverage of the sampling effort. The extra data pledged during the meeting will go some way to alleviate this problem. Widely publicising the activities of the NSBP (see below) was seen as a good way to attract more collaborators, and hence a better data coverage of the area of interest.

2) The majority of species are only represented in one data set. Part of this can be explained by the wide geographical range of the samples and/or the different levels to which the taxa have been identified in the different national projects. The largest part of the problem probably results from different concepts that different research groups have about the species involved and/or different identification keys used. This problem needs to be solved in future workshops, where the taxonomy of the difficult groups has to be discussed.

Information to be included in the NSBP database was discussed. In view of the apparent problems with taxonomy, it was agreed that information on the identification keys used, and the persons doing the identifications need to be part of the mandatory information. A complete list of information needed will be circulated to the project participants by E. Vanden Berghe.

It was proposed and agreed that J. Craeymeersch will take over the responsibility of compiling the information on feeding types of species, and also include information on species sensitivity as used by Borja and co-workers in calculating the Biotic Index.

Taxonomic names will be further checked, and also compared with the ITIS database. K. Essink informed BEWG that M. de Kluijver will provide a list of synonyms, on which he is working presently.

The proposal made at the Oostende workshop to build a website for the NSBP was accepted. This website will initially serve to communicate the contents and goals of the NSBP; actual data will be made available at a much later stage. Apart from this, it was decided that the NSBP activities would be presented in two conferences: the ICES Annual Science Conference (Theme Session on the Census of Marine Life; Copenhagen, October 2002), and the Oceanographic Data Management conference in Brussels (November 2002).

A next workshop of the NSBP group is scheduled to be held in Bremerhaven, from 9 to 11 September 2002, hosted by E. Rachor. On the agenda will be the list of information needed for inclusion in the NSBP database, and synchronisation of taxonomic identifications. For the latter part, problematic taxonomic groups will be identified on the basis of the project data set, and from other sources.

K. Essink, who is stepping down as Chair of BEWG, will no longer be available to coordinate the activities of the NSBP. He proposed that his role be taken over by a steering group, consisting of I. Kröncke, G. Duineveld and H. Rees, who all agreed to do so in collaboration with data manager E. Vanden Berghe. The new steering group proposed inclusion of J. Craeymeersch and S. Cochrane. The BEWG agreed with this proposal and decided that the steering group will be responsible for properly structuring the programme for the next workshop in Bremerhaven.

Finally, a deadline for data delivery by the end of 2002 was agreed upon. The NSBP will work only with data delivered to E. Vanden Berghe before this deadline.

9 REVIEW OF STUDIES IN NORTHERN SEAS IN COMPARISON WITH, E.G., THE BALTIC SEA AND NORTH SEA – ECOSYSTEM FUNCTIONING, HUMAN IMPACTS, CRITERIA FOR ECOSYSTEM HEALTH, GAPS IN KNOWLEDGE, IMPACT OF FISHING ACTIVITIES ON THE MARINE BENTHIC SYSTEM

9.1 Benthic communities in the deep Eurasian Arctic Ocean

I. Kröncke, of the Senckenberg Institute in Wilhelmshaven, Germany, gave an account on benthic communities in the deep Eurasian Arctic Ocean.

At 30 stations along a transect from northern Svalbard towards the Makarov Basin, macrofauna samples were taken during autumn 1991. Depths ranged between 1018 m and 4478 m. Species numbers, abundances and biomasses were extremely low with 0 to 11 / 0.02 m^2, 0 to 950 ind./m^2, and 0 to 82.65 g/m^2 wet weight, respectively. A total of 42 species was found. The most common species was the Amphipod *Jassa marmorata*. Both numbers and biomasses of suspension-feeding species increased at the Lomonosov Ridge, probably due to the lateral transport of organic material via deep currents.

Additionally, macrofaunal communities of the western Eurasian Arctic Ocean were studied along a transect from the North Pole, across the Amundsen Basin and Gakkel Ridge towards the Morris Jesup Rise and the Yermak Plateau. Samples were collected from depths of 560 m to 4411 m, using a box corer. Macrofaunal species numbers varied from 1 to 11 per 0.02 m^2 in the Basins approaching the Morris Jesup Rise and from 42 to 82 per 0.25 m^2 at the Yermak Plateau. Abundances increased from 1 to 31 per 0.02 m^2 in the Basin and on the Morris Jesup Rise to 24 to 60 per 0.02 m^2 on the Yermak Plateau. Biomass was low in the Basin and at the Morris Jesup Rise (0.5 to 68.9 mg per 0.02 m^2) but increased to 116.4 mg per 0.02 m^2 at the Yermak Plateau. A total of 108 taxa were recorded. The results contradict the hypothesis that diversity decreases with increasing latitude, and the high species richness at low abundance was comparable with that observed in Antarctic and tropical regions.

Samples for macrofauna, meiofauna, foraminifera, bacteria and sediment chemistry were taken at 13 stations along a transect from the Barents Sea shelf across the deep Arctic Eurasian Basins towards the Lomonosov Ridge. Water depths ranged from 258 m to 4427 m.

In general, all benthic compartments as well as total organic carbon (TOC) and total hydrolysable amino acids (THAA) showed highest values at the Barents Sea slope compared to data from the deeper stations in the basins and the ridge slopes. A significant correlation was only found between macrofaunal abundance and depth. Bacterial and all faunal abundances as well as bacterial and macrofaunal biomass decreased significantly with increasing latitude. Although the correlations between food items like TOC and THAA and fauna were found to be weak, the significant relationships between the bacterial and faunal size classes reflect a distinct food chain typical for oligotrophic systems.

The smallest compartments—bacteria, foraminifera and meiofauna—were more abundant than the macrofauna in the central Arctic Ocean. Biomass of macrofauna was dominant at the Barents Sea shelf and slope and at the Lomonosov Ridge, but bacterial biomass became equally or even more important at the Gakkel Ridge and in the deep basins.

The results indicate that the Eurasian Basin is one of the most oligotrophic oceanic regions. Although primary production is low, recent foraminiferal investigations revealed that benthic communities in the central Arctic Ocean are controlled by the sedimentation of fresh organic material. Lateral transport of organic material from the Siberian shelf might provide additional food. The different benthic compartments compete either for fresh organic matter or for refractory material that is transferred to higher levels of the food chain by bacterial mineralisation.

L. Watling commented that bacteria are not unusually abundant in Arctic waters. They are clearly able to take advantage of old as well as new organic matter whereas the metazoans generally need fresh organic matter. If there were no fresh material available, then metazoans would be generally absent. This is the situation often observed in deep oceans throughout the world.

9.2 Benthic studies in the White Sea

E. Rachor gave an account on benthic studies in the White Sea, where several multidisciplinary projects are performed. A European "Copernicus" project investigates the food relationships of the inshore and offshore (deep) parts of the sea (see website WWW.WOMP.narod.ru/).

T. Brattegard inquired whether the White Sea system is nutrient limited. Though research results are insufficient so far, E. Rachor stated that weak limitation by nitrogen compounds seems to exist, however, with a strong pelagic recycling in summer.

Furthermore, E. Rachor mentioned a Russian-German research project ("SIRRO") in the Kara Sea, by which the influences of river runoff on the sea and also the deep Arctic Ocean basin is being investigated (for more information: contact fschoster@awi-bremerhaven.de).

Another project of AWI Bremerhaven concentrates on a deep-water site (ca. 2000 m) in the Fram Strait west of Spitsbergen, where long-term observations on benthic processes with the help of the French ROV "Victor" are performed (for more information: contact mklages@awi-bremerhaven.de).

An overview of the projects can be found in Annex 10.

9.3 BIOMARE

S. Cochrane gave an update on BIOMARE (website: www.biomareweb.org), a European Union networking project on Marine Biodiversity. Reference sites play an important role. A general description was given of BIOMARE and the information that was available on the web. Participants were encouraged to look at the lists of metadata available for each country and to take contact with the speaker if any data sets should be added. Members of BEWG were invited to submit useful links and additional information.

9.4 Trajectories of Marine Ecosystem Response to Arctic Climate Change

M. Carroll gave a presentation on trajectories of marine ecosystem response to Arctic climate change.

The idea of this American-Norwegian-Russian project is to explore older archives of benthic fauna in the Barents and Bering Seas, and relate the variation in the benthos to large-scale variation in climatological conditions.

A comprehensive abstract can be found in Annex 11.

G. Duineveld asked whether short-term fluctuations in climate would cause variations in the benthic communities. M. Carroll replied that every individual taxon would respond in a different way but that there would be correlations. H. Rumohr noted that were still problems with availability of Russian data, because institutes are still in the process of transferring data into the computer. S. Dahle remarked that there was ongoing effort with regard to exploring the huge Russian data archives. These Russian data are of great interest, but cause many problems because of the methods used.

9.5 Work in the North Sea and in the northern seas by Norway

S. Dahle reported about Norwegian benthic work in the North Sea, and on ten years of cooperation with Russian institutes in northern seas. In the North Sea monitoring is performed around oil platforms. The study of benthic fauna of Franz Josef Land showed a diversity and biomass comparable to those of boreal waters. The biogeographical distribution of the species could be explained by the structure of the water masses penetrating the archipelago.

I. Kröncke commented on the approach adopted of relating benthic communities to differing water masses. This would be a useful tool if any warming were to occur. L. Watling queried whether the 4 % Pacific species occurring at the shallow stations were relict, as in the past exchanges between Pacific and Arctic were much greater than in the present day. E. Rachor stated that invasions of Pacific species had occurred throughout geological time using the transpolar drift. Currently, migrations occur along the northern shores of Russia where it is generally warmer.

9.6 Norwegian Benthic Research

T. Brattegard talked about problems of properly documenting changes in faunal composition along a longitudinal gradient as along the Norwegian coast. Along this coast, the fauna is bound to geographic regions that correlate with different temperature regimes. New species have been found, but it was difficult to be sure about these being new (a result of immigration from other regions); the species may have been there already but never noticed. He presented a possible way to overcome some of these problems and referred to the following relevant literature:

Brattegard, T., and Holthe, T. (eds.), 2001. Distribution of marine, benthic macro-organisms in Norway. (pdf lists updated August 2001 are available from http://www.dirnat.no or http:/www.ifm.uib.no/WebSider/Forsking /Foskersside_N.asp?P_Ansatt_ID=1071.

Costello, M.J., Emblow, C. and White, R. (eds.). 2001. European Register of Marine Species. A check list of the marine species in Europe and a bibliography of guides to their identification. Patrimaoines Naturels, 50: 1–463 (see also: http://www.erms.biol.soton.ac.uk).

Dinter, W.P. 2001. Biogeography of the OSPAR maritime area. Federal Agency for Nature Conservation, Bonn. 167 pp. (info: http:/www.lv-h.de/bfn*).*

H. Rumohr asked whether species changes could be attributed to global warming. T. Brattegard stated that he thought that this was the case and that there was an observable increase in water temperature along the coastline. We should now experience a period of warming followed by a sudden period of cooling resulting in another ice age. L. Watling commented that there were two approaches to biogeography described where animals appeared in faunal lists and immediately disappeared while others also appeared but could maintain a pseudo-population for up to a decade. Should the possibility of the existence of pseudo-populations be incorporated within the pan-Norwegian species category? H. Rumohr concluded that it was worthwhile to look further at these pseudo-populations, also with regard to the establishing of Red Lists.

10 DEVELOPMENT OF THEME SESSION FOR ASC 2003 OR 2004—THE ROLE OF BENTHIC COMMUNITIES AS INDICATORS OF MARINE ENVIRONMENTAL QUALITY [TOR: D]

BEWG prepared a proposal for a theme session to be included in the programme for the 2003 ASC, focusing on the role of benthic communities as indicators of marine environmental quality and ecosystem change.

A Theme Session on this subject will allow the synthesis of state-of-the-art knowledge, which will contribute to the further development of operational ecological quality objectives for marine benthic communities. This is relevant for application in the context of the EU Habitats Directive, the EU Water Framework Directive, and the OSPAR and HELCOM Conventions. There will be a great demand for operational indices, performance indicators, metrics for ecological quality of the benthic system, since the 5th North Sea Conference (Bergen, March 2002).

Contributions are welcome using different organism groups of the benthos, e.g., bacteria, algae, higher plants, invertebrates, and levels of integration (species vs. communities). Also welcome are critical reviews of applicability and limitations of used indices, indicators, etc., as well as innovative developments in this field. Finally, papers are welcome illustrating the use of benthos to document ecosystem changes due to anthropogenic or natural causes, e.g., climate variability.

The BEWG agreed to nominate Dr H. Rumohr (BEWG) and Dr C. Frid (WGECO) as Co-conveners.

11 REVIEW OF FURTHER NEEDS FOR QUALITY ASSURANCE IN BENTHIC MONITORING AND RESEARCH [TOR: E]

11.1 Outcome of BEQUALM project

H. Rumohr reported about the final phase of the EU-funded Quality Assurance project BEQUALM. This project aimed at QA and Quality Control of Biological Effects techniques similar to QUASIMEME in the field of chemical analysis. The final report is due at the end of April 2002 and the forthcoming self-funding phase is already planned and structured. The benthos community analysis work package organised an international ring test and a taxonomic workshop in Hamburg in 2000. As a teaching and training module, H. Rumohr demonstrated an interactive CD-ROM that was initially based on the ICES TIMES document 27 (1999). It contains images of the main sampling devices for benthos and teaching sequences covering sampling, sieving treatment of samples on board the ship and in the lab including quality assurance aspects. The CDROM is freely available for teaching and training purposes and will be part of the CD-ROM cassette coming with the final BEQUALM report. It can be also seen on the web page www.asa-multimedia.de/bequalm/start.htm. The future BEQUALM macrobenthos community analysis activities will be in close cooperation with the UK NMBAQC scheme, who already have seven years' of experience in this field.

K. Essink enquired as to when the BEQUALM report would be delivered and was informed that it was available now. A. Borja commented that there was a problem in Spain with benthic taxonomy in that they experience a general lack of taxonomic expertise in benthic taxonomy. H. Rumohr stated that this situation was mirrored all over Europe. Benthos taxonomy is regional; it is very difficult to work on material from outside your own area of work and expertise. L. Watling commented that there was no regionalism on how samples should be handled; these methods are applicable wherever a benthic study is taking place. The CD-ROM was considered a very useful advance on the Holme and McIntyre benthic methodology handbook.

11.2 Ring test experience

M. Zettler (Germany) presented the results of the Third National Macrozoobenthos Ring Test on "Determination of 30 Selected Macrozoobenthos Species from the North and Baltic Sea". The ring test was organised by the Quality Assurance Panel at the Federal Environmental Agency in 2001. The samples were prepared by an external expert. Fifteen participating laboratories in the German Marine Monitoring Programme (GMMP) took part. Selected species of Mollusca, Polychaeta and Crustacea had to be determined taxonomically. For data analysis purposes, two methods were tested: the method of Successful Hits considering defined categories and the Maximum-Likelihood-Method comparing automatic assessment of difficulties in species determination to laboratory assessment of difficulties in species determination. Two laboratories achieved completely correct results, whereas six laboratories made one or two mistakes. Only four laboratories succeeded in solving a problem of average difficulty to a degree of less than 80 %. The determination of *Parvicardium ovale*, *Spio martinensis*, *Sphaeroma hookeri* and *Gammarus oceanicus* was most problematic.

S. Cochrane commented that the results of this should be used as a starting point for the planning of the September workshop of the North Sea Benthos Project (NSBP) in Bremerhaven.

M. Zettler replied that the greatest problem encountered at present was to determine Oligochaetes correctly. K. Essink then asked why these 30 species were selected for use in the Ring Test. M. Zettler indicated that they were selected to try to represent fauna encountered in the Baltic and in the North Sea.

E Vanden Berghe asked whether there was a full report available and was told that the report on the Ring Test was available now.

11.3 Dutch experience with macrozoobenthos monitoring

K. Essink informed the BEWG of recent analyses of annual taxonomic lists resulting from the long-term Rijkswaterstaat macrozoobenthos monitoring programme of the Dutch Continental Shelf. Annual variations in taxonomic lists were found to be correlated with the names of people doing the species identifications. Differences in identification relate to, among others: 1) use of synonyms, 2) incorrect identification of juveniles, 3) mixing up of some difficult species, and 4) inconsistency in the notation of "spec", "indet" and "juv". Last week this matter was extensively discussed between responsibles of Rijkswaterstaat and the contracted institute, and first actions were defined for a "clean-up" of the data.

11.4 Other national QA/QC programme experiences

H. Rumohr informed BEWG of a ring test exercise in the UK AQC programme applying a CD-ROM for the identification of epifauna, using colour images of various epifauna species. The CD-ROM is available at JNCC, Peterborough, UK.

11.5 New developments in computer-based taxonomic identification aids, including the Web

K. Essink was informed by M. de Kluijver that a CD-ROM on identification of Crustacea is planned to be published later this year.

11.6 Digital identification key, developed under EC FAIR project CT 95-0817

I. Kröncke gave information on SID, a Species IDentification key for epifauna that was compiled during the EC project "Monitoring biodiversity in the North Sea using ground fish surveys" (FAIR-CT-0817). This identification key was compiled for use on board fisheries research vessels, especially for fisheries biologists to identify the by-catch of benthic invertebrates in bottom trawls.

The key contains about 120 epifauna species from the whole North Sea. Images are given for almost all species as well as basic information about biology and ecology. Special emphasis was put on "difficult" species like Anthozoa, Hydrozoa, Bryozoa and Porifera. But also common epifauna species from the North Sea are documented.

The key is available from Ruth Callaway (née Zühlke) at the University of Swansea, School of Biological Sciences.

12 LIST OF INFAUNAL AND EPIBENTHIC INVERTEBRATE SPECIES/TAXA THAT CAN BE MONITORED BY BEAM TRAWL AND ALLOW IDENTIFICATION OF ECOSYSTEM CHANGES IN BENTHIC COMMUNITIES [TOR:F]

K. Essink informed the BEWG that the Working Group on Beam Trawl Surveys (WGBEAM) deals with international collaboration in beam trawl surveys in the southeastern and central North Sea, the English Channel, the Celtic Sea and the Irish Sea.

Many invertebrates are caught as by-catch in these surveys. The level of sampling varies depending on the gear and type of vessel used, but the larger (epi)benthic invertebrates are generally all identified and their abundances recorded. The less frequently observed, and smaller, epibenthic species do not form part of the WGBEAM database, but standardised sampling methods for this part of the biota are now becoming established by the UK and the Netherlands.

There is still much that needs to be done by WGBEAM to set quality standards for species identification, and to describe the main species that need to be recorded with a view tomonitoring any ecosystem change in the benthic communities.

The Working Group on Beam Trawl Surveys (WGBEAM) had asked the Benthos Ecology Working Group (BEWG) to provide a list of infaunal and epibenthic invertebrate species that can be monitored with a beam trawl (as by-catch) and so allow identification of ecosystem changes in the communities impacted by the fishery. A comprehensive list of the families, genera and species encountered throughout the areas of interest, namely the English Channel, the Irish Sea and the southeastern and western central North Sea, was provided by WGBEAM.

A subgroup of BEWG was set up to deal with the request from WGBEAM.

After much discussion, the subgroup concluded that the list would need to be drastically reduced. The approach adopted was to pinpoint indicator species from both northern and southern waters that, in case any significant changes in abundance occur, would indicate changes in water temperature. Using T. Brattegard's data set as a reference for faunal geographical distributions, the molluscs, echinoderms, and the large decapods from the WGBEAM list were allocated to the following four categories:

Extreme Southern Species (**es**):	Do not occur on any Norwegian coasts;
Southern Species (**s**):	Northern border of occurrence is situated along the Norwegian coast;
Pan-Norwegian Species (**x**):	Northern border lies north of Norwegian coasts and southern border to the south;
Northern Species (**n**):	Southern border of occurrence is situated along the Norwegian coast.

The species allocated to these categories were further distilled down to 14 species that could be used as sensitive indicators of persistent water mass changes (such as due to inflow of southern or northern water masses) in the areas of interest. In Annex 12, the original species list provided by WGBEAM is presented with annotations regarding geographic grouping (**es-s-x-n**) and sensitivity as an indicator of persistent water mass change (last column).

For example, the disappearance of the bivalve *Mya truncata* mollusc from northern areas of the North Sea would indicate a persistent increase in water temperature. In contrast, an increase in numbers of hermit crab *Pagurus pubescens* would imply a reduction in average water temperatures.

It was stressed that any ecosystem change associated with fishing pressure from beam trawling would be apparent in changes in size composition rather than in species composition. This will require size measurements to be made in order to allow relevant interpretations.

BEWG realises that the above reply to WGBEAM has a number of limitations. These are related to the generality of the question posed, and the absence of more detailed information. WGBEAM should realise that:

- Different configurations of beam trawls can have variable effects on the catchability of epifauna. If different fishing gears are employed in the southeastern and central North Sea, the English Channel, the Celtic Sea and the Irish Sea this will have implications for the monitoring potential of the species annotated in Annex 12.
- Mesh size has considerable size-selective effects on the by-catch. So, different mesh sizes used in different bottom trawls and areas will have consequences for the monitoring potential of the species annotated in Annex 12.
- The list of organisms provided by WGBEAM contains duplications, many errors in spelling and in taxonomic status. For monitoring purposes, an up-to-date list with verified species names would be required.
- BEWG has now interpreted the term "ecosystem changes" mainly as changes in water mass distribution. Any further specification of this term may provide opportunities to propose specific indicators among the by-catch.

13 REVIEW OF STUDIES ON ECOLOGICAL QUALITY OBJECTIVES FOR THE NORTH SEA WITH REGARD TO: (I) NUTRIENTS AND EUTROPHICATION EFFECTS AND (II) BENTHIC COMMUNITIES [TOR: G]

Under ToR (g) the BEWG was requested to review studies under way on ecological quality objectives for the North Sea with regard to:

i) nutrients and eutrophication effects; and

ii) benthic communities.

ICES had received an additional request from OSPAR to assess the data upon which an initial list of species and habitats in need of protection measures has been based. The purpose of this assessment is *"to ensure that the data used (…) is sufficiently reliable and adequate to serve as a basis for conclusions that the species and habitats concerned can be identified (…) as requiring action in accordance with the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area"*.

The ICES Management Committee for the Advisory Process (MCAP) considered this request at its meeting on 22–24 January 2002 and decided in principle to accept the request. Subsequently, BEWG received a request from the Chair of the Advisory Committee on Ecosystems (ACE) to assess the benthic invertebrates included in a draft OSPAR priority list of threatened and endangered species and habitats and the data relating to them. The basis for inclusion of species in this priority list should be consistent with the "Texel-Faial criteria".

A subgroup was formed to carry out the above tasks. The review of the BEWG is as follows.

13.1 Changes/kills in relation to eutrophication

For the above ecological quality element, the following Ecological Quality Objective (EcoQO) has been proposed:

There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.

BEWG expressed doubts as to the unquestionability of the causal relationship between algal blooms (of toxic and/or non-toxic species) and eutrophication. Indeed, increased frequency of occurrence of phytoplankton blooms has been documented over a long period of time. However, strong evidence that this increase in blooms is fully or largely of anthropogenic origin is missing. Nutrient enrichment is accepted as a potential cause, as indicated in the schematic presentation of cause-effect relationships (see Annex 13), but there is no proven clear-cut direct causal relationship. The effects, if any, will also be dependent on other factors, such as local or regional hydrographic conditions.

Local oxygen deficiencies and associated kills of zoobenthos may occur as a result of natural processes, especially in shallow and semi-enclosed water bodies. In this respect, the scale of occurrence of oxygen deficiencies is of importance, both temporally and spatially.

As this EcoQO is meant to be operational, the main problem is that these oxygen deficiencies and benthos kills are not uniquely related to anthropogenic influence. There may be natural causes as well, which do not necessarily require managerial actions to be taken.

A final disadvantage to operationalise this EcoQO is that it very much resembles a "post-mortem" statement. In other words, when the observation of oxygen deficiency or zoobenthos kill is being made, it is too late to take action. Operationality should, in this case, be more at the beginning of the cause-effect chain involved.

13.2 Imposex in dogwhelks (*Nucella lapillus*)

For the above ecological quality element, the following Ecological Quality Objective (EcoQO) has been proposed:

A low (<2) level of imposex in female dogwhelks, as measured by the Vas Deferens Sequence Index (VDSI).

The BEWG does not know of additional information. The justification as given by OSPAR is accepted.

It was mentioned that in the meantime measures to reduce the use of organotin products have been agreed, which will become effective in a number of years. Therefore, the VDS Index may be used to check the effectiveness of these measures.

The dogwhelk does not occur everywhere. Therefore, it is advised to apply placing dogwhelks as test organisms at selected places for monitoring purposes as an addition to regular monitoring of native populations.

It was advised to explore the operational use for the same purpose of other gastropods, such as the whelk (*Buccinum undatum*) and the periwinkle (*Littorina littorea*).

13.3 Density of sensitive (e.g. fragile) species

By OSPAR, the EcoQO has been described as:

Maintain or restore populations of sensitive indicator species

This is because fragile species would be the first to disappear due to mechanical disturbance of the seabed, especially by towed fishing gears. As examples of such fragile species, the heart-urchin (*Echinocardium cordatum*) and the helmet crab (*Corystes cassivelaunus*) are given.

BEWG commented that *Echinocardium cordatum* can be considered as fragile, but at the same time it is capable of an opportunistic response, resulting in a quick recovery of abundances.

The formulation of the EcoQO suggests—be it implicitly—that there would be a "normal" density to be aimed at. BEWG is of the opinion that it is not easily possible to define such a "normal" density, nor is it easy to state what density or densities could be used as a baseline, as the abundance of species will show natural spatial variation.

The nomination of further indicator species as being fragile for mechanical disturbance needs to be based on knowledge gained from long-term observations as well as on autecological studies. These both are scarce.

BEWG is of the opinion that this EcoQO will not be easily operational for more localised seabed disturbances due to other human activities such as sand extraction, or pipeline laying. An example may be the removal of sea pens due to fishing for *Nephrops norvegicus.*

13.4 Density of opportunistic species

By OSPAR, the EcoQO has been described as:

Maintain or representative (low) abundance of opportunistic species

This is because some species have been observed to show a so-called opportunistic response to physical disturbance of the seabed. These species are characterised by a short generation time and a high reproductive potential. Some examples are the polychaete worms *Spio filicornis, Owenia fusiformis* and *Magelona* sp.

BEWG stressed that opportunistic species generally show a rather short-lived response to physical disturbance. Such a response may follow up on an anthropogenic as well as a natural disturbance of the seabed. From sampling the benthos, and assessing the densities of the species alone, it will not easily be possible to discriminate between these two.

The nomination of further indicator species as being opportunistic and suitable for indication of physical disturbance of the seabed needs to be based on knowledge gained from long-term observations as well as on autecological studies. Such data are scarce. Moreover, it should be given attention that some species listed as opportunistic may show a different response under different conditions. If this is known of a species, the species will not be well suited as an indicator for the EcoQO concerned.

13.5 Benthic invertebrates as included in a draft OSPAR priority list of threatened and endangered species

The information on the invertebrates on the draft OSPAR list, as presented in the OSPAR document BDC 01/4/1-E, was reviewed. BEWG gave the following general comments and evaluation.

Composing a list of species, such as now under consideration, should be based on extensive biogeographical information on the respective species. It is necessary to have good knowledge of the geographical distribution of the species, and of the areas where it is threatened or declining, and where it is not. Also needed is a good long-term documentation of any decline; a conclusion on decline may not be based on limited information regarding spatial and temporal dynamics of the populations involved. Special care is required for any conclusion regarding decline of species in areas at the border of its geographical distribution range.

With respect to the listed invertebrate species, the following comments apply:

Megabalanus azoricus

There was no expertise in BEWG regarding this barnacle species.

Patella ulyssiponensis aspera

With respect to this subspecies of limpet, no expertise was available in BEWG either. It was noted, however, that the species *Patella ulyssiponensis* is abundant in the Cantabrian Sea (Northern Spain) as well as along exposed Norwegian shores. This may indicate that decline in this species may be rather local. More information on the wider occurrence and development of the subspecies is therefore needed.

***Arctica islandica* (Ocean quahog)**

BEWG agrees that this species is impacted by bottom trawling fisheries. The decline reported by Witbaard and Klein (1994) is acknowledged, but there is no indication that the entire population of this long-lived bivalve species is threatened. For instance, there is no decline in the Baltic Sea. The species is common along the Norwegian coast. The threat due to bottom trawling is to a large extent of a regional nature.

There is, however, a possible point of concern, because for many years recruitment did not occur in the North Sea. This may be a signal. There is, however, no clue as to the cause. One might think of climate change. BEWG concluded that recruitment biology of this species should be studied in order to find possible explanations.

Additional reference

Witbaard, R., and Klein, R. 1994. Long-term trends on the effects of the southern North Sea beamtrawl fishery on the bivalve mollusc *Arctica islandica* L. (Mollusca, bivalvia). ICES Journal of Marine Science, 51: 99–105.

***Nucella lapillus* (Dogwhelk)**

BEWG is in support of the argumentation given with respect to TBT and related compounds. However, there is some reason for caution, as this species does not seem to be declining or threatened along the French coast of the eastern Channel. There is some doubt that the decline mentioned at Helgoland still exists.

In Belgium the species became practically extinct by 1987. Any recovery will be slow due to the absence of pelagic larvae and still too high TBT concentrations. *N. lapillus* is reduced in the Skagerrak and in Icelandic harbours.

***Ostrea edulis* (Flat oyster)**

The information presented is accepted by BEWG. This species also shows a decline along the Galician coast and in the Bay of Biscay. This is due to competition with other oysters of the genus *Crassostrea*, and parasite infection.

There may be some signs of recovery, e.g., in the outer Skagerak area, and along the Belgian and Normandy coast, where occasionally specimens are found.

In conclusion, BEWG is of the opinion that the invertebrate species listed should be considered as preliminary. Systematic inspection of data on geographical distribution and abundance (and changes therein) should be carried out for many species. This may lead to more species to be included on the OSPAR list. An example of such a species to be added to the list would be the bivalve *Scrobicularia plana*, which has shown a decline in Baltic and North Sea waters, and the Bay of Biscay in the last 20 years. In contrast, the species has been increasing along the Norwegian coast.

14 VARIABILITY IN REFERENCE SITES IN BENTHIC MONITORING PROGRAMMES [TOR:H]

The Working Group on Effects of the Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) had requested BEWG to consider the variability in some reference sites in benthic monitoring programmes with a view to developing a better understanding of the observed variability. WGEXT, however, did not make reports available providing working material, nor was the request further elaborated.

Members of BEWG gave the following presentations that relate to variability in reference sites.

Effect of migrations of the bivalve *Macoma balthica*

J. G. Hiddink gave an account of the effect of migrations of an intertidal bivalve on its abundance.

Many benthic intertidal species redistribute somewhere during their life history. These migrations can have large effects on the local, but also on the large-scale, abundance of a species. In this talk, the effect of pelagic migration on abundance of *Macoma balthica* on the tidal flats of the Wadden Sea will be examined. *Macoma* settles on low tidal flats and subsequently migrates to high tidal flat nurseries, as postlarvae. After 7–9 months, the juveniles migrate back to the low intertidal and North Sea. Due to these migrations, density decreases at some stations, while it increases at others; mortality and primary settlement alone (as one would assume if no knowledge on the biology of the species was available) cannot explain these density changes.

The mortality of the whole *Macoma* population was higher during both the spring and winter migrations than outside these migration periods, even at a large-scale with many sampling stations. This increased mortality may be explained by increased predation on pelagic, as compared to buried, bivalves by fish and crabs, as was found in laboratory experiments. Additionally, many animals may "disappear" from the population because they end up in unsuitable locations (e.g., on the saltmarsh).

In conclusion, because of migrations of benthic animals, for good abundance estimates many stations should be sampled, spread over the whole area of interest. Furthermore, it is important that the migratory behaviour and possibly associated increased mortality rates of examined species are known. Effect studies should preferably not be undertaken during migrations, because redistributions and increased mortality may easily obscure treatment effects.

References

Hiddink, J. G., and Wolff, W. J. (In press) Changes in distribution and decrease of numbers due to migration of the bivalve *Macoma balthica*. Marine Ecology Progress Series.

Hiddink, J. G., Kock, R. P., and Wolff, W. J. (In press) Active pelagic migrations of the bivalve *Macoma balthica* are dangerous. Marine Biology.

M. Zettler asked whether these molluscs only migrate during first year of life. Do adults still retain the ability to migrate? G.J. Hiddink said that he has only seen migrating animals up to one year old.

H. Rumohr remarked that settling larvae of *Arctica* have a long byssus thread when they settle. This is how they attach to the bottom. *Ensis* also employs this method, as do most bivalves. L. Watling wanted to know what the benefit is of the upper intertidal nursery areas. Migration from this area may be food driven. Hiddink replied that this is mainly to avoid shrimp predation on the very small *Macoma*. K. Essink said the high intertidal may experience a temperature regime that triggers migration. According to J.G. Hiddink, parasitism and bird predation probably drive the migration of the larger individuals down from the upper intertidal.

14.1.1 Variability in reference site in benthic monitoring programmes

J. van Dalfsen illustrated the importance of references stations or reference areas in impact studies using results from several benthic effect studies conducted in the North Sea, such as RIACON (effects of shoreface nourishment and sand extraction), Punaise*3 (effects of sand extraction near the coast), and from the Macrozoobenthic Monitoring Programme of the Dutch Continental Shelf.

The following conclusions were drawn:

- Selection of an area that could function as a reference for an impacted area has to be done with care. A reference site should have seabed and hydrodynamic conditions comparable to the impacted site as well as a comparable benthic community;

- Variation in benthos can occur on species level, group level and community level, but scale variability (locally, regionally) and variation over time (seasonal, annual or longer periods) is not uncommon. These factors may all influence community structure and influence the results of a single survey, providing only information from a single point in time and space. This has to be taken into account when conducting impact studies.

Therefore, it is very important to conduct the monitoring surveys in parallel in both impacted and reference sites in order to be able to include any natural variation occurring within the area studied.

Recovery of the benthic community of an area after impact does not necessarily imply a return to the original state present before the impact. Deviations from the starting point due to natural variation are often the case. The importance in measuring recovery is that no differences are found between impacted and reference sites both in community structure as well as in behaviour in terms of species diversity, abundance and biomass.

References

van Dalfsen, J.A., Essink, K., Toxvig Madsen, H., Birklund, H., Romero, J., and Manzanera, M. 1999. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the western Mediterranean. ICES Journal of Marine Science, 57: 1439–1445.

van Dalfsen, J.A., and Lewis, W. E. 2001. PUNAISAE*3. Lange-termijn effecten op de bodemfauna van een tijdelijke zandwin/overslagput in de kustzone ter hoogte van Heemskerk (NH). TNO Milieu, Energie en Procesinnovatie, den Helder. TNO-Rapport R 2001/494.

H. Hillewaert noted that in the Punaise study the reference and impacted communities were possibly different populations even before the disturbance event. MDS plots of the species composition and abundance may also show effects of factors other than the disturbance by sand extraction. J. van Dalfsen replied that, in this specific study, there were large numbers of *Ensis americanus* in the baseline observations. These had totally disappeared after the disturbance event.

L. Watling disagreed with the speaker with regard to the necessity of more than one baseline survey. A long baseline is not needed to interpret the observed benthic community shifts. These shifts can be due to natural cycling and long-term population changes. This means that the populations will be moving all around the MDS plot naturally. The trajectory of successive surveys over an MDS plot may therefore also be interpreted as the effects of, e.g., temperature and seasonality. Reference sites must be sampled constantly, i.e., in complete parallel with the impacted sites. There will be recovery of the site as soon as the impacted and reference areas start "wandering" over the MDS plot close together again; whether this is on the same spot where they started from is not really relevant. J. van Dalfsen answered that in the reported studies the reference sites were always sampled at every occasion when the impacted site was sampled. This is an example where the populations after 4 years just happened to return to an almost identical community.

K. Essink remarked that patchy distributions of species may require adjustments of sampling regimes. E. Rachor wondered whether fisheries have had any impact on the bivalve populations. J. van Dalfsen did not think that fisheries have had any impact. But there is a good argument for the creation of unfished reference sites.

BEWG drew the following conclusions:

- In impact studies, reference areas should cover relative large areas including sources as well as sinks for any migrating species. Moreover, in the sampling programme periods of known migratory activity should be avoided;

- Impact studies need to be long-term to enable a reliable assessment of the impact and of the recovery after impact;

- Reference areas need to be studied in full parallel with the impacted area as the benthic community in the reference area may develop due to natural processes;

- Recovery of impacted areas must be assessed against reference areas after impact, and not against the (reference) situation before impact;

- In specific locations, reference areas should be free of human activities (e.g., fishing) in order to facilitate proper impact/recovery assessment;

- In specific locations with patchy benthos distribution, special attention is needed for a sampling strategy that guarantees "representative" sampling in both the impacted and reference areas.

15 ANY OTHER BUSINESS

15.1.1 The Huntsman award

Last year BEWG nominated T. H. Pearson as recipient for the Huntsman Award 2002. However, it was awarded to Dr David M. Karl, Professor of Oceanography at the University of Hawaii in Honolulu. The 2003 Huntsman Award is to be presented in the field of Marine Geosciences, so BEWG decided to make no nomination this year.

15.1.2 ICES Biological Community Data Reporting

J. N. Jensen gave an account of ICES Biological Community Data Reporting.

L. Watling asked whether there were any future plans to link these data to geo-referenced systems such as ArcView. J. Jensen replied that this was being considered but ICES still had still to decide on acceptable formats. Discussions are ongoing regarding data exchange problems. However, faunal data can be passed on now as comma-separated ASCII files.

15.1.3 ICES meetings and other symposia

Attention was drawn to the following meetings of interest:

- 37th European Marine Biology Symposium "Migrations and dispersal of marine organisms", 5–9 August 2002, Reykjavik, Iceland. Info: www.37embs.is.

- 2002 ICES Annual Science Conference, 1–5 October 2002, Copenhagen, Denmark.

- "Colour of Ocean Data": a Symposium on Oceanographic Data and Information Management with special attention to Biological Data, 25–27 November 2002, Brussels, Belgium. Info: www.vliz.be

- Symposium on the effects of fishing activities on benthic habitats: linking geology, biology, socioeconomics, and management, 12–14 November 2002, Tampa-St. Petersburg, Florida, USA. Info: http://walrus.wr.usgs.gov/bh2002 or benthic@esa.org

- In spring 2003 a BIOFAR conference will be held on the Faroe Islands. Info: www.biofar.fo

15.1.4 Publications of interest

Self, R.F.L. *et al.* 2001. Effects of macrofauna on acoustic backscatter from the seabed: field manipulations in West Sound, Orcas Island, Washington USA. J. Mar. Res, 59: 991–1020.

Ysebaert, T. *et al*., 2002: Macrobenthic species response surfaces along estuarine gradients: prediction by logistic regression. Mar. Ecol. Progr. Ser., 225: 97–108.

Herman, P.M.J. *et al.* 1999. Ecology of estuarine macrobenthos. Adv. Ecol. Res, 29: 195–240.

Ysebaert, T., and Herman, P.M.J. 2001. Scale-dependent prediction modelling of estuarine benthic community structure. Progress Report November 2001, Neth. Inst. Ecol., Centre Est. Coast. Ecol., Yerseke, Netherlands.

15.1.5 Effects of fish farms

A new EU project has been launched, entitled "Effects of nutrient release from Mediterranean fish farms on benthic vegetation in coastal ecosystems (MedVeg)", which will deal with the effects of nutrient release from Mediterranean fish farms on benthic communities. The project is coordinated by Prof. Marianne Holmer, University of Southern Denmark, Odense. Details can be found on www.medveg.dk.

15.1.6 Benthic landers, Autonomous vehicles

In April 2001, a meeting was held in Aberdeen, with local organisers M. Priede and M. Solan, discussing aspects of benthic research, deep-sea landers and autonomous vehicles. A special volume of the Journal of the Marine Biological Association dedicated to this meeting will be published soon.

K. Essink informed BEWG of the development of a novel Mobile Lander for Autonomous Monitoring and Sampling of the seabed environment, called SEABEE. Further information is available in Annex 14. For further information, contact: wernerus @corsecologie.com.

15.1.7 Wind farms

H. Rumohr mentioned wind farms as being a new issue in coastal development, requiring Environmental Impact Assessment. He stressed that all data held on this topic should be held on one database and quality checked. This information should be made easily available in order to prevent inventing the wheel over and over again. Further to this, the Dutch, Belgian, Polish, German, French and Danish BEWG members stated that wind farms were being built in their areas of interest. However, data were not easily obtainable. H. Rumohr agreed to follow all this information up and possibly coordinate BEWG efforts.

15.1.8 eSeFDee marine science portal

H. Hillewaert took the opportunity to mention the eSeFDee marine science internet portal which lists and provides links to up to 1000 institutes operating in a wide variety of subject areas in marine science. He also put forward the idea that BEWG should create a website and he also volunteered to webmaster the site. This proposal was gladly accepted.

15.1.9 ISO standards in benthic research

S. Cochrane mentioned the work on orientation and development of standards in benthic research run under the auspices of ISO. Representatives of the BEWG should be contacted by their national ICES representatives regarding this initiative; however, if this does not happen, contact S. Cochrane who will provide information.

16 RECOMMENDATIONS AND ACTION LIST

16.1 Nomination for the new Chair

The second term of the Chair, K. Essink, ends in 2002. He is not available for a next term.

A three-round voting process, involving all BEWG members present at the meeting, was performed. This resulted in two final candidates, of which Dr H. Rumohr, with 15 against 6 votes, was nominated as next Chair. This nomination needs to be endorsed by the Marine Habitiat Committee, the Consultative Committee, and the ICES Council at their meetings in October 2002 .

16.2 Recommendations for the 2003 BEWG meeting

After having discussed three offers for hosting the 2003 meeting, the BEWG recommended to have its next meeting in the Smithsonian Marine Institute, Fort Pierce, Florida from 28[t] April to 1 May 2003. B. Tunberg will act as local organiser.

For the proposed Terms of Reference and their justification, see Annex 15.

16.3 Recommendation for a 2003 ASC Theme Session

BEWG recommends having a Theme Session on "The role of benthic communities as indicators of marine environmental quality and ecosystem change" at the 2003 Annual Science Conference. Such a Theme Session will allow synthesis of state-of-the-art knowledge, which will contribute to the further development of operational ecological quality objectives for marine benthic communities. It provides a follow up of the 5th International North Sea Conference (Bergen, March 2002) and is relevant to OSPAR and HELCOM.

BEWG proposes that H. Rumohr (BEWG) and C.F.L. Frid (WGECO) act as Co-conveners for this Theme Session.

This recommendation is included as proposed Terms of Reference (b) in the recommendation for the 2003 BEWG meeting (see Annex 15).

16.4 Recommendation for a publication of a TIMES report

The BEWG recommends publication of the draft report "Guidelines for the Study of the Epibiota of Subtidal Environments", after finalisation by Dr H. Rees, in the ICES TIMES series (see Annex 15).

16.5 Action List for the 2003 BEWG meeting

The following BEWG members agreed to report on the following issues (list not exhaustive!):

1.	Eike Rachor	Possible marine protected areas in the German Exclusive Economic Zone of the North Sea;
2.	Jan Warzocha	Studies on structure and long-term development of macrofauna in the Gulf of Gdansk;
3.	Mike Robertson	FRS benthic surveys in the North Sea;
4.	Bjorn Tunberg	Ecological assessment in the Indian River Lagoon, eastern Florida;
5.	Les Watling	Application of landscape ecology methods to the subtidal benthos;
6.	Ingrid Kröncke	Macrofauna - micro-organism – food relationships in the North Sea;
7.	Jan van Dalfsen	Progress in development of BEAST;
8.	J.-M. Dewarumez/Nicolas	Desroy Impact of *Phaeocystis* bloom on benthic communities in the eastern Channel;
9.	Santiago Parra	Final results of spatial/temporal distribution of infaunal subtidal communities in Ferrol Bay;
10.	Santiago Para	Preliminary data on hyperbenthos in La Coruña Bay;

11. Steven Degraer Preliminary results of ecosystem effects of sandy beach replenishment;

12. Steven Degraer Remote sensing of benthic communities with acoustic techniques (Belgian Cont. Shelf);

13. Fritz Gosselck Macrozoo- and phytobenthos of bays and lagoons of the German Baltic coast;

14. Fritz Gosselck Monitoring of macrozoobenthos in the Mecklenburg and Pommeranian Bay;

15. Michael Zettler Macrozoobenthos database for German Baltic waters;

16. Michael Zettler First results of impact studies of wind farms on macrozoobenthos.

17 REPORT OF THE MEETING

17.1 Adoption of the report

The draft report was briefly reviewed by the group. Several small amendments were made. K. Essink agreed to have a final look at the text and to add an Executive Summary. He will also take care of timely submitting the draft report to the ICES Secretariat, with a copy to the participants of the meeting.

17.2 Executive Summary

The Benthos Ecology Working Group (BEWG) met at Tromsø, Norway, from 24–27 April 2002. There were 28 participants representing Belgium, Canada, France, Germany, the Netherlands, Norway, Spain, United Kingdom, and U.S.A. The following issues were covered.

Guidelines for epibenthos sampling [ToR: a]

Due to illness of coordinating author H. Rees, the final draft of this document, to be published in the *ICES Techniques in Marine Environmental Sciences* (TIMES) series, could not be completely finalised. Some sections need yet to be completed. A draft resolution was prepared for the formal procedure of publishing this document in the ICES TIMES series.

North Sea Benthos Project [ToR: b]

Intersessionally, a workshop was held in January 2002 at Oostende, Belgium, where the information available to the project and protocols for data exchange were discussed, and agreement was reached on data structures and conditions for the release of data. Since then, additional national data sets have been made available to the data manager of the project. During the meeting, additional UK data were identified that need to be included in the project.

Progress was made in checking of taxonomic lists of the different data sets supplied to the project. Much inconsistency, however, still needs to be solved. The same holds for the proper allocation of feeding types, life strategies, etc., to species. And a website will be made, initially for communication purposes. On database matters there is continued communication with J.N. Jensen of ICES.

A next workshop of participating scientists was agreed to be held in Wilhelmshaven in November 2002, at the Alfred Wegener Institute.

Because of the stepping down of K. Essink as Chair of BEWG and convener of the project, a steering group was chosen to continue his coordinating activities in the project.

Review of studies on northern seas in comparison with, e.g., North Sea and Baltic Sea [ToR: c]

There were a limited number of presentations on studies in North Sea and Arctic waters; no presentations on the Baltic Sea. Few really comparative studies had been carried out.

A common point of interest in these studies is the issue of climatic change, and its possible influence on distribution of different water masses and on the benthic system in different basins. In relation to this, the exchange of species between warmer and colder waters (e.g., between Pacific and Arctic Oceans) may have large impact on the functioning of the ecosystem and fisheries, as shown for the case of the range expansion of the Red King Crab (*Paralithodes camtschaticus*).

Development of a Theme Session for the 2003 Annual Science Conference [ToR: d]

A Theme Session was proposed on "The role of benthic communities as indicators of marine environmental quality and ecosystem change". This subject will allow the synthesis of state-of-the-art knowledge, which will contribute to the further development of operational ecological quality objectives for marine benthic communities. This is relevant for application in the context of the EU Habitats Directive, the EU Water Framework Directive, and OSPAR and HELCOM Conventions. There will be a great demand for operational indices, performance indicators, metrics for ecological quality of the benthic system, since the 5th North Sea Conference (Bergen, March 2002).

Dr H. Rumohr (BEWG), and Dr C. Frid (WGECO) are nominated as Co-convenors.

Review of further needs for Quality Assurance [ToR: e]

Experience with the BEQUALM project and other ring tests was reviewed. These activities are considered a useful QA activity. Only in a few countries is good performance in ring tests effectively used to control the quality of (commercial) laboratories carrying out monitoring programmes. Certification of laboratories in the field of taxonomic expertise is not yet a commonly accepted issue.

The Species Identification (SID) key developed for epifauna sampled with bottom trawls is a new tool to improve the taxonomic quality of epifauna monitoring by non-benthos specialists.

List of infaunal and epibenthic invertebrate species/taxa that can be monitored by beam trawl [ToR: f]

On request of the Working Group on Beam Trawl Surveys (WGBEAM), a preliminary list of 14 species was compiled that can be used as sensitive indicators of persistent water changes, such as due to inflow of southern (warmer) or northern (colder) water masses.

For monitoring the effects of fishing pressure, changes in size composition rather than in species composition can be used as an indicator.

The practicality of using these indicator species and size distributions, however, is limited due to the use of different fishing gear configurations in different areas and periods.

Review of studies on Ecological Quality Objectives (EcoQOs) for the North Sea [ToR: g]

BEWG commented on a number of proposals as developed under the auspices of OSPAR. These were the following:

- No kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton blooms

This EcoQO was not considered operational, firstly because it resembles a "post-mortem" statement, and secondly because oxygen deficiency and toxic phytoplankton blooms are not uniquely related to human influence.

- A low (<2) level of imposex in dogwhelk (*Nucella lapillus*)

BEWG agrees. However, as the dogwhelk does not occur everywhere, alternative approaches may be necessary to operationalise this EcoQO (e.g., use of test specimens or other gastropod species).

- Maintenance or restoration of populations of sensitive (e.g., fragile) indicator species

BEWG is of the opinion that it is not easily possible to define such a "normal" density, nor is it easy to state what density or densities could be used as a baseline, as the abundance of species will show natural spatial variation.

The nomination of further indicator species as being fragile for mechanical disturbance needs to be based on knowledge gained from long-term observations as well as on autecological studies. These are both scarce. The heart urchin *Echinocardium cordatum* can be considered as fragile, but at the same time it is capable of an opportunistic response.

This EcoQO will not be easily operational for more localised seabed disturbances, e.g., sand extraction, or pipeline laying.

- Maintenance or low abundance of opportunistic species

BEWG stressed that opportunistic species generally show a rather short-lived response to physical disturbance, either anthropogenic or natural. Discrimination will not be easily possible using only benthos data.

The nomination of further indicator species as being opportunistic and suitable for indication of physical disturbance of the seabed needs to be based on knowledge gained from long-term observations as well as on autecological studies. Such data are scarce. Some species listed as opportunistic may show a different response under different conditions. In such a case, the species will not be well suited as an indicator for the EcoQO concerned.

Benthic invertebrates as included in a draft OSPAR priority list of threatened and endangered species [added ToR]

BEWG did not have expertise to comment on all species on the list. In some of the cases, the inclusion of species on the list seems to be based on limited biogeographical information. BEWG concluded that the list of invertebrate species should be considered as preliminary. Systematic inspection of data on geographical distribution and abundance (and changes therein) should be carried out for many species. This may lead to more species to be included on the OSPAR list, e.g., the bivalve *Scrobicularia plana*, and will it clearer in what area and due to which cause(s) a species is threatened or declining.

Variability in reference sites in biological monitoring [ToR: h]

After having reviewed a few studies, BEWG concluded that in monitoring programmes for impact assessments, the following should be taken into consideration:

- In impact studies, reference areas should cover relative large areas including sources as well as sinks for any migrating species. Moreover, in the sampling programme periods of known migratory activity should be avoided;

- Impact studies need to be long-term to enable a reliable assessment of the impact and of the recovery after impact;

- Reference areas need to be studied in full parallel with the impacted area as the benthic community in the reference area may develop due to natural processes;

- Recovery of impacted areas must be assessed against reference areas after impact, and not against the (reference) situation before impact;

- In specific locations, reference areas should be free of human activities (e.g., fishing) in order to facilitate proper impact/recovery assessment;

- In specific locations with patchy benthos distribution, special attention is needed for a sampling strategy that guarantees ‘representative’ sampling in both the impacted and reference areas.

18 CLOSING OF THE MEETING

K. Essink officially closed the BEWG meeting on Saturday 27 April at 12.15 hrs.

Thanks were transferred to Merete Stefanussen for all her hard work in the background, to Salve Dahle and Sabine Cochrane for the organisation of the meeting and to Akvaplan-niva for the provision of excellent meeting facilities.

On behalf of the BEWG, Salve Dahle rendered thanks to Karel Essink for all his work over six years as Chair of the BEWG and presented a book as a small token of the BEWG’s appreciation.

Most of the BEWG stayed on to enjoy the last dog sledge ride of the season or fishing in Tromsøysund. The latter provided ingredients for a rich fish soup that, along with various drinks, formed the informal closure of the meeting at the private home of one of the local organisers.

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ANNEX 2: AGENDA

Annotated agenda

1. Opening and Local Organisation

2. Appointment of Rapporteur

3. Terms of Reference

4. Adoption of Agenda

5. Report on ICES meetings and other meetings of interest

- ASC 2001 (Oslo) / ICES Annual Report for 2001
- Marine Habitat Committee, Oslo 2001
- Report of the ICES Advisory Committee on Ecosystems, 2001 (Coop. Res. Rep. 249)
- SGQAE/SGQAB meeting, 19-22 February 2002, Copenhagen (H. Rumohr)
- WGMHM meeting, 2-5 April 2002, San Sebastian (H. Rumohr)
- WGITMO meeting, 20-22 March 2002, Göteborg
- WGEXT meeting , 9-13 April, Boulogne-sur-Mer (J. van Dalfsen/H. Hillewaert)
- 6th Conference of Parties to the Convention on Biological Diversity (K. Essink)
- ICES Marine Data Management Group, 17-19 April, Helsinki (W. Vanden Berghe)

6. Report of cooperative studies and other studies relevant to ICES (incl. Action List of 2001 BEWG meeting)

6.1. Cooperative studies

- SG on Mapping the Occurrence of Cold Water Corals
- Effects of extraction of marine sediments on the marine ecosystem (Coop. Res. Rep. 247)

6.2. Benthos and fisheries

- *Spisula*: habitat preferences, surveys, fishery (J. Craeymeersch)
- Outcome of EU PESCA project (H. Rumohr)
- Effect of King Crab on Scallop beds (L.L. Jorgensen)

6.3. Benthos of soft sediments

- North Sea epifauna sampling by FRS in 2001 (M. Robertson)
- Macrobenthic community structure[….] Belgian Continental Shelf (G. Van Hoey)
- Progress in Friese Front studies (G. Duineveld)
- Progress on BEAST (J. van Dalfsen)
- Recent drastic changes in the soft-bottom macrofauna assemblages above the halocline in the Gulf of Gdansk (southern Baltic proper) (J. Warzocha)
- French benthic research (J. Dewarumez)
- Benthic studies in Ferrol Bay, NW Spain (S. Parra)
- Benthic monitoring 1998-2001 in the Basque coast (N. Spain) (A. Borja)
- Benthic research and monitoring at the Smithsonian Institution (B. Tunberg)
- Other US benthic studies (L. Watling)

6.4. Benthos of rocky substrates

- Mapping of benthos along the Norwegian coast (T. Brattegaard)

6.5. Assessment of marine quality

- The use of a marine biotic index (Borja) see: Mar. Pollut. Bull. 40: 1100-1114 (2000)
- Ecological monitoring of anthropogenic perturbations of the sea (H. Hillewaert)
- Ecological assessment and biodiversity of the Indian River Lagoon (B. Tunberg)

7. Guidelines for epibenthos sampling and community description [ToR: a]

- Status and what still to be done (H. Rees)
- Proposal for TIMES report according to ICES procedure
- Status of IBP Handbook on Benthos Methods, 3rd edition (Heip *et al.)*
- Other matters

8. Progress of the North Sea Benthos Project, incl. first results of data analysis [ToR: b] [See guidance document]

- Progress report (E. Vanden Berghe)
- Gaps Scottish/UK waters (M. Robertson/P. Kingston)
- Planning of workshop in Bremerhaven, autumn 2002
- Organisational aspects (K. Essink)

9. Review of studies in northern seas in comparison with e.g., the Baltic Sea and North Sea – ecosystem functioning, human impacts, criteria for ecosystem health, gaps in knowledge [ToR: c]

- Benthos studies in the White Sea (E. Rachor)
- Long-term monitoring of rocky bottom biotopes using image analysis (F. Beuchel)
- BIOMARE (S. Cochrane)
- Norwegian studies in North Sea and Arctic waters (Dahle)
- Benthic communities in the deep Eurasian Arctic ocean (Kröncke)
- Trajectories of marine ecosystem response to Arctic climate change (M. Carroll)

10. Development of Theme Session for ASC 2003 or 2004 – the role of benthic communities as indicators of marine environmental quality [ToR: d] [See guidance document]

11. Review of further needs for Quality Assurance in benthic monitoring and research [ToR: e]

- outcome of BEQUALM project (H. Rumohr)
- Ring test experience (M. Zettler)
- Dutch experience with macrozoobenthos monitoring (K. Essink)
- Other national QA/QC programme experiences
- Digital identification key, developed under EC FAIR project CT 95-0817 (I. Kröncke)

12. List of infaunal and epibenthic invertebrate species/taxa that can be monitored by beam trawl and allow identification of ecosystem changes in benthic communities [ToR: f] [See guidance document]

13. Review of studies on ecological quality objectives for the North Sea with regard to:

i) nutrients and eutrophication effects
ii) benthic communities [ToR: g]
[See guidance document]

- Extra: Request from OSPAR on threatened and declining invertebrates

14. Variability in reference sites in benthic monitoring programmes [ToR: h]
[More guidance is expected from WGEXT]

- Effect of migrations of the bivalve *Macoma balthica* ……… (J.G. Hiddink)
- Experience from shoreface nourishment and sand extraction projects (J. van Dalfsen)

15. Any other business

- Huntsman Award 2001 and 2002 (K. Essink)
- ICES Biological Community Data Reporting Format (J.N. Jensen)
- Publications of interest (published/submitted)
- Upcoming symposia, etc.

16. Recommendations and Action List

- Nomination of new Chair
- Recommendations for next years' meeting
- Recommendation for ASC Theme Session/Mini Symposium
- Recommendation for TIMES report on epifauna sampling, etc.
- Action List

17. Adoption of the report

18. Closing of the meeting

ANNEX 3: EFFECTS OF THE NON-NATIVE RED KING CRAB *PARALITHODES CAMTSCHATICUS* IN *CHLAMYS ISLANDICA* BEDS (FINNMARK FJORDS, NORTHERN NORWAY)?

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1. Background

During the period 1961–1969, the red king crab *Paralithodes camtschaticus* was intentionally released in the Barents Sea to create a new and valuable fishing resource in the region (Orlov and Karpevich, 1965; Orlov and Ivanov, 1978). The crab has become abundant around the Kola Peninsula (Russia) and coastal Finnmark (Northern Norway) (Kuzmin *et al.*, 1996; Kuzmin and Sundet, 2000).

This non-native species is migrating westwards along the coast of northern Norway. Local divers report that scallop-beds (*Chlamys islandica*) and flatfish populations in northern Norway are being reduced due to predation by the red king crab.

The king crab is now known to hatch at several places in Norwegian waters with frequent abundant year classes, and the steadily increasing numbers of crabs are invading new coastal areas (Sundet, 1998, 1999).

The crab performs extensive annual migrations from deep waters in the winter months, to shallow waters (10–30 m) in spring. In the shallow water it mates and breeds (Marukawa, 1933). After the molting, mating and breeding the king crab feeds most intensively (Takeuchi, 1967). Kulichkova (1955) suggests that crabs need to replace calcium carbonate lost during molting (in April) and those young clams and barnacles in shallow waters represent an abundant resource to fulfil this need. It is reasonable to believe that scallop beds may represent a shallow water area with high availability of calcified prey species. The king crabs aggregate in large groups and the availability of prey species is one factor in this patchy distribution (Chebanov, 1965; cited in Fukuhara, 1985). High density of king crabs (1.7 ind/1000 m^2) was recorded in Varanger (unpublished data from 2001), but due to the aggregation behaviour of the king crab, numbers of individuals could be 100 to 1000 times larger. The question is if predation from the king crab could control or eradicate scallops beds along the Finnmark coast. Alternatively, may other factors such as predation by eiders or sea stars (Hemmingsen and Sundet, 1987) or temperature (Wiborg, 1962) be the explanation for the reduction in scallop beds in northern Norway? Distribution and mapping (Hemmingsen and Sundet, 1987; Sundet, 1995) of *Chlamys islandica* beds in northern Norway, together with growth (Wiborg, 1962), population biology and reproduction (Clausen, 1975) of the scallop has been thoroughly studied.

The closely-dated (year 2000) documentation of the first collections, increased abundance, and spread of the king crab throughout Porsanger fjord (Northern Norway) provide a rare opportunity to observe in progress a biological invasion of scallop beds, and to observe community-level alternations as they occur. Such documentation provides a foundation for experimental studies to determine the mechanisms by which introduced species may alter and influence community structure.

2. Goals

Based on the information given, scallop beds may represent a shallow water area with high availability of possible prey-items for the king crab. This could stimulate an aggregation of king crabs and, depending on king crab abundance and the extent of the scallop bed, give a measurable effect of predation.

The main goal of this proposed project will therefore be to study possible effects by the king crab on the fauna composition in scallop beds. To achieve this main goal, we would like to focus on following objects:

1. By long term monitoring, to evaluate possible fauna differences between *Chlamys* beds with different abundances of the king crab.

2. A field experiment with living crabs in open bottom cages, for studying what species in the *Chlamys* beds the king crabs affect, and if there are differences in food consumption between immature and mature king crabs.

3. Laboratory experiments to investigate the mechanisms behind the system changes.

Literature cited

Fukuhara, F.M. 1985. Biology and fishery of south-eastern Bering Sea red king crab (Paralithodes camtschatica). Northwest and Alaska Fisheries Centre. Processed Report 85–11.

Hemmingsen, W., and Sundet, J. 1987. Årsrapport for kartleggingsarbeid av hanesjell Chlamys islandica, innafor grunnlinja i Troms og Finnmark. Notat, 8 pp. [In Norwegian].

Kulichkova, V.A. 1955. Pitanie Kamchatskogo kraba v vesenneletnii period u beregov Kamchatki i Sakhalina [The feeding pattern of the Kamchatka crabs of the coasts of Kamchatka and Sakhalin.] Izvestiya Tikhookeanskogo Nauchno-Issledovatel'skovo Istituta Rybnogo Khoziaistva i Okeanografii [TINRO], 43: 21–42. [In Russian].

Kuzmin, S., Olsen, S. and Gerasimova, O. 1996. Barents Sea king crab (*Paralithodes camtschatica*): Transplantation experiments were successful. pp. 649–663. *In*: High latitude crabs: Biology, management, and economics. Alaska Sea Grant College Program Rep., 96–02, 713 pp.

Kuzmin, S., and Sundet, J.H. 2000. Joint report for 2000 on the red king crab *(Paralithodes camtschaticus)* investigations in the Barents Sea. Basic requirements for managements of the stock. Report to the 29th Session for the Mixed Russian-Norwegian Fisheries Commission, 24 pp.

Marukawa, H. 1933. Taraba-gani chosa [Biological and fishery research on the Japanese king crab *Paralithodes camtschatica* (Tilesius)]. Sui Shi Ho [J. Imp. Fish. Exp. Sta., Tokyo], 4(37), 152 pp. [In Japanese with English abstract].

Orlov, Y.I. and Ivanov, B.G. 1978. On the introduction of the Kamchatka king crab *Paralithodes camtschatica* (Decapoda: Anomura: Lithodidae) into the Barents Sea. Mar. Biol., 48(4): 373–375.

Orlov, Yu.I. and Karpevich, A.F. 1965. On the introduction of the commercial crab *Paralithodes camtschatica* (Tilesius) into the Barents Sea. Pp. 59–61, *In*: Cole, H.A. (ed.) ICES Spec. Meeting 1962 to consider problems in the exploitation and regulation of fisheries for Crustacea. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 156: 59–61.

Sundet, J.H. 1995. Toktrapport fra haneskjellundersøkelser i ytre Troms 20–23. juni 1995. Fiskeriforskning, Rapport, 1995.10 pp. [In Norwegian].

Sundet, J. H. 1998. Bifangst av kongekrabbe i det ordinære fisket. En kartlegging blant fiskere i Øst-Finnmark. Fiskeriforskning, Rapport. 1/1998. 15 pp. [In Norwegian].

Sundet, J. H. 1999. Bifangst av kongekrabbe i garn- og linefisket i 1998. Fiskeriforskning, Rapport. 2/1999. 20 pp. [In Norwegian].

Takeuchi, I. 1967. Food of king crab, *Paralithodes camtschatica*, of the west coast of Kamchatka Peninsula, 1958-1964. Bull. Hokkaido Reg. Fish. Res. Lab., 33: 32-44. [In Japanese with English summary] Also as: Fish. Res. Bd. Can., Transl. Ser., 1194 (1968).

Wiborg, K.F. 1962. Haneskjellet, Chlamys islandica (O.F. Müller) og dets utbredelse i noen nordnorske fjorder. Fisken og Havet, 1962(3): 17–23. [In Norwegian, Summary in English].

ANNEX 4: MACROBENTHIC COMMUNITY STRUCTURE AND SPATIAL DISTRIBUTION AT THE BELGIAN CONTINENTAL SHELF

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The Belgian Continental Shelf (BCS) (2600 km²) is situated in the southern part of the North Sea and covers a very small part (< 0.5 %) of the whole North Sea Shelf. This area covers a diverse range of habitats: from the sandy beaches to the open sea, from the gullies in between sandbanks to the top of the sandbanks, and from coarse sandy to muddy sediments. The Belgian Continental Shelf (BCS) can be divided into 6 areas: the Hinderbanks, Zeelandbanks, Flemish Banks, Western Coastal Banks, Eastern Coastal Banks and the beaches. To investigate the spatial or temporal distribution of the macrobenthos and their related communities, these areas were sampled, with different intensity, during two different periods (1970–1982; 1994–2000)

Early descriptions (1970–1982) of the macrobenthos at the BCS discerned between three zones: a coastal zone with a set of species- and density-poor communities; a species and density-rich transition zone, and a species-rich and density-poor open sea zone zone (Govaere *et al*., 1980). Although the Flemish Banks are situated in the transition zone, their macrobenthic communities are described as being an impoverished version of the open sea (Rappé, 1978).

Between 1982 and 1994, no macrobenthos surveys were performed at the BCS. From 1994 onwards, new macrobenthos samples were collected within the framework of several research projects. Yet, a clear classification of and comparison between the different macrobenthic communities described in the different studies was very difficult. To overcome these difficulties within the recognition of the macrobenthic communities, all macrobenthos data collected at the Belgian Continental Shelf between 1994–2000 (740 samples), were gathered into a database and reanalysed. Through multivariate analyses (Two Way Indicator Species Analysis, Detrended Correspondence Analysis and Cluster Analysis), ten sample groups were distinguished. Each sample group is found in a particular physico-chemical environment and contains a specific set of species.

Five sample groups differ drastically, both in habitat and species composition, and are considered to represent four macrobenthic communities. A first community, the *Abra alba – Mysella bidentata* community, is found in fine sandy sediments (median grain size: 213 µm on average) with a relatively high mud content (5 % on average). This community is characterized by a high macrobenthic diversity (N_0: 25 species/0.1 m² on average) and density (5356 ind/m² on average). The dominant species are the bivalves *Abra alba, Spisula subtruncata* and *Mysella bidentata,* the polychaetes *Lanice conchilega* and *Sthenelais boa,* and the crustacean *Pariambus typicus*.

The second community, the *Nephtys cirrosa* community, is found in stations with medium sandy sediments (median grain size: 274 µm on average) in absence of mud. This community is less diverse (N_0: 7 species/0.1m² on average) and the densities are low (402 ind/m² on average).

The macrobenthic diversity and densities of the third community, the *Ophelia limacina – Glycera lapidum* community, are very low, respectively, 5 species/0.1m² and 180 ind/m² on average. This community is found in coarse sandy sediments (median grain size: 409 µm on average) and is typically encountered at the tops of sandbanks or in shell fragment banks.

The fourth community, the *Eurydice pulchra – Scolelepis squamata* community, is exclusively found at the high intertidal of sandy beaches and is characterized by a low diversity (N_0: 5 species/sample on average) and high densities (305 ind/m² on average). Typical species are the crustaceans *Eurydice pulchra* and *Bathyporeia* spp. and the polychaete *Scolelepis squamata*.

Next to these four macrobenthic communities, Degraer *et al*. (1999) found an extremely rare (only one station) macrobenthic community in outcropping tertiary clay layers (e.g., nearby Oostende): the *Barnea candida* community. This rather diverse community occurs in a muddy (median grain size: 14 µm), deeper lying (8.2 m) sediment, containing high numbers of *Barnea candida* (117 ind/m²). A sixth community at the BCS is probably present in gravel areas, but this habitat is not yet investigated.

Of course these macrobenthic communities are not isolated from each other and five specific transitional species associations were found. The transition between the *Abra alba* - *Mysella bidentata* and the *Nephtys cirrosa* community is characterized by a decreasing diversity, mainly correlated with a decrease in mud content. This transitional species association contains high densities (1263 ind/m² on average) of the polychaete *Magelona mirabilis*. The transition between the *Nephtys cirrosa* and the *Ophelia limacina – Glycera lapidum* community is characterized by decreasing densities and coincides with a gradual transition between medium to coarse sandy sediments. From the *Nephtys cirrosa* to the *Eurydice pulchra – Scolelepis squamata* community, transitional species associations, related to the transition from the subtidal to the intertidal environment, were found. No transitional species associations were found between the *Abra alba – Mysella bidentata* and *Ophelia limacina – Glycera lapidum* communities, nor between the *Ophelia limacina–Glycera lapidum* and the *Eurydice pulchra – Scolelepis squamata* communities.

The macrobenthos of the BCS is thus characterized by four communities, "connected" with each other by means of gradual transitional species associations. In contrast to the three zones of Govaere *et al*. (1980), the spatial distribution of the four communities seems to be correlated mainly with depth and sediment grain size distribution (e.g., median grain size and mud content), combined with the sediment mud content. Sandbank systems are abiotically extremely diverse and even within some tens of metres completely different types of sediment can be encountered, as seen in the Western Coastal banks, each with their own typical macrobenthic community. The distribution of the macrobenthic communities on the BCS is thus far more complex than the onshore – offshore gradient as shown by Govaere *et al.* (1980).

Macrobenthic communities in temperate regions are subjected to a large year-to-year variability of the community parameters (Turner *et al*., 1995). The four macrobenthic communities were detected based on data collected during different years. Yet, a global evaluation of the temporal variation of the macrobenthic communities on the BCS was not made. To study the temporal variation of the macrobenthic communities at the BCS, a PhD research, focusing on the temporal variation within the *Abra alba – Mysella bidentata* community, was set up.

References

Degraer, S., Vincx, M., Meire, P., Offringa, H., 1999. The macrozoobenthos of an important wintering area of the common scooter (*Melanitta nigra*). J. Mar. Biol. Ass. U.K., 79: 243–251.

Govaere, J.C.R., Van Damme, D., Heip, C., and De Coninck, L.A.P., 1980. Benthic communities in the Southern Bight of the North Sea and their use in ecological monitoring. Helgolander Wissenschaftliche Meeesuntersuchungen, 33: 507–521.

Rappé, G., 1978. Studie van het macrobenthos van de zandbanken Kwintebank en Buiten Ratel. Ghent: Licentiate thesis RUG.

Turner, S.J., Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., and Maskery, M., 1995. Are soft-sediment communities stable? An example from a windy harbor. Mar. Ecol. Prog. Ser., 120: 219–230.

ANNEX 5: SPREADING AND DISTRIBUTION OF *ENSIS DIRECTUS* ON THE FRENCH COAST OF THE NORTH SEA AND IN THE EASTERN CHANNEL

10 years after its first record in French waters

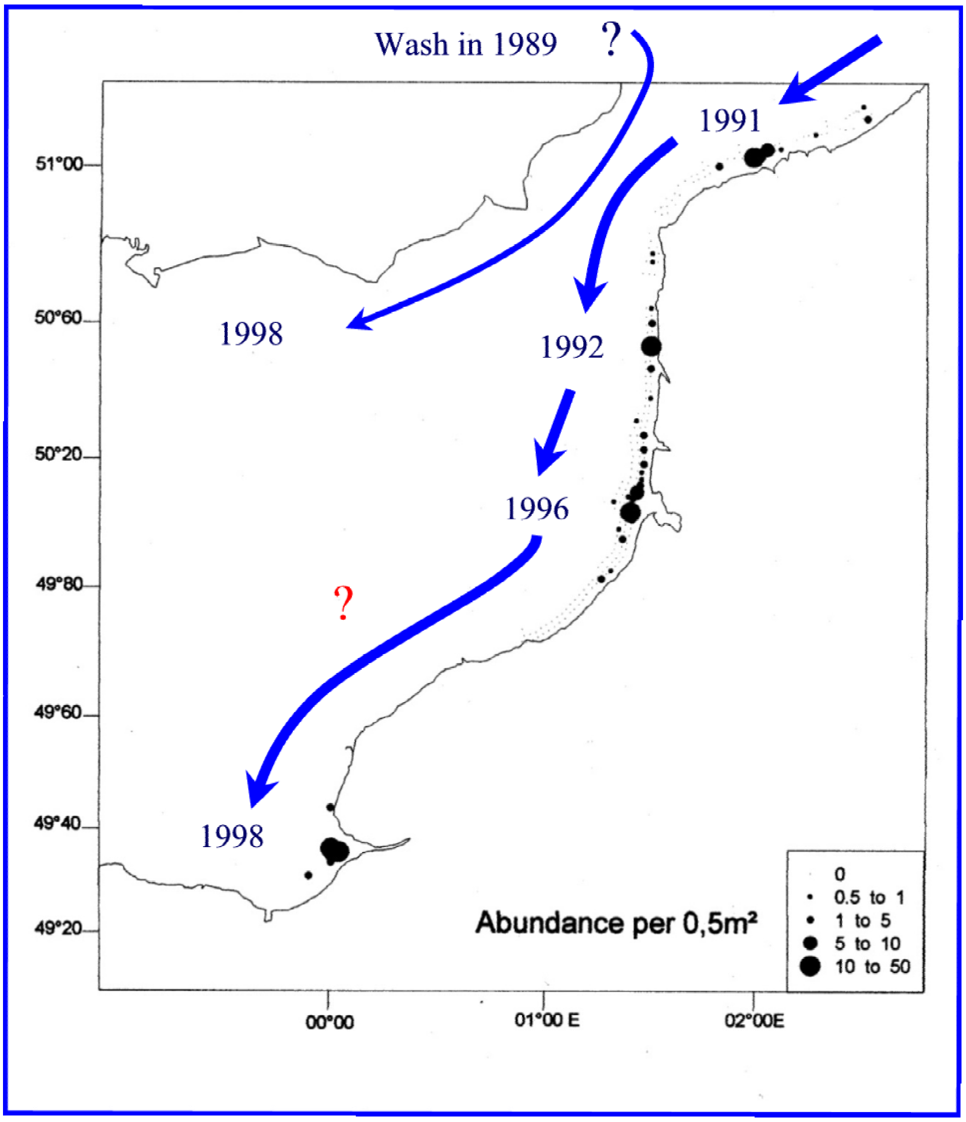
Dewarumez J.-M., Dauvin J.-C., Desroy N., Desprez M. and Luczak. C.

Ensis directus occurred for the first time in 1991 on the French coasts near Dunkirk, but it was recorded since 1986 on the Belgian coast at Ostend. After a period of nine days of strong northeast wind, juveniles were sampled in the benthos at the beginning of May 1991 in front of Gravelines. The patch of recruitment was 10 km long. The area of maximum density of juveniles was located 2 km west of the dykes of the river Aa.

This fast-growing razor clam was recorded near Boulogne-sur-Mer in 1992, in 1993 near Hardelot, in 1996 in the Bay of Somme and in 1998 in the Bay of Seine. This rapidly spreading can be explained by natural expansion against the general direction of particularly strong tidal currents. It is well known that the normal drift can be inverted by northeast winds but such a spreading is surprising. Another explanation is possible, such as a new introduction in the harbour of Le Havre as well as it was introduced in the Wash estuary in 1989.

After the appearance of this species, generally in very high density (up to 30.000 /m² of 10 mm in the Gravelines area in 1991), the densities remained high (between 200 and 50/m²) forone or two years. Afterwards the density was rarely higher than 100/m². This species is integrated in the community without damage to the other species, especially when the carrying capacity of the community is sufficient.

A general study is projected on the state of the population of *Ensis directus* along the French coasts of the North Sea and of the English Channel 10 years after its introduction, including mapping of the densities and the biomass, age structure of the populations, growth, production and dynamics in two areas: Dunkirk and the Bay of Seine.


Wash in 1989
?
1991
1998
1992
1996
?
1998
51°00
50°60
50°20
49°80
49°60
49°40
49°20
00°00
01°00 E
02°00E
Abundance per 0,5m²
0
0.5 to 1
1 to 5
5 to 10
10 to 50

ANNEX 6: PRELIMINARY RESULTS ON SPATIAL AND TEMPORAL DISTRIBUTION OF THE INFAUNAL BENTHIC COMMUNITIES OF FERROL BAY, NORTH-WEST SPAIN

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SUMMARY

Benthic samples for study of sediment parameters and the infaunal subtidal community were collected at 35 stations in the Ferrol Bay, Northwest Spain. In addition, benthic samples were collected from October 1999 to August 2000 in order to study the temporal changes of three benthic stations, two to study the infaunal subtidal community and one for the study of sedimentary variables.

In the distribution of the sedimentary types, we can notice four large areas: internal harbour zone, where sediments are muddy with very high organic content; medium zone, where sediments are muddy or sandy with high organic content; the channel, with sediments of medium or coarse sand and low organic content; external area of the bay, with sediment of fine sand and low organic content.

In the stations when the temporal variation of the characteristics of the sediment has been studied, only slight variations could be observed in the mean diameter of the sediment in Station 2 which is situated in the medium part of the bay.

In the spatial distribution, five groups or infaunal subtidal communities have been identified in this bay:

1) Group A, situated in the internal zone, with very muddy sediments from the harbour, with very high organic content. It shows an impoverished infaunal community dominated by the oligochaete *Tubificoides* sp.

2) Group B, situated in the internal zone of the bay, in the harbour or close to it, in sandy sediments with very high organic content. The main species are the polychaetes *Paradoneis lyra* and *Prionospio fallax* and the bivalve mollusc *Thyasira flexuosa*.

3) Group C, at stations situated in the middle of the bay, in sediments that vary from mud to fine sand. The organic content is very high in all stations and the characteristic species are the polychaetes *Paradoneis lyra*, *Ampharete finmarchica* and *Monticellina dorsobranchialis*.

4) Group D, that occupies sediments of medium to coarse sand in the channel with low organic content. The infaunal species that dominate the group are the amphipods and tanaids crustaceans.

5) Group E, set in sediments of fine sand, with low to moderate organic content, located in the outside part of the bay. The main species of the group are the polychaete *Spio decoratus* and unspecified Nemertina.

The infaunal community of Station 3 does not show a clear pattern of temporal variation; its specific composition remains relatively stable, although some species could show moderate seasonal variations (for example, *Monticellina dorsobranchialis*, *Prionospio fallax* and *Abra nitida*). In Station 20, the pattern of variation is clearer, with an increase in abundance in summer and autumn months, both in the total abundance in some species (for example, *Paradoneis armata* and *Magelona filiformis*) reaching large temporal variations in some of them (for example, *Spio decoratus*).

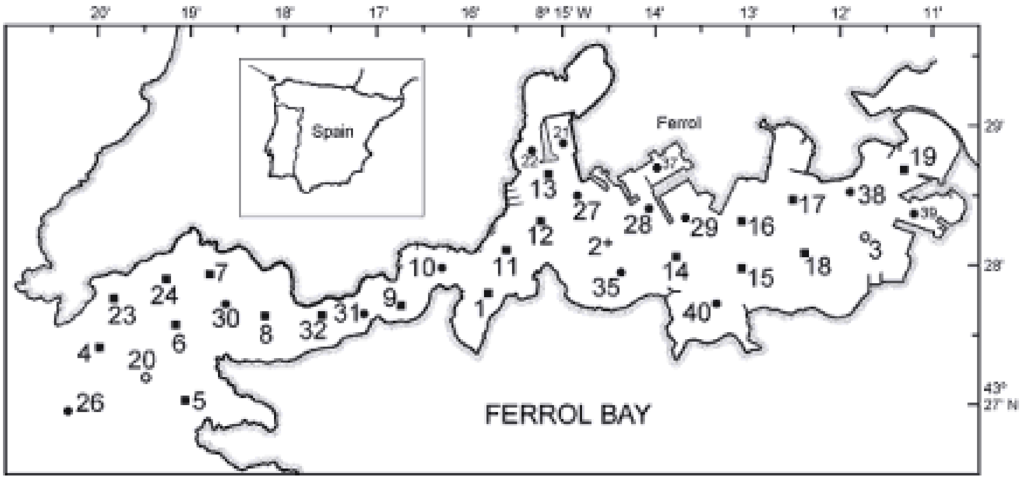
INTRODUCTION

The Galician Bays have special characteristics; in general, they are very influenced by human activities such as commercial fishing, aquaculture, urban and industrial waste, etc. In the South Galician Bays, called "Rias Baixas", there are many studies about spatial distribution of infaunal subtidal communities (López-Jamar, 1978, 1981, 1982; López-Jamar and Cal, 1990; Mora, 1980). On the contrary, in the North Galician Bays, called "Rias Altas" the spatial benthic studies are less abundant (López-Jamar and Mejuto, 1985; Parapar, 1991; Sánchez-Mata *et al.*, 1993a, 1993b, 1999).

The Ferrol Bay is a small North Galician embayment, characterized by a great narrowness in the mouth of the bay, that has a large influence on the general hydrodynamics of the bay. Currents up to 2 m/s were registered in the narrow zone, in the channel of the Ferrol Bay. This Bay has important phytoplankton blooms mainly due to the water accumulation in the inside of the bay. The high primary production inside the bay is an important source of organic matter for pelagic and benthic communities.

The present preliminary report provides the spatial and temporal distribution of the infaunal benthic communities in the Ferrol Bay and describes their biomass, diversity, and sedimentary environment.

Figure A6.1. Situation of the stations in Ferrol Bay. Black circles: infauna and sediment stations (only one sampled). Black squares: only sediment stations (only one sampled). White circles: bimonthly infauna and sediment samples. Cross: only bimonthly sediment station.



MATERIAL AND METHODS

For the spatial community study, 35 stations were sampled at the Ferrol Bay and only one from the near continental shelf (Station 26; Figure A6.1). 18 stations were selected for infaunal and sedimentary studies and the other 18 only for spatial sedimentary studies. Also, two stations were selected for a bimonthly sampling programme (from October 1999 to August 2000), to study the infaunal community and sediment variables (Stations 3 and 20), and only one to study the sedimentary characteristics (St. 2).

Five samples were obtained with a modified Bouma box corer (0.0175 m^{-2} surface area) at each station. This sample size was considered to be adequate from a previous study in other Galician bays (López-Jamar and Mejuto, 1985). The samples were sieved on board (0.5 mm), anaesthetized with a $MgCl_2$ solution and then preserved with 5 % buffered formaldehyde containing Rose Bengal solution. Sediment samples were also collected for particle size analysis and organic content determinations. Organisms were sorted out in the laboratory and identified to species level whenever possible, counted and weighed. Correlations of wet weight (WW) to ash-free dry weight (AFDW) were calculated to estimate the biomass of each individual species (López-Jamar, unpublished data). Particle size analysis was carried out by a combination of dry sieving and sedimentation techniques (Buchanan, 1984). The organic content of the sediment was estimated as the loss in weight of dried material (100 ºC, 24 h) after combustion (500 ºC, 24 h).

The faunistic similarity between stations was estimated for the Bray-Curtis measure (Bray and Curtis, 1957), after transforming (“root-root”) of the abundance raw data. Dendrograms were used for the station’s classification starting from the similarity matrix (Field *et al*., 1982). Diversity was calculated using abundance data with the Shannon function (Shannon and Weaver, 1963). Evenness was also estimated as defined by Pielou (1966).

RESULTS AND DISCUSSION

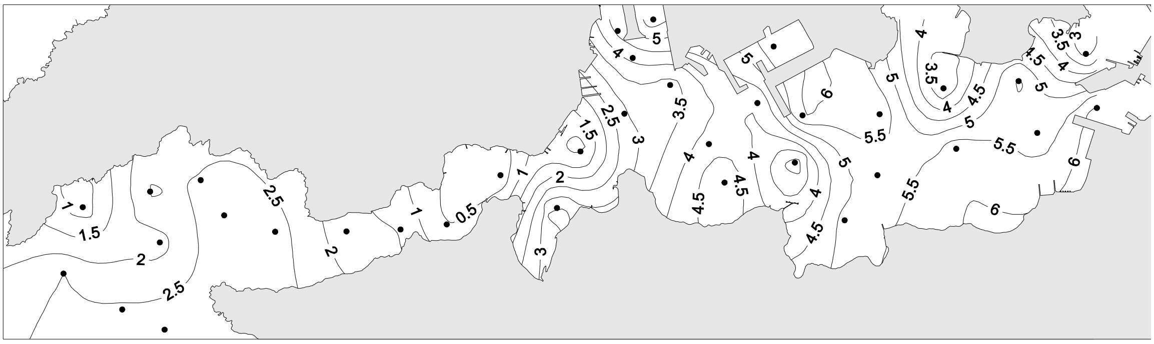
Spatial distribution of sediment characteristics

The sediment in the internal part of Ferrol Bay, to outline, was composed mainly of mud and in the outside part and in the channel of the bay the sediment was formed with sand. The granulometric parameters are shown in Table A6.1. The Ferrol Bay was divided into four areas according the mean particle size of the sediment (Figures A6.2, and A6.3):

1) Internal harbour area: Stations 3, 14, 15, 16, 17, 18, 19, 21, 22, 29, 35, 37, 39 and 40 were included in this area. Mean depth ranges from 6 m (Sts. 39 and 40) to 16 m (St. 14). At these stations the sediment is composed of mud, except in the Sts. 14, 18 and 19 that are composed of fine sand. Spatial variations of sediment size are important; mean diameter ranges from 12.7 µm (St. 39) to 40.1 µm (St. 22).

2) Central area: Sts. 1, 2, 12, 13, 27 and 28 were included in this area. The depth ranges from 12 m in St. 28 to 16 m in Sts. 1 and 2. The sediment is composed of mud, very fine sand or fine sand, and the main diameter ranges between 54.4 µm (St. 2) and 126.7 µm (St. 12).

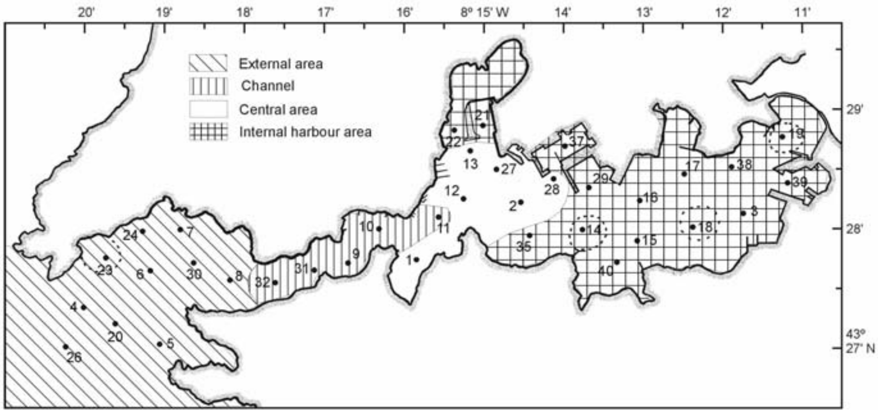
Figure A6.2. Spatial distribution of mean diameter (phi units) of sediment throughout study area. Black circles: sample stations.



3) Channel: Is a narrow area (minimum width of 420 m in high tide) located between the central area and the external area, and Sts. 9, 10, 11, 31 and 32 from this area. The depth ranges from 14 m in St. 32 to 24 m in St. 10. The sediment is formed of medium or coarse sand, with a variable proportion of gravel and dead shell of bivalves. Mean diameter ranges from 312.1 µm (St. 32) to 926.6.1 µm (St. 10).

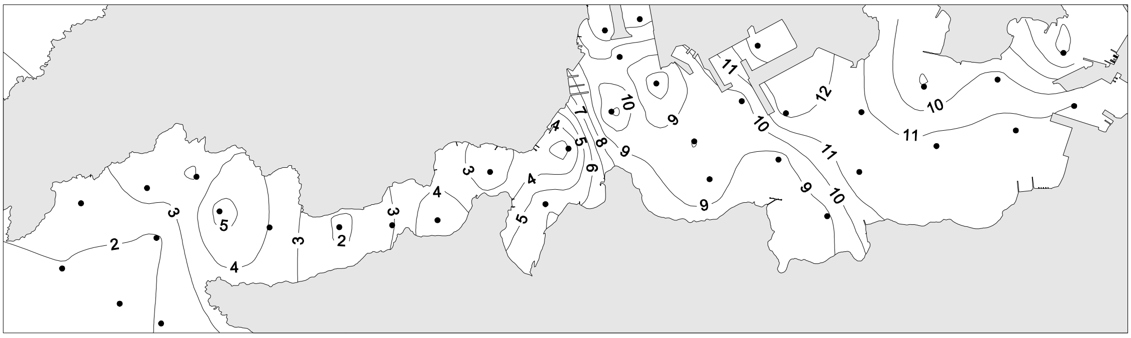
4) External area: Is the most external area of the bay, near to the adjacent continental shelf. Sts. 4, 5, 6, 7, 8, 20, 23, 24, 26 and 30 have been included in this area. Mean depth ranges from 19 m (St. 23) to 42 m (St. 26). The sediment is composed of fine sand, except Sts. 6 and 23 that are formed with medium and coarse sand respectively. The main diameter ranges between 138.7 µm (St. 5) to 289.2 µm (St. 5). Station 23 has a very high mean diameter (624.2 µm).

Figure A6.3 Spatial distribution of different areas according to mean diameter of the sediment. Broken line encloses the stations that do not fit the area characteristics.



Parapar (1991) has reported a similar spatial distribution of the sediment types in the Ferrol Bay, according with others southern Galician bays; in all of them the mud is the dominant sediment in the internal area (López-Jamar, 1978, 1981, 1982: López-Jamar and Cal, 1990). On the contrary, the nearest bays (La Coruña Bay and Ares-Betanzos Bay) showed a dominance of sandy sediment similar to the external area of the Ferrol Bay, with small harbour areas of muddy sediment (López-Jamar and Mejuto, 1985; Sánchez-Mata *et al*., 1999).

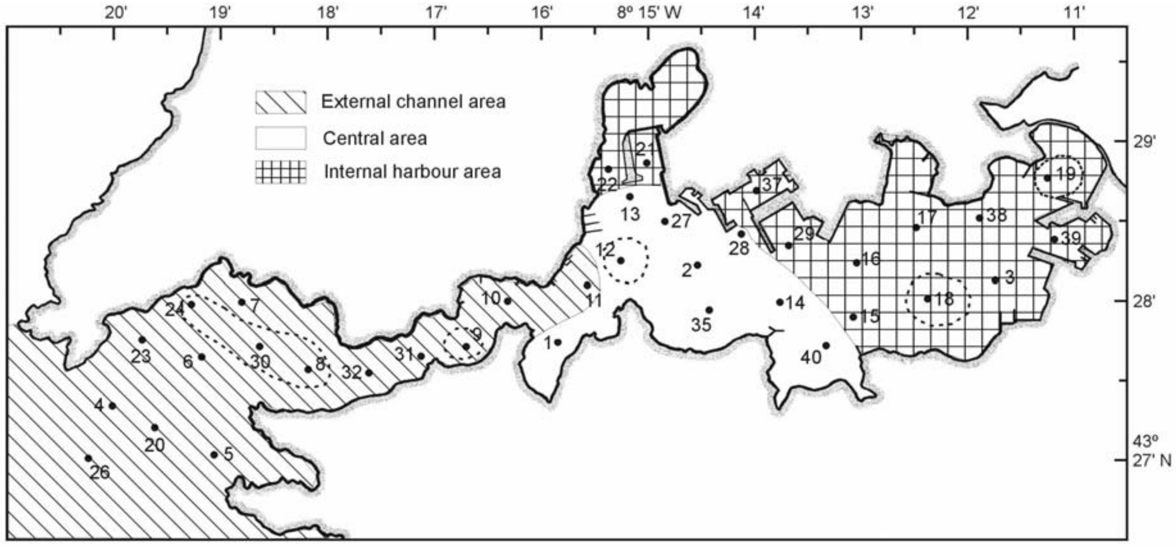
Figure A6.4. Spatial distribution of organic content (%) of sediment throughout study area.



The spatial distribution of the sediment organic content in Ferrol Bay is similar to the mean particle size distribution, but with some differences. In Table A6.2, the total sediment organic content in Ferrol Bay is reported. Only three areas are described (Figures A6.4 and A6.5):

1) Internal harbour area: It coincides with the internal harbour granulometric area, with exception of some stations (14, 35 y 40). The sediment organic content had very high values, ranging from 10.32 % in the St. 38 to 13.74 % in the St. 37 (there were some exceptions: the stations 18 and 19 with 8.81 and 6.70 %, respectively).
2) Central area: The granulometric central area was amplified for the organic matter content with the inclusion of Sts. 14, 35 and 40. This content is high and it varies from 6.09 % in St. 1 to 10.11 % in St. 2, with exception of 11.80 % in St. 12.
3) External channel area: The external granulometric area and channel granulometric areas were included in this new organic content area. The sediment organic content is low, from 1.42 % in the St. 20 to 2.85 % in the St. 31. A group of three stations (Sts. 8, 24 and 30) were described in the central part of external area with a moderate organic matter content, ranging from 3.58 and 5.61 %. The St. 9, situated in the middle of the channel area, also showed a moderate organic matter content (5.09 %).

Figure A6.5. Spatial distribution of different areas according to organic content of the sediment. Broken line encloses stations that do not fit the area characteristics.



Parapar (1991) has reported lower values of spatial distribution of the organic matter content in the sediments of the Ferrol Bay. In the nearest bays (La Coruña Bay and Ares-Betanzos Bay), low values were founded too (López-Jamar and Mejuto, 1985;Sánchez-Mata *et al*., 1999). On the contrary, similar values have been registered in other southern Galician bays, even higher (e.g., in Pontevedra Bay). In general, low levels of organic content have been registered at the mouth of the bays which have increased progressively as we went into them (López-Jamar, 1978, 1981, 1982;López-Jamar and Cal, 1990).

Temporal variation of sediment characteristics

For the study, the temporary variation of the granulometric characteristics and the organic content of the sediment at three stations have been chosen. The sampling has been done every two months in a year. The St. 2 is situated in the middle zone of the Ferrol Bay, 16 m in depth. The sediment is formed mainly by mud or fine sand, with a mean diameter that ranges from 58 to 155 µm. The sorting is poor in all the samples, and the organic content is very high (8.16 a 10.00 %). In previous studies, the sediment of this station was finer, with a mean diameter from 27 to 54 µm, with an organic content over 13 % (López-Jamar *et al.*, 1996).

The St. 3 is situated in the inner part of the bay, 6 m in depth. The sediment is formed of very fine mud, with a mean diameter that goes from 16 to 20 µm. The sorting varies between poor and moderated, and the organic content is very high (10.61 to 11.95 %). These values coincide with the values obtained in previous studies (López-Jamar *et al.*, 1996).

The St. 20 is the most external, situated 28 m. in depth. The sediment is formed of fine sand and its mean diameter is between 101 and 166 µm. The sorting in all the samples is moderated, and the organic content is low (1.35 a 2.67 %). In previous studies the sediment for this station was slightly coarser, going from 144 to 210 µm, with a similar organic content to the one obtained in this project (López-Jamar *et al.*, 1996).

Spatial distribution of the infaunal subtidal communities

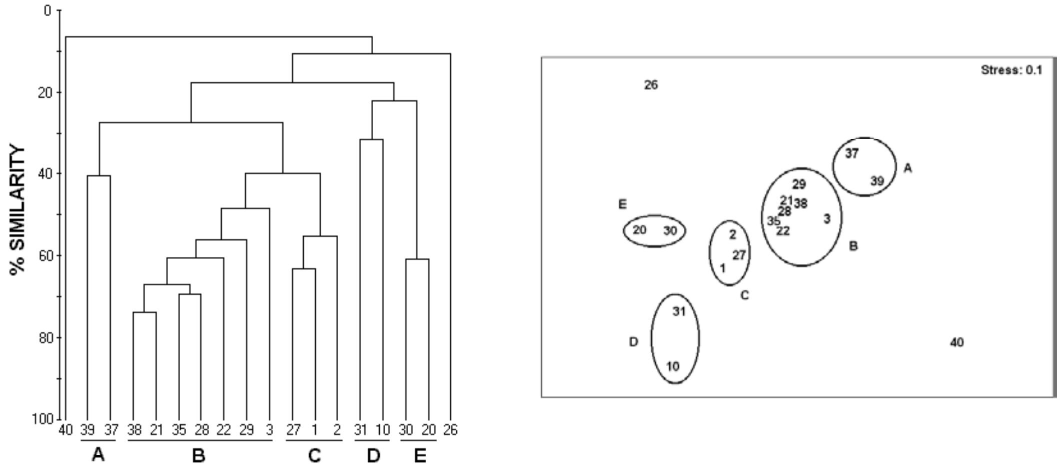
The inventory of the collected species in Ferrol Bay is related in Table A6.3, and its abundance (ind m^{-2}) in each station. The total number of taxa is 254. The faunal group that is best represented is the polychaetes that represent 44.4 % of the total. Crustaceans represent 25.2 %, molluscs 22.8 %, the group “others” (oligochaetes, nemerteans, etc.) 5.2 % and echinoderms 2.4 %.

From the matrix of the index of similarity (Bray-Curtis) among inventories, a dendrogram of similarity and a MDS ordination were developed, as a first approach to delimit the infaunal communities. We can distinguish 5 groups of stations with a similarity quite high between them (Figure A6.6):

- Group A: formed by Sts. 37 and 39.
- Group B: formed by Sts. 3, 21, 22, 28, 29, 35 and 38.
- Group C: formed by Sts. 1, 2 and 27.

- Group D: formed by Sts. 10 and 31.
- Group E: formed by Sts. 20 and 30.

Figure A6.6. Cluster diagram of similarity of species composition between stations and MDS ordination. Five groups (A-E) can be distinguished.

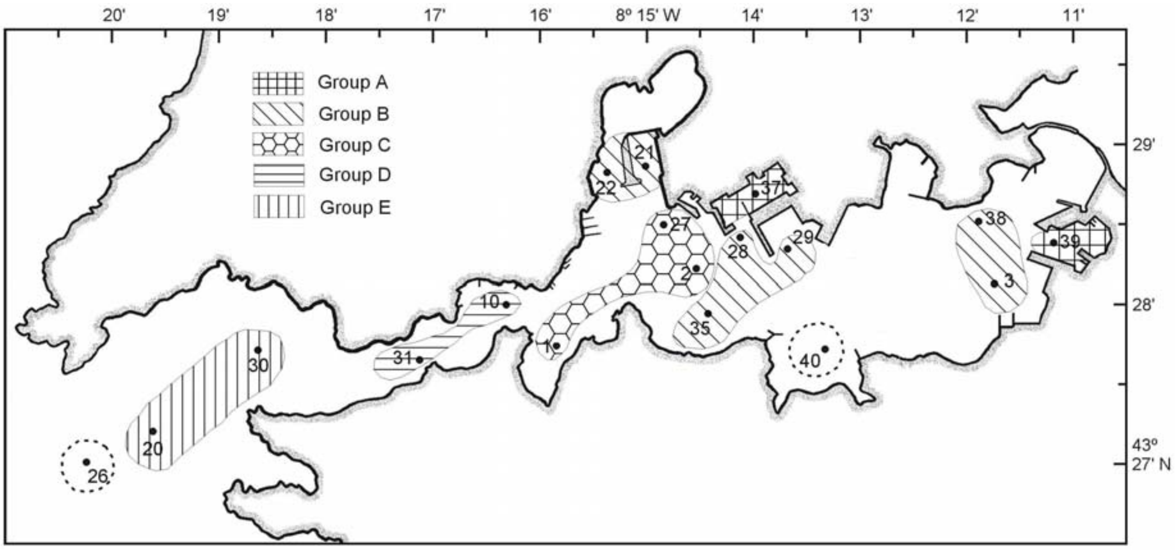


The Sts. 26 and 40 have little similarity with the other stations. The different groups and their corresponding stations are described below:

Group A

The stations that form Group A show a moderate similarity. They are situated in harbour zones, highly rich organically by urban and harbour waste (Figure A6.7). The sediment is muddy with a high organic content, that in St. 39 is above 13 %. These two stations show a very poor infauna, characteristic of polluted harbour areas, dominated by the oligochaete *Tubificoides* sp.

Figure A6.7 Spatial distribution of the 5 infaunal groups in Ferrol Bay.



The St. 37 is situated in the military harbour of Ferrol, in muddy sediments and very rich in organic matter. The dominant species is the oligochaete *Tubificoides* sp. The polychaete *Paradoneis lyra* and the bivalve *Abra alba* are relatively abundant too. The number of species is very low (15), normal in this type of disturbed communities. The infaunal abundance is low (1726 ind m^{-2}), the same of the biomass (2.30 g m^{-2} AFDW), and the diversity (1.98) is very low (Table A6.2).

The St. 39 is situated in muddy sediments of the harbour, and its specific composition is relatively similar to the composition in St. 37. The dominant species are the oligochaete *Tubificoides* sp and the polychaetes *Prionospio fallax*, *Cossura* cf. *soyeri* and *Spio decoratus.* The number of species is very low (12), the same as the infaunal abundance (823 ind m^{-2}) and the biomass (0.75 g m^{-2} AFDW). The diversity in this station is low (2.64) and the evenness moderate (J' = 0.74, Table A6.2).

Group B

The stations that belong to this group show a high similarity. They are located in the inner part of the bay or in the harbour zones or next to them (Figure A6.7). The typical sediment of the group is mud with a high organic content (up to 12.45 %). The dominant infaunal species of the group are the polychaetes *Paradoneis lyra* and *Prionospio fallax*; the bivalve mollusc *Thyasira flexuosa* is relatively abundant.

The St. 3 is situated in muddy beds of the inner part of the bay close to the shipyard. The dominant species are the polychaetes *Paradoneis lyra*, *Pseudopolydora pulchra* and *Chaetozone gibber.* The number of species is low (24), equal to the infaunal abundance (2960 ind m^{-2}) and the biomass (1.47 g m^{-2} AFDW). The diversity in the station is high (3.48) and the evenness moderate (J' = 0.76, Table A6.2). In an earlier study in 1993, this station was dominated by the polychaete *Paradoneis lyra*, the bivalve *Abra nitida* and the oligochaete *Tubificoides* sp. The number of species was similar (K = 27) and the abundance and biomass were larger (5118 ind m^{-2}, 7.3 g m^{-2} AFDW; López-Jamar *et al.*, 1996).

The St. 21 is located in the harbour zone at the north seaside of the bay and it is characterized by a muddy sediment with a high organic content. The typical species are the polychaetes *Paradoneis lyra*, *Monticellina dorsobranchialis* and *Prionospio fallax*. The abundance of organisms is moderate (7292 ind m^{-2}) and the biomass is quite low (3.85 g m^{-2} AFDW). The number of species is moderate (33) and the diversity and evenness are low (H' = 2.90; J' = 0.58, Table A6.2).

The St. 22 is located at the harbour zone close to St. 21. The sediment is formed by mud with high organic contents. The more abundant species are the polychaetes *Prionospio fallax*, *Spio decoratus* and *Paradoneis lyra*. The number of species is moderate (41). The total infaunal abundance is moderate (6869 ind m^{-2}) and the biomass very low (1.52 g m^{-2} AFDW). The diversity is high (3.83) and the evenness moderate (J' = 0.71, Table A6.2).

The St. 28 is placed close to the harbour of Ferrol, in sediment of very fine sand, with high organic content. The typical species are the polychaetes *Paradoneis lyra* and *Prionospio fallax*, and the bivalve *Thyasira flexuosa*. The infaunal abundance is moderate (5726 ind m^{-2}), although the biomass is quite low (2.74 g m^{-2} AFDW). The number of species, diversity and evenness are similar to the St. 22 (K = 43; H' = 3.64; J' = 0.67, Table A6.2).

The St. 29 is placed close to the previous station. It shows a muddy sediment from the dock with a high content of organic matter (12.45 %). The community is dominated by the polychaetes *Paradoneis lyra* and *Chaetozone gibber*, and the bivalve *Thyasira flexuosa*. This station shows low values of infaunal abundance (3418 ind m^{-2}), the same forthe biomass (2.78 g m^{-2} AFDW) and the specific richness (K = 25, Table A6.2).

The St. 35 is situated at the south seaside of the bay, moved away from the influence of the harbour. Its shows muddy sediment with high organic content. The typical species are the polychaetes *Paradoneis lyra* and *Prionospio fallax*, and the bivalve *Thyasira flexuosa*. The infaunal abundance is moderate (7475 ind m^{-2}), although the biomass is relatively low (3.03 g m^{-2} AFDW). The number of species is moderate (44) and the diversity and evenness are low (H' = 2.79; J' = 0.51, Table A6.2).

The St. 38 is located in the inner part of the bay, in the proximity of the shipyard, on muddy sediments of high organic content. The characteristic species are the same as the ones in the previous station (St. 35). It is characterized by moderate values of abundance and infaunal biomass, of 7461 ind m^{-2} and 6.54 g m^{-2} AFDW, respectively, being the biomass with the highest value in the group B. The number of species is moderate as well (33), as are the diversity (3.01) and the evenness (J' = 0.60, Table A6.2).

Group C

This group is formed by Sts. 1, 2 and 27. The stations of this group, which represent high similarity, are located in the middle zone of the bay (Figure A6.7). The sediment varies between the mud of the St. 2 and the fine sand of the Sts. 2 and 27. The organic content is very high in all the stations. The dominant infaunal species are the polychaetes *Paradoneis lyra*, *Ampharete finmarchica* and *Monticellina dorsobranchialis*.

The St. 1 is situated in the inlet of Baño, close to the channel, in the south bank of the bay. The sediment is formed of very fine sand and high organic content. The characteristic infaunal species are the polychaetes *Paradoneis lyra*, *Ampharete finmarchica*, *Mediomastus fragilis* and *Monticellina dorsobranchialis*, and the bivalve *Mysella bidentata*. The abundance and infaunal biomass are very high (20814 ind m^{-2} and 14.37 g m^{-2} AFDW, respectively). The specific richness is very high (101), as well as the diversity (4.83). The evenness is moderate, reaching a value of 0.73 (Table A6.2). In the previous study made in 1993, the dominant species were the same, with the absence of the polychaete *Ampharete finmarchica* and the presence of the bivalve *Thyasira flexuosa*. The total infaunal abundance and the specific richness were lower (12780 ind m^{-2}, K = 69) and the total biomass was higher (21.7 g m^{-2} AFDW, López-Jamar *et al.,* 1996).

The St. 2, situated in a central position of the medium zone, shows a muddy sediment with high organic content. The dominant species are the polychaetes *Paradoneis lyra*, *Chaetozone gibber*, *Spio decoratus* and *Ampharete finmarchica*. The abundance and infaunal biomass have lower values than St. 1, but very high (16585 ind m^{-2} and 6.18 g m^{-2} PSSC). The number of species and the diversity are high (K = 69; H' = 3.93), while the evenness is moderate (J' = 0.64, Table A6.2). In the earlier study carried out in 1993, the dominant species were the same, with absence of the polychaete *Ampharete finmarchica* and the presence of the bivalve *Thyasira flexuosa* (the same that in the previous station). The abundance showed a lower level (9521 ind m^{-2}), the same for the number of species (52). The total infaunal biomass was very high (11.97 g m^{-2} AFDW, López-Jamar *et al.,* 1996).

The St. 27 is placed in the medium zone close to the harbour of Ferrol. The sediment is formed by very fine sand with very high content in organic matter. The characteristic species of this community are the polychaetes *Paradoneis lyra*, *Prionospio fallax*, *Caulleriella* sp. and *Monticellina dorsobranchialis*, and the bivalve mollusc *Mysella bidentata*. The infaunal abundance is very high (12539 ind m^{-2}) the same for the total infauna biomass (8.21 g m^{-2} AFDW). The specific richness is high (K' = 67), the same for diversity (H' = 4.43), and evenness is moderate (J' = 0.73, Table A6.2).

Group D

This group is formed by Sts. 10 and 31. The similarity between stations is relatively low. The stations are situated in the channel, in a central zone (St. 31) and the other closer to the medium zone of the bay (St. 10, Figure 7). This area shows very active hydrodynamics, with important flows of tide. The sediment is formed of medium or coarse sand with a variable proportion of dead shells of bivalves and low content of organic matter. The dominant infaunal species of the group are amphipods and tanaids crustaceans.

The St. 10 is characterized by a sediment formed by coarse sand with a variable proportion of dead shells of bivalves and a low content of organic matter. The infaunal community is dominated by crustaceans (80.72 % of the total abundance and 52.31 % of total biomass), with the amphipods the dominant group (68.9 % of the total abundance). Other typical species are the polychaetes *Sphaerosyllis* spp. and unspecified Syllidae, and the crustaceans *Pisidia longicornis* and unspecified Tanaidacea. The abundance and the infaunal biomass are very high, reaching 68534 ind m^{-2} and 13.16 g m^{-2} AFDW. The number of species is very high (K = 106), while the diversity and the evenness are low (H' = 2.48; J' = 0.37, Table A6.2).

The St. 31, situated in the middle of the channel, shows a sediment of medium sand with a low organic content. The same happened in the previous station, the infaunal community is dominated in abundance by crustaceans (57.39 %), but the biomass is dominated by polychaetes (56.54 %). The characteristic species are the crustaceans unspecified Tanaidaceos indet. and *Photis reinhardi* and the polychaete *Notomastus latericeus*. The infaunal abundance is moderate (6732 ind m^{-2}), although the biomass is relatively low (4.56 g m^{-2} PSSC). The number of species and the diversity are high (K = 65; H' = 4.46), although the evenness is moderate (J' = 0.74, Table A6.2).

Group E

This group is formed by the Sts. 20 and 30 that show a notable similarity. They are situated in the outer zone of the bay (Figure A6.7). The sediment is formed by fine sand with an organic content that varies between low to moderate. The infaunal species that dominate are the polychaete *Spio decoratus* and unspecified Nemertina.

The St. 20 is the most external of this group, close to the adjacent continental shelf. The sediment is formed by fine sand with a low content of organic matter. The dominant species of the community are the polychaetes *Spio decoratus*, *Mediomastus fragilis* and *Paradoneis armata*, and unspecified Nemertina. The infaunal abundance in this station is very high (14002 ind m^{-2}), and the biomass is moderate (5.54 g m^{-2} AFDW). The specific richness is high (K' = 67), while the diversity and the evenness are low (H' = 2.64; J' = 0.44, Table A6.2). In the previous study carried out in 1993, the dominant species were the polychaete *Spio decoratus* and the bivalve mollusc *Venus striatula*. The specific richness was lower (K’ = 38), as was the total infaunal abundance (11508 ind m^{-2}). The infaunal biomass was similar (5.4 g m^{-2} AFDW, López-Jamar *et al.,* 1996).

The St. 30 is placed more internally than the previous one; it is characteristic because it has a sediment formed by fine sand with a moderate organic content. The characteristic infaunal species are the polychaete *Spio decoratus*, unspecified Nemertina, the amphipod crustacean *Urothoe brevicornis* and the bivalve mollusc *Thracia phaseolina*. The infaunal abundance is very high (13213 ind m^{-2}), lower than the other station of the group, and the infaunal biomass is very high (7.55 g m^{-2} AFDW). The specific richness is high (K’ = 76), while the diversity and evenness are low (H’ = 2.96; J’ = 0.47, Table A6.2).

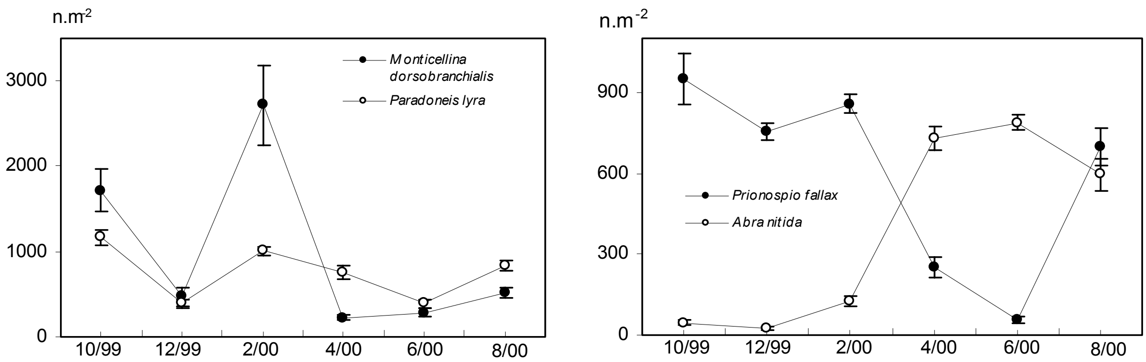
Now we are going to describe Sts. 26 and 40 that are quite different from the other stations. The St. 26 is the most external of this project; it is placed in the adjacent continental shelf at 42 m depth (Figure A6.7). The sediment is formed by fine sand and its content of organic matter is very low. The infaunal community is dominated by the polychaete *Prionospio fallax* and more moderately by the echinoderm *Leptosynapta bergensis*. The total number of species is low (K’ = 25) and the diversity and evenness are high (H’ = 3.90; J’ = 0.84, Table A6.2).

The St. 40 is situated in the south bank of the internal area of the bay (Figure A6.7). The sediment is formed by mud with a high percentage of organic matter. The infaunal community is becoming impoverished with a very low specific richness (K’ = 6), dominated by the polychaetes *Malacoceros fuliginosus*, *Capitella capitata* and *Spio decoratus*. The infaunal abundance and biomass are very low (472 ind m^{-2} and 0.13 g m^{-2} AFDW). The diversity shows a very low value (H’ = 1.95) and the evenness is moderate (J’ = 0.75, Table A6.2).

Temporal variation of infaunal subtidal communities

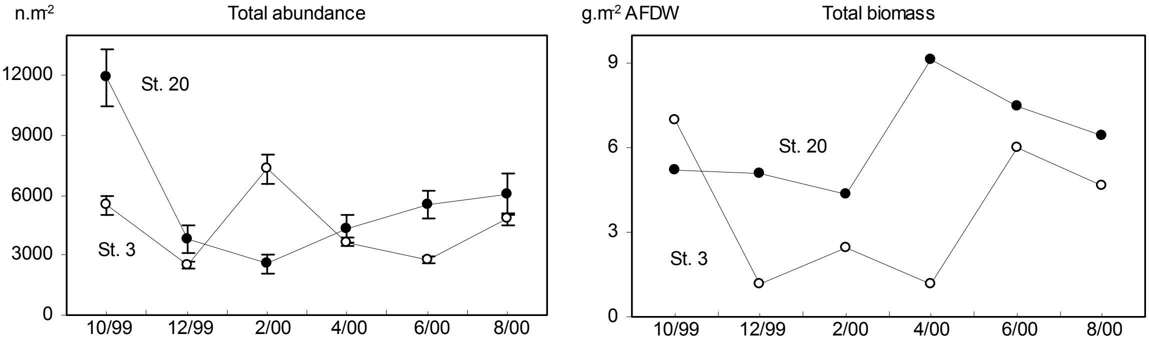
Temporal variations of two infaunal subtidal communities have been studied; the St. 20, situated in the external zone of the bay of Ferrol, and the St. 3 situated in the internal zone of the bay. In this project the results of the temporal study in the St. 2 are not shown (St. 2 situated in the middle of the bay) because they are not complete.

Figure A6.8. Temporal variation of *Monticellina dorsobranchialis*, *Paradoneis lyra*, *Prionospio fallax* and *Abra nitida* in Station 3.



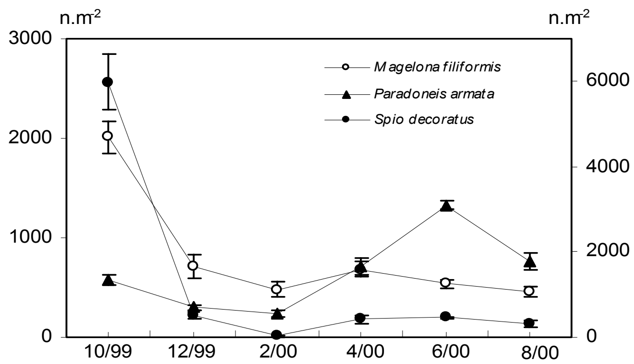
In the temporal variation of the specific composition of the St. 3, there are few species where a clear pattern of temporal variation could be seen. The abundance of the polychaete *Monticellina dorsobranchialis*, is an example. This species dominates in abundance in October (1715 ind m^{-2}) and in February (2720 ind m^{-2}), showing relatively lower values in the rest of the year (Figure A6.8). The polychaetes *Paradoneis lyra* and *Prionospio fallax* show a similar pattern of variation, with a slightly decreasing in density in spring, although it is not really marked (Figure A6.8). The bivalve *Abra nitida* shows a clearer tendency; its abundance increases in spring-summer with a maximum in June (789 ind m^{-2}), decreasing sharply in autumn-winter. The polychaete *Prionospio multibranchiata* shows a similar distribution to *A. nitida*, but with an important peak of its abundance in February (640 ind m^{-2}). The polychaete *Chaetozone gibber* and the bivalve *Thyasira flexuosa* are two other species where slight temporal variation is observed: the density is low in winter, increasing progressively in spring, reaching the maximum in April (331 ind m^{-2}) and in June (263 ind m^{-2}), respectively.

Figure A6.9. Temporal variation of total abundance and biomass in Stations 3 and 20.



The temporal evolution of the abundance in this station shows two maxima of abundance, one that is higher in February (7315 ind m^{-2}) and another one that is lower in October (5509 ind m^{-2}, Figure A6.9). The total biomass for the station is shown in Figure A6.9, where higher values are noted in spring-autumn, with a maximum in October (7 g m^{-2} AFDW). The biomass by taxonomic groups is dominated in spring and summer by the molluscs and in October the dominance of echinoderms shows up because *Leptosynapta inhaerens* appears (up to a 69.5 % of the total abundance) (Figure A6.12). The number of species is low, without a specific pattern of temporal variation, oscillating between 22 species in April and 33 in August (Figure A6.11). The diversity in this station is low, increasing slightly in spring and summer (Figure A6.11).

Figure A6.10. Temporal variation of abundance of some polychaetes in Station 20. Axis Y1: abundance of *Paradoneis armata* and *Magelona filiformis*; Axis Y2: abundance of *Spio decoratus*.



The dominant species in total abundance at St. 20 is the polychaete *Spio decoratus*, that shows a large abundance in autumn (5989 ind m^{-2} in October), and a constant value in abundance all year (from 329 to 526 ind m^{-2}), with the exception of March (23 ind m^{-2}, Figure A6.10); this pattern of variation of *Spio decoratus* is similar to the one found in former studies (López-Jamar *et al.,* 1996). The polychaetes *Paradoneis armata* and *Magelona filiformis* show higher values and homogeneous during the whole year. *P. armata* shows an increase in abundance in spring-summer with a maximum in June of 1326 ind m^{-2}, while *M. filiformis* shows its higher values in autumn-winter with its maximum in October of 2012 ind m^{-2} (Figure A6.10). The Nemertina indetermined show an unchanging value during the whole year with a maximum in October (491 ind m^{-2}). On the other hand the echinoderm *Leptosynapta bergensis* shows the maximum of abundance in spring, with a maximum in June of 377 ind m^{-2}. The amphipods *Ampelisca* cf. *brevicornis* and *Urothoe* cf. *brevicornis* and the polychaete *Magelona alleni* show a pattern of temporal variation of abundance very similar in autumn-winter (maximum in August, except *A.* cf. *brevicornis*, that shows a maximum of 491 ind m^{-2} in June) and decreases in winter, going up in June.

Figure A6. 11. Temporal variation of diversity (H') and species number in Stations 3 and 20.

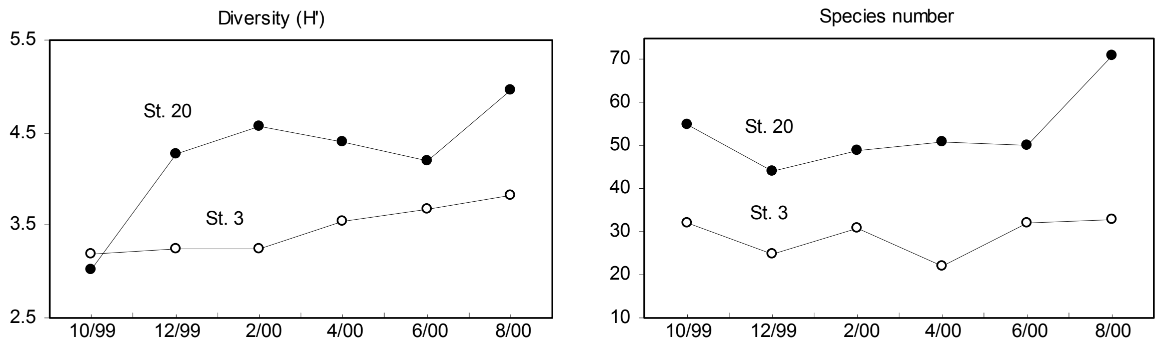
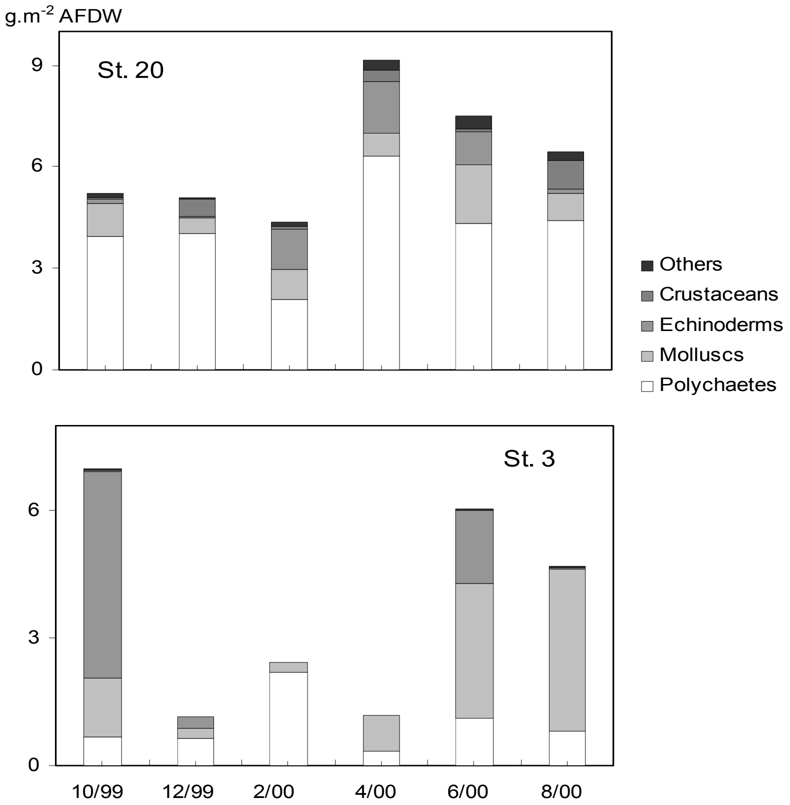


Figure A6.12. Temporal variation of total biomass, according to the different taxonomic groups, in Stations 3 and 20.



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Regarding the total temporal abundance in the St. 20, it shows a maximum of abundance in October (11910 ind m^{-2}, Figure A6.9), dominated by the high abundance of the polychaete *Spio decoratus* (5989 ind m^{-2}). The total biomass for the station is shown in Figure A6.9, where higher values are shown in spring-summer, reaching the peak in April (9.1 g m^{-2} AFDW). The biomass by groups is dominated the whole year by the polychaetes, with a maximum of 69 % in April (Figure A6.12). The number of species is high in summer and autumn (up to 71 species in October), oscillating between 44 and 51 species the rest of the year (Figure A6.11). The diversity shows a low value in October (H' = 3.03), due to the dominance of the polychaete *S. decoratus*. The rest of the year the variation of the diversity shows high values, reaching the maximum in August (H' = 4.95, Figure A6.11).

Table A6.1. Sediment parameters of stations in the spatial study. Symbols: % M.O.: organic content; Q_{50}: mean diameter; Q_{25}: first quartile; Q_{75}: third quartile; S_0: sorting coefficient; CS: coarse sand; MS: medium sand; FS: fine sand; VFS: very fine sand; M: mud; B: bad sorted; P: poorly sorted; Mod: moderately sorted; modW: moderately well sorted.

Station	Date	Grade	% M.O.	Q_{50} (phi)	Q_{50} (mm)	Q_{25} (phi)	Q_{75} (phi)	S_0	Sorted
1	04/10/95	VFS	6.09	3.72	0.076	2.00	5.81	3.46	B
2	03/10/95	M	10.11	4.20	0.054	2.50	6.00	3.36	B
3	02/10/95	M	11.45	5.10	0.029	3.50	6.50	2.83	B
4	05/10/95	FS	1.97	2.50	0.177	2.18	2.81	1.24	modW
5	05/10/95	FS	2.15	2.85	0.139	2.41	3.40	1.41	Mod
6	05/10/95	MS	1.78	1.79	0.289	1.30	2.35	1.44	Mod
7	05/10/95	FS	2.85	2.52	0.174	2.20	2.99	1.31	modW
8	05/10/95	FS	3.96	2.71	0.153	2.31	3.36	1.44	Mod
9	04/10/95	CS	5.05	0.45	0.732	-0.45	2.20	2.51	P
10	04/10/95	CS	2.14	0.11	0.927	-0.49	0.71	1.52	Mod
11	04/10/95	CS	2.28	0.69	0.620	-0.10	1.65	1.83	Mod
12	03/10/95	FS	11.80	2.98	0.127	1.41	5.10	3.59	B
13	03/10/95	M	9.00	4.10	0.058	2.30	6.10	3.73	B
14	03/10/95	FS	8.33	2.60	0.165	0.15	5.40	6.17	B
15	02/10/95	M	12.03	5.05	0.030	3.12	6.27	2.98	B
16	02/10/95	M	11.11	5.92	0.017	4.89	7.22	2.24	P
17	02/10/95	M	11.61	5.92	0.017	5.00	6.92	1.95	P
18	03/10/95	FS	8.81	2.89	0.135	1.75	5.52	3.69	B
19	02/10/95	FS	6.70	2.70	0.154	1.47	4.40	2.76	B
20	06/10/95	FS	1.42	2.58	0.167	2.20	3.02	1.33	modW
21	19/10/99	M	11.51	5.83	0.018	4.92	6.84	1.95	P
22	19/10/99	M	11.88	4.64	0.040	2.79	6.30	3.38	B
23	18/10/99	CS	2.41	0.68	0.624	-0.09	2.00	2.73	P
24	18/10/99	FS	3.58	2.59	0.166	2.00	3.11	1.47	Mod
26	18/10/99	FS	1.47	2.35	0.196	1.91	2.70	1.31	modW
27	20/10/99	VFS	7.10	3.19	0.110	1.21	5.71	4.76	B
28	22/10/99	VFS	9.39	4.00	0.063	1.00	5.99	5.64	B
29	22/10/99	M	12.45	6.15	0.014	5.15	7.20	2.03	P
30	20/10/99	FS	5.61	2.80	0.144	2.29	3.63	1.59	Mod
31	21/10/99	MS	2.85	1.49	0.356	0.90	1.97	1.45	Mod
32	21/10/99	MS	1.71	1.68	0.312	0.11	2.48	2.27	P
35	20/10/99	M	9.51	5.09	0.029	3.68	6.71	2.86	B
37	22/10/99	M	13.74	5.85	0.017	5.26	6.70	1.65	Mod
38	20/10/99	M	10.32	5.61	0.020	4.40	6.72	2.23	P
39	20/10/99	M	11.36	6.30	0.013	5.59	6.89	1.57	Mod
40	21/10/99	M	8.69	5.21	0.027	4.12	6.58	2.35	P

TableA6.2. Community variables. Symbols: N m^{-2}: total abundance (ind. m^{-2}); B m^{-2}: total biomass (g m^{-2} PSSC); % P: % polychaetes; % M; % molluscs; % E: % echinoderms; % C: % crustaceans; % O: % others; K: species number; H': diversity; J': evenness.

					Biomass					
Station	**N m^{-2}**	**B m^{-2}**	**% P**	**% M**	**% E**	**% C**	**% O**	**K**	**H'**	**J'**
1	20814	14.37	60.31	12.46	0.95	0.59	25.70	101	4.83	0.73
2	16585	6.18	76.67	13.47	6.02	1.16	2.70	69	3.93	0.64
3	2960	1.47	72.89	26.71	0.00	0.12	0.29	24	3.48	0.76
10	68534	13.16	39.03	7.80	0.46	52.31	0.40	106	2.48	0.37
20	14002	5.54	73.02	13.40	6.94	1.58	5.06	67	2.64	0.44
21	7292	3.85	35.77	62.61	1.34	0.01	0.27	33	2.90	0.58
22	6869	1.52	76.90	22.31	0.00	0.17	0.62	41	3.83	0.71
26	697	1.95	8.29	62.42	28.33	0.94	0.03	25	3.90	0.84
27	12539	8.21	59.63	15.26	6.33	3.90	14.98	67	4.43	0.73
28	5726	2.74	24.37	35.09	0.00	40.06	0.48	43	3.64	0.67
29	3418	2.78	71.41	12.54	0.00	1.37	14.68	25	3.24	0.70
30	13213	7.55	62.62	26.05	0.34	3.14	7.85	76	2.96	0.47
31	6732	4.56	56.54	31.58	0.00	8.76	3.12	65	4.46	0.74
35	7475	3.03	51.49	47.30	0.00	1.08	0.14	44	2.79	0.51
37	1726	2.30	0.09	98.50	0.00	0.00	1.40	15	1.98	0.51
38	7761	6.54	36.19	54.46	9.09	0.18	0.08	33	3.01	0.60
39	823	0.75	4.09	94.88	0.00	0.02	1.02	12	2.64	0.74
40	472	0.13	95.96	0.00	0.00	4.04	0.00	6	1.95	0.75
Mean	10980	4.81	50.29	35.38	3.32	6.64	4.38	47	3.28	0.64
Max.	68534	14.37	95.96	98.50	28.33	52.31	25.70	106	4.83	0.84
Min.	472	0.13	0.09	0.00	0.00	0.00	0.00	6	1.95	0.37

References

Bray, J.R., and Curtis, J.T. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr., 27: 325–349.

Buchanan, J.B. 1984. Sediment analysis. *In* Methods for the study of marine benthos, pp. 41–65. Ed. by N.A. Holme and A.D. McIntyre. Blackwell Scientific Publications, Oxford.

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

López-Jamar, E .1978. Macrobentos infaunal de la Ría de Pontevedra. Bol. Inst. Esp. Oceanogr. IV(264): 111–130.

López-Jamar, E . 1981. Spatial distribution of the infaunal benthic communities of the Ría de Muros, North-West Spain. Mar. Biol. 63: 29–37.

López-Jamar, E. 1982.Distribución espacial de las comunidades bentónicas infaunales de la Ría de Arosa. Bol. Inst. Esp. Oceanogr. 7(2): 255–268.

López-Jamar, E. and Mejuto, J. 1985. Bentos infaunal en la zona submareal de la ría de La Coruña. I. Estructura y distribución espacial de las comunidades. Bol. Inst. Esp. Oceanogr. 2(3): 99–109.

López-Jamar, E and Cal, R.M. 1990. El sistema bentónico de la zona submareal de la ría de Vigo. Macroinfauna y microbiología del sedimento. Bol. Inst. Esp. Oceanogr. 6(2): 49–60.

López-Jamar, E., Bode, A, Parra, S. and Dorrío, A.V. 1996. Consecuencias del vertido de crudo del *Aegean Sea* sobre la macrofauna bentónica submareal. En: Seguimiento de la contaminación producida por el accidente del buque Aegean Sea. Ministerio de Medio Ambiente, Serie Monografías. Madrid. pp. 67–106.

Mora, J. 1980. Poblaciones bentónicas de la Ría de Arosa. Tesis Doctoral. Universidad de Santiago.

Parapar, J. 1991. Anélidos poliquetos bentónicos de la Ría de Ferrol (Galicia). Tesis Doctoral (Inédita), Universidad de Santiago de Compostela, 1104 pp.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. J. Theor. Biol. 13: 131–144.

Sánchez-Mata, A., Mora, J., Garmendia, J.M., and Lastra, M. 1993 a. Estructura trófica del macrozoobentos submareal de la ría de Ares-Betanzos. I: Composición y distribución. Publ. Espec. Inst. Esp. Oceanogr. 11: 33–40.

Sánchez-Mata, A., Lastra, M., Currás, A. and Mora, J. 1993 b. Estructura trófica del macrozoobentos submareal de la ría de Ares-Betanzos. II: Ordenación y clasificación de categorías tróficas en relación a los factores medioambientales. Publ. Espec. Inst. Esp. Oceanogr. 11: 41–47.

Sánchez-Mata, A, Glémarec, M., and Mora, J. 1999. Physico-chemical structure of the benthic environment of a Galician ría (Ría de Ares-Betanzos, north-west Spain). J. Mar. Biol. Ass. U. K. 79: 1–21.

Shannon, C.E., and Weaver, W. 1963. The mathematical theory of communication. Univ. Illinois Press, Urbana, Illinois, 111 pp.

Trask, P.D. 1950. Applied sedimentation. John Wiley & Sons Inc., New York, 707 pp.

ANNEX 7: A PROPOSAL FOR THE USE OF BENTHOS IN ECOLOGICAL QUALITY OBJECTIVES: THE DEVELOPMENT OF A MARINE BIOTIC INDEX

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Marine environmental quality control is undertaken usually by means of monitoring different parameters in water, sediment and sentinel organisms (i.e., Mussel Watch), as in the USA (O'Connor, 1992), France (RNO, 1998) or Great Britain (Franklin and Jones, 1994). This control is centred on physico-chemical and ecotoxicological variables and, less usually, on biological variables. Dauer (1993) stated that biological criteria are considered important components of water quality because: (i) they are direct measures of the condition of the biota; (ii) they may uncover problems undetected or underestimated by other methods; and (iii) such criteria provide measurements of the progress of restoration efforts.

New European rules (see Directive Proposal 2000/60/EC) emphasise the importance of biological indicators, in order to establish the ecological quality of European coasts and estuaries. Benthic invertebrates are used frequently as bio-indicators of marine monitoring, because various studies have demonstrated that macrobenthos responds relatively rapidly to anthroprogenic and natural stress (Pearson and Rosenberg, 1978; Dauer, 1993).

River ecology has an established long tradition in applying macrobenthos as bio-indicators; likewise some biotic indices have been proposed (Woodiwiss, 1964; Cairns *et al.*, 1968; Chandler, 1970; ISO-BMWP, 1979; etc.). On the other hand, some attempts to provide useful "tools" to measure ecological quality in the marine environment have been developed in Europe and North America (Hily, 1984; Majeed, 1987; Dauer, 1993; Grall and Glémarec, 1997; and Weisberg *et al.,* 1997).

All the aforementioned studies utilise soft-bottom communities to construct the indices, because macrobenthic animals are relatively sedentary (and cannot avoid deteriorating water/sediment quality conditions), have relatively long life-spans (thus, indicate and integrate water/sediment quality conditions, with time), consist of different species that exhibit different tolerances to stress and have an important role in cycling nutrients and materials between the underlying sediments and the overlying water column (Hily, 1984; Dauer, 1993).

Borja *et al.* (2000) developed a marine Biotic Index designed to establish the ecological quality of European coasts. This explores the response of soft-bottom communities to natural and man-induced changes in water quality, integrating long-term environmental conditions.

The model is based on that first used by Glémarec and Hily (1981) and then by Hily (1984), which utilises soft-bottom benthos to construct a biotic index.

Soft-bottom macrobenthic communities respond to environmental stress (i.e., the introduction of organic matter in the system) by means of different adaptive strategies. Gray (1979) summarizes these strategies into three ecological groups: *r* (r-selected: species with short life-span, fast growth, early sexual maturation and larvae throughout the year); *k* (k-selected: species with relatively long life, slow growth and high biomass); and *T* (stress tolerant: species not affected by alterations).

Salen-Picard (1983) has proposed four progressive steps relating to stressed environments: (i) initial state (in an unpolluted situation, there is a rich biocenosis in individuals and species, with exclusive species and high diversity); (ii) slight unbalance (regression of exclusive species, proliferation of tolerant species, the appearance of pioneering species, decrease of diversity); (iii) pronounced unbalance (population dominated by pollution indicators, very low diversity); and (iv) azoic substrata.

Following these four steps, Hily (1984) and Glémarec (1986) have stated that the soft-bottom macrofauna could be ordered in five groups, according to their sensitivity to an increasing stress gradient (i.e., increasing organic matter enrichment). Their concept is similar to that developed for the Infaunal Index for Southern California, described by Mearns and Word (1982) and Ferraro *et al.* (1991). These groups have been summarized by Grall and Glémarec (1997), as outlined below.

Group I: Species very sensitive to organic enrichment and present under unpolluted conditions (initial state). They include the specialist carnivores and some deposit-feeding tubicolous polychaetes.

Group II: Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance). These include suspension feeders, less selective carnivores and scavengers.

Group III: Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding species, as tubicolous spionids.

Group IV: Second-order opportunistic species (slight to pronounced unbalanced situations). Mainly small-sized polychaetes: subsurface deposit-feeders, such as cirratulids.

Group V: First-order opportunistic species (pronounced unbalanced situations). These are deposit-feeders, which proliferate in reduced sediments.

The distribution of these ecological groups, according to their sensitivity to pollution stress, provides a biotic index with eight levels, from 0 to 7 (Hily; 1984, Hily *et al.*, 1986; Majeed, 1987) (Figure A7.1, Table A7.1).

In our Biotic Index we have classified more than 1500 taxa. These species are representative of the most important soft-bottom communities present in European estuarine and coastal systems. The taxa have been classified according to the above ecological groups, following Majeed (1987), Dauer (1993), Weisberg *et al.* (1997), Grall and Glémarec (1997) and Roberts *et al.* (1998). The list of species, an Excel tool for the calculation of the BI and a program to calculate and represent the BI are available upon request to aborja@pas.azti.es or in the near future in AZTI's web page (http://www.azti.es/).

The Biotic Coefficient, proposed here as a Biotic Index to establish the ecological quality of the soft-bottom benthos within the European coastal environments, takes into account the faunal composition. As such, it ascribes each species to an ecological grouping, according to their sensitivity to an increasing stress gradient.

The different composition in terms of the abundance of the various ecological groups in these samples provides a continuous Biotic Coefficient (with values between 0 and 6). This is referenced to a Biotic Index, representing quality of bottom conditions in a discreet range from 0 (unpolluted) to 7 (extremely polluted). This composition is governed by the physico-chemical factors within the sediments and the overlying water column in terms of: organic matter content; percentage of mud within the sediments; dissolved oxygen content within the bottom waters; and the concentration of pollutants.

Biological parameters (such abundance, richness, biomass or diversity) provide a useful (and more broadly applicable) description of each level of the Biotic Index. It is considered (as described by Dauer, 1993) that biological criteria may complement toxicity and chemical assessment methods, to serve as independent evaluations of the ecological quality of marine and estuarine ecosystems.

Validation of the model developed shows that different anthropogenic changes in the environment can be detected through the use of the Biotic Index, including alterations to the natural system such as dredging, engineering works, sewerage plans and the dumping of polluted waters. On the other hand, the Biotic Coefficient provides a more accurate view of the evolution of the ecological status of a particular location. Further, the fact that this particular coefficient can derive continuous values makes it more suitable for application to statistical analysis than the Biotic Index (i.e., temporal trend analysis).

The Biotic Index proposed here is relatively simple and can, meaningfully, be applied when attempting to determine the ecological status of European coastlines. Although this index has been developed in the Bay of Biscay, the methodology can be applied for other European coastal areas, only conditioned by the assignation of the species to the ecological groups described here. In fact, many of the species compiled in the Appendix A are present in North Sea and Mediterranean. So, the index may be improved with the contributions of newly assigned species from these seas and further examples of its more general application and validation.

This index facilitates the understanding of complex benthic data, summarising a considerable amount of ecological information into a single representative value.

The BC and BI values provide an easy and clear way to establish the ecological quality of soft-bottom benthos. The results obtained by us fit in well with those obtained using several indices, such as richness, diversity, evenness, ABC plots, and univariate and multivariate statistical analyses.

The BC and BI would seems appropriate to use along all European coastal environments, as it is independent of longitude and latitude; they have been used in the Atlantic (North Sea; UK, French and Spanish coast), a transitional area between the Atlantic and the Mediterranean (in the south of Spain), as well as in the Mediterranean (Spain and Greece coast).

The BC and BI are independent of the pollution source, e.g., drilling cuts, outfalls (submarine or otherwise), heavy metals, marinas and civil works (dikes, sewerage works…). On the other hand, the BI and BC vary only little throughout the year. Hence, samples obtained at different times can be compared, if there is not any main changes in the source of the pollution.

The BC and BI are useful to apply to the comparison of the ecological quality of the soft-bottom benthos, before and after a stress episode takes place; and they are also useful to identify spatial trends and gradients, related to the hydrodynamic and dilution processes.

References

Borja, A., Franco, J. and Pérez, V. 2000. A Marine Biotic Index to Establish the Ecological Quality of Soft-Bottom Benthos Within European Estuarine and Coastal Environments. Marine Pollution Bulletin, 40(12): 1100–1114.

Cairns, J., Douglas, W.A., Busey, F., and Chaney, M.D. 1968. The sequential comparison index – a simplified method for non-biologists to estimate relative differences in biological diversity in stream pollution studies. Journal of Water Pollution Control. Fed, 40: 1607–1613.

Chandler, J.R. 1970. A biological approach to water quality management. Water Pollution Control, 69: 415–422.

Dauer, D.M. 1993. Biological criteria, environmental health and estuarine macrobenthic community structure. Marine Pollution Bulletin, 26(5): 249–257.

Ferraro, S.P., Swartz, R.C., Cole, F.A., and Schults, D.W. 1991 Temporal changes in the benthos along a pollution gradient: discriminating the effects of natural phenomena from sewage-industrial wastewater effects. Estuarine, Coastal and Shelf Science, 33: 383–407.

Franklin, A., and Jones, J. 1994. Monitoring and surveillance of non-radiactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1992. Aquatic Environment Monitoring Report, MAFF 40: 1–83.

Glémarec, M. 1986. Ecological impact of an oil-spill: utilisation of biological indicators. IAWPRC-NERC Conference, July 1985. IAWPRC Journal, 18: 203–211.

Glémarec, M., and Hily, C. 1981. Perturbations apportées à la macrofaune benthique de la baie de Concarneau par les effluents urbains et portuaires. Acta Oecologica Oecologia Applicata, 2: 139–150.

Grall, J. and Glémarec, M. 1997. Using biotic indices to estimate macrobenthic community perturbations in the Bay of Brest. Estuarine, Coastal and Shelf Science*,* 44(sup. A): 43–53.

Gray, J.S., 1979. Pollution-induced changes in populations. Philosophycal Transactions of the Royal Society of London Series, B, 286: 545–561.

Hily, C. 1984. Variabilité de la macrofaune benthique dans les milieux hypertrophiques de la Rade de Brest. Thèse de Doctorat d'Etat, Univ. Bretagne Occidentale. Vol. 1: 359 pp., Vol. 2: 337 pp.

Hily, C., Le Bris, H., and Glémarec, M. 1986. Impacts biologiques des émissaires urbains sur les écosystèmes benthiques. Oceanis, 12: 419–426.

ISO-BMWP. 1979. Assessment of the biological quality of rivers by a macroinvertebrate score. ISO/TC147/SC5/WG6/N5, International Standards Organisation, 18 pp.

Majeed, S.A. 1987. Organic matter and biotic indices on the beaches of North Brittany. Marine Pollution Bulletin, 18(9): 490–495.

Mearns, A.J., and Word, J.Q. 1982. Forecasting effects of sewage solids on marine benthic communities. *In:* Ecological Stress and the New York Bight: Science and management (Mayer, G.F., ed.) Estuarine Research Federation, Columbia, South Carolina. 495–512.

O´Connor, T.P. 1992. Recent trends in coastal environmental quality: results from the first five years of the NOAA Mussel Watch project. US Department of Commerce, NOAA, Rockville, 45 pp.

Pearson, T., and Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review, 16: 229–311.

Roberts, R.D., Gregory, M.R., and Fosters, B.A. 1998. Developing an efficient macrofauna monitoring index from an impact study – A dredge spoil example. Marine Pollution Bulletin, 36(3) : 231–235.

R.N.O. 1998. Surveillance du Milieu Marin. Travaux du Réseau National d'Observation de la Qualité du Milieu Marin. Edition 1998. Ifremer et Ministère de l'Aménagement du Territoire et de l'Environnement, 52 pp.

Salen-Picard, C. 1983. Schémas d'évolution d'une biocénose macrobenthique du substrat meuble. Comptes Rendus de l'Academie des Sciencies de Paris, 296: 587–590.

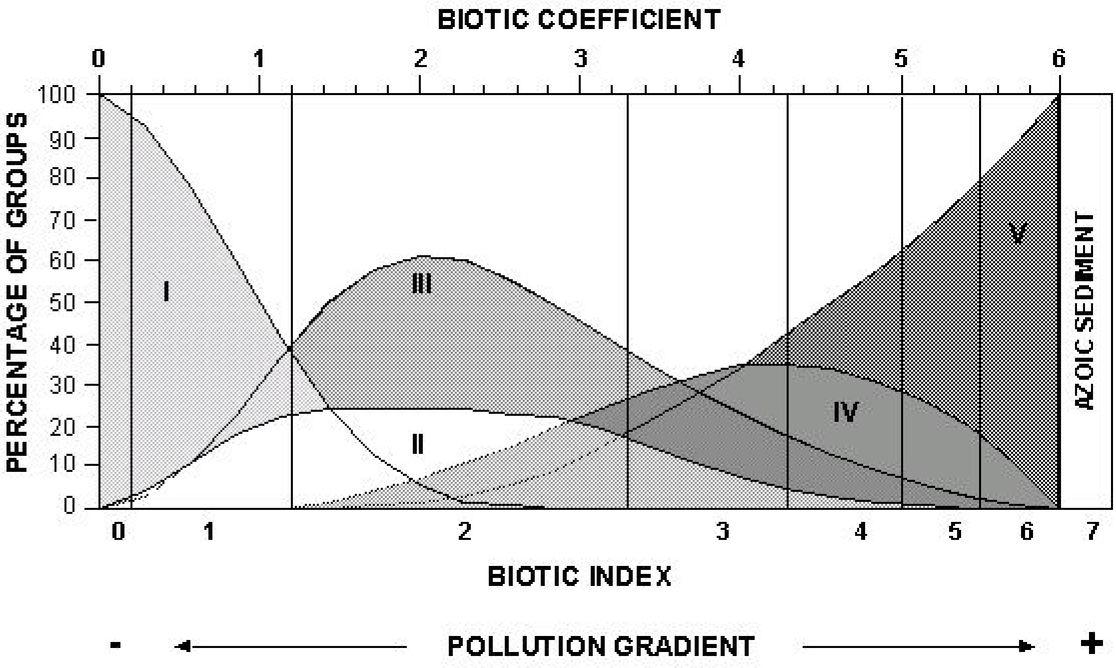
Weisberg, S.B., Ranasinghe, J.A., Dauer, D.M., Schaffner, L.C., Diaz, R.J., and Frithsen, J.B. 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. Estuaries, 20(1): 149–158.

Woodiwiss, F.S. 1964. The biological system of stream classification used by the Trent River Board. Chemistry Industries, 11: 443–447.

Table A7.1. Summary of the Biotic Coefficient and Biotic Index (after Borja *et al.*, 2000).

Site Pollution Classification	Biotic Coefficient	Biotic Index	Dominating Ecological Group	Benthic Community Health
Unpolluted	0.0 < BC ≤ 0.2	0	I	Normal
Unpolluted	0.2 < BC ≤ 1.2	1		Impoverished
Slightly Polluted	1.2 < BC ≤ 3.3	2	III	Unbalanced
Moderately Polluted	3.3 < BC ≤ 4.3	3		Transitional to pollution
Moderately Polluted	4.3 < BC ≤ 5.0	4	IV–V	Polluted
Heavily Polluted	5.0 < BC ≤ 5.5	5		Transitional to heavy pollution
Heavily Polluted	5.5 < BC ≤ 6.0	6	V	Heavy polluted
Extremely Polluted	Azoic	7	Azoic	Azoic

Figure A7.1. Theoretical model (in Borja *et al.*, 2000), modified from Hily (1984), Hily *et al.* (1986) and Majeed (1987), which provides the ordination of soft-bottom macrofauna species into five ecological groups (Group I: species very sensitive; Group II: species indifferent; Group III: species tolerant; Group IV: second-order opportunistic species; Group V: first-order opportunistic species), according to their sensitivity to an increasing pollution gradient. The relative proportion of abundance of each group in a sample provides a discreet Biotic Index with eight levels (0 to 7) and an equivalent continuous Biotic Coefficient (values between 0 and 6).



ANNEX 8: MONITORING OF ROCKY-BOTTOM BIOTOPES IN NORTHERN NORWAY AND SVALBARD USING IMAGE ANALYSIS

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Abstract

Temporal variations and succession of a macrobenthic community from rocky bottom localities on Svalbard and Northern Norway are investigated by analysis of long time series of photographs of permanently marked underwater areas. This photographic monitoring represents the longest time series of rocky bottom biota from these areas, with pictures taken annually (July–September) from 1977.

Underwater photography is a useful "non-destructive" method for obtaining information on conspicuous epifaunal organisms. Photographs of permanently marked areas over long time periods give the opportunity to study population dynamics (settlement, age, mortality), individual growth, productivity, competition for space, predation and community succession.

Many high latitude fjords, such as Kongsfjorden on Svalbard, are heavily influenced by glacial discharges of cold water, glacial ice and sediments. There are also strong seasonal fluctuations in light, sea-ice cover, freshwater inflow, surface salinities and sediment input. These environmental factors have major impacts on the composition and temporal variations of benthic communities.

The photographed areas (ten ¼ m^2 squares) are marked on the rock bottom and re-found each year using landmarks and GPS positions. The studied area is located on horizontal bottom at 15 m depth near Kvadehuken (Position: 78° 58.6' N, 11° 30.1' E) in the outer part of Kongsfjorden. At the start of the project in 1980, all organisms from half of the monitored area were removed, with the aim to study the succession of cleaned areas. The other part remained undisturbed as a reference area.

The marked areas were photographed using a Hasselblad SWC fitted with correction lenses in a Hasselblad underwater housing. The technique is based upon stereo-photographs and was developed by Tomas Lundälv at the Kristineberg Marine Biological Station, Sweden (Lundälv, 1971). Positive Ectachrome 200 was used throughout the study. A flat bed scanner (Saphir ultra 2-Linotype Hell) and the software package "Lino color", version 6.0.5. was used to perform the scanning process of the photographed pictures.

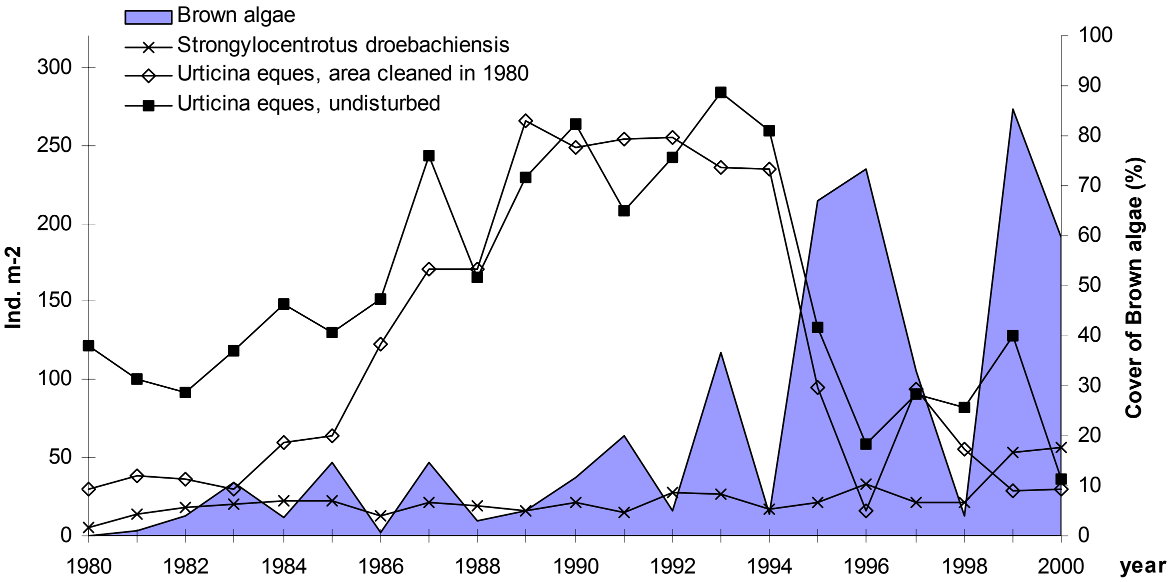
Digital image analysis and processing was carried out using Adobe Photoshop/Macintosh with the "Fovea pro"-measurement toolkit. Special effort was paid to develop an efficient method in order to retrieve quantitative data on conspicuous macrobenthic solitary (e.g., sea anemones and sea urchins) and colonial invertebrates (e.g., colonial ascidians and bryozoans) and algae. The automation of selected steps during the procedure of image analyses in Adobe Photoshop made the work more efficient. After image corrections of light and colour, the organisms were individually selected by using "magic wand tool" or by their special colour range (colonial organisms) and placed on separate image layers. Data on abundance and the covered area can be retrieved using the measuring filter toolkit. For this reason, a unique colour code in RGB was assigned to each species, in order to identify it in the subsequent data file.

During the analysis, 19 species/taxa and typical bottom features such as cover of sediments were treated. The most abundant solitary organism was the actinian *Urticina eques*. The densities ranged from 50–300 ind m^{-2}, the relative covered area ranged from 5–12 % during the period of investigation. The cleaned area revealed values comparable to the reference area from a period of 6–8 years after the starting point; thus, this period is regarded as a natural recovery time for this species. In the beginning of the 1990s, a drastic decline of the population was observed, which seems to be a negative correlation to the extended cover of brown algae (Figure A8.1).

The sea urchin *Strongylocentrotus droebachiensis* was recorded in high densities (20–40 ind m^{-2}), which induces a heavy predation pressure on the locality. It is thus referred as a keystone species in the area (Jørgensen and Gulliksen, 2000). A positive correlation to the occurrence of brown algae as a major food resource of sea urchins was observed (Figure A8.1).

Brown algae and calcareous algae were covering large areas. Brown algae showed increased densities from the beginning of the 1990s. Nevertheless, huge variations are observed during the monitoring period, which could be connected to variations in ice cover during the photosynthetically active period (Figure A8.1).

Figure A8.1 Variation of brown algae, the sea urchin *Strongylocentrotus droebachiensis* and the sea anemone *Urticina eques* at 15 m depth, Kvadehuken, Kongsfjord.



ANNEX 9: REPORT OF THE ICES-BEWG NORTH SEA BENTHOS PROJECT WORKSHOP

Oostende, Belgium
28–29 January 2002

Opening of the meeting and appointment of the rapporteur

The meeting took place at the "Tulip Inn" in Oostende, Belgium. The group was welcomed by the chair of the Benthos Ecology Working Group (BEWG), K. Essink, who also acted as Chair of the workshop. The list of the 18 participants for the meeting is appended as Appendix 1.

E. Vanden Berghe, acting data manager of the NSBP, was appointed as rapporteur, and was assisted in this task by K. Deneudt. The agenda for the workshop is appended as Appendix 2.

1. Existing structure of the NSBS-1986 data; structure of taxonomic component

E. Vanden Berghe reported on the current way of integration of the NSBS-1986 data into the existing taxonomical database TISBE and on how these data are available on the VLIZ-website. The permission needed for making these data public was discussed. It was concluded that these data were previously published in the *ICES Cooperative Research Report* no. 218; therefore, there cannot be a problem in making this information public on the VLIZ-web site, as long as the ICES report is cited.

2. Data available to NSBP (2000/2001)

In order to get a general idea of the status of the NSBP, the data contribution from each participating group was presented by E. Vanden Berghe. The members of the different institutes explained in detail which data are still to be expected.

The geographical distribution of sampled stations over the entire North Sea area is not nice and even. Some gaps in coverage were identified. To fill in the lack of data in the northern part of the North Sea (meaning north of the area covered by CEFAS), it was agreed that M. Robertson (Aberdeen) and P. Kingston (Edinburgh) should be contacted. Regarding the area in front of the Danish coast, there are no Danish benthos programmes known to any of the participants.

The suggestion was made that, in order to be able to get data coming from these areas, it will be advisable not to be too restrictive in accepting data of sampling campaigns. The standard rule is that data of 2000 should be used. Only if there is no other possibility, data of 1999 and data of 2001 can be used.

A short discussion was held on whether the NSBP should not be regarded more as a form of continuous process rather then a strict one-year project. Though the continuous process approach was considered valuable, it was decided to first concentrate on the 2000 NSBP as a finality on its own. Later on, inclusion of data sets from later years may be included in new data analyses in a flexible way.

- ***Action point***:

1. K. Essink to contact M. Robertson and P. Kingston for Scottish data.

3. Other relevant data

The main goal is still, as decided during the BEWG meeting in Wimereux, an overall comparison with the NSBS-1986 data. All the additional information that can help achieve this goal is considered relevant.

H. Hillewaert and S. Degraer were invited by the Chair to inform the other participants about relevant information on sea bed maps available through the ICES Working Group on Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) and the ICES Working Group on Marine Habitat Mapping (WGMHM).

H. Julie or J.Nørrevang Jensen (at ICES) should be contacted in order to obtain good bathymetric maps of the North Sea and possibly bottom trawling intensity information. The search for this trawling intensity information should be based on the Monitoring Report 2001 by Ruth Zühlke *et al.*

Furthermore, information on water temperature, water quality and benthic biomass were mentioned as interesting and relevant data. It was decided that data regarding salinity, currents (hydrography), wave-induced bottom stress and primary production-related information are welcome. Also, it was considered useful to compare the observed distributions of macrozoobenthos with the results of a number of existing models, such as ERSEM (NIOZ, Netherlands), hydrographic models (Hamburg University, Germany) and models at the BMM in Belgium.

- ***Action points***:

2. *H. Hillewaert to make available seabed maps available from WGEXT (ICES).*

3. *S. Degraer to make available relevant maps or information available from WGMHM (ICES).*

4. *E. Vanden Berghe to contact H. Julie or J.Nørrevang Jensen (ICES) concerning bathymetric maps of the North Sea.*

5. *G. Duineveld, I. Kröncke and H. Hillewaert to provide information on the models available at ERSEM, the Hamburg University and the BMM.*

4. Data ownership, rights and credits

For some of the data owners in the NSBP there are national reporting obligations. Because of this, it was agreed that the raw data should be kept within the group of NSBP people for as long as the analyses have not been fully completed and a formal publication has been made under the name of the NSBP.

All data contributors will be co-authors on any publication based on the integrated data set. For any use of raw data by scientists other than the data owner(s), permission has to be asked and obtained from the original data owner(s).

A list of agreed rules with respect to access to, and use of, individual data sets is appended as Appendix 3.

It was agreed that no restrictions apply to the meta-data, as these are data concerning the sampling campaign and do not include the raw data. A list of what constitutes a complete description of meta-data will be sent around to the participants to be filled in with their available meta-data. On an introductory website of the NSBP, these meta-data will be made public.

- ***Action point***:

6. *E. Vanden Berghe to send around to the participants a list to be filled in with the available meta-data.*

5. Quality control

Other than in normal coordinated projects, the NSBP has to deal with a "*fait acompli*", implying that no proper Quality Assurance and Control could be arranged *a priori.* The participants accepted that for the next steps in the project they have to make the best of it.

Taking into account the large amount of species that are reported in only one of the delivered data sets it was agreed that the need for a taxonomical workshop is high. However, it was considered advisable to carry out an exploratory analysis first. In this way, a realistic assessment can be made of the extent of this taxonomic issue.

It was considered possible that differences between the data sets can arise out of the fact that a variety of sampling gear was used. However, the use of different gear can only partly explain taxonomic differences.

It was agreed that each data contributor to the NSBP should send a list with quality control procedures and standard operating procedures, including identification keys used, to E. Vanden Berghe. This information will become part of the meta-data documenting the data sets.

- ***Action points***:

7. *All data providers to send a description of quality control procedures used to E. Vanden Berghe.*

8. *E. Vanden Berghe to circulate a combined list to the participants in the NSBP.*

6. Integration of data sets

A large part of this subject was already dealt with under the previous agenda items. Some important questions, however, concerning integration of data sets still remained.

It was decided that for each sample taken, the date, the exact time and information about the sampling gear used should be provided.

In order to standardise the data delivered to the data manager at the level of variables and methodologies used, the ICES standard list should be taken as a reference and therefore distributed amongst the participants. Biomass data should be delivered in units as determined; during data analysis conversion to a common unit will be done.

Regarding taxonomy and nomenclature, the following agreements were made. Firstly, every "species cf." and every morphospecies will be integrated in the final database on the genus level. This will be well described. Secondly, species lists will no longer be delivered in form of code. And finally, for each species both the person identifying as well as the keys used for identification should be mentioned.

- ***Action points**:*

9. *E. Vanden Berghe to investigate which standard lists are prescribed by ICES, and circulate this information.*

7. Integration of data structures

E. Vanden Berghe presented a prototype of the database structure, which was to serve as a basis for discussion. A proposition was made to put in extra fields for indication of feeding types, life history traits, etc. The data for the input will be compiled out of existing lists on feeding types and life history traits; it was realised that these lists need to be harmonised. These lists will be delivered to the data manager and, after compilation, distributed amongst the participants two weeks before the BEWG meeting in Tromsø at the latest.

It was also proposed to put in an extra flag for quality control. This flag should be included in the database structure at the level of the sample.

It was noted that it might be useful to have a field saying whether or not the chemical, sediment and benthos information was gathered out of one and the same sample.

It was finally agreed that the geographical location of the stations and replicates have to be stored. Data from replicates should be kept, data from horizontal slices of cores on the other hand, were not considered useful to store.

Protocols for data exchange were listed and general agreements were made to make the data exchange more efficient. A list of these will be distributed later.

Database exchange protocols based on XML were considered unnecessary at this point.

- ***Action points**:*

10. *J. Craeymeersch, H. Rees, G. Duineveld, I. Kröncke and S. Nehring to deliver lists of feeding types and life history traits to E. Vanden Berghe.*

11. *E. Vanden Berghe to distribute a combined/harmonised version of these lists, for further consideration at the BEWG meeting, if necessary.*

8. Deliverables

As decided earlier (BEWG meeting in Wimereux), the final results of the NSBP shall lead to publication in an *ICES Cooperative Research Report* and in scientific journals. At this moment, however, it is still too early to make practical arrangements on this matter in more detail. Publications as foreseen at the Wimereux meeting of the BEWG are listed in Appendix 4**.**

As mentioned under agenda item 4, a website will be constructed to present the NSBP. On this website a general description will be given of the NSBP, explaining the general aims, presenting the participating institutes and describing the area of the North Sea covered. This website will start off with a hidden link, so that the participants in the NSBP can make remarks and suggestions internally, before the website will be open to visits by the public.

- ***Action point****:*

12. E. Vanden Berghe to construct a website presenting the NSBP, and to check this with the participants in the NSBP, before putting it really on the web.

9. Analysis

The Chair invited E. Vanden Berghe to make the primary exploratory analyses, as already discussed. The outcome of this analysis shall be distributed to the participants. Proposals for further analyses shall be made in a later stage, the first opportunity for this being the BEWG meeting in Tromsø.

- ***Action point****:*

13. E. Vanden Berghe to make primary exploratory analyses, to be presented at the BEWG meeting in Tromsø.

10. Data distribution

It was agreed that, except for the meta-data, no data shall be made public at this moment (see under agenda item 4). The meta-data shall be made public on the website as soon as possible. For every use of the raw data, permission is needed from the original data owner.

11. Collaboration with other ventures

Other international projects may be of importance for the NSBP, and may be interested to know of the NSBP. Therefore, it was decided that contact will be made with the data owners of the European Marine Register of Species (ERMS) and the Integrated Taxonomic Information System (ITIS). It was considered too early to consider any formal collaboration with these or any other ventures.

It was noted that also meiofauna samples and data are available at CEFAS (Lowestoft) and University of Gent. As the CEFAS samples have not yet been analysed, and the Gent data do not allow for a comparison with 1986 data, it was decided not to include these data in the NSBP. Meta-data on these samples, however, will be included in the database.

- ***Action point****:*

14. E. Vanden Berghe to contact data owners of the ERMS and the ITIS.

12. Timetable

K. Essink indicated that a next meeting of the NSBP will take place during the ICES BEWG meeting that will take place from the 24–27 April 2002 in Tromsø (Norway). Then, among others, the following issues will be on the table: results of exploratory analyses, quality control on taxonomy, and list of feeding types and life history traits.

A next workshop will necessarily have to deal with solving the taxonomy problems in the total NSBP data set. This next workshop is suggested to take place somewhere in autumn this year, possibly at the Alfred Wegener Institute in Bermerhaven (to be checked with E. Rachor).

- ***Action point****:*

15. K. Essink to contact E. Rachor in connection with hosting a workshop in autumn 2002.

13. Other business

H. Hillewaert reported on the existence of a portal to marine-related websites developed by the Sea Fisheries Department (SFD) at Oostende.

On a question as to the costs of participating in NSBP meetings/workshops, K. Essink responded that any costs involved in cooperating with the NSBP will be on the budget of the institutes participating.

K. Essink informed the meeting of the end of his term as Chair of the BEWG in 2002. A new Chair has to be chosen at the meeting in Tromsø. In Tromsø, also a decision needs to be made on who will further act as coordinator of the NSBP.

14. Closing of the meeting

K. Essink formally closed the meeting on 29 January at 12.30 hours, and expressed his thanks and appreciation to the participants for their contributions to this valuable meeting and to the staff of the Flanders Marine Institute for the organisation.

Appendices

Appendix 1: List of participants

Appendix 2: Agenda of the workshop

Appendix 3: Agreed rules with respect to access to, and use of, individual NSBP data sets

Appendix 4: Provisional list of intended publications

APPENDIX 1:

LIST OF PARTICIPANTS

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APPENDIX 2

ICES – BEWG

North Sea Benthos Project Workshop
Oostende, Belgium
28-29 January, 2002

PROPOSED AGENDA

MONDAY, 14:00 – 19:00 hrs

Introduction and adoption of the agenda/ practical arrangements

Existing structure of the NSBS-1986 data; structure of taxonomic component

Data available to NSBP (2000/2001)

- > stations (including map)
- > sampling methodology
    - - instrumentation
    - - sample size
    - - replication
- > environmental parameters (plus methodology)
- > taxonomic list (plus works used in identification)

Other relevant data

- > seabed maps
- > bottom trawling intensity
- > other

TUESDAY, 09:00 – 12:00 hrs

Data ownership, rights and credits

Quality control

Integration of the data sets

- > Environmental data
- > Taxonomy/Nomenclature
    - - Synonyms/Alternative identifications
    - - "'Qualified" identifications (Juvenile/Indet.)
    - - Morphospecies (problem of Sp. a, Sp. b...)
- > Densities/biomass

Integration of data structures

- > Structure of the database
- > Protocols for data exchange (XML?)
    - - Adding data

- Updating exisiting records

Deliverables

> Reports

> Scientific papers

> Website

> Job allocation: lead-persons & writer-groups

Analysis

> Exploratory data analysis

> Distribution maps

> Analysis of 2000 data

- Community structures
- Correlations with environmental parameters

> Comparison with 1986 data

> Gaps and how to deal with them

Data Distribution

> What to distribute

> How to distribute

> To whom (role of ICES??)

Collaboration with other ventures

> Other North Sea Atlasses

- Epifauna (Ruth Zuhlke)
- What about meiofauna?
- Others??

> Taxonomy (e.g., ERMS, ITIS, ETI)

Timetable

> BEWG (Tromsø) end of April

> Follow-up activities

> Next workshop (at AWI-Bremerhaven?)

Any other business

> finances

> other

APPENDIX 3

ICES – BEWG

"North Sea Benthos Project 2000"
Re: Access to, and use of, data sets

The participants of the workshop on the North Sea Benthos Project (NSBP-2000), held in Oostende, Belgium, at 28–29 January 2002 agreed on the following rules with respect to access to, and use of, individual or institutional data sets:

1) The raw data will only be available for participants in the NSBP-2000 for the purpose of data analysis aimed at the production of common reports/publications. At a later moment it will be decided when public access to the raw data can be allowed.

2) All data contributors will be co-authors on any publication based on the integrated data set. For each publication there will be a group decision regarding the name of the "first" author.

3) The timing of any common report or publication will consider and respect any national requirement with regard to reporting on national data sets.

4) Any participant who wants to use data from another data owner can do so only after having been given consent by the respective data owners.

5) The meta-data regarding individual or institutional data sets will be made available to public access via the web. These meta-data will not include any raw data as mentioned under (1) nor species lists.

APPENDIX 4

NORTH SEA BENTHOS PROJECT 2000

Preliminary list of endproducts
ICES reports
ICES Cooperative Research Report No. xxx

(comparable to ICES Coop. Res. Rep. No. 218 on the 1986 North Sea Benthos Survey)

Publications in scientific journals

1. An overall comparison with the results from the 1986 NSBS. Also indication of limitations of comparison due to differences in approach.

2. Comparison of 1986–2000 data in relation to North Atlantic Oscillation and other environmental settings (e.g. input of nutrients).

3. Testing the applicability of the EUNIS habitat classification system as developed by the European Environment Agency

4. Investigation of the relationship between benthos (long-lived/large species) and bottom trawling intensity. This will be dependent on the degree of detail of fishing intensity data. A similar approach is followed in the CEFAS-coordinated epibenthos surveys (EC Project: 98/021).

ANNEX 10: ECOLOGICAL STUDIES IN THE WHITE SEA

Eike Rachor
Alfred Wegener Institute for Polar and Marine Research,
Bremerhaven Germany

The White Sea is an almost enclosed marine environment of about 91,000 km^2, where strong interrelationships between the Boreal coastal and the Arctic deep offshore ecosystems exist. It is connected with the Barents Sea via the Voronka and Gorlo, which parts function like a sill. There are also strong riverine inflows into the sea, amongst which the Northern Dvina is the most important (120 km^3 per year; this is more than the contribution of Rhine, Elbe and Weser together to the North Sea). According to these features, the White Sea can be regarded as a fjord-like system as well as a large estuary. Its central part is occupied by an up to 340-m deep basin, which extends northwestward into the Kandalaksha Bay. Although there exists a strong persistent stratification of the waters in the basin part and though there seems to be a strong input of organic matter into the basin and an enrichment of organic particles on the sea floor, oxygen saturation of the near-bottom waters was never reported to fall below 65–70 %. There seems to exist an efficient deep convection due to advection of highly saline Barents Sea water and brine release during ice formation in the Gorlo area during normal winters, by which the White Sea is well distinguished, e.g., from the Baltic Sea.

Due to the persistent stratification and the effective winter renewal, the deep water of the White Sea has always negative temperatures, which support a cold-adapted Boreo-Arctic to Arctic fauna. Seasonality of the zoobenthos in the basin seems to be weak, while the organisms in the shallow inshore waters are adapted to strong seasonal variations in temperature as well as salinity.

Preliminary results of oxygen consumption rate measurements at the interface water - sea floor in deeper waters indicate a relatively high benthos activity which seems to be comparable to those in the Baltic and other neighbouring seas.

Table: Sediment oxygen uptake rates (compiled by Anders Tengberg, Goeteborg University)

Preliminary White Sea measurements of the author from waters deeper than 70 m in October 1998 and in June 1999 arrived at consumption rates between 3.5 and 7.2 mmol m^{-2} day^{-1}.

As the relationships between the coastal and offshore parts are poorly understood so far, the origin, nutritional role and fate of particulate organic matter is being investigated in inshore and offshore waters by three Russian and four EU member state institutions (in UK, Sweden, Finland, and Germany) within a multidisciplinary European INCO project ("WOMP"*) during joint sea-going and land-based research.

Area	O_2 Uptake [mmol*m-2*day]	Reference
At the Yenisey river mouth	about 6	ANDERSON *et al*., 1998
North of Kola peninsula	about 1	ANDERSON *et al*., 1998
White Sea Kartesh stat.	about 10	VERSHININ *et al*., 1998
Around Svalbard	2 to 11	HULTH *et al*., 1994
Skagerrak	10 to 20	STÅHL *et al*., 1994
Deep N. Atlantic (5000 m)	0.5 to 1	STÅHL *et al*., 1994
S. Baltic Sea	5 to 10	Unpublished data

Table 1: Examples of oxygen uptake data from the White Sea and neighboring areas.

The relative importance and transformation of the organic matter in the food chains, including higher trophic levels (fish, birds), and thus, humans, are insufficiently studied in this region. Since water and oxygen renewal in the deep basins seem to depend on processes in the northern entrance of the sea (via the Gorlo), any changes in these processes will endanger the Arctic biota in the permanently cold White Sea deep basins.

The overall objective of the project is to investigate the origin, transportation, transformation and nutritional role of particulate organic matter (POM) in the White Sea with special regard to its deep basin as an example of an Arctic marine ecosystem. Various items are addressed:

- The seasonal changes in the main POM sources including sea ice assemblages, plankton and detached coastal macroalgal material.
- The major hydrography, with special regard to the currents important for transportion and POM deposition and to processes important for deep-water renewal.
- The diversity of pelagic and benthic assemblages, namely the deep-water Arctic, and the shallow-water Boreal populations, and their role in the transformation and use of POM.
- Sedimentary processes and their influences on the near-bottom oxygen regime, including the use of "state-of-the-art-technology" such as autonomous benthic landers.
- Links of larger, migrating or widely foraging animals (especially fish and birds) with the inshore and offshore POM sources.
- Ecosystem modeling, also to develop various advisory scenarios for sustainable exploitation of regional resources including comparison with other marine environments, especially the Baltic Sea and northern Eurasian marginal seas of the Arctic Ocean.

* European INCO project ICA2 - CT-2000 - 10053: Pathways of organic matter and its implication for biodiversity and sustainable uses in the White Sea (Acronym: "WOMP"), see http://www.womp.narod.ru.

OTHER WHITE SEA RESEARCH

There are several Russian research stations at the White Sea, e.g., of the Moscow State University, of St. Petersburg University and of the Zoological Institute RAS in St. Petersburg (ZISP), all situated at the Karelean Coast of Kandalksha Bay. Benthic as well as many other ecological studies have been performed there for decades.

Socio-economic aspects and research about inputs of contaminants and nutrients are considered in the work of the Northern Water Problems Institute in Petrozavodsk. There are also cooperative studies about zoobenthos distribution patterns, partly done in cooperation with ZISP.

Within the framework of LOIRA (Land-Ocean-Interactions in the Russian Arctic) activities of the Shirshov-Institute of Oceanology Moscow have their focus in the White Sea, too. These activities have strong sedimentological components, including studies of fluxes of contaminants and nutrients via the atmosphere and land runoff as well as sediment trap measurements, which are performed in close cooperation with "WOMP". Faunal zonations and benthic processes related to transformations of particulate matter along the plumes of main rivers are also studied within this frame.

LITERATURE

Rachor, E. (ed., 2000). Scientific Cooperation in the Russian Arctic: Ecology of the White Sea with Emphasis on its Deep Basin. - Berichte Polarforschung (Bremerhaven), 359: 1–109.

Berger, V., Dahle, S. *et al.* 2001. White Sea. Ecology and environment. Derzavets Publ. St. Petersburg - Tromsoe, 157 pp.

Naumov, A.D., and Fedyakov, V.V (eds., 1991): Bentos Belogo Morya (Benthos of the White Sea). Proc. Zool. Inst. USSR Acad. Sci. 233, 159 pp. (in Russian).

ANNEX 11: TRAJECTORIES OF MARINE ECOSYSTEM RESPONSE TO ARCTIC CLIMATE CHANGE: A BARENTS-BERING SEA COMPARISON

Progress Report Presentation 26 April 2002 by Michael Carroll, Akvaplan-niva, Tromsø Norway

The lack of integrated, long-term data series of biological and physical variables is one of the major shortcomings currently limiting research into the effects of climate change in the Arctic. Benthic communities are particularly well-suited to examining the effects of climatic changes because they cannot emigrate when physical conditions change, and because they have been studied for over 100 years using essentially the same methods.

Akvaplan-niva is leading a consortium of Norwegian, American, and Russian researchers, with funding from the International Arctic Research Center (IARC) in Fairbanks, Alaska, USA, to determine how marine benthic communities co-vary with physical and hydrographic factors associated with periodic and repeating regime shifts in Arctic circulation. By examining variations of ecosystems over the last 100 years and their relationship with climatic variations, we hope to be able to estimate how ecosystems might respond in the future in the face of more sustained climatic shifts. This is a comparative study of the Barents and Bering Chukchi Seas, two important marginal areas of the Arctic Ocean using historical data collected by American, Norwegian, and Russian Institutes.

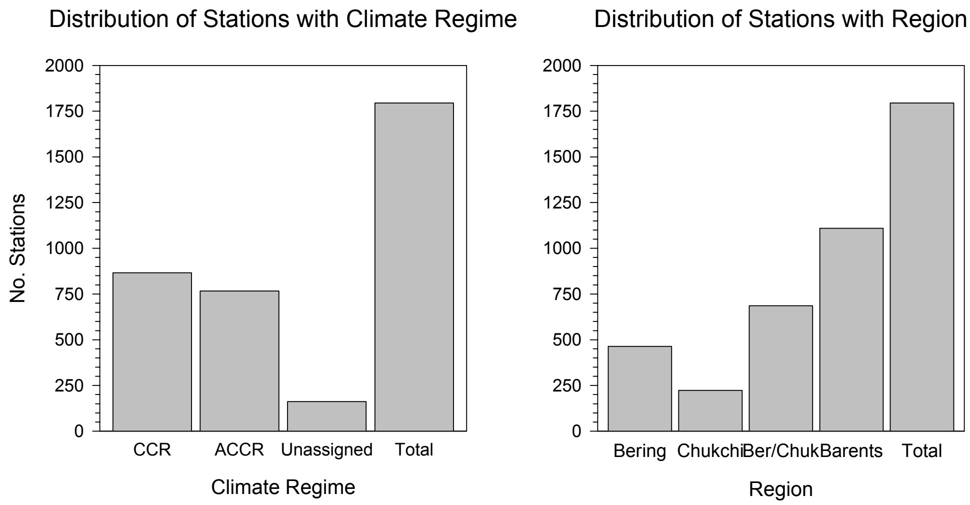
Benthic organisms are generally sedentary and long-lived organisms (as adults), and integrate environmental conditions over time at a particular location. Therefore, in marginal Arctic seas, benthic communities directly (or indirectly) respond to changes in surface ocean conditions allowing the benthos to serve as a proxy of ecosystem response to environmental changes. Conceptually, the linkage between climate, physical and hydrological variables of importance to the biota, and benthic ecosystems is illustrated in Figure A11.1. The arrows refer to the linkages of the cascading effects of climate variations through to benthic ecosystems.

Figure A11.1. Conceptual diagram of the linkage between the climatic driver of variation, the resulting variation in physical and hydrological variables that directly affect organisms, and the response in marine ecosystems.

Year 1 of this two-year programme was focused on identifying, accessing, formatting, and entering data from laboratory archives into a common database for further analysis and developing a set of analytical tools to conduct the comparisons.

We have achieved good spatial coverage in both the Bering/Chukchi and Barents Sea regions. To date, we have accessed, collated, and entered total of 1794 stations spanning the time period from 1924 to 1992 into a single, commonly-formatted database. The distribution of station data related to climate regime and region is shown in:

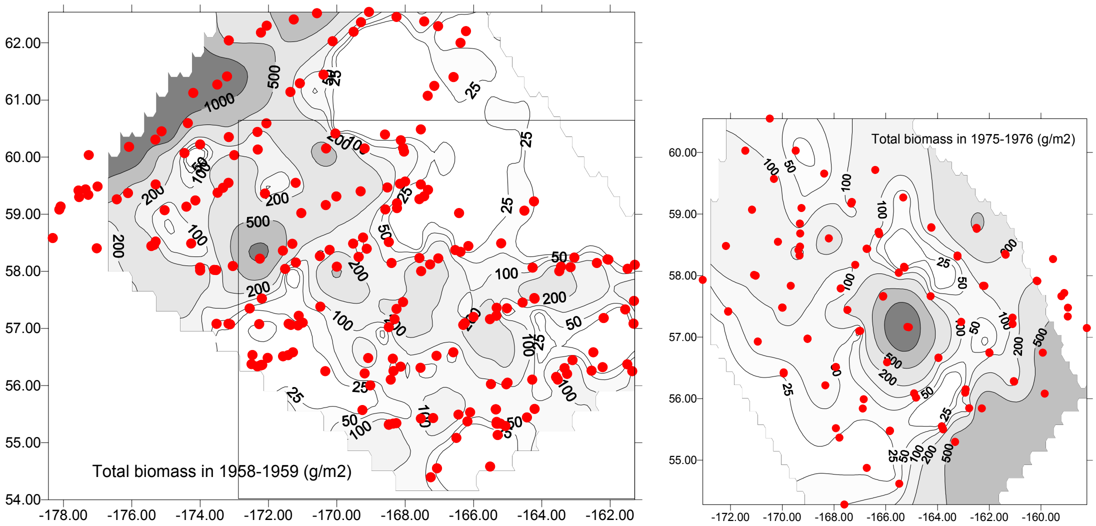
Figure A11.2. Bar Charts showing distribution of stations with respect to climatic regime and region. (CCR=Cyclonic Circulation Regime; ACCR=Anticyclonic Circulation Regime.) The region Ber/Chuk represents the sum of stations in the Bering and Chukchi.



In order to determine the extent of covariation between benthos and climatic forcing through time and space and their synchrony or asynchrony, we must first demonstrate that we can disentangle patterns of benthic variation from the background noise. In other words, are our collated data on benthos sufficiently detailed and informative enough to allow us to discern significant spatial and temporal patterns?

Figure A11.3 shows variation in total biomass of benthic organisms in the southeast Bering Sea during two time periods: 1958/1959 and 1975/1976. The distribution of biomass has clearly changed over the 17-year period. In the earlier period, benthic biomass was highest (over 1000 g/m^2) in the northwest of the region and had a mosaic of fluctuating levels throughout the rest of the region varying from <25 to about 200 g/m^2. In contrast, the later period biomass is shifted toward the southeast of the region, with a distinct hotspot of biomass in the center of the region, and also high biomass in the far southeast, with other areas generally <100 g/m^2. This time period had far less of a mosaic pattern, with biomass concentrated in small, well-defined areas within the region.

Figure A11.3. Total biomass of benthic organisms in the southeast Bering Sea in 1958–1959 (left panel) and 1975–1976 (right panel). Station locations are red dots. Contours interpolated using Surfer. The marked box in the left panel corresponds to the total area covered in the right panel.



ANNEX 12: ANNOTATED LIST OF BENTHIC INVERTEBRATES IN BOTTOM TRAWL BY-CATCH

Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
N	Mollusca	*Beringius turtoni*				X	
N	Mollusca	*Colus islandica*				X	
X	Crustacea	*Lithodes maja*				X	y
X	Crustacea	*Pagurus pubescens*				X	y
X	Crustacea	*Spirontocaris lilljeborgi*				X	y
X	Crustacea	*Carcinus maenas*	X	X	X	X	
X	Crustacea	*Crangon allmani*	X	X		X	
X	Crustacea	*Crangon crangon*	X	X	X	X	
X	Crustacea	*Hyas araneus*	X	X			
X	Crustacea	*Hyas coarctatus*	X	X		X	
X	Crustacea	*Liocarcinus depurator*	X	X		X	
X	Crustacea	*Pandalus borealis*				X	
X	Crustacea	*Pandalus montagui*	X	X		X	
X	Echinodermata	*Echinocardium flavescens*				X	y
X	Echinodermata	*Henricia sanguinolenta*		X		X	y
X	Echinodermata	*Luidia sarsi*		X		X	y
X	Echinodermata	*Psolus phantapus*				X	y
X	Echinodermata	*Asterias rubens*	X	X	X	X	
X	Echinodermata	*Crossaster papposus*	X	X	X	X	
X	Echinodermata	*Echinus acutus*				X	
X	Echinodermata	*Echinus esculentus*		X		X	
X	Echinodermata	*Hippasteria phrygiana*				X	
X	Echinodermata	*Leptasterias muelleri*		X		X	
X	Echinodermata	*Marthasterias glacialis*		X			
X	Echinodermata	*Ophiothrix fragilis*	X	X	X	X	

Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
X	Echinodermata	*Ophiura albida*	X	X		X	
X	Echinodermata	*Pseudarchaster parelii*				X	
X	Echinodermata	*Solaster endeca*		X		X	
X	Mollusca	*Arctica islandica*		X	X	X	y
X	Mollusca	*Astarte sulcata*				X	y
X	Mollusca	*Colus gracilis*		X		X	y
X	Mollusca	*Mya truncata*				X	y
X	Mollusca	*Neptunea antiqua*		X	X	X	y
X	Mollusca	*Pseudamussium peslutrae*				X	y
X	Mollusca	*Tridonta montagui*				X	y
X	Mollusca	*Buccinum undatum*	X	X	X	X	
X	Mollusca	*Chamelea striatula*				X	
X	Mollusca	*Gibbula cineraria*	X				
X	Mollusca	*Hiatella arctica*				X	
X	Mollusca	*Mya arenaria*		X			
X	Mollusca	*Mytilus edulis*	X	X	X	X	
X	Mollusca	*Spisula elliptica*				X	
S	Crustacea	*Anapagurus laevis*				X	
S	Crustacea	*Atelycyclus rotundatus*	X	X	X	X	
S	Crustacea	*Atelycyclus undecimdentatus*	X				
S	Crustacea	*Callianassa*				X	
S	Crustacea	*Calocaris macandreae*		X			
S	Crustacea	*Cancer pagurus*	X	X	X	X	
S	Crustacea	*Corystes cassivelaunus*	X	X	X	X	
S	Crustacea	*Eurynome aspera*	X	X			
S	Crustacea	*Eurynome spinosa*	X				

Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
S	Crustacea	*Galathea squamifera*	X				
S	Crustacea	*Galathea strigosa*	X	X			
S	Crustacea	*Geryon tridentatus*				X	
S	Crustacea	*Homarus gammarus*	X	X	X	X	
S	Crustacea	*Inachus dorsettensis*	X	X		X	
S	Crustacea	*Liocarcinus corrugatus*		X			
S	Crustacea	*Liocarcinus holsatus*	X	X	X	X	
S	Crustacea	*Liocarcinus marmoreus*	X	X		X	
S	Crustacea	*Liocarcinus pusillus*	X	X		X	
S	Crustacea	*Macropodia rostrata*	X	X			
S	Crustacea	*Munida rugosa*		X		X	
S	Crustacea	*Necora puber*	X	X	X	X	
S	Crustacea	*Nephrops norvegicus*		X	X	X	
S	Crustacea	*Pagurus bernhardus*	X	X		X	
S	Crustacea	*Pagurus prideaux*	X	X			
S	Crustacea	*Palaemon serratus*	X	X			
S	Crustacea	*Pandalina brevirostris*	X				
S	Crustacea	*Pilumnus hirtellus*	X	X	X		
S	Crustacea	*Pinnotheres pisum*	X				
S	Crustacea	*Pisidia longicornis*	X	X		X	
S	Crustacea	*Pontophilus spinosus*		X		X	
S	Crustacea	*Processa canaliculata*	X			X	
S	Crustacea	*Thia scutellata*	X				
S	Crustacea	*Upogebia deltaura*	X			X	
S	Crustacea	Xanthidae		X			
S	Echinodermata	*Amphiura chiajei*	X				

Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
S	Echinodermata	*Amphiura filiformis*	X			X	
S	Echinodermata	*Anseropoda placenta*				X	
S	Echinodermata	*Antedon bifida*	X	X		X	
S	Echinodermata	*Asteronyx loveni*				X	
S	Echinodermata	*Astropecten irregularis*		X	X	X	
S	Echinodermata	*Brissopsis lyrifera*		X		X	
S	Echinodermata	*Echinocardium cordatum*	X	X		X	
S	Echinodermata	*Echinus elegans*				X	
S	Echinodermata	*Luidia ciliaris*		X		X	
S	Echinodermata	*Ophiocomina nigra*	X	X			
S	Echinodermata	*Ophiura ophiura*				X	
S	Echinodermata	*Psammechinus miliaris*	X	X	X	X	
S	Echinodermata	*Spatangus purpureus*	X	X		X	
S	Echinodermata	*Stichastrella rosea*		X		X	
S	Mollusca	*Abra alba*	X	X			
S	Mollusca	*Acanthocardia echinata*			X	X	
S	Mollusca	*Aequipecten opercularis*	X	X	X	X	
S	Mollusca	*Aporrhais pespelicani*	X	X			
S	Mollusca	*Aporrhais serresianus*				X	
S	Mollusca	*Barnea candida*				X	
S	Mollusca	*Calliostoma zizyphinum*	X	X			
S	Mollusca	*Capulus ungaricus*		X		X	
S	Mollusca	*Chlamys varia*	X	X			
S	Mollusca	*Circomphalus casina*		X			
S	Mollusca	*Colus jeffreysianus*				X	
S	Mollusca	*Crepidula fornicata*	X				

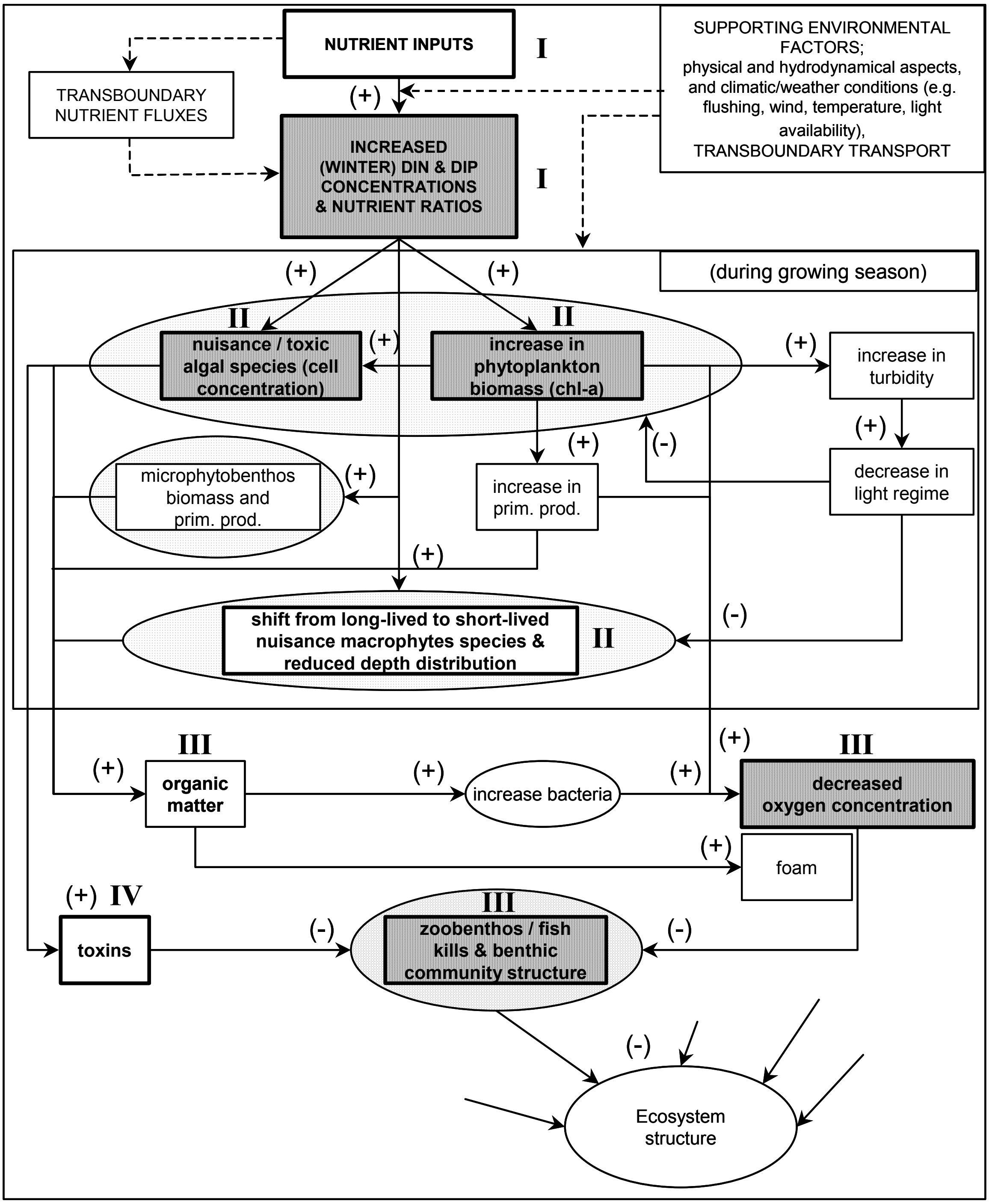
Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
S	Mollusca	*Dosinia exoleta*	X				
S	Mollusca	*Ebalia cranchi*				X	
S	Mollusca	*Ebalia tuberosa*	X	X		X	
S	Mollusca	*Ensis arcuatus*	X			X	
S	Mollusca	*Ensis ensis*	X				
S	Mollusca	*Ensis siliqua*		X		X	
S	Mollusca	*Ensis spec.*			X	X	
S	Mollusca	*Euspira catena*			X	X	
S	Mollusca	*Euspira pulchella*	X	X			
S	Mollusca	*Glycymeris glycymeris*	X	X			
S	Mollusca	*Heteranomia ephippium*				X	
S	Mollusca	*Laevicardium crassum*	X				
S	Mollusca	*Lutraria lutraria*				X	
S	Mollusca	*Mactra stultorum*	X				
S	Mollusca	*Modiolus modiolus*		X		X	
S	Mollusca	*Mytilus galloprovincialis*	X				
S	Mollusca	*Nassarius reticulatus*	X	X			
S	Mollusca	*Nucula nucleus*				X	
S	Mollusca	*Ocenebra erinacea*	X				
S	Mollusca	*Ostrea edulis*	X				
S	Mollusca	*Paphia rhomboides*	X				
S	Mollusca	*Pecten maximus*	X	X	X	X	
S	Mollusca	*Phaxas pellucidus*	X				
S	Mollusca	Solenidae		X			
S	Mollusca	*Spisula solida*	X			X	
S	Mollusca	*Spisula subtruncata*	X	X			

Distribution	Major taxon	Taxon	English Channel	Irish Sea	South-eastern North Sea	Western Central North Sea	Sensitive species
S	Mollusca	*Turritella communis*		X	X	X	
S	Mollusca	*Varicorbula gibba*	X	X			
	Mollusca	Veneridae		X			
Es	Crustacea	*Alpheus macrocheles*	X				
Es	Crustacea	*Dromia personata*	X	X			
Es	Crustacea	*Goneplax rhomboides*		X		X	
Es	Crustacea	*Macropodia tenuirostris*				X	
Es	Crustacea	*Maja squinado*	X	X	X	X	
Es	Crustacea	*Modiolus barbatus*		X			
Es	Crustacea	*Pisa armata*	X	X			
Es	Crustacea	*Pisa tetraodon*	X				
Es	Crustacea	*Portumnus latipes*				X	
Es	Crustacea	*Squilla mantis*	X				

Distribution:
es = Extreme Southern Species
s = Southern Norwegian Species
x = Pan-Norwegian Species
n = Northern Species

Sensitive species:
y = sensitive to changes in water masses

ANNEX 13: MAIN CAUSE-EFFECT RELATIONSHIPS BETWEEN THE ASSESSMENT PARAMETERS OF THE COMPREHENSIVE PROCEDURE (COMPP)



Main cause-effect relationships between the Assessment Parameters (in bold) of the Comprehensive Procedure (COMPP). Parameters for which Assessment Criteria and their assessment levels are identified are shown in boxes with bold lines. Biological elements are grey shaded. **EcoQOs** are presented in dark shaded boxes and bold font. Continuous arrow lines with (+) and (-) indicate “having stimulating effect upon”, and “having inhibiting effect upon”, respectively. Dashed arrow lines indicate “having influence upon”.

Key:			
I =	Category I.	Degree of Nutrient Enrichment (Causative factors)
II =	Category II.	Direct Effects of Nutrient Enrichment
III =	Category III.	Indirect Effects of Nutrient Enrichment
IV =	Category IV.	Other Possible Effects of Nutrient Enrichment

ANNEX 14: SEABEE

A Mobile Lander for Autonomous Monitoring and Sampling

The objective of our project is to develop a new clean technology to survey and monitor the seabed environment (geology and biology) in a cost-effective manner.

Traditionally, benthic survey and sample collection is performed by a research vessel and/or divers. Because the use of a research vessel and of divers is time consuming and expensive, and because sampling is not always accurate (ship surface drift, sampler underwater drift, positioning error, sample disturbance), research strives to continuously improve and automate survey and sampling techniques.

A major improvement of survey and sampling techniques has been the development of ROVs (Remotely Operated Vehicles), Landers (equipped with a multicorer), or even semi-autonomous systems (meaning systems that are not physically linked to the supporting vessel, but still require online operator control). Still, sampling is decoupled from any actual survey line. ROVs and Landers are physically bound to supporting vessels by cables and semi-autonomous systems need the supporting vessel to be located directly above the vehicle. Monitoring campaigns are thus still time consuming (dependent on weather conditions) and costly (ship time, specialised personnel).

The answer to these problems is the development of a fully autonomous vehicle (meaning no communication between the operator and the vehicle during the survey). Based on an existing commercial AUV (Autonomous Underwater Vehicle), the end-product of our project will be a fully autonomous vehicle (***SEABEE*** vehicle) combining survey capacities (video, photographs, sonar, echo sounder, sub-bottom profiler) and simultaneous water sampling, core sampling and environmental data gathering capacities.

The ***SEABEE*** vehicle will be able to dive and transit to the survey area after being launched from a boat, a harbour, or a helicopter; perform surveys by following a defined path at specified altitudes while switching payload sensors on and off according to the survey plan; take sediment and water samples at programmed locations, and record environmental and geological data while performing the survey; surface at a predefined location and wait for recovery, or return to launching point.

The advantages of ***SEABEE*** are numerous and include time saving (not dependent on weather conditions, or if used from a ship, they each can perform their tasks simultaneously and independently), costs saving (no need for a support vessel, or reduced campaign times), sampling accuracy (done exactly on the survey line), less or no sample disturbance, increased safety and easy access to otherwise high risk areas (estuaries and harbours, waste water or nuclear power plant outfalls, under ice, etc.).

In order to ensure that we design ***SEABEE*** to match most end-user's needs, we have decided to conduct a survey. It will help us assess what these needs are regarding survey, sediment and water sampling, and sensors specifications. Please take the time to fill in the attached questionnaire and send it back by mail, fax, or e-mail to:

Francois Wernerus – CORSECOLOGIE Marine Consultancy
56 rue du Fond – 20214 Calenzana – Corsica – France
Fax : +33-(0)4 95 62 79 07
Email : wernerus@corsecologie.com

ANNEX 15: RECOMMENDATIONS

The **Benthos Ecology Working Group** [BEWG] (new Chair: H. Rumohr, Germany) will meet in Fort Pierce, Florida, U.S.A., from 28 April–1 May April 2003 to:

a) report on the progress in the North Sea Benthos Project: quality control, data analysis, workshops, end-products;

b) make further organisational arrangements for a Theme Session (or Mini Symposium) at the ICES 2003 ASC, focusing on the role of benthic communities as indicators of marine environmental quality and ecosystem change, and to discuss possibilities for further theme sessions;

c) review new developments on quality control in zoobenthos- and phytobenthos monitoring and research;

d) together with the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM), analyse trend monitoring data with a view of obtaining insight into the role of Quality Control (QC);

e) review the role of phytobenthos in coastal marine ecosystems with a view to obtaining insight into the diversity and dynamics of phytobenthic communities, their role in the ecosystem, and their vulnerability to human activities;

f) provide recommendations to OSPAR on monitoring and assessment, and quality assurance related to Ecological Quality indicators;

g) review the possible effects of wind farms on the marine benthic system.

BEWG will report by 19 May 2002 for the attention of the Marine Habitat and Oceanography Committees and ACME.

Supporting Information

Priority:	The current activities of this Group will lead ICES into various issues related to the role of marine benthos. There is a great demand by international fora, consequently these activities are considered to have a very high priority.
Scientific Justification:	a. The further guidance of the BEWG is needed for the continuation of the North Sea Benthos Project under the ICES umbrella. This work will contribute valuable validation of the EUNIS habitat classification. b. A Theme Session (or Mini-symposium) on this subject will allow the synthesis of state-of-the-art knowledge, which will contribute to the further development of operational ecological quality objectives for marine benthic communities. It provides a follow up of the 5th International North Sea Conference (Bergen, March 2002) and is relevant to OSPAR and HELCOM. c. It is necessary to keep abreast of and review experiences and new developments in national QA/QC programmes with respect to: • Integration of spatial information, e.g., survey data from different institutes; • Consistency of data and information in trend monitoring programmes (e.g., influence of change in contractors, methods); d. This is a request of the ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (SGQAE); e. This information will be useful to coastal zone managers and direct future research and monitoring; f. This follows up on a request of the OSPAR/ASMO Committee, as formulated in its meeting in Stockholm, 8–12 April 2002; g. This is a recent development, in which the role of benthos in the marine

	ecosystem needs to be involved. Important for the advisory role of ICES.
Relation to Strategic Plan:	Scientific Objectives 1(c), 1(e), 3(d).
Resource Requirements:	
Participants:	BEWG members
Secretariat Facilities:	None
Financial:	
Linkages to Advisory Committees:	ACME, ACE
Linkages to other Committees or Groups:	WGMHM, SGQAB, SGQAE, WGSAEM, WGECO, WGEXT, WGITMO
Linkages to other Organisations:	HELCOM, OSPAR
Cost share	ICES 100 %

The report **Guidelines for the Study of the Epibiota of Subtidal Environments,** edited by Dr H. Rees (United Kingdom), as reviewed by the Chair of the Marine Habitat Committee, will be published in the *ICES Techniques in Marine Environmental Sciences* series. The estimated number of pages is 50.

Supporting Information

Priority:	This report concludes the work in successive meetings of the Benthos Ecology Working Group (BEWG) and of intersessional work. It will lead ICES into various methodological and quality aspects related to the study of marine epibenthos. This report responds to a need, consequently publication is considered to have a high priority.
Scientific Justification:	This report represents a synthesis of the most important methodological issues to be considered in the planning and conducting of marine epibenthic research and monitoring. It is the first ICES guidelines for epibenthos, and is a valuable addition to the TIMES report No. 27 (H. Rumohr, 1999. Soft bottom macrofauna: collection, treatment and quality of samples) that was also compiled by the BEWG.
Relation to Strategic Plan:	Scientific Objectives …. ; Institutional objective …….
Resource Requirements:	Publication as TIMES report will cost ca. DKK 20,000.
Participants:	Some 2 months of work is required by the editor to finalise this draft.
Secretariat Facilities:	About 1 month work of the services of the ICES secretariat, etc., will be required.
Financial:	Publication costs.
Linkages to Advisory Committees:	
Linkages to other Committees or Groups:	WGMHM, SGQAB, SGQAE
Linkages to other Organisations:	OSPAR, HELCOM.