Marine Habitat Committee **ICES CM 2003/E:09**
Ref. ACME, C

REPORT OF THE

Benthos Ecology Working Group

Fort Pierce, Florida, USA
28 April–1 May 2003

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

Section **Page**

1 OPENING OF MEETING

The Chair, Dr H. Rumohr welcomed participants to the 2003 Benthos Ecology Working Group (BEWG) meeting, kindly hosted by the Smithsonian Institution, with the local organization efficiently conducted by Bjorn Tunberg. A list of participants is given at Annex 1, and the Terms of Reference for the 2003 meeting at Annex 2.

Apologies were received from Fritz Gosselck, Jørgen Nørrevang-Jensen, Jan Warzocha, Jan van Dalfsen, Hans Hillewaert and Ingrid Kröncke.

2 ADOPTION OF AGENDA

The draft agenda for the meeting (previously circulated) was adopted with minor changes, and forms the basis for the structure of this report.

3 APPOINTMENT OF RAPPORTEUR

Dr Rumohr appointed Rapporteurs on a daily basis (Edward Vanden Berghe, Steven Degraer, Hasse Kautsky, Mike Roberston), with oversight of the timely production and editing of the report provided by Dr Rees.

4 REPORT ON ICES MEETINGS AND OTHER MEETINGS OF INTEREST

4.1 ASC 2002 (Copenhagen)/ICES Annual report for 2002

Heye Rumohr reported on the Annual Science Conference (ASC) held in 2002 in Copenhagen. He explained the structure of the ASCs to new members of the group and outlined the topics of the theme sessions and the invited open lecture speakers. Over 500 people attended the meeting. Invited speakers and open lecture were held in plenum. Invited speakers were Gunnar Kullenberg and Tom Malone. As in other years, the main part of the meeting was conducted in theme sessions.

A complete report is available on a CD-ROM published by ICES, which can be obtained from the ICES secretariat (info@ices.dk). Reports of other meetings are also available on this CD.

The next Annual Science Conference will be held in Tallinn (Estonia), from 24 to 27 September 2003. Members of the BEWG were urged to submit abstracts for contributions despite the short deadline (early May 2003).

4.2 Marine Habitat Committee 2002 (Copenhagen)

Heye Rumohr also briefly reported on the meetings of the Marine Habitat Committee, the parent committee of this Working Group.

This committee met during the ASC, during two sessions, under the chairmanship of Paul Keizer. The report is available on the ASC CD-ROM. The main results of these meetings were the adoption of the TORs for the BEWG meeting and the installation of the new Study Group for the North Sea Benthos Project 2000 (SGNSBP) under the chairmanship of Hubert Rees, UK.

4.3 ICES Advisory Committee on Ecosystems (ACE), 2002

Heye Rumohr reported about the meeting of the Advisory Committee on Ecosystems held in May 2002 in Copenhagen. A report of this meeting was published as *ICES Cooperative Research Report* 254. In this report the input of the BEWG is included.

4.4 ICES Regional Ecosystem Study Group for the North Sea

The first meeting of this SG was held in April 2003. The objectives are to use an integrated approach to study the North Sea. Recommendations are made on how research and functioning of national and international bodies (including ICES) should be organised. Proposals have also been developed to integrate more closely the activities of ICES WGs in the pursuit of the overall aim of ecosystem-level studies and management. The BEWG took note of these developments and looked forward to appropriate future interaction with the SG.

Some concern was expressed at the danger of double-tasking within ICES.

4.5 ICES Steering Group on Quality Assurance of Biological Measurements in the NE Atlantic (SGQAE)

Dr Rees reported on the outcome of the February 2003 meeting of SGQAE. As in the previous two years, much of the meeting was held in joint session with the ICES/HELCOM SGQAB (its Baltic counterpart) on matters of common interest. One session was even held jointly between these two groups and the ICES/HELCOM SGQAC (dealing with QA of chemical determinands in the Baltic area).

A report on general QA guidelines for the ICES/OSPAR area has now been finalized, and will be published in the ICES TIMES series. A number of agenda items addressed in 2003 were relevant to the work of BEWG, including:

a) review progress in the development and use of the ICES Biological Community Database;
b) explore and make recommendations on means for screening of biological (phytoplankton, phytobenthos, zoobenthos) data prior to the evaluation of trends;
c) further review existing criteria for determining the acceptability of biological sampling and analytical practices in monitoring programmes, and make recommendations for future improvements;
d) assess the final outcome of a questionnaire concerning QA of biological community measures in the ICES/OSPAR area, and make appropriate recommendations for follow-up action;
e) review progress in the preparation of taxonomic checklists as aids to the study of biological communities, and identify priorities for future action.

Further information on these items will appear in the 2003 SGQAE and SGQAB reports.

Proposed Terms of Reference for 2004 SGQAE activities relevant to the ongoing work of BEWG included:

a) review progress in the development and use of the ICES Biological Community Database;
b) review the performance of the guidelines for determining the acceptability of biological sampling and analytical practices in monitoring programmes, and make recommendations for future improvements;
c) develop guidelines on QA/AQC for the application of an environmental indicator approach employing biological measures;
d) review progress with the implementation of phase II of the BEQUALM scheme;
e) consider the QA implications arising from the use of "rapid" or partial assessments of biological samples;
f) evaluate the feasibility of developing standard test data sets as a basis for intercalibrating data handling and data analyses within monitoring programmes.

Proposed activities in relation to the development/application of environmental indicators employing biological measures included:

- identify appropriate ICES groups to review the performance of indicators that have been proposed for widespread use in reporting on marine systems;
- identify a standard (or approved) set of indicators;
- investigate the sensitivity of common indicators to changes in data quality;
- develop guidelines on establishing trigger points for biological indicators;
- develop a standard test data set for benchmark analyses to assess indicator performance and identify QA/AQC issues in their calculation; and
- establish closer links with the Working Group on Statistical Aspects of Environmental Monitoring to evaluate statistical QA/AQC issues for the use of biological indicators.

Further discussion on the interface between SGQAE and BEWG activity is given in Section 8 below.

4.6 ICES Working Group on Marine Habitat Mapping (WGMHM)

Heye Rumohr reported that WGMHM met from 1 to 4 April in New Jersey; the host was Tom Noji. The Terms of Reference for this meeting are given at Annex 3. Part of the meeting was dedicated to national status reports, and to documenting mapping activities. There is a trend towards more coastal activities. The EUNIS classification system, which has been discussed in several meetings of this WG, seems not to be ideally suited to the marine environment.

WGMHM will start creating a map of the North Sea as a pilot project. All available data will be used. There is a need to create links between the ICES SGNSBP and WGMHM (see Section 6, below).

Several other mapping activities were discussed; it was noted that the North Sea and the Baltic Sea are very different environments. Sensitivity maps to disturbance by oil spills are now ready for both the North Sea and Baltic Sea – the one from the Baltic being completed recently. The sensitivity maps take into account both geological and biological information.

4.7 ICES Working Group on Introductions and Transfers of Marine Organisms

No information was available.

4.8 ICES WG on the Effects of the Extraction of Marine Sediments on the Marine Ecosystem

No information was available.

4.9 SGXML

Meeting will be held later.

4.10 ICES WG on Marine Data Management

Meeting will be held later.

4.11 BIOFAR Meeting, 24–26 April, 2003

Les Watling reported on a symposium summarizing the major findings of the BIOFAR programme held in Torshavn, Faroe Islands. The 25 participants reviewed the biogeographic and water mass affinities of many of the benthic invertebrate and plant taxa found during the two BIOFAR sampling programmes. All participants agreed that the programme was successful beyond most people's expectations and that the model developed during BIOFAR would work well in other areas, such as Iceland and around Greenland. In fact, it was reported that the BIOICE programme around Iceland was approaching some of the goals achieved by BIOFAR.

4.12 North Sea and West Coast of Scotland Epifaunal and Infaunal Sampling by FRS, Aberdeen in 2001 and 2002

Mike Robertson reported that, to date, FRS Aberdeen has completed two years' epifaunal and infaunal sampling in the North Sea and to the north and west of Scotland in August 2001 and 2002, and in November/December 2001 and 2002. A total of, respectively, 70 and 47 stations were occupied from each study area over the sampling years and, at each station, up to two 0.25 m^2 box core deployments were collected while a 2-metre beam trawl was towed at speeds of less than 2 knots for 5 minutes. Subsamples for meiofaunal investigations and cores for sediment particle analysis were also collected while salinity and temperature data were logged by CTD.

Where possible, the invertebrates and vertebrates caught in the beam trawl were identified to species onboard the research vessel; all others were preserved and returned to the laboratory for examination. Individual animal metrics such as length and weight were also recorded for each species encountered. Infaunal samples collected in 2002 from the North Sea were sieved over five mesh sizes ranging from 4.0 mm to 0.25 mm at sea while all the others (from 2001 and west coast 2002) were multi-sieved back in the laboratory.

Epifaunal and infaunal abundance and biomass data from 2001 are now available and will be analysed over the next few months. These data will not only provide information for FRS but will also add to the existing North Sea Benthos Project data set. Analysis of the epifaunal samples collected in 2002 has started while the infaunal analysis will commence as soon as possible.

This work, the field component of which will continue until August 2004, was undertaken as part of the EC funded project "Managing Fisheries to Conserve Groundfish and Benthic Invertebrate Species Diversity" (MAFCONS) which attempts to relate fishing disturbance to benthic secondary production and species diversity. The final product from MAFCONS will be a protocol which will allow managers to relate commercial fishing activities to impacts on benthic and fish community species diversity.

A discussion of the use of production calculations of surveyed areas followed, and the possible problems arising from the employment of alternatives to classical cohort growth analyses. It was also noted that the question posed was analogous to the starting point for benthos studies in the early part of the twentieth century, namely "how much fish can be supported by one m^2 of sea floor".

5 REPORT OF COOPERATIVE STUDIES AND OTHER STUDIES RELEVANT TO ICES

5.1 Effects of dumping on the benthos in the Kattegat, Sweden

Susan Smith reported on the outcome of benthic studies in the vicinity of a dredgings disposal site in the Kattegat. Muddy material has been dredged in Falkenberg harbour at the mouth of the river Aetran on Sweden's west coast four times since 1991. The material here studied arises from maintenance dredgings from the two last occasions (50, 000 and 30, 000 cubic metres, respectively). The dredged material was dumped at a depth of 20 m on a licensed site, some 10 km offshore, where the substratum was sandy silt. The macrozoobenthos has been monitored about a year and a half after each dumping along a transect parallel to the coast, at the same depth as that of the dump site at the centre of the transect.

The effects of this disposal of dredged material were similar to those of the "classical" model of organic enrichment presented by Pearson and Rosenberg (1978), showing different successional stages. In the first place, the structure of the community on the dump site itself was different from that of the surroundings, since (*inter alia*) diversity was higher and one third of the species were only found at the former location. Also, the number of individuals was greater, as was the weight, than in the surroundings.

Secondly, in a zone adjacent to the dump site biomass, mean weight of brittlestars and species numbers were enhanced in comparison with areas further away. Measuring the species diversity by means of Sanders' rarefaction technique revealed an increasing diversity along the transect in the direction of the dump site, where there was a maximum diversity. The response of the infauna might indicate that the re-suspended material was being transported primarily northwards along the coast.

To conclude, fine material disposed in high energy systems will be transported to more distant areas and the farfield effects become more relevant. The same would apply to the dredged material from the Falkenberg harbour consisting of marine and fluvial deposits with a high content of organic material and nutrients. This tends to be forgotten, there being greater concern as to the content of contaminants, leaving the question of the mobilization of the eutrophication components unaddressed.

The question was raised whether setting up general guidelines/rationale for dumping site selection throughout the ICES region was desirable, and, if yes, possible. The BEWG recommends that information on the effects on benthos of disposal of dredged material should be collected and criteria for site selection should be developed from a benthic perspective, to be taken into account next to other viewpoints (e.g., economic perspectives). It was suggested to take this issue as a future focal point of the BEWG. Contact with WGEXT, eventually through the *ex officio* BEWG member, is necessary to avoid duplication of the work.

5.2 Trilateral Monitoring and Assessment Programme (TMAP)

K. Essink informed the meeting about the TMAP initiative that relates to a harmonized physical, chemical and biological monitoring effort in the Wadden Sea by different authorities in Denmark, Germany and the Netherlands. A major goal of TMAP is to provide information to enable periodic assessment of the quality status of the Wadden Sea and of the progress with regard to the trilaterally agreed "targets".

Presently, a new Quality Status Report (QSR) is being prepared as an update of the 1999 QSR. In 2004, an evaluation will also be made of the TMAP, not only the programme as such, but also the data management involved. Most recently, the Wadden Sea Forum was installed in which various stakeholder groups participate. Furthermore, the next Scientific Wadden Symposium is planned for 2005.

The Quality Status Report, TMAP evaluation, results from the Wadden Sea Forum, as well as the conclusions by the Scientific Symposium will provide input for the next Trilateral Governmental Conference in 2005 where further policy decisions regarding the protection and management of the international Wadden Sea area will be taken.

5.3 AMBITION project

Angel Borja (AZTI, Spain) presented a project submitted to the European 6th Framework Programme, under the acronym AMBITION. There are 19 partners and 6 subcontractors involved, including most of the European countries. The proposal takes into consideration the Water Framework Directive (WFD) requirements regarding chemical and biological (macrobenthos and phytobenthos) indicators in estuarine and coastal waters, in order to assess their ecological status in relation to man-made activities. The overall objective is to develop, evaluate, validate, and implement practical benthic community-based tools, in European estuarine and coastal waters, in order to assess natural and man-induced stress/disturbance, and to determine the five classes of ecological status established by the WFD.

The specific objectives, in order of achievement, are: (i) to assess the applicability of existing Biotic Indices (BIs) on soft- and hard-bottom communities (benthic macroinvertebrates and phytobenthos), on a pan-European scale, by comparing existing and/or new data sets; results arising will be compared with those obtained by alternative methods, such as multivariate analyses and graphical methods; (ii) to develop new BIs, where appropriate, and to assess their applicability (as outlined above), for the above-mentioned biological elements; (iii) to provide macroinvertebrate and phytobenthos taxonomic check-lists at an international level, along with new quantitative data and methodology; (iv) to link the ecological status of transitional and coastal waters with their chemical status, on a pan-European scale, to better define the good surface water status, *sensu* the WFD; (v) to develop decision-support tools (software), available over the Internet, for the application of BIs and the assessment of the ecological status of European transitional and coastal waters, based on macroinvertebrate and phytobenthos taxa lists and chemical status; and (vi) to make the developed tools available to a wide audience (including the broad scientific community, environmental managers and policy makers) via workshops targeted at academic/research establishments and environmental agencies, implementing the WFD, throughout Europe.

BEWG is listed as an end user in the project proposal.

5.4 Monitoring in the Basque Country (N of Spain)

Dr Borja noted that this monitoring programme, which started in 1995, is addressed to the implementation of the Water Framework Directive, in coastal and estuarine waters. It establishes that the ecological status of the water masses must be assessed, considering some biological components, such as phytoplankton, macroalgae, benthic invertebrates and fish fauna (only in transitional waters).

In the Basque Country, the former 33 sampling stations have been increased in 2002 to 51 stations (32 in the 12 estuaries and 19 in coastal waters: 18 over 30 m water depth and 1 over 110 m). At each of the stations is sampled:

- Water (4 times per year, and including hydrographic variables and contaminants, such as heavy metals and organic compounds);
- Sediments (in winter, analysing granulometry, organic matter, redox potential, C/N relationship, TOC, heavy metals and organic compounds);
- Biomonitors (mussels and oysters are sampled in autumn, analysing heavy metals and organic compounds);
- Soft-bottom benthos (in winter, including identification, density, biomass, richness, diversity and biotic index);
- Phytoplankton (in spring and summer, including identification and abundance);
- Macroalgae (in spring, sampling 4 estuaries each year, and including distribution and cover in the estuary and the adjacent coastal area);
- Estuarine fishes (in summer, sampling 4 estuaries each year, including identification, abundance, diversity, introduced species, etc.).

At present, there are eight years of time-series data, and new methods for the establishment of the ecological status are being developed, taking into account the different typologies defined for the Basque Country and the reference conditions for each of the types.

The monitoring, and the choice of the monitoring sites, is in response to the European Water Framework Directive (WFD).

The Biotic Index is useful for deriving an Ecological Quality Ratio (EQR) for the WFD; however, a problem is the lack of pristine sites.

The high variability between different years could at least partly be attributable to sampling error.

5.5 "Prestige" oil spill on the North Spanish coast: preliminary Spanish Oceanographic Institute (IEO) impact studies on the benthic habitat

S. Parra presented an account of ongoing studies in relation to the "Prestige" oil spill (a full account of this work is given in Annex 4). News that an enormous single-hulled tanker was foundering off the coast of Muxía was first disclosed on 13 November 2002. On 19 November, the ship broke in two and sank 13 miles from the coast. Over the course of these 6 days the vessel was estimated to have lost over 20,000 tonnes of fuel oil, unleashing a vast black tide which has affected the entire coast of Galicia spreading, months later, to the whole of the Cantabrian Sea.

Once the magnitude of the "Prestige" oil spill became evident, the research team at the Instituto Español de Oceanografía (IEO) (Spanish Oceanographic Institute) began to devise a strategy to study and assess the effects of the fuel oil released from the tanker (www.ieo.es/prestige). Various teams from the IEO have been conducting oceanographic surveys to monitor the evolution of the fuel oil and its effect on the water, sediments and living organisms. This paper focuses on the impact that this spill has had on the epibenthic ecosystem.

Multidisciplinary benthic samples for study of the benthic community were collected at 25 stations in the Galician continental shelf, Northwest Spain. The sampling equipment used included a beam trawl, a photographic and hyperbenthic sled, and a box corer. Fuel oil aglomerates were collected using the beam trawl in the area off Finisterre in the depth stratum of 100–200 metres (a maximum of 420 grams of fuel oil occurred at station 8). In reference to the studies of the epibenthic community, molluscs were the dominant group in biomass for the whole area and in stratum A (less than 100 metres in depth). In stratum B (ranging from 100 m to 200 m in depth) the most prevalent group in terms of biomass is the fishes, and in stratum C (ranging from 200 m to 500 m in depth) the crustaceans have the greatest biomass. In the geographic distribution of the abundance of the 5 main groups, fishes were the most homogeneous group and annelida and molluscs showed the highest abundance in stratum A. However, the crustaceans are the most abundant group on the edge of the shelf (stratum C). With reference to the geographic distribution, after clustering, six groups or epifaunal continental shelf communities were identified in this area:

1) Group I, placed in stratum A, shows an epifaunal community dominated by the fishes *Callionymus lyra* and *Solea lascaris*, and the crustacean *Palaemon serratus*.

2) Group II, located near the Sisargas Islands in stratum A, was characterised by the mollusc *Turritela communis* and the echinoderms *Stichopus regalis* and *Luidia ciliaris*.

3) Group III occurred throughout stratum A. This epibenthic community is dominated by the fishes *Arnoglossus laterna* and *Microchirus variegatus* and the mollusc *Eledone cirrosa*.

4) Group IV is found mainly in stratum B and the group is characterised by the crustacean *Chlorotocus crassicornis*.

5) Group V, distributed throughout the whole area of stratum C, was characterised by the crustaceans *Plesionika heterocarpus* and *Solenocera membranacea*.

6) Group VI, placed in the deepest stations in the vicinity of La Coruña, in stratum C was dominated by the crustaceans *Munida sarsi* and *Munida intermedia* and the fish *Lepidorhombus boscii*.

A problem in assessing the impact of the "Prestige" oil spill is that there are no pre-impact data.

The real disaster was the lack of correct decisions – the oil should have been contained in the first place; the breaking up of the ship was caused by another wrong decision. There is an urgent need for an international framework to reach early decisions in situations like this.

5.6 Macrozoobenthos and habitat survey in the southeastern North Sea to identify areas important for nature protection

Eike Rachor described the outcome of recent studies aimed at identifying areas of value for nature protection. Biotopes and benthic communities in the southeastern North Sea (mainly the German EEZ) were investigated by compiling data especially on morphological (depth) and sedimentological conditions, to which information of a survey of in- and

epifauna in the whole area in 2000 was added. Sampling was done at 225 stations with van Veen grabs (0.1 m^2) and at about 100 stations by small beam trawls and/or video imaging.

A main morphological structure in the area is the Pleistocene Elbe River valley, a depression (channel) filled with muddy bottom and running from the inner German Bight to the northwest and connecting it with the central North Sea east of the Dogger Bank. East of this "Heligoland Channnel" there are sandy sediments, with sand banks and moraine remainders. These relict moraines form complex habitats with mosaics of fine to coarse sands, gravel, pebbles, stones and boulder fields (reefs). In the southwest of the channel there are also mainly sandy habitats, among which the moraine bank of "Borkum-Riffgrund" again forms a habitat mosaic of the mentioned substrata (only large boulder fields are lacking).

The macrozoobenthos as well as the epifauna (mobile and sessile) mirror these conditions very well (Table 5.6.1).

Table 5.6.1. Sublittoral benthic communities in the offshore waters of the German EEZ in the North Sea.

No. and acronym	Community	Synonyms	Characteristics	Occurrence (region)
1 Fab fab	Fabulina-fabula	Tellina-fabula-Ass. (SALZWEDEL *et al.,* 1985) Venus-gallina-Ass. (STRIPP, 1969; HAGMEIER, 1925)	Fine to medium sand fauna between 15 and 30 m	A, C
2 Gon Spi	Goniadella-Spisula	Goniadella-Spisula-Ass. (SALZWEDEL *et al.,* 1985) "Verarmte" Variante der Venus-gallina-Ass. (STRIPP, 1969); Grobsand-Gemeinschaft (DÖRJES, 1977)	Fauna of moraine banks (coarse sands to gravel)	A, C and Heligoland area
3 Bat Fab	Bathyporeia-Fabulina	Tellina-fabula-Gem. (KRÖNCKE, u.a. 1991) Venus-gallina-Gem. (URSIN, 1952; BIRKETT, 1953)	Fine sand fauna of the Doggerbank	G (Doggerbank)
4 Amp fil	Amphiura-filiformis	Echinocardium cordatum-Amphiura filiformis-Ass. (STRIPP, 1969; HAGMEIER, 1925)	Fauna of muddy substrates admixed with fine sands, not in front of estuaries	E, F (from pleistocene Elbe valley to the NW)
5 Mac bal	Macoma-balthica	Macoma-balthica-Ass. (u.a. STRIPP, 1969)	Sublittoral variant outside the Wadden Sea	A, B, C
6 Myr zNS	Myriochele (central N Sea)		Deep sublittoral fauna on muddy mixed substrates of the central North Sea	H (central North Sea)
7 Nuc nit	Nucula-nitidosa	Abra-(Scrobicularia-)-alba-Ass. (STRIPP, 1969; HAGMEIER, 1925)	Mud inhabiting fauna in the vicinity of estuaries	B
8 Hel TR	Helgoland Deep Trench	Nucula-nucleus-Gem. (CASPERS, 1938)	Fauna of mixed substrates (coarse sands with mud and shell remainders)	B
9 Hel FF	Helgoland rock fauna		On the rocky basement of Heligoland Island	B

Compared with earlier descriptions of the fauna (e.g., Salzwedel *et al.,* 1985, in Veröff. Inst. Meeresforsch. Bremerhaven, 20: 199–267) the general distribution patterns of communities did not change, except for a spreading of the *Nucula nitidosa* community to the northwest.

With respect to nature conservation, especially the European Habitats Directive, the *Goniadella-Spisula*-community on coarse sands (moraine remainders) appears to be most important, as it is a clear indicator of sandbanks and (together with the typical rock epifauna) stone reefs, the only offshore habitats of the Directive to be considered for protection measures. This community appears to be very rare in the German EEZ and fulfils several ecological functions such as providing shelter for rare fish and epifauna and as "stepping stones" for the spreading of rock fauna in the southern North Sea.

Normally, the moraine habitats form a mosaic habitat with at least three communities included (nos. 1 and 2 (Table 5.6.1) and rock epifauna). Accordingly, species diversity in these mosaic habitats is very high (200–250 species), which is exceptional for the German Bight.

It is recommended that four areas in the German EEZ should be considered for protection measures: the Borkum-Riffgrund (mosaic sandbank), an area west of the North Frisian Islands (sandbanks), an area on the eastern slope of the Pleistocene Elbe valley (stone reefs), and a part of the Dogger Bank (sandbank), which should be protected in an internationally agreed framework.

In discussion following this presentation, it was noted that the definitions of Natura 2000 areas were not very good and that new definitions as well as new area types have to be added. Also, Susan Smith mentioned the possibility of restricted areas for fisheries. Angel Borja commented on the conflict between restricted areas and fisheries and fishermen.

5.7 Macrobenthic resources of the shallow soft-bottom sediments in the eastern English Channel and southern North Sea

Jean-Marie Dewarumez reported on the outcome of the above study (with acknowledgements to his colleagues N. Desroy, C. Warembourg and J.C. Dauvin). To obtain a baseline for future comparisons and to assist in the conservation of marine biodiversity, the distribution patterns and faunal composition of very shallow (0–10/15 m depth) macrobenthic assemblages were studied along the French coast of the eastern English Channel and southern North Sea from two complementary surveys conducted in 1998 and 2000. A total of 227 sites were sampled from Cap d'Ailly to the Belgian border, from which a total of 167 species were collected. Species richness, abundance and biomass were enhanced in the survey area by outflows from harbours, major bays and estuaries.

Three principal macrobenthic assemblages were defined: (i) the *Ophelia borealis* medium to fine sand assemblage; (ii) the muddy heterogeneous sediment assemblage; and (iii) the *Abra alba* muddy fine sand assemblage. The *Abra alba* assemblage covered approximately 80% of the seabed in the survey area. Sediment characteristics and a latitudinal gradient accounted for a significant proportion of the observed variability in assemblage distribution patterns. In the eastern English Channel, the distribution patterns of species diversity, abundance and biomass values were most continuous, whereas in the southern North Sea patchy distribution was observed.

As few studies have been conducted on the assemblages associated with the soft bottom sediments of very shallow areas (less than 15 m depth), this work was carried out to compensate for this lack of knowledge. However, evidence from recent events (e.g., the "Prestige" oil spill) shows that there are still many important areas, especially offshore, where there is little or no knowledge of the benthic biota. It is recommended that there should be national and international coordinated effort to identify such areas, to rank them in order of perceived importance (especially in relation to their vulnerability to human impacts) and then to conduct appropriate investigations in order to fill such gaps in knowledge.

5.8 Macrozoobenthos database for German Baltic waters

Michael Zettler reported on the outcome of a project to create a macrozoobenthos database derived from literature sources and finished in 2003. This project was financed by the Federal Agency for Water Management (BfG in Koblenz). Almost all literature is included, the taxonomical status was proofed and the recently published Register of European Marine Species was used. Approximately 500 literature sources were analysed, about 500 taxa were found and 45,000 data were included. This was the first step to build a database for German Baltic waters. All historic data (beginning at 1839) were included. This database gives a tool to assess the development of macrozoobenthos in this area within the last 170 years. The next steps should be to include other parts of the Baltic and to integrate recent, unpublished data.

5.9 Spatio-temporal variability of intertidal macrozoobenthos in response to spring phytodetritus sedimentation in the eastern English Channel

Nicolas Desroy reported on progress with the above study (with acknowledgements also to his colleague Denis Lionel). The eastern English Channel – North Sea shallow waters are recurrently affected by high algal spring blooms of the Prymnesiophyte *Phaeocystis*. At the termination of the bloom, foam accumulations, resulting from release of mucilaginous polysaccharides after disruption of senescent colonies, are observed at the sea surface and on the beaches. Results describe changes in physical (granulometry) and chemical (oxygen flux, organic matter content, benthic pigments) conditions within the intertidal sediment as well as in macrofauna associated with the phytodetritus sedimentation in the bay of Canche (French coast of the eastern English Channel).

Four sites, impacted (NM-mud and NS-sand) or not (SM-mud and SS-sand), were sampled from April to December and April to August 2001, respectively. The most obvious changes were found at sites located in accumulation areas (site NM) where *Phaeocystis* post-blooms may profoundly change the grain size distribution. Due to the rapid decomposition of decaying colonies, organic content increased consistently in sediments at sites NM and NS during the termination of the *Phaeocystis* bloom through a single sporadic peak on sands (site NS) or a large and persistent enrichment on muds (site NM). In response to organic matter input, oxygen fluxes increased with time at sites NM and NS. At site NM, severe anoxic conditions rapidly occurred whereas at site NS, superficial residual crusts resulting from foam drying prevent the oxygen diffusion in sandy sediment. At impacted sites, all macrobenthic taxa were affected and both number of species and densities were simultaneously reduced. The sandy assemblage at site NS showed a better recovery from July in relation to more suitable environmental conditions.

An increasing flow appeared to decrease the negative effect of organic enrichment probably through increased oxygen concentrations in the sediment. Disturbance in recruitment subsequent to the foam accumulation is suggested as a possible reason for lack of faunal recovery at site NM. This study has, for the first time, permitted the quantification of the effects of a natural non-toxic bloom on benthic habitat and is a precursor to assessment of the effects of phytodetritus sedimentation at the scale of the eastern English Channel – North Sea intertidal area.

BEWG encourages new research on the post-bloom effects of *Phaeocystis* on benthic communities, especially following the depositing of foam on beaches.

5.10 Dredging operations in the Gothenburg harbour, Sweden

Susan Smith reported that 12 million tonnes of sediment has to be removed to enable Sweden's biggest port to receive postpanamax ships. The work will be finished in three years' time, during which a BACI benthic sampling programme is in operation. As regards benthos the Underwood strategy is applied with 5 sampling localities (2 grabs × 4 and 4 grabs × 1) and 5 stations are included from the regional programme mainly in the direction of the prevailing current to the north. There will be two reference areas from other parts of the coast (Lysekil and Stromstad areas) so that an asymmetrical variance analysis can be performed. In addition to this, 6 sites will be investigated by a SPI camera and the images will be analysed with the BHQ index. All dredging material will be disposed at a previously licensed site further out at sea (Vinga), where hydrological and geological conditions according to new findings are to a greater part not suited for this purpose. As a mitigation action some rocky material from the operations will be used to erect artificial reefs in the archipelago, hopefully to attract lobsters and fish. A five-year research programme for this has already been launched.

5.11 The Indian River Lagoon Estuary - removal of soft sediments

Bjorn Tunberg reported that certain soft sediments in the Indian River Lagoon (IRL) are commonly being referred to as muck, or ooze accumulation. According to some agencies this muck/ooze is negatively affecting the ecology of the IRL by causing a number of water quality problems. A common assumption is that many of the muck/ooze sites have minimal or no living organisms, and that re-suspension of this muck/ooze during wind events causes elevated turbidity levels, increasing the potential for algal blooms and decreasing the light penetration resulting in very little submerged aquatic vegetation growth. A proposed solution for this ecological problem is the removal of muck/ooze.

However, in certain cases this may cause severe damage to the natural balance in the IRL and the breakdown of organic compounds. The bacterial activity in these soft deposits is of vital importance to the IRL system. Therefore any removal of these deposits should only be done after a thorough evaluation of the potential ecological consequences.

The BEWG felt that "muck" should be regarded as a natural phenomenon and thus part of the ecosystem. Through information on the ecological importance of "muck" (e.g., analogy with wetlands), a positive public opinion towards "muck" should be aimed for.

5.12 Dredge hole depressions in Lake Worth Lagoon, Florida: habitat utilization by benthic macrofauna and fishes

Bjorn Tunberg reported that early dredging activities in Lake Worth Lagoon, eastern Florida have produced persistent, deep holes used for refuge and feeding by important gamefish including common snook and tarpon. Plans are under way to restore some of these areas to a shallower depth by refilling the holes with material removed as part of ongoing land enhancement projects. For this reason, Palm Beach County, Department of Environmental Resources Management (PBC-ERM), has proposed a cooperative agreement with Florida Marine Research Institute and the Smithsonian Marine Station, Fort Pierce to evaluate the use of dredge holes by benthic macrofauna and fishes, and to establish a baseline data set of the estuarine community, with the following goals: (a) survey the dredge holes already permitted for filling by Florida Department of Environmental Protection, (b) evaluate other potential dredge holes for receiving spoil in future projects and recommend which areas are potentially suitable for refilling, (c) to avoid filling areas that are already deemed productive from a fisheries utilization standpoint, which may then be considered for artificial development/enhancement.

Heye Rumohr asked whether the holes were filling in naturally and whether the material used to fill them artificially was clean. Bjorn Tunberg stated that the water movements in the lake were very limited so the holes remained for many years. Also, the deeper holes were inhabited by sharks. Eike Rachor wondered whether the sharks preferred the holes because they contained colder water than the upper waters.

5.13 Intensive evaluation of the evolution of a protected benthic habitat: HABITAT

Steven Degraer reported on an investigation of the macrobenthic community structure at the western Coastal Banks. The western Belgian Coastal Banks are an area of international ecological importance. Because of its biodiversity and the presence of several shallow sites (up to 0 m MLWS), the area has been proposed (1) as a Site of Community Importance and (2) as the first Belgian marine protected area. To evaluate the evolution of the benthic habitat on a quick and low-cost base, a standardized biological-geological research strategy was set up. The macrobenthos was selected as the key component because of its important place in the ecosystem and its clear relation with the physico-chemical environment. The research involves a detailed mapping of the macrobenthos, sedimentology, bathymetry, geomorphology and hydrodynamics. New sampling campaigns and geophysical surveys were carried out in October 1999, March and October 2000. On a 500 m grid, biological as well as physico-chemical samples were taken.

Three macrobenthic communities were defined using multivariate analyses. The surficial sediments of the area are dominated by fine up to coarse sands: due to the shallowness of the area, the size ranges can be explained in terms of the ruling hydrodynamics. Multibeam registrations allowed a detailed digital terrain modeling. Very-high resolution digital side-scan sonar imagery was used to study the small-scale morphology. A habitat structure map was set up as an integration of the available data and interpretations and reflecting information on the bathymetry, sediment nature, the acoustic facies and the occurrence of the macrobenthic communities. This approach visualises the interactions between the physical environment and the macrobenthos and is a tool for a scientifically sustained evaluation of this unique ecosystem. Together with the other maps, the habitat structure map reflects the situation of the ecosystem before the implementation of a management plan. Knowledge on the t_0-situation is of primary importance for the evaluation of the effects of the policy decisions.

Side-scan sonar imagery was further used as a tool to study the distribution of benthic communities. Two approaches were followed in the interpretation of side-scan sonar imagery in terms of the occurrence of macrobenthic communities (Macrobenthic Side-scan Sonar Interpretation).

The first approach was based on a direct correlation of high abundances of macrobenthos with specific acoustic facies. A medium to high reflectivity patchy to mottled texture was correlated with the presence of dense fields of the tube-building polychaete *Lanice conchilega.* If the density of this polychaete worm is indeed high enough, local sediment accumulations, detectable by side-scan sonar technology, can be formed. Because of its ecological importance (e.g., *L. conchilega* densities are positively correlated to macrobenthic species richness and density), mapping *L. conchilega* beds is important from a nature conservation perspective.

Secondly, an indirect link was sought based on the known correlations of the macrobenthos versus sedimentology on the one hand and sedimentology versus side-scan sonar imagery on the other hand. This means that if side-scan sonar imagery can be interpreted in terms of sediment nature, the occurrence of macrobenthic communities can be predicted. To facilitate this process, a standardised interpretation is put forward through the set-up of a table with different criteria and interpretation keys. This table provides a discrimination of acoustic facies into a maximum of classes which are finally linked to a macrobenthos community preference. The accuracy of this predictive table was assessed at 70 %.

The approach is a step forward in the definition of quick and low-cost evaluation tools for the follow-up of the evolution of a shallow marine, soft-bottom environment. The advantage of macrobenthic side-san sonar interpretation as complementary to traditional benthos sampling techniques is illustrated by (1) the higher representativeness through full-coverage delineation of the benthic habitats (versus point data) and (2) the time- and cost-efficiency (versus elaborate benthos work). Yet, a lower accuracy compared to direct observations of the macrobenthos has to be taken into account. Ground-truthing through benthos sampling remains indispensable.

5.14 Benthic research in northern Norway

Frank Beuchel reported on three ongoing projects at the Norwegian College of Fishery Science in Tromsø.

5.14.1 Monitoring of rocky-bottom macrobenthic communities on locations in northern Noway and Jan Mayen using image-based analysis

Temporal and spatial variations of macrobenthic communities of rocky bottom localities on Svalbard and Jan Mayen are investigated by analysis of underwater photographs. The sampling can be characterised as a "non-destructive" method in order to obtain information about conspicuous epifaunal organisms. The photographs are taken using a metal frame (area 0.25 m^2) and a Hasselblad SWC in an underwater housing. The technique is based on stereo-photographs developed by Thomas Lundälv (Lundälv, 1971; Torlegard and Lundälv, 1974). Digital image analysis was carried out using Adobe Photoshop and the measurement plug-in Fovea Pro. An efficient method was developed to retrieve data for macrobenthic solitary and colonial organisms and algae. Data for abundance and covered area are retrieved using the measurement toolkit.

Spatial variations of benthic hard-bottom communities after a volcano eruption in 1970 around the subarctic island Jan Mayen were studied on pictures from different localities. From five stations, three were located on old grounds, while two were situated on new submarine lava grounds that emerged. Investigations on the benthic communities at Jan Mayen showed that the differences between new and old grounds increased with increasing depth and were most different below 15 m (Gulliksen *et al.,* 1980). There the species composition is most biologically controlled. It becomes evident that 24 years after the eruption, the benthic communities on the new lava grounds were still different from old ground communities. The bivalve *Hiatella arctica* is the dominating species on new grounds, with abundances up to several thousand individuals m^{-2}.

Contact: Frank Beuchel, Norwegian College of Fishery Science. E-mail: frankb@nfh.uit.no.

5.14.2 Introduction, spread and potential impact of the introduced Red King Crab *Paralithodes camtschaticus* in coastal subarctic Norway

Feeding behaviour of the introduced Red King Crab *Paralithodes camtschaticus* will be studied as part of a possible larger programme investigating the ecological effects of this invasive species. Scallop beds provide a species-rich and individual-rich community which is used to model the benthic community. They represent a shallow-water area with high availability of calcified prey organisms. The research consists of laboratory feeding experiments, manipulated field experiments and long-term monitoring of scallop beds before and after invasion. Questions arising from the first field experiments are, e.g., How many geographically separated areas should be used as controlled sites? Is this mapping sensitive for mechanisms of the system change? How to estimate the number of invading crabs?

Contact: Lis Lindal Jørgensen, Norwegian College of Fishery Science. E-mail: lisj@nfh.uit.no.

5.14.3 Productivity and production of macrobenthic invertebrates in northern Norwegian fjords

Empirical models (e.g., Brey, 1999) will be further developed to obtain community productivity and production values. The data from different northern Norwegian fjords will be compared. Special attention is paid to the crab *Hyas* sp., due to its importance in the diet of fish and interactions with other crab species.

Contact: Marianne Nilsen, Norwegian College of Fishery Science, E-mail: mnilsen@nfh.uit.no.

During the subsequent discussion, Les Watling stated that indirect assessment of productivity (e.g., P/B ratio) should be critically evaluated before use. A link to the "Virtual Handbook on Secondary Production" will be provided through the BEWG website (www.dvz.be/BEWG) or the AWI website in Germany (tbrey@rwi-bremerhaven.de).

5.15 From pattern to process in trawling studies

Les Watling reviewed a paper presented at the benthic habitat meeting held in Tampa, Florida in November, 2002. Many papers and posters presented at the meeting dealt with impacts of mobile fishing gear on benthic habitats. With the exception of one study conducted in a very shallow, wind dominated bay in North Carolina, all studies showed some modification of the bottom by the fishing gear.

Les Watling made the point that virtually all studies, including earlier ones, were basically pattern studies. In these instances, whether the studies were comparing areas heavily fished with those less heavily or not fished, or whether the studies were experiments of a BACI design, the basic objective was to compare counts of taxa in disturbed areas with those in less disturbed areas. In almost all cases multivariate statistics were applied and a verdict pronounced about the degree of impact observed. Generally, few data are provided on the component benthic taxa beyond the most dominant species, on details of the sediment beyond use of brief summary descriptors, and almost nothing is said about other factors such as geochemical data or organic matter features. As a result only the most common of ecological predictions can be made when extrapolating from the trawling studies already conducted.

Examples of additional information that would prove useful in making predictions about trawling impacts are:

1) sediment porosity. As the porosity of fine sediment habitats increases, the ability of the bottom to support organisms into the zone of oxygenated water is decreased. In particular, small bivalves will sink beyond the reach of their siphons if the bearing load of the sediment is strongly decreased by the addition of water to the upper sediment layers by the passage of trawl gear;
2) details of near-bottom hydrographic regime and sediment structure. In sandy bottoms, Huetell and colleagues have shown that sand waves established during periods of high current flow set up turbulent flow over the bottom. This turbulent flow enhances the movement of oxygenated water into the sediments so that in the sand wave troughs the depth of penetration of oxygen is as much as 6 times as great as in flat sandy areas;
3) details of organic matter content (beyond measures of organic carbon). Not all bottom dwellers are generalist deposit-feeders. In fact, many species will eat only higher quality organic matter. Quantification of high quality organic matter can be done simply, by measuring total chlorophyll *a* or total phytopigments, or more complexly by assessing the total protein (as measured by amino acid concentration) and lipid content;
4) species composition or lists of taxa at least to family level. Knowledge of species identities can be used to understand the function of the community. For example, some species make tubes, others make burrows, others live freely on the sediment, and still others burrow without any fixed structure. As a consequence, some species will more likely be impacted to a greater extent than others. Some of the species that make tubes, for example, lose their ability to construct tubes later in their lives, so having their tube destroyed when they are fully grown means that there is no chance for the species to recover from the disturbance; and
5) size structure of the benthos. In areas where disturbance is high, the species may be smaller than in areas where the stress is lower. As well, some communities exhibit high bimodality in the size of the species. Both cases suggest that attention needs to be paid to the disturbance environment. In the latter case, for example, it may be that the high number of smaller species could be due to excessive sediment movement by the larger, deep burrowers.

In general, it appears that for most studies there is a premium in establishing a result for the study rather than developing an understanding of how benthic communities function and are capable of responding to heavy levels of disturbance. By including the kinds of data noted above, it will be possible for others to use the results of the study more effectively.

5.16 Use of landscape ecology methods in marine benthic ecology

Les Watling reported on some observations relating landscape ecology methods to sampling in the marine benthos. In his opinion, most benthic surveys are conducted in a backwards fashion. That is, samples are taken on some sort of grid or stratified random pattern, and the relationship of the samples to the bottom characteristics is determined after the fact. In landscape ecological investigations, however, the habitat types are mapped first and then are sampled. Depending on the objectives of the study, one or more samples will be taken within each habitat type, and many patches of each habitat type are usually sampled. The habitat patches can also be characterized using many variables such as perimeter length, patch shape, area, etc. Having these variables quantified allows one to ask questions about the relationship of patch characteristics to biodiversity levels, abundances of various species, etc. In addition, the effect of neighboring patches of various types on the species content of a specific patch type can be evaluated. Watling suggested two books on the introduction to the methods of landscape analysis as good starting points (Gergel, S., and M.G. Turner. 2002. Learning landscape ecology: a practical guide to concepts and techniques. Springer, New York. 316 pp. plus CD-ROM.

Turner, M.G., R.H. Gardner, and R.V. O'Neill. 2001. Landscape ecology in theory and practice: pattern and process. Springer, New York. 401 pp. plus CD-ROM).

5.17 EU CHARM Project

Michael Zettler gave a short report about a meeting of Baltic benthos ecologists in Tvarminne at the end of March 2003. This meeting was organized by Erik Bonsdorff and motivated by the EU project CHARM. This project deals with aspects of the EU Water Framework Directive. About 15 benthic scientists from all Baltic countries met at the Finnish Zoological Station. This group discussed tasks and solutions relating to the Directive in respect of macrozoobenthos (e.g., typology, indicator species, biotic indices).

5.18 MARBLE and MARBENA E-conferences

Edward Vanden Berghe reported that these are both EU projects under FP5. The objective of the e-conferences is to discuss topics relevant to marine biodiversity, to be reported at the European Platform for Biodiversity Research Strategy (EPBRS) meetings. EPBRS meetings are organised every six months, in the country holding the EU presidency. The Marble conference was held in preparation for the Brussels meeting. Four Marbena conferences are planned in response to EPBRS meetings; meetings have been held in preparation for the EPBRS meetings in Spain, Denmark and Greece. An extra meeting will be held on the marine biodiversity of the NAS countries.

Part of each Marbena e-conference is run in collaboration with the Bioplatform e-conference.

After each of the e-conferences, a small document is prepared with a summary of discussions. These documents are available from VLIZ, and are also available in PDF format from the VLIZ website.

5.19 MARBEF proposal for a Network of Excellence under FP6

Edward Vanden Berghe reported that MARine Biodiversity and Ecosystem Functioning is a proposal for a Network of Excellence submitted to the EU under FP6. Preparation of the proposal was coordinated by Carlo Heip and Pim van Avesaet of NIOO/CEME. The project activities will build strongly on previous EU projects, e.g., Biomare, Marble, Marbena.

The proposal has three scientific themes: biodiversity/biogeography, ecosystem functioning, and socio-economic aspects of marine biodiversity. The last theme is cutting across the first two themes.

Though the project will be science-driven, the scientific part is not the main one in the proposal; the emphasis in the proposal is on integrating and coordinating activities: building a project website, portal sites, distributed databases and other joint activities. A series of workshops will be instrumental to realise all the project objectives.

6 REPORT ON THE PROGRESS IN THE NORTH SEA BENTHOS PROJECT: QUALITY CONTROL, DATA ANALYSIS, WORKSHOPS AND END-PRODUCTS

Dr Rees reviewed the background to this project, which involved a combination of re-sampling of stations from the 1986 ICES NSBS and the compilation of data from other relevant sources (including national monitoring programmes) collected in the period 1999–2001. So far, data were available from Germany, Holland, Belgium, Norway, Sweden, France and the UK. The activity was initially coordinated by a Steering Group comprising members of the ICES BEWG, with data management being led by Edward Vanden Berghe (VLIZ). In 2002, ICES agreed to the formation of a Study Group on the North Sea Benthos Project (SGNSBP), in recognition of the wide interest in the initiative; the Terms of Reference of this Study Group are given at Annex 5. Three workshops have been held since the initiation of the project: at Ostende (January 2002), Bremerhaven (September 2002) and Yerseke (March 2003), with the principal aim of addressing problems associated with the intercompatibility of data from different sources. Future work and reporting cycles, and the objectives to be addressed, were also agreed. The reports of all three workshops will shortly be available via the 2003 report of the ICES SGNSBP (www.ices.dk). An ICES paper summarizing the scope and objectives of the survey was also presented (by Heye Rumohr) at the 2002 ICES ASC meeting (ICES CM 2002/L:09).

The following key hypotheses for future testing assume the occurrence of changes to the status of benthic assemblages in parts of the North Sea between 1986 and 2000, and that the magnitude of these changes are sufficient to warrant further explanation:

- Are changes an artefact of sampling/analytical practices between laboratories/countries?

- Can changes be ascribed to the effects of eutrophication (including amelioration in conditions)?
- Can changes be ascribed to alterations in the pattern and intensity of demersal fishing between 1986 and 2000?
- Can changes be linked to climatic trends/cycles such as increased water temperatures or storminess (including variation in the NAO index)?
- Can changes (especially in coastal environments) be linked with changes to the nature and quantities of contaminant/organic matter inputs?

One approach for future testing will be to compare changes within similar habitat types. Several measures of assemblage structure or function may be employed, including the occurrences of rare species and their sensitivity to natural or man-made influences.

Initial multivariate analyses of the incomplete data set was conducted at the March 2003 workshop and, while in-depth interpretations of the output would at this stage be inappropriate, the geographical spread of cluster groups was encouraging as an indicator that interlaboratory inconsistencies did not dominate patterns. Further detailed work on taxonomic matters is proceeding, including useful inputs of advice from outside experts.

A further small-scale workshop is planned for November 2003 (Oostende) to progress data compilation issues, and a meeting of wider scope is planned for March 2004 (Wilhelmshaven). Both will be held under the auspices of the ICES SGNSBP 2000.

Long-term data sets should assist in the interpretation of differences between NSBP 2000 and NSBS 1986 results. H. Rees/E. Vanden Berghe will contact P. Kingston on the availability of long-term benthos data from UKOOA. Long-term (1970–2000) benthos data off the Belgian coast will be provided by S. Degraer, and other sources of such data sets will be pursued.

Dr Rumohr summarized the outcome of the 2003 meeting of the ICES WG on Marine Habitat Mapping (WGMHM). At this meeting, there was a proposal to further develop a map of the southern North Sea to encompass all relevant biotic and environmental data in up-to-date GIS format, to be coordinated by Canadian colleagues. There was discussion on the possible contribution of benthos data arising from the work of the SGNSBP. It was noted that the mapping exercise would have the potential to benefit both ICES groups in pursuing their aims. However, it was also necessary to ensure that the analytical and reporting needs (and associated time-scales) of the NSBP data contributors must be adhered to. Thus further work was still required to resolve issues of data intercompatibility, and new data were still awaited from some sources. However, the data and findings from the 1986 NSBS were already available for contribution to a North Sea mapping initiative, and the BEWG and the SGNSBP would fully support cooperative effort to apply this source of information. It was agreed that Dr Rees would contact David Connor (Chair, ICES WGMHM) with a view to establishing a basis for effective future collaboration with SGNSBP.

7 THEME SESSION AT THE 2003 ICES ANNUAL SCIENCE CONFERENCE

Three papers for presentation at the 2OO3 ICES ASC, Theme Session on "The role of benthic communities as indicators of marine environmental quality and ecosystem change" (Tallinn) were submitted (deadline for abstract submission: 5 May). However, more papers are expected after the session of the ICES programme committee. It will be of great interest to establish what contribution this Theme Session can make to the ongoing development of EcoQOs (see Section 11, below).

8 REVIEW NEW DEVELOPMENTS ON QUALITY CONTROL IN ZOOBENTHOS AND PHYTOBENTHOS MONITORING AND RESEARCH AND COMMUNICATE THIS TO SGQAE AND SGQAB

8.1 Criteria for evaluating the acceptability of biological data in monitoring programmes

The BEWG reviewed and commented upon the benthic component of a draft paper produced by SGQAE/SGQAB concerning the above AQC issue. These comments are incorporated into a revised draft which is given at Annex 6.

8.2 Methods of monitoring and surveys of the phytobenthic plant and animal communities

Hasse Kautsky reported that the area of interest is the phytobenthic plant and animal communities found on both hard and soft substrates. The limits of the system are set by the depth extension of the euphotic zone. In the Baltic Sea it also includes deeper *Mytilus edulis* beds on hard substrate as the same technique can be applied. The main purpose of the

phytobenthic monitoring programme is to establish and see the temporal change of the species depth distribution and coverage of the substrate as a tool for the evaluation of environmental change.

The method described is used in the Swedish national monitoring programme of the vegetation-covered substrate of the Baltic Sea, financed by the Swedish EPA. It is also included in the HELCOM recommendations. The estimate of species depth distribution and coverage is mandatory. Additional sampling (e.g., photographs, quantitative destructive sampling) may be decided by each Baltic country. Below a brief summary of the methods is given.

In the monitored (surveyed) area, fixed transects are placed in sub-areas so that replicates are obtained representing the environmental gradient of interest, e.g., in the sheltered, the intermediate, and the outer part of an archipelago area. Using SCUBA technique, a metre-marked line is placed perpendicular to the depth lines down to maximum depth. In monitoring, the transect line has a permanently fixed staring point (marking on shore, additional GPS, etc.) and a given compass direction. SCUBA-divers make notes of all observations on a protocol directly under water. All observations are preceded by the distance from shore obtained from the transect line and the depth measured by a calibrated depth gauge. Within a corridor of 3–5 m on both sides of the transect line, the type of substrate (7 types or combinations thereof) and its percentage coverage, and the siltation (4-grade scale) are estimated and noted. Then, the depth distribution and coverage (7-grade scale) of the identified plant and animal species is noted. The coverage estimates are made within an imagined area set by the limits of the corridor and site of the diver. A new observation is done when either the type of substrate changes, new species occur or the coverage of the species changes. Within identified belts, as an option, quantitative samples are collected randomly—in the case of monitoring they are collected randomly at fixed depths. Along the transect also underwater photographs and/or video imaging may be done. If quantitative samples, pictures, etc., are collected, e.g., the frame size and number are noted together with substrate type and plants and animals found within the frame. The percentage coverage is noted for the observations.

If samples are collected, preferably they are deep frozen, but other preservation methods may be considered if necessary. Samples are sorted and each species is counted (animals) and dried separately at 60^{o} C to constant weight (at least two weeks) and weighed for dry weight. Data are presented using standard methods including multivariate analysis.

In Sweden only sampling of the plants and the blue mussel (*Mytilus edulis*) is financed by the national monitoring programme. Depth extension, coverage and quantitative sampling are performed.

Monitoring and surveys of the phytobenthic communities may also include video transects using, e.g., a hanging camera, stereo-photography of horizontal and vertical facies ("Lundälv"-method), areal photography, when, e.g., shallow bays and reeds are mapped. Satellite imaging is in general less applicable as the resolution is too low. Promising are the different beaming techniques allowing large-scale mapping of areas, but today the interpretation of the signals in most cases is still a major problem, i.e., what are plants, what is not.

It was felt necessary to include phytobenthos sampling methodology recommendations as a new core theme of the BEWG. SOPs for phytobenthos will be covered during next year's workshop (see Recommendations and Action List at Annexes 8 and 9).

9 TOGETHER WITH THE WORKING GROUP ON STATISTICAL ASPECTS OF ENVIRONMENTAL MONITORING (WGSAEM) ANALYSE TREND MONITORING DATA WITH A VIEW TO OBTAINING INSIGHT INTO THE ROLE OF QUALITY CONTROL (QC)

In previous years, WGSAEM had conducted some preliminary work on the evaluation of temporal trends in biological (plankton) data in cooperation with Jørgen Nørrevang-Jensen, who had attended the meetings. WGSAEM had also addressed appropriate methods for the analysis of biological community data. Presently, WGSAEM is revising its Terms of Reference in the light of demands from various WGs for expert statistical advice. WGSAEM had also been contacted in 2003 by SGQAE (H. Rees) with a view to future advice/collaboration on QA/AQC aspects of data analyses and data management. BEWG could not make further progress with this agenda item at this stage, but looked forward to the possibility of future interaction on long-term benthic ecological data analyses and associated QA considerations (see Action List at Annex 9). The question arose whether the Swedish long-term benthos data sets are already included in the ICES database, and therefore accessible for such work. Long-term benthos data derived from the earlier EU COST 647 initiative should also be taken into account. Other appropriate sources of long-term data sets were also discussed.

10 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

H. Kautsky reported that the phytobenthic communities are the most species-rich areas containing both plants and animals. Many species are sensitive to environmental change, both anthropogenic and climatic. The depth distribution of the attached plants correlates well with the water quality as reflected by light, e.g., the Secchi depth influenced by eutrophication increasing pelagic production. In the Baltic Sea some species are specifically sensitive to effluents, e.g., the bladderwrack *Fucus vesiculosus* is sensitive to chlorate and derivates thereof found outside pulp mills. Clear patterns can be seen reflecting the contents of effluents in the receiving area. A national monitoring programme in the Askö area, northern Baltic proper is financed by the Swedish EPA and has run since the year 1993. During the 1990s there were interannual variations of the plant and animal communities, but the trend was neutral. Compared to results from the mid-1970s, the change in species biomass indicates eutrophication (increase in filter feeders and detritivores) but the general trend is positive. For example, when looking at the maximum depth distribution of *Fucus vesiculosus*, this species has increased by about 1 m since the 1970s, in parallel with Secchi-disk readings in the area which also increased by about 1 m.

11 COMMENCE DEVELOPMENT, ON THE BASIS OF THE CRITERIA FOR SOUND EcoQOs ESTABLISHED BY ICES IN 2001, OF RELATED METRICS, OBJECTIVES AND REFERENCE LEVELS FOR THE EcoQOs RELATING TO (O) DENSITY OF SENSITIVE (E.G., FRAGILE) SPECIES, (P) DENSITY OF OPPORTUNISTIC SPECIES, AND (B) PRESENCE AND EXTENT OF THREATENED AND DECLINING SPECIES IN THE NORTH SEA [OSPAR 2003/3.3]

Karel Essink and Eike Rachor presented comments on a substantial (45-page) report from the 2003 meeting of WGECO which related to the development of sound Ecological Quality Objectives. Following some amendments arising from the input of other BEWG members, these comments are given at Annex 6. The accompanying BEWG discussion was wide-ranging and a summary is provided below.

Definitions

WGECO offered the following definitions as an aid to allocating benthic taxa for the purpose of EcoQO derivation:

Opportunistic species: those with early maturation, high fecundity and a high colonisation potential achieved through intrinsic long-distance dispersal and a high reproductive rate. These characteristics allow for colonising habitats of a temporary nature often created through physical disturbance. Such species are referred to as r-strategists in the ecological literature.

Scavenger species (invertebrates): opportunistic feeders who respond to chemical signals and are mobile over scales of tens of metres.

Fragile species: ssessile and slow-moving species, often characterised by rigid bodies or tubes that are particularly sensitive to physical damage, usually with a body size >2 cm and living as epifauna or sub-surface infauna. This term is often used in the literature, including the ICES literature, to describe species that are vulnerable to human-induced or environmental change due to their life-histories. Species such as elasmobranches would fall into this latter definition. Here we (WGECO) restrict our usage of the term to those species that are physically vulnerable.

Sensitive species: a species easily depleted by a human activity, and/or if affected is expected to only recover over a very long period, or not at all (OSPAR, Texel/Faial criteria).

Habitat-forming species: those that form habitats for others.

Densities of Sensitive and Fragile species

The main source of information available to WGECO was the outcome of the 1986 ICES North Sea Benthos Survey. The list of taxa was augmented by other information sources. However, WGECO recognised that a bias towards soft bottom fauna remained, with the English Channel fauna representing a significant gap. The majority of taxa amenable to classification could be deemed "fragile" according to the above definition and 130 were allocated. Of these, only about 20 were identified as "sensitive" (but see below for comments on a subsequent WGECO pooling of lists under this category). BEWG considered that this provisional list provided a reasonable basis to proceed, but cautioned that a more critical evaluation of information sources was needed to accompany inclusions, along with more information on the nature of the activities to which taxa may be considered sensitive.

Densities of Opportunistic and Scavenger species

WGECO provisionally identified 24 opportunists and 16 scavenger species. Comments from BEWG included a suggestion that *Echinocardium* (a "fragile" species) might be classified as "opportunistic", at least at the population level. Also, the inclusion of *Amphiura* and *Ophiothrix* (particle feeders) in the list of scavengers was questioned by some, and there was disagreement over a WGECO comment regarding the relative lack of mobility of amphipods. It was also noted that many species switch from one feeding mode to another depending on circumstances (e.g., density-dependent responses of polychaetes). Again, while recognising the efforts of WGECO to provide source information for the list, BEWG considered that there was a need for a more critical and in-depth review. (Considering the range of taxa in the various categories, and the likelihood that such lists would increase in the future, this will require significant additional effort.) For opportunists, it was particularly important to identify specificity in responses, as far as possible, and the potential for confounding natural and man-made influences. Without such supporting information, observations would be of doubtful operational value in an EcoQO context.

There was concern over reference to all scavenger taxa as opportunistic in the final WGECO synthesis, since the latter are conventionally defined as r-strategists with a short life-span, high fecundity and small size. The typical scavenger response, e.g., the profiting by adult populations from discards from fishing boats, was not analogous.

Densities of Habitat-forming species

It was noted that some of those listed were habitat-modifying rather than habitat-forming. A number of omissions were noted, including the absence of flora, the lack of recognition of the role of certain species as "gardeners" of the environment, and the role of tube-dwelling spionids in promoting settlement of organic particles. Again, a more critical review of information sources was needed to justify the inclusion of many taxa, along with a better (i.e., wider) conceptualisation of the "habitat-forming" activity.

Densities of Threatened and Declining species

WGECO proposed a four-step approach, namely:

1. establish whether the species occurs in the greater North Sea;
2. establish whether the status of the species can be quantified accurately;
3. establish why the species is threatened or declining;
4. establish whether trends in population status can be detected reliably on time frames relevant to management (perhaps over 5 years).

There was some support within BEWG for the wider application of these steps to the evaluation of sensitive and opportunistic species (see above). However, qualifying remarks included an observation that step 1 was a "trivial" undertaking. Also step 3, while critical, may be difficult to establish and perceptions may change over time. For example, over the last 20 years, there was evidence of a shift in emphasis regarding the causes of changes in benthic communities in some parts of the North Sea from eutrophication to that of fishing practices.

Other discussion points

WGECO scenarios on the application of possible EcoQOs

Of 5 scenarios presented by WGECO, the first two, involving the monitoring of trends in densities of >>100 sensitive/opportunistic species on a sea-wide or even assemblage/habitat-specific scale, were recognised as impractical. However, BEWG endorsed the potential value and practicality of monitoring selected "sentinel" species, along with related (multi-species) indices, with the qualification that small species may be at least as important as larger ones in the early detection of adverse trends. BEWG proposed further evaluation of the practicality of the proposed scenarios, with the emphasis on relative simplicity and transparency in order to meet the management need. Dr Borja agreed to provide BEWG members with copies of species lists from within his "biotic index" database (allocated to sensitive, opportunistic and fragile categories) in order to facilitate future work.

Benthic communities and change

Concern was expressed over the limited attention given to the benefits of measures at the community level in evaluations of quality status, recognising that cause/effect attribution relating solely to the densities of individual taxa was a high-risk undertaking in the absence of strong supporting evidence. This raised an important (if obvious) issue regarding the behaviour of populations and communities employed in evaluations of the effects of man's activities, namely their propensity to change naturally over time rather than to exist as static entities. There was, nevertheless,

significant scope for making allowances for this propensity through appropriate sampling designs, rather than rejecting targets simply on grounds of the occurrence of "noise".

Information sources

It was noted that the trend away from studies of the natural history of species and communities hampered the ability to authoritatively address issues such as sensitivity and fragility, across all marine areas. Nevertheless, it was clear that significantly greater effort was required to exploit existing sources in order to support EcoQO development; the associated resource implications were equally significant in this respect.

Conclusions and Recommendations

BEWG welcomed the effort of WGECO in attempting to address the important issue of EcoQO development in relation to benthic communities. However, there were a number of concerns over the content of the report, and further effort was clearly required to promote the production of operationally useful measures. BEWG therefore recommended:

- the creation of an *ad hoc* ICES group of invited experts to provide such an impetus, and to address any associated resource implications;
- preliminary discussions to this end, including the production of Terms of Reference, as part of the Theme Session on benthic indicators at the forthcoming ICES ASC in Tallinn (September 2003) under the guidance of the Co-Conveners (Chris Frid and Heye Rumohr) and other available specialists (including Hubert Rees and Angel Borja).

12 REVIEW THE CRITERIA FOR THE INCORPORATION OF BENTHOS COMMUNITY STUDIES INTO MONITORING PROGRAMMES ON BIOLOGICAL EFFECTS OF CONTAMINANTS AND PROVIDE FEEDBACK TO WGBEC BEFORE 31 MARCH

Heye Rumohr proposed that the structure of the BEQUALM project should be followed and stated that we have to know the species, their abundance and biomass in order to detect the influence of contaminants on ecological processes. Karel Essink commented that, for long-lived species, the age structure (e.g., year classes) should be included. H. Kautsky commented that in studies of phytobenthic communities, cover and depth extension of species should also be included.

13 REVIEW THE POSSIBLE EFFECTS OF WIND FARMS ON THE MARINE BENTHIC SYSTEM

13.1 Investigations into possible impacts of wind farms on the macrozoobenthos of German Baltic waters

Michael Zettler presented preliminary results of investigations on possible impacts of wind farms on macrozoobenthos communities in German Baltic waters. At two different potential wind farm areas *status quo* studies were carried out. Parts of these areas are very important in respect to the NATURA 2000 programme. They are characterised by unique glacial reefs (sand banks, boulder grounds, stone fields) and *Mytilus edulis* banks. These build important macrozoobenthos refuges at the slopes of the Arkona Basin. The depth range is between 45 m and 25 m. Due to the potential destructive effects of the grounding of windmill piles and their connecting power cables these areas are not suitable for wind farms.

A second point was the investigation of electromagnetic fields and their impact on macrozoobenthos. In short- and long-term experiments different benthic species were exposed to different electromagnetic fields. Until now no negative impacts have been found. Only one species (*Crangon crangon*) is sometimes positively attracted. These experiments will be continued to find an explanation for this behaviour.

In April a field experiment started where a model windmill pile was exposed on a sand area in a big measuring field in the Baltic at the Darss rise in depths of 20 m. Three ropes with iron plates at different depths were mounted to observe the succession of epibenthos growth on this material during a one-year time period.

In discussion, Eike Rachor commented on the lack of spatial planning in Germany, where small areas are allowed for exploitation without prior coordination with plans for other activities in the vicinity and thus large areas may be exploited on a piecemeal basis without consideration of the holistic status.

13.2 Wind farm plans in the Netherlands

K. Essink gave a concise account of the plans for installation of wind farms along the Dutch coast. At present a 100 MW nearshore wind park (NSW) and a 120 MW offshore wind park (Q7) are planned to be built NW of IJmuiden. The responsible Ministries of Economic Affairs and of Traffic, Public Works and Water Management have initiated a Monitoring and Evaluation Programme (MEP) which consists of (1) a baseline study (2003–2004), (2) effect monitoring (2005–ca. 2008), and (3) an evaluation phase (2008–...).

The Monitoring and Evaluation Programme includes macrozoobenthos (endo- and epifauna), demersal fish, pelagic fish, birds and sea mammals. The wind parks will be closed for fisheries. As a consequence, the wind park area may function as a refuge for certain organisms.

Among the effects anticipated are seabed erosion, disturbance of bird flight patterns, changed behaviour of, e.g., marine mammals due to underwater noise and the development of a refuge for certain organisms.

The work on macrozoobenthos will be carried out by the University of Hull (for the baseline surveys) and the Netherlands Institute for Sea Research and partners (for the effect monitoring).

13.3 Wind farm developments in Sweden

Susan Smith gave a short review of the Swedish windmill programme on account of the government energy policy demanding a 10 TW contribution from wind power within a 10-year period. The interest for different companies to exploit offshore banks, also in the EEZ, is increasing and 22 banks have been identified that could be of interest in this context. In Sweden there are four small installations (1–7 turbines each) in operation today situated in the southern Baltic. Some thirteen other larger projects are in a planning stage—half of them will consist of more than 50 turbines.

For more reading see Annex 7 and a review of impacts on biota:
www.seaflow.org/pdf/Sea%20Animals%20and20Sound.pdf.

13.4 Wind farm planning in the German Bight (North Sea) and related research

Eike Rachor reported that there is a great number of offshore wind farm plannings in the German Bight (more than 20 locations), and the first permissions for so-called pilot farms have been given by the BSH (Federal Ministry of Transportation). A general study about technology, risk for navigation and what is to be investigated during an environmental impact assessment study is available (UBA Berlin, information available at: rknust@awi-bremerhaven.de). Open questions regarding technology and environmental problems, e.g., through fundamentation, acoustic emissions and vibrations, effects on whale and bird behaviour will be tackled on new research platforms being installed in the German EEZ now.

Some main points regarding possible effects on benthos:

a. during construction (not persistent):
   - fundament building;
   - burying cables.

Both will produce increased turbidity which may harm filter feeders and meroplankton larvae; small- scale effects on zoobenthos.

b. during operation of wind converters (persistent):
   - new (hard) substrates will change the benthic environment and favour epifauna and filter feeders;
   - the converters (piles) will be obstacles and influence the erosion and small-scale sediment conditions (changed turbulence);
   - it is also discussed whether hundreds of converters may change the larger-scale current regime and, thus, water exchange and transportation of suspended food matter, and plankton, including larvae;
   - changes in the predator regime may also occur, as wind farms may become refuges of benthos-eating fishes while sensitive, diving birds may avoid such areas.

A few general recommendations can be made:

- Do not build wind farms in sensitive mud habitats (where hard substrates are normally totally lacking);
- No wind farms should be permitted in areas protected or to be protected (e.g., according to the European Habitats and Bird Directives, e.g., on sensitive sandbanks, stone reefs and boulder habitats on moraine relict banks);
- Consider cumulative effects (in time and space) of several wind farms.

Accordingly, there is urgent need for integrated spatial planning and coordination, not only on the national, but also on the international, level for the North Sea.

In discussion, Eike Rachor emphasised the danger with multiple effects, i.e., small sites for windmills given permission in a subarea add up to large areas in the whole region. Karel Essink commented on the additional problem arising from wind parks placed on the border between countries. Edward Vanden Berghe commented on the need for actual plans for the areas of interest and not only maps. Francis O'Beirn commented on the lack of knowledge of the design of the piles for the windmills. Different types will have different effects on the system. Also there is a lack of national and international coordination. Les Watling commented that fishing in the North Sea is so intensive that the wind farms are nothing negative as they may increase substrate diversity and hamper fishing. H. Kautsky commented that there is a difference between the North Sea and the Baltic Sea. In the Baltic Sea unique, low-diversity areas are exploited and probably destroyed.

Michael Zettler commented on the problem with the placement of the cables on the sea floor. Jean-Marie Dewarumez informed about the French wind farms. There are only 50 windmills in France, but 500 are planned on sand banks along the coast about 15 km from shore. There are conflicts with the local fishermen (see below). Angel Borja informed the BEWG of plans for offshore wind farms in Spain, where conflicts with bird migration may occur.

13.5 Wind farm developments off the French coast

Jean-Marie Dewarumez reported on the situation in the north of France (Region Nord - Pas de Calais). Despite the low number of terrestrial windmills in this area: less than 50 including about 20 in the coastal zone, it was designated as a pilot zone for the development of offshore wind farms. The initial project was to install 500 windmills offshore in the southern North Sea, on the Flanders Banks (at less than 20 km from the shore line) and in the English Channel on the Bassure de Baas (5 km), the Vergoyer bank (20 km) and the Bassurelle bank (30 km). A working group was created in 1999–2000 including windmill technicians, scientists (specialists in plankton, hydrology, benthos, geology, hydrodynamics, fish, birds, modelling, animal behaviour) and the socio-economic world (fishermen, tourism, etc.).

There was strong opposition from the fishermen; nevertheless a pre-pilot baseline study was carried out in 2001 in a very shallow area (5 m depth, at less than 1 km of the coastline), just in front of the 9 windmills of the terrestrial wind farm of Gravelines. Scientific debate regarding the significance of the environmental effects of offshore wind farms is still continuing, but adverse biological effects are suspected.

The project on the development of all offshore wind farms was temporarily abandoned at the beginning of 2002. Following a review of political and economic issues a new decision will be taken in 2003, which will probably result in re-initiation of the project.

Hubert Rees informed of the wind farms in the UK. He commented on the problem that scientists usually come in too late for the planning and placement of the wind farms. Also, there is a lack of knowledge among the constructors of how the marine systems function.

14 ANY OTHER BUSINESS

J-M. Dewarumez and J.C. Dauvin proposed that all members of the BEWG follow their example in the English Channel by updating the polychaete lists for the full ICES zone in order to provide improved reference data for the compilation of comprehensive databases using the same taxonomical criteria. Please refer to the paper in Cahier Biologie Marine 44: 67–95, 2003. "Liste actualisee des especes d'Annelides Polychetes presentes en Manche". Jean-Claude Dauvin, Jean-Marie Dewarumez et Franck Gentil.

15 DATE AND VENUE OF NEXT MEETING

Dr Borja offered to host the 2004 BEWG meeting at AZTI (Spain) from 19–22 April 2004, and this was accepted with thanks by the Chair.

16 RECOMMENDATIONS AND ACTION LIST

The ICES Benthos Ecology Working Group recommends that it meet from 19–22 April 2004 at AZTI, San Sebastian, Spain, in order to address the Recommendations at Annex 9. Actions for intersessional activity associated with these recommendations are given at Annex 10.

17 CLOSING OF THE MEETING/ACKNOWLEDGEMENTS

Heye Rumohr proposed that the draft report be adopted by all members of the BEWG present at the meeting. This was accepted and the report was adopted. Heye Rumohr then formally closed the 2003 BEWG meeting in Fort Pierce, Florida by thanking the participants for their valuable contributions. Special thanks were given to the host institute (Smithsonian Marine Station) and in particular Bjorn Tunberg and Sherry Reed for their hard work and efficiency in organizing the meeting and associated events. The workshop was part-financed by several local interests to whom acknowledgements are also due: St Lucie County Tourist Development Council, Smithsonian Institution, Florida Marine Research Institute, Harbor Federal Bank, Lawnwood Regional Medical Center and Southern Eagle Distributing Inc.

ANNEX 1: LIST OF PARTICIPANTS

NAME	ADDRESS	TELEPHONE	E-MAIL
Frank Beuchel	Norwegian College of Fishery Science University of Tromsø Breivika, N-9036 Tromsø Norway	(+47) 77646723 (47) 984040 77	frankb@nfh.uit.no
Angel Borja	AZTI Herrera Kaia Portualdea s/n 20110 Pasaia Spain	+34-943 004 800	aborja@pas.azti.es
Steven Degraer	University of Gent Dept. of Biology Marine Biology Section Krijgslaan 281-S8 B-9000 Gent Belgium	+32-(0)9-264 85 22	Steven.degraer@rug.ac.be
Nicolas Desroy	Station Marine Universite de Lille 1 28, Avenue Foch BP 80 62930 Wimereux France	+33-(0)3 21 99 29 00	Nicolas.desroy@univ-lille1.fr
Jean-Marie Dewarumez	Station Marine Universite de Lille 1 28 Avenue Foch 62930 Wimereux France	+33-(0)3-21 99 29 00	Jean-marie.dewarumez@univ.-lille1.fr
Karel Essink	Rijkswaterstaat/RIKZ PO Box 207 NL-9750 AE Haren The Netherlands	+31-(0)50 5331 373	k.essink@rikz.rws.minvenw.nl
Hasse Kautsky	Dept. System Ecology Stockholm University SE-10691 Stockholm Sweden	+46(0)8 164244	hassek@system.ecology.su.se
Francis O'Beirn	Marine Institute Galway Technical Park Parkmore Galway Ireland	-353 91 730400	Francis.obeirn@marine.ie
Santiago Parra	Instituto Español de Oceanografia C.O. de La Coruña 15080, La Coruña Spain	+34 981 205362	Santiago.parra@co.ieo.es
Eike Rachor	Alfred-Wegener-Institut for Polar and Marine Research Dept. Comparative Ecosystem Research P.O. Box 12 01 61 27515 Bremerhaven Germany	+49 (471) 4831-1310	erachor@awi-bremerhaven.de
Sherry Reed	Smithsonian Marine Station 701 Seaway Drive Fort Pierce FL 32962 USA	1-772-465-6630	reed@sms.si.edu

Hubert Rees	CEFAS Burnham Laboratory Remembrance Avenue Burnham-on-Crouch Essex CMO 8HA United Kingdom	+44 1621 787200	h.l.rees@cefas.co.uk
Mike Robertson	FRS Marine Laboratory Victoria Road Torry Aberdeen AB11 9DB United Kingdom	044 1224 876544	m.r.robertson@marlab.ac.uk
Heye Rumohr	Institut für Meereskunde Dusternbrooker Weg 20 D-24105 Kiel Germany	+49 431 600 4524	hrumohr@ifm.uni-kiel.de
Susan Smith	National Board of Fisheries P.O. Box 423 SE-401 26 Gothenburg Sweden	+46-(0)31 7430362	Susan.smith@fiskeriverket.se
Bjorn Tunberg	Smithsonian Marine Station 701 Seaway Drive Fort Pierce, FL 32962 USA	1-772-465-6630	tunberg@sms.si.edu
Les Watling	Darling Marine Center University of Maine 193 Clarks Cove Road Walpole, ME 04573 USA	1-207-563-3146 x 248	watling@maine.edu
Edward Vanden Berghe	Vlaams Instituut voor de Zee Vismyn Pakhuizen 45-52 B-8400 Oostende Belgium	+32-(0)59-34 21 30	wardvdb@vliz.be
Michael Zettler	Instituut fur Ostsee-forschung Warnemunde Seestrasse 15 D-18119 Rostock Germany	+49 (381) 5197236	Michael.zettler@io-warnemunde.de

ANNEX 2: TERMS OF REFERENCE FOR THE 2003 ICES BENTHOS ECOLOGY WORKING GROUP MEETING

2E08 The **Benthos Ecology Working Group** [BEWG] (Chair: H. Rumohr, Germany) will meet in Fort Pierce, FL, USA, from 28 April–1 May 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 at the ICES 2003 ASC, focusing on the role of benthic communities as indicators of marine environmental quality and ecosystem change, and discuss possibilities for further theme sessions;

c) review new developments on quality control in zoobenthos and phytobenthos monitoring and research and communicate this to SGQAE and SGQAB;

d) together with the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM), analyse trend monitoring data with a view to 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) commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQOs relating to (o) density of sensitive (e.g., fragile species), (p) density of opportunistic species, and (b) presence and extent of threatened and declining species in the North Sea [OSPAR 2003/3.3]. In this respect,

   i) for EcoQ elements (o) and (p), identify possible species in the respective categories, consider further the spatial scale requirements of sampling and the adequacy of existing monitoring activities to determine their status and trends, and provide further advice based on scenario considerations on the applications of possible EcoQOs;

   ii) for EcoQo element (b), consider benthic species and the habitats on the Draft OSPAR priority list of threatened and declining species for their relevance and usefulness as a basis for EcoQOs for the North Sea;

   iii) where possible and appropriate, reconstruct the historic trajectory of the metrics and determine their historic performance (hit, miss or false alarm) relative to the objective being measured, as a basis for deciding their relationship to management.

   This information is required by WGECO before 31 March 2003.

g) review the criteria for the incorporation of benthos community studies into monitoring programmes on biological effects of contaminants and provide feedback to WGBEC before 31 March;

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

BEWG will report by 19 May 2003 for the attention of the Marine Habitat and Oceanography Committees and ACME.

ANNEX 3: TERMS OF REFERENCE FOR THE 2003 ICES WORKING GROUP ON MARINE HABITAT MAPPING

2E06 The **Working Group on Marine Habitat Mapping** [WGMHM] (Chair: D. Connor, UK) will meet in Sandy Hook, USA from 1–4 April 2003 to:

a) present and review National Status Reports on habitat mapping and classification activities according to the standard reporting format;

b) review the application of EUNIS classification to existing marine habitat maps;

c) review the habitat maps for the southern North Sea and the international Wadden Sea;

d) review the outcome of the OSPAR workshop for the development of a North Sea broadscale map;

e) discuss progress in setting up classification for the Baltic Sea area [HELCOM 2003];

f) assess progress on setting up a habitat mapping data exchange platform;

g) discuss U.S., Canadian and European mapping approaches and assess their relevance to each other;

h) review the progress in the intersessional workshops on standardising techniques for habitat mapping, to include members of WGEXT and BEWG and national agencies;

i) consider opportunities for subsidiary groups of the Fisheries Technology Committee to provide products and support.

WGMHM will report by 22 April 2003 for the attention of the Marine Habitat and Fisheries Technology Committees and ACE.

ANNEX 4: "PRESTIGE" OIL SPILL ON THE NORTH SPANISH COAST: PRELIMINARY SPANISH OCEANOGRAPHIC INSTITUTE (IEO) IMPACT STUDIES ON THE BENTHIC HABITAT

F. Sánchez[1], A. Serrano[1], S. Parra[2], F. Velasco[1], A. Punzón[1] and I. Frutos[2]
[1]Instituto Español de Oceanografía, Centro Oceanográfico de Santander, Apdo. 240, 39080 Santander, Spain.
[2]Instituto Español de Oceanografía, Centro Oceanográfico de La Coruña, Apdo. 130, 15080 La Coruña, Spain.

INTRODUCTION

News that an enormous single-hulled tanker was foundering off the coast of Muxía was first disclosed on 13 November 2002. Gale-force winds coming from the NW were pushing the "Prestige" dangerously close to the shore, so the maritime safety experts decide to force the ship out to sea, away from the coast to prevent a collision. On 19 November, the ship breaks in two and sinks 13 miles from the coast. Over the course of these six days the vessel is estimated to have lost over 20,000 tonnes of fuel oil, unleashing a vast black tide which has affected the entire coast of Galicia (Figure A4.1), especially devastating the Costa de la Muerte, spreading, months later, to the whole of the Cantabrian Sea.

Once the magnitude of the "Prestige" oil spill became evident, the research team at the Instituto Español de Oceanografía (IEO) (Spanish Oceanographic Institute) began to devise a strategy to study and assess the effects of the fuel oil released from the tanker (www.ieo.es/prestige). The IEO, which is the only national government agency devoted exclusively to marine research, has a solid background in the scientific monitoring of accidental spills of toxic substances into the sea. Prior to the case of the "Prestige", the IEO took part in studies to assess the impact of the spills caused by the vessels "Polycommander" (1970), "Monte Urquiola" (1976), "Casón" (1987) and "Aegean Sea" (1992; López-Jamar *et al.*, 1996; Parra and López-Jamar, 1997), all off the coast of Galicia.

Starting on 7 December, 2002 up to the present time, various teams from the IEO have been conducting oceanographic surveys to monitor the evolution of the fuel oil and its effect on the water, living things and sediments (Table A4.1). Below we present the preliminary results of the research cruises "Prestige-Contaminación 1202", "Prestige-Plataforma 1203" and "Prestige-Plataforma 0103", all of which are directed at evaluating the impact of the "Prestige" oil spill on the benthic habitat.

PRELIMINARY RESULTS

1. Hydrocarbon Content in the sediment

During the "Prestige-Contaminación 1202" oceanographic cruise, samples were taken at 23 stations located on the Galician continental shelf, and the total concentrations of polyaromatic hydrocarbons found in the sediment were analysed. The samples were collected with a Bouma type box-corer and quantified by high performance liquid chromatography with a programmable wave length fluorescence detector.

Total concentrations of polyaromatic hydrocarbons in the sediment of the stations sampled are shown in Figure A4.2. The lowest values are probably near the level found prior to the "Prestige" oil spill. It must be remembered that in an area of heavy maritime traffic the sediment is bound to contain a certain amount of hydrocarbons. We should, however, point out that some stations showed values of up to ten times higher than this level. In general, the samples collected from the shelf near the Rías Bajas exhibited lower concentrations of polyaromatic hydrocarbons than the levels found in the zone located north of the Ría de Muros, with the exception of the station located to the west of the Island of Ons (outer area of the Ría de Pontevedra), which had the highest values of the entire study area. Comparatively higher concentrations were also encountered in the stations nearest to the coast, as can be seen in Malpica and Finisterre (Viñas *et al.*, 2003).

2. Presence and quantification of fuel oil on the bottom of the continental shelf of Galicia and the Cantabrian Sea

During the two research cruises, "Prestige-Plataforma 1202" and "Prestige-Plataforma 0103" the most efficient method of sampling the bottom to detect and quantify the presence of fuel oil on the sea floor was clearly the beam trawl. In each of the 26 stations (Figure A4.3) a 15-minute trawl was taken at a speed of 2.5 knots. During the two cruises the mean distance covered along the bottom with the beam trawl was 1246 ± 64.1 metres and the area swept per tow measured 4362 m^2.

The fuel oil settled on the bottom appeared in the form of small, scattered agglomerations with sizes ranging between 5 cm and 15 cm in diameter. The analyses carried out at the Laboratory of the Oceanographic Center in Vigo (IEO)

revealed that they came from the "Prestige". The concentrations of fuel per stratum, expressed in grams of fuel oil per 15-minute trawl (Yst), are given below:

Stratum	Yst	SE
70–120 m	26.77	10.40
121–200 m	419.54	379.44
201–500 m	131.64	95.93
TOTAL	252.59	194.74

The standard error (SE) of these estimations is high, owing mainly to the fact that this material is not distributed in a homogeneous fashion. On the basis of these data, and using the method of the area surveyed, we are able to make some preliminary estimates as to the total amount of fuel oil on the Galician continental shelf, which would give us values in the vicinity of 526.3 tonnes.

Oil has been found mainly in the region around the shelf off the area known as the Costa de la Muerte (Figure A4.4), with the greatest densities (over 300 kg/km^2) located on the bottoms ranging between 100 m and 200 m in depth off Finisterre. When interpreting these results, we must bear in mind that the oil does not cover the ocean floor in a continuous line, but rather it exhibits a scattered, uneven pattern, so a considerable effort is required in the sampling in order to be able to quantify and determine the distribution of this oil with the utmost accuracy (Sánchez, 2003).

During the "Prestige Cantábrico-0303" research cruise, 27 stations were sampled with the beam trawl to estimate the amount of oil that had accumulated on the bottom all along the continental shelf of the Cantabrian Sea. Fuel oil had settled on the ocean floor in all the stations located east of Cabo Peñas (Figure A4.5). The fragments were small and did not exceed 20 g/tow, except in stations 17 and 23, where the sludge weighed over 100 g/tow. No oil was detected in any of the 6 stations sampled between Ribadeo and Cabo Peñas and there was no sign of the spill in the area from Ribadeo to Cabo Peñas. This distribution is in keeping with the available information on the trajectory of the slicks obtained from buoys monitored by satellite (www.cmima.csic.es/prestige). The amount of fuel oil found on the bottom of the Cantabrian shelf was generally substantially less than on the continental shelf of Galicia. The greatest concentrations were discovered off Guetaria and, to a lesser extent, off Gijón (Punzón and Serrano, 2003).

3. Impact of the spill on the benthic and demersal communities living on the continental shelf of Galicia. Preliminary Data

3.1 Infaunal communities

During the two research cruises "Prestige-Plataforma 1202" and "Prestige-Plataforma 0103", a total of 15 stations were sampled using the box corer (type Bouma, 0.0175 m^2 surface area) for the purpose of studying the infaunal communities and sediment characteristics (Sánchez *et al.*, 2003). This sampling was conducted in the same stations where the trawl surveys had been carried out using the bottom trawl type "Baca 44/60" and beam trawl (at the mid-trawling point).

Table A4.2 presents the values of organic matter content and the granulometric characteristics of the sediment in the stations sampled. In all the stations sampled the sediment types are dominated by fine or very fine sands or by the silt on the shelf, except in station 26, which at a depth of 60 m, is characterised by a sediment of coarse sand with shell material. The organic content fluctuated between low values (ranging from 1.14 % in station 15 to 2.93 % in station 24) and moderate values (from 3.04 % in station 16 to 4.17 % in station 19). The mean diameter of the particles in the stations analysed ranged between 0.163 mm pertaining to the fine sand particles in station 6 and 0.41 mm corresponding to the silt in station 15. The sediment selection alternated between poor (stations 1, 4 and 14) and moderately good (stations 2 and 6).

The Redox potential indicates the chemical conditions of oxidation-reduction which determine the way in which the organic matter degrades in the sediment (Gray, 1981). Positive values are indicative of oxidation conditions (good exchange of oxygen between the sediment and the free water), while negative values imply reductive conditions (build-up of organic matter on the surface and a slow rate of oxygen renewal in the interstitial water), which are dominated by anaerobic processes of degradation of organic matter.

The Redox potential of the sediment was only measured during the January, 2003 cruise and the results are presented in Figure A4.6. The oxidation-reduction conditions observed in the stations sampled indicate that, in general, oxidation

was good in the first few layers of the sediment, except in station 19, which had negative values all the way up to the surface. In stations 15, 16, 24 and 26, the variation in the Redox potential as compared to depth was very similar, reaching a depth of 3 cm in station 15, which was the highest negative potential value of the group. Station 23 exhibited a great fluctuation in the oxidation-reduction potential between the surface and the deepest measurement, where the highest negative value of all the samples analysed was reached (−160.7 mV).

The fauna samples are still being processed and to date we only have data from four stations (Tables A4.3 and A4.4). Station 1 is located on the continental shelf near the mouth of the Ría de Vigo, at a depth of 102 metres. The sediment is composed of fine silt (41 μm mean diameter) with a poor selection and a moderate organic content (4.07 %). The community is dominated by the spionid polychaetes *Prionospio fallax* and *P. steentrupii*. The number of species is small (22), as is infaunal abundance (1897 ind m^{-2}). Diversity presents a low value (H' = 2.84), while equitableness is moderate (J' = 0.64, Table A4.3).

Station 2 is located at a depth of 155 metres near station 1. The sediment is made up of fine sand (153 μm), with a moderately good selection (S_0 = 1.28) and a moderate organic content (3.36 %). The characteristic species in this station are the polychaetes *Prionospio fallax* and the family Paraonidae. Infaunal abundance is very low (1186 ind m^{-2}) and there is a small number of species (28). Diversity and equitableness are high (H' = 4.12; J' = 0.86, Table A4.3).

Station 8 is located in the vicinity of Finisterre, at a depth of 157 metres. The sediment is composed of very fine sand particles (103 μm), of moderate selection and low organic content (1.90 %). The community is characterized by the polychaetes *Prionospio fallax*, *P. steentrupii*, *Monticellona dorsobranchialis*, and *Aricidea* sp. Species richness is high, while infaunal abundance is low (1897 ind m^{-2}). Diversity and equitableness are high (H' = 4.48; J' = 0.82, Table A4.3).

Station 10, at 166 metres depth, is located on the shelf near the Ría de Muxía. This is one of the areas that was hit the hardest by the first waves of the oil spill. The typical sediment is made up of very fine sand (74 μm), with a low organic content (3.12 %) and moderate selection (S_0 = 1.73). The characteristic species are the Peracarida *Ampelisca* sp. and the polychaetes *Prionospio fallax*, *P. steentrupii* and *Monticellona dorsobranchialis*. The infaunal abundance and species richness are high (3452 ind m^{-2}, K = 37), as are diversity and equitableness (H' = 3.80; J' = 0.73, Table A4.3).

In general, the striking feature would be the relatively low infaunal abundance, which is characteristic of the macroinfaunal communities inhabiting the shelf of this zone during the winter season (Tenore *et al*., 1984). We would also like to point out that in all the samples collected with the box corer, there were no visible signs of oil or the iridescent patches that are so typical of hydrocarbon pollutants.

It was not possible to collect samples from the stations located in the deepest stratum (200–500 m) of the continental shelf as had been planned during these cruises, mainly because of the bad weather conditions at sea and the fact that the box corer was not heavy enough to be used.

3.2. Hyperbenthic communities

A total of 4 stations were sampled using the suprabenthic sled to study the suprabenthic communities on the shelf (Table A4.5). At each station, a 2–3 minute trawl was carried out over the seabed at a speed of 2 knots. We attempted to sample the same stations that had been surveyed with the "Baca" type and beam trawl. Table A4.4 shows the location and depth of the stations sampled. The taxonomic work is still under way (Sánchez *et al.*, 2003).

3.3. Epibenthic communities

These communities were studied by means of a beam trawl having a mouth that is 350 cm wide and 65 cm long, and a mesh size of 10 mm. The effective trawl lasted 15 minutes at a speed of 2.5 knots. The mean bottom distance covered was 1246 ± 32.1 metres and the mean area swept per tow measured 4362 m^2. A total of 26 stations were surveyed (Sánchez *et al.*, 2003). The location of these is provided in Figure A4.3.

In terms of biomass, molluscs are the group with the highest mean biomass (4662.9 g/tow), followed by fish, crustaceans, and echinoderms (2020.4, 1042.1 and 414.3 g/tow, respectively). The composition of the biomass did, however, change depending on the stratum (Figure A4.7). In stratum A (70–120 m) molluscs were the most prevalent, with abundances of 11,569.8 g/tow. Stratum B (121–200 m) was dominated by fish (2222.5 g/tow), followed by the molluscs, presenting a lower biomass than in the previous stratum (1614.5 g/tow). By contrast, in stratum C (201–500 m) crustaceans were the predominant taxon in terms of biomass (1787.5 g/tow), followed by molluscs, with a mean biomass similar to the value found in stratum B (1571.9 g/tow).

Figure A4.8 presents the geographic distribution of the abundance of the five main groups. The homogeneity of the fish stand out, with the exception of the tows carried out in the Rías Bajas (December, 2002), which revealed a greater presence of annelids and molluscs all along stratum A, particularly in the most shallow water tow (50 m, Carnota). The crustaceans, on the other hand, were more abundant on the edge of the shelf (stratum C).

This biomass distribution reflects prevalence on the species level (Table A4.6). The most abundant species in biomass was the mollusc *Turritella communis*, followed by some of the pleuronectiform fish, such as the soles *Arnoglossus laterna* and *Microchirus variegatus* and the megrim *Lepidorhombus boscii*, as well as several molluscs, namely the curled octopus *Eledone cirrhosa*, the gastropod *Neptunea contraria* and the common octopus *Octopus vulgaris*.

Stratum A was also dominated by the gastropod *T. communis*, followed by several of the species mentioned in the paragraph above (Table A4.6), particularly the ophiuroid echinoderm *Ophiocomina nigra* (very abundant in the most shallow water tow, Carnota). In stratum B the curled octopus was the most prevalent, followed by the flatfishes cited for the total distribution (*A. laterna*, *M. variegatus*, *L. boscii*), even though the most abundant species was the large-sized gastropod *Charonia lampax*. Also found in stratum C was the curled octopus—the species having the highest mean biomass—followed by several crustacean species (the anomurans *Munida intermedia* and *M. sarsi* and the natantia *Plesionika heterocarpus*), which caused this stratum to be dominated by the crustacean group.

The mean richness in the whole area was 33.42 spp/tow (Table A4.7). The sectors/strata 1A, 1B and 2B had higher than average values, while the rest were lower. The mean biomass per tow was 8.34 kg, with higher mean values in strata 1A and 2A. Measured on Shannon's diversity index, the total mean biomass amounts to 2.57. The most diversified strata were strata 2B and 1B, while the lowest mean value was found in 2A.

Figure A4.9 shows the geographic distribution of the indices. Richness and diversity in biomass are extremely homogeneous, whereas abundance values in number and biomass are higher in the tows carried out in the most shallow waters (especially off the rías de Muros and Laxe).

After clustering, using the Bray-Curtis Index of Similarity, we have summarised and simplified the intragroup similarity criteria as well as the intergroup dissimilarity criteria, making it possible to designate the groups obtained in terms of their characteristic species as follows:

Group I: *C. lyra* + *S. lascaris* + *P. serratus* group

Group II: *T. communis* + *S. regalis* + *L. ciliaris* group

Group III: *A. laterna* + *M. variegatus* + *E. cirrhosa* group

Group IV: *C. crassicornis* group

Group V: *P. heterocarpus* + *S. Membranacea* group

Group VI: *M. sarsi* + *M. intermedia* + *L. boscii* group

Figure A4.10 shows the geographic distribution of these groups, highlighting the differences between the Laxe and Muros stations (group I) and the Sisargas station (group II) as compared to the other stations in stratum A (group III). Strata B and C present a community structure that differs from that of stratum A, but they do include three groups (IV, V, VI), composed of a bathymetric pattern.

The values described for richness, biomass and diversity indices are similar to those obtained in the Cantabrian Sea using the same sampling methodology (Serrano *et al*., in press). Species composition follows the same pattern reported for environmental conditions similar to those found on the continental shelf of Galicia and Cantabria (López-Jamar *et al.*, 1992; Serrano *et al*., in press). We did not detect the prevalence of any opportunistic species such as those described in sediments contaminated by fuel oil (Plante-Cuny *et al.*, 1993; Parra and López-Jamár, 1997).

The multivariate analyses denote the role played by bathymetry as being the principal factor in terms of how the communities are structured, as has been reported in other papers (Olaso, 1990; Sánchez, 1993; Sánchez and Serrano, in press; Serrano *et al.*, in press). An analysis of the effect of the sediment characteristics on community structure is under way, and we would expect this to be another factor of prime importance.

REFERENCES

Gray, J.S. 1981. The ecology of marine sediments. Cambridge University Press. Cambridge. 185 pp.

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, pp. 67–106. Ministerio de Medio Ambiente, Ser. Monogr., Madrid, 185 pp.

López-Jamar, E., Cal, R.M., Gonzalez, G., Hanson, R.B., Rey, J., Santiago, G., and Tenore, K.R. 1992. Upwelling and outwelling effects on the benthic regime of the continental shelf off Galicia, NW Spain. J. Mar. Res., 50: 465–488.

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.

Olaso, I. 1990. Distribución y abundancia del megabentos invertebrado en fondos de la plataforma cantábrica. Publ. Espec. Inst. Esp. Oceanogr. n° 5, 128 pp.

Parra, S., and López-Jamar, E. 1997. Cambios en el ciclo temporal de algunas especies endofaunales como consecuencia del vertido del petrolero Aegean Sea. Publ. Esp. Ins. Esp. Oceanogr., 23: 71–82.

Plante-Cuny, M.R., Salen-Picard, C., Grenz, C., Plante, R., Alliott, E., and Barranguet, C. 1993. Experimental field study of the effects of crude oil, drill cuttings and natural biodeposits on microphyto- and macrozoobenthic communities in a Mediterranean area. Marine Biology, 117: 355–366.

Punzón, A., and Serrano, A. 2003. Presencia y cuantificación de fuel en el fondo de la plataforma de Galicia. Informe técnico sobre el vertido del "Prestige" nº 3 (www.ieo.es), 4 pp.

Sánchez, F. 1993. Las comunidades de peces de la plataforma del Cantábrico. Publ. Espec. Inst. Esp. Oceanogr. 13, 137 pp.

Sánchez, F. 2003. Presencia y cuantificación de fuel en el fondo de la plataforma del mar Cantábrico. Informe técnico sobre el vertido del "Prestige" nº 9 (www.ieo.es), 5 pp.

Sánchez, F., Blanco, M., and Gancedo, R. 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997–1999. Instituto Español de Oceanografía, 158 pp.

Sánchez, F., Parra, S., Serrano, A., and Velasco, F. 2003. Primera estimación del impacto producido por el vertido del "Prestige" en las comunidades demersales y bentónicas de la plataforma continental de Galicia. Informe técnico sobre el vertido del "Prestige" nº 6 (www.ieo.es), 26 pp.

Sánchez, F., and Serrano, A. (en prensa). Variability of benthic and demersal fish communities of the Cantabrian Sea during the last decade (90–99). ICES Marine Science Symposia.

Serrano, A., Sánchez, F., and García-Castrillo, G. (en prensa). Epibenthic communities of trawlable grounds of the Cantabrian Sea. Oceanologica Acta.

Tenore, K.R., Cal, R.M., Hanson, R.B., López-Jamar, E., Santiago, G., and Tietjen, J.H. 1984. Coastal upwelling off the Rías Bajas, Galicia, Northwest Spain. II. Benthic studies. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 183: 91–100.

Viñas, L., Franco, A., Soriano, J.A., and De Armas, D. 2003. Contenido de hidrocarburos en el sedimento. Informe técnico sobre el vertido del "Prestige" nº 2 (www.ieo.es), 2 pp.

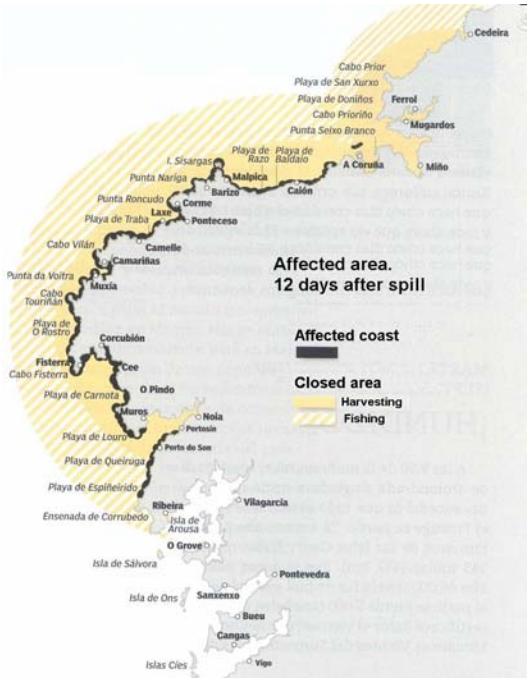

Figure A4.1. Situation of the Galician coast 12 days after the spill.

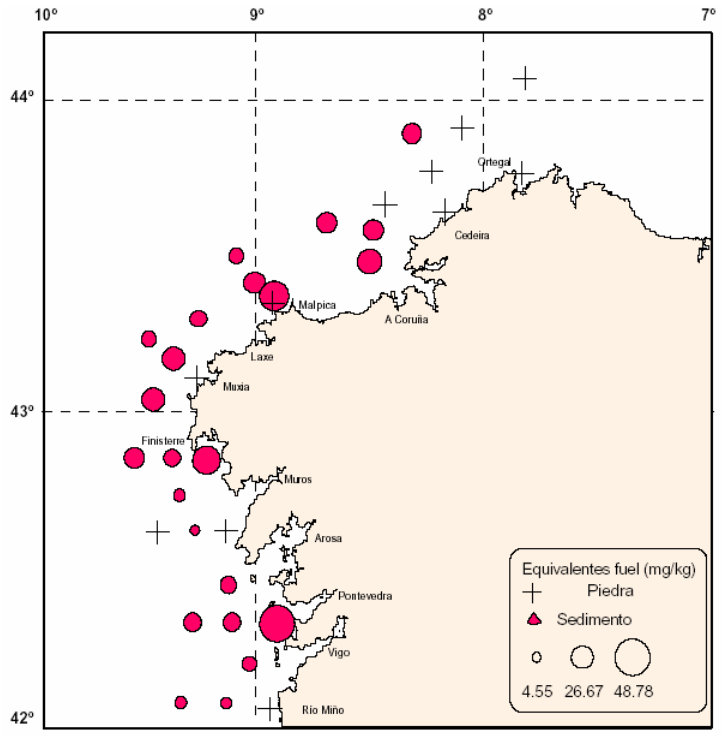

Figure A4.2. Spatial distribution of the concentration of total polyaromatic hydrocarbons in the sediment of the Galician shelf. +: not sampled, rocky bottom.

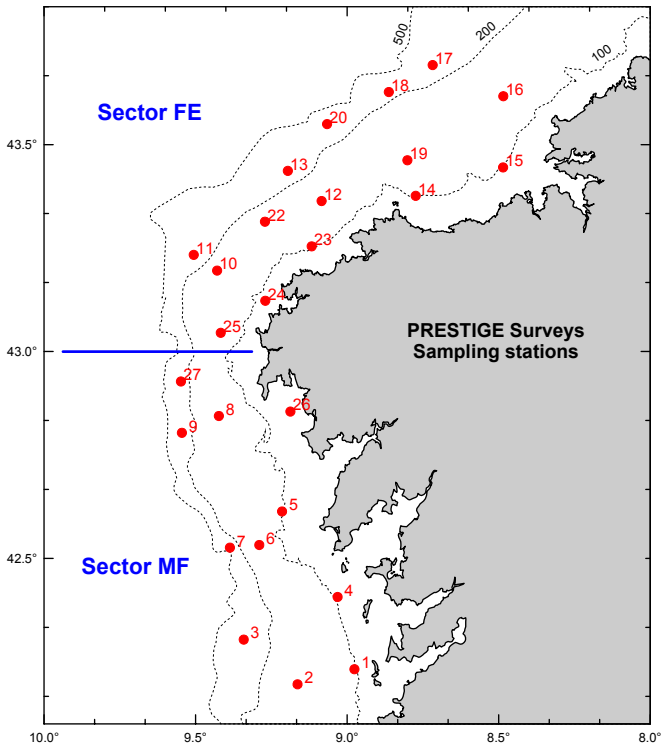

Figure A4.3. Stratification and position of the bottom stations.

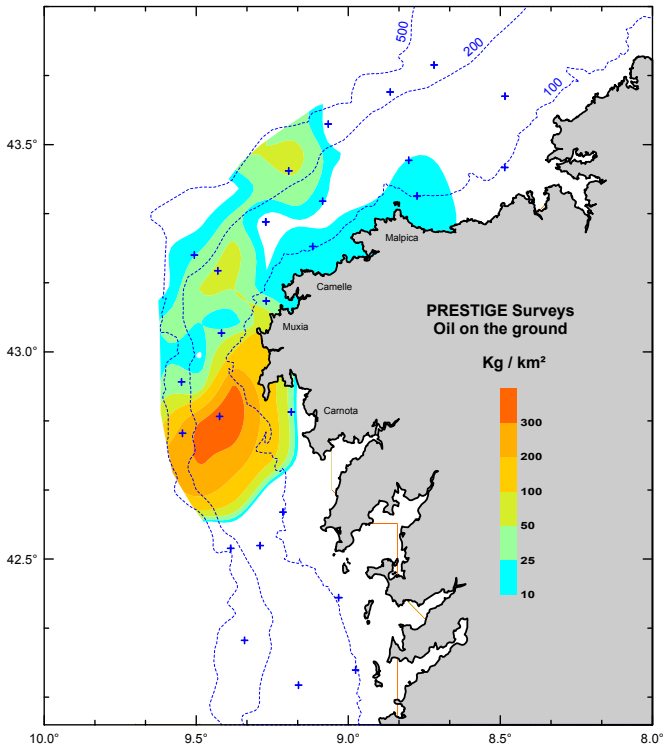

Figure A4.4. Distribution of oil on the bottom of the Galician shelf.

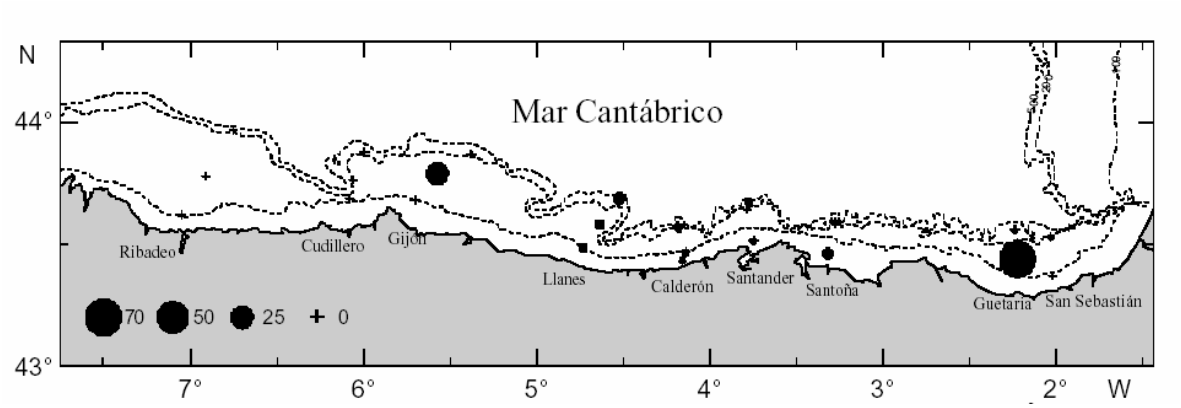

Figure A4.5. Distribution of oil on the shelf of the Cantabrian Sea (kg km^{-2}).

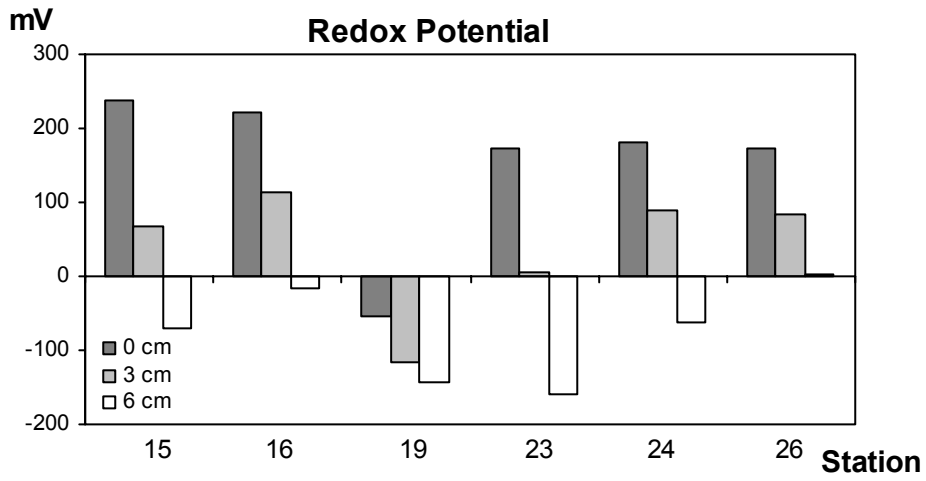

Figure A4.6. Variations of the Redox potential in the surface sediment of the stations sampled.

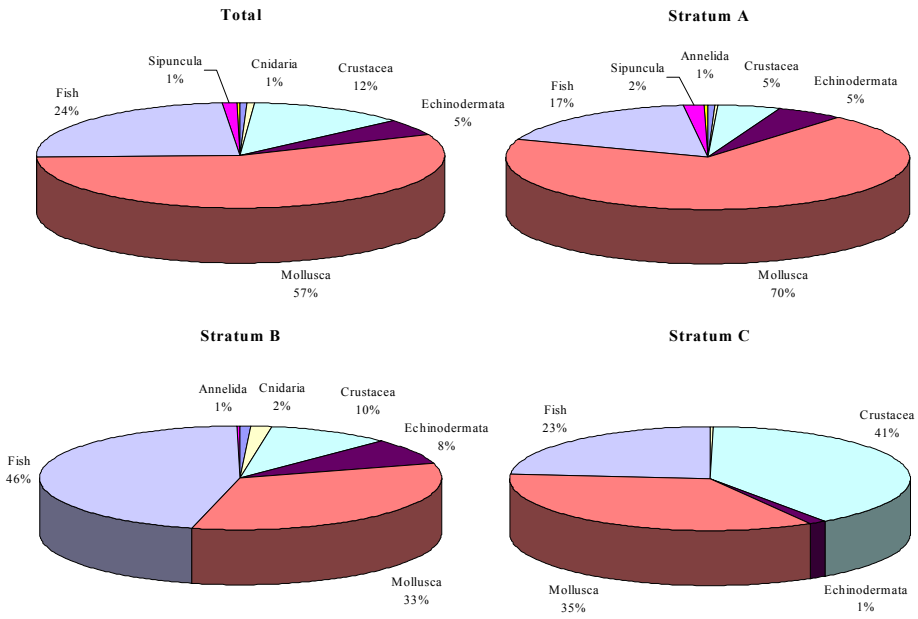

Figure A4.7. Composition of the biomass per tow for the whole area and by depth strata.

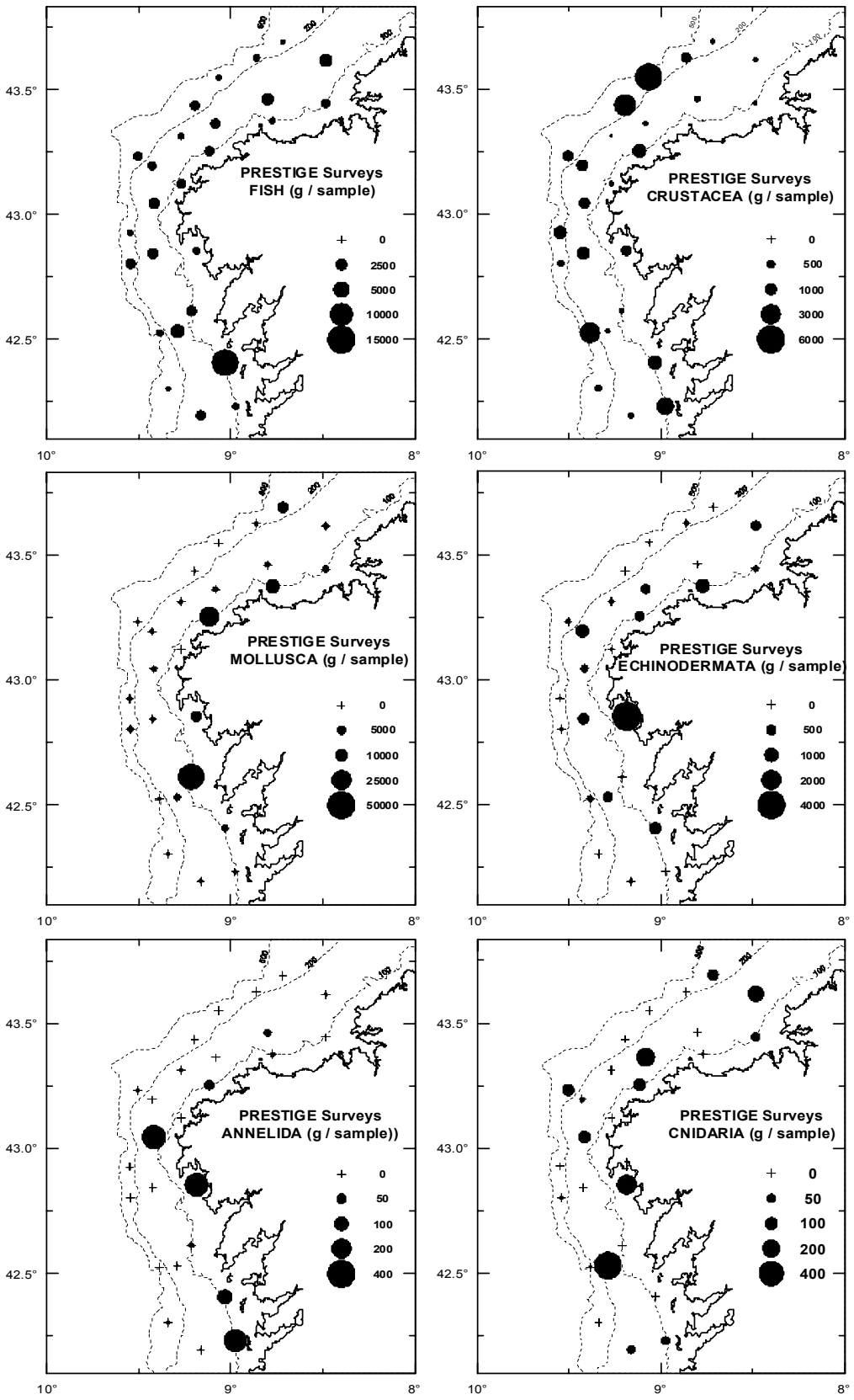

Figure A4.8. Geographic distribution of the abundance of the main taxa.

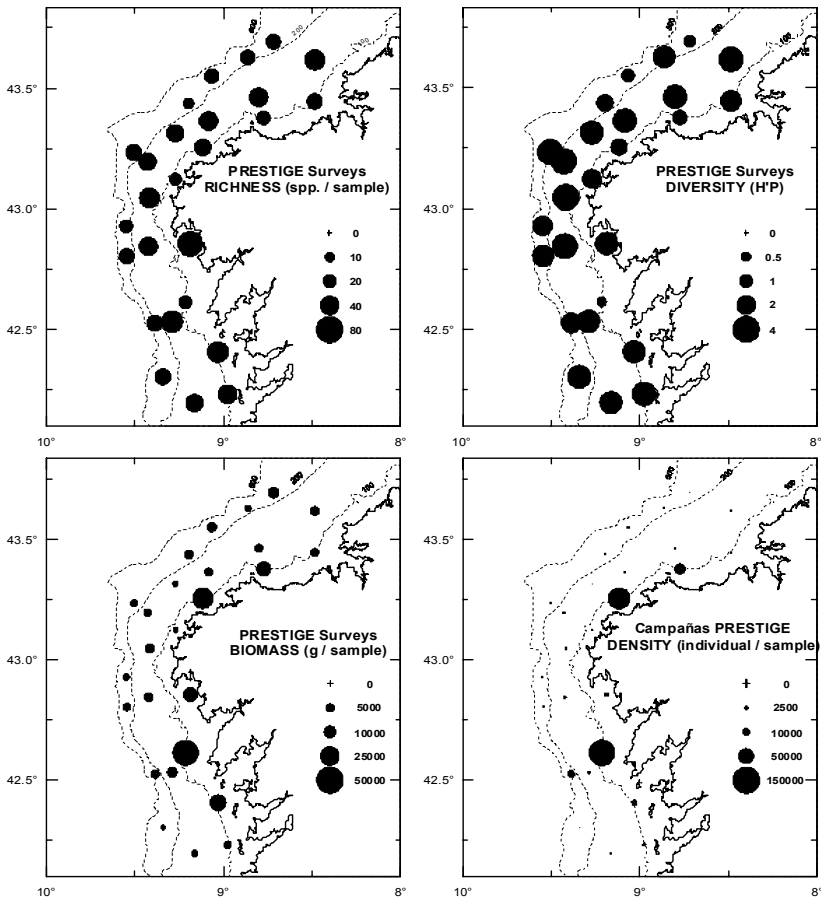

Figure A4.9. Geographic distribution of the ecological indices of richness, biomass and diversity.

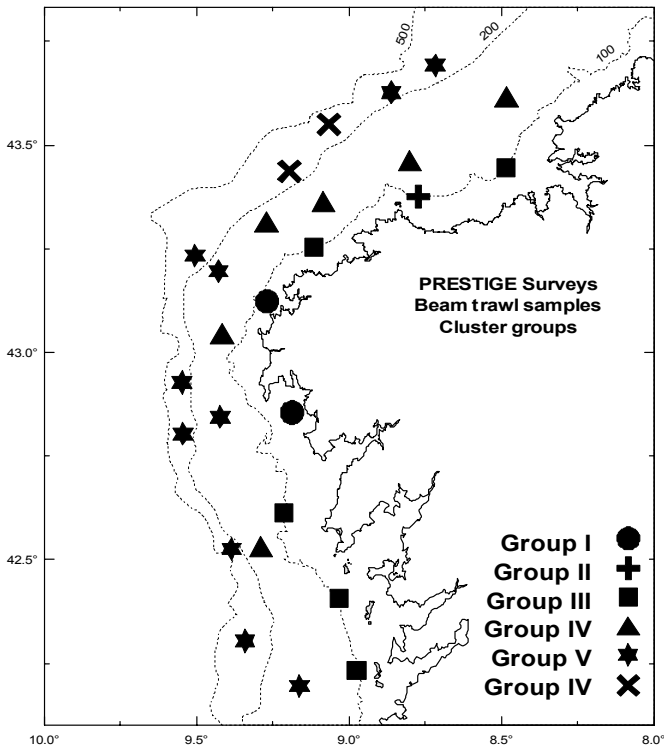

Figure A4.10. Geographic distribution of the cluster groups.

Table A4.1. IEO research cruises.

Cruise	Dates	Vessel	Main objectives	Results (as of 15/04/03)
Prestige-Contaminación 1202	07–13/12/02	Cornide de Saavedra	- Concentrations of hydrocarbons and PAH in the water and sediments	-Low concentrations in water -High values near the bottom -Higher values off Finisterre and Carnota
Prestige-Plataforma 1002	13–22/12/02	Cornide de Saavedra	- Estimate fuel oil between midwater and the bottom - Abundance and biomass indices of benthic species - Hydrographic information - Abundance indices of species of commercial interest - Concentration of hydrocarbons in the biota	-Information on the fuel acoustic signature in midwater -No oil was detected in midwater - High abundance of commercial species - Considerable amounts of oil on the bottom (especially in Finisterre)
Prestige-Geología 0103	02–14/01/03	Vizconde de Eza	- Detailed morphological survey of the sea floor - Knowledge of the sediment characteristics of the sea floor and sub-sea floor - Prospect possible remains of fuel oil in midwater by means of a hydrographic echosound - Identification and mapping of areas with oil deposits using a high frequency lateral scan sonar	- Study under way
Prestige-plataforma 0103	15–23/01/03	Vizconde de Eza	- Determine if there are significant differences between the distribution and abundance of the most important species - Estimate the possible impact on the structure of benthic communities and - Trophic ecology of the most important species of demersal and benthic fish. - Presence of oil derivatives in stomachs and/or prey - Estimate the presence of matter or substances released from the spill, on both the bottom and biota.	- Considerable amounts of oil on the bottom (especially in Finisterre) - No changes in the distribution and abundance of the major benthic and demersal communities have been detected.
Prestige-Acústica 0103	15–23/01/03	Cornide de Saavedra	- Estimation of the abundance of pelagic species using the echo integration method - Spatial distribution of pelagic species - Detection of the possible presence of fuel oil from the "Prestige" in midwater - Collection of samples from the biota to analyse hydrocarbons	- Study under way
Prestige-Contaminación 0203	9–14/02/03	Cornide de Saavedra	- Evaluation of the total polyaromatic hydrocarbon content in the water column - Evaluation of the total polyaromatic hydrocarbon content in the sediments of the Galician shelf	- Study under way
Prestige-Cantábrico 0303	7–14/03/03	Cornide de Saavedra	- Quantify the amount and distribution of matter or substances released from the spill - Determine if there are significant differences between the distribution and abundance of the most important species -- Estimate the possible impact on the structure of benthic communities - Determine the hydrological situation of the shelf and the Cantabrian slope.	- Considerable amounts of oil on the bottom (to the east of Cabo Peñas and the highest concentration off Guetaria)

Cruise	Dates	Vessel	Main objectives	Results (as of 15/04/03)
Prestige-Pelágicos 0303	10–14/03/03 17–21/03/03	Commercial Commercial	- Collect specimens of commercial pelagic fish for later chemical analysis in order to estimate the levels of hydrocarbon contamination - Find out how functional the fishing gears of purse seine and hand line are in the presence of oil.	- Study under way

Table A4.2. Sediment parameters. Symbols: % M.O.: organic content; Q_{50}: mean diameter; Q_{25}: first quartile; Q_{75}: third quartile; S_0: sorting coefficient; CS: coarse sand; FS: fine sand; VFS: very fine sand; M: mud; 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	16/12/02	M	4.07	4.60	0.041	4.00	5.85	1.90	P
2	16/12/02	FS	3.36	2.62	0.163	2.30	3.02	1.28	modW
4	17/12/02	FS	3.40	2.91	0.133	2.45	5.20	2.59	P
5	18/12/02	M	3.23	4.11	0.058	3.50	5.08	1.73	Mod
6	18/12/02	FS	1.85	2.68	0.156	2.37	3.11	1.29	modW
8	19/12/02	VFS	1.90	3.28	0.103	2.69	3.81	1.47	Mod
10	20/12/02	VFS	3.12	3.76	0.074	3.30	4.88	1.73	Mod
12	21/12/02	VFS	2.79	3.28	0.103	3.30	4.88	1.73	Mod
14	21/12/02	VFS	3.86	3.77	0.073	3.20	5.00	1.87	P
15	15/01/03	FS	1.14	2.97	0.128	2.48	3.52	1.43	Mod
16	16/01/03	FS	3.04	2.95	0.129	2.39	4.30	1.94	P
19	17/01/03	VFS	4.17	4.00	0.063	2.86	5.73	2.70	P
23	18/01/03	VFS	3.26	3.02	0.123	2.40	3.89	1.68	Mod
24	19/01/03	FS	2.93	2.79	0.145	2.35	3.43	1.45	Mod
26	22/01/03	CS	1.86	-0.09	1.064	-0.58	1.39	1.98	P

Table A4.3. Community variables. Symbols: N m^{-2}: total abundance (ind. m^{-2}); % P: % polychaetes; % M: % molluscs; % E: % echinoderms; % C: % crustaceans; % O: % others; K: species number; H': diversity; J': evenness.

				Abundance					
Station	N m^{-2}	% P	% M	% E	% C	% O	K	H'	J'
1	1897.4	77.11	5.42	0.60	0.00	16.87	22	2.84	0.64
2	1186.1	91.57	0.00	1.20	1.20	6.02	28	4.12	0.86
8	1897.4	82.53	4.22	0.60	2.41	10.24	44	4.48	0.82
10	3551.9	65.23	4.30	0.00	27.15	3.31	37	3.80	0.73
Mean	2133.2	79.11	3.49	0.60	7.69	9.11	33	3.81	0.76
Max.	3551.9	91.57	5.42	1.2	27.15	16.87	44	4.48	0.86
Min.	1186.1	65.23	0.00	0.00	0.00	3.31	22	2.84	0.64

Table A4.4. Species composition in the study area, −: absent.

			Station	
Species	**1**	**2**	**8**	**10**
Polychaetes				
Ampharete sp.	−	−	−	91
Ampharetidae indet.	11	14	103	23
Aonides sp.	v	−	−	23
Aricidea sp.	−	14	126	−
Armandia sp.	−	14	−	−
Capitellidae indet.	−	14	11	−
Chaetopteridae indet.	−	v	23	11
Chaetozone gibber	−	14	−	−
Cirratulidae indet.	−	57	−	−
Cirratulus sp.	v	29	−	−
Cossura sp.	11	−	−	−
Diplocirrus glaucus	−	−	−	11
Exogone sp.	−	−	11	−
Galatowenia oculata	−	129	57	160
Glycera rouxii	23	−	46	34
Glycera sp.	−	29	−	−
Goniada maculata	−	−	11	−
Gyptis capensis	11	14	11	−
Hyalinoecia sp.	−	−	11	−
Lumbrineris gracilis	34	−	−	−
Lumbrineris sp.	−	14	23	23
Magelona cf. *wilsoni*	23	29	69	160
Maldanidae indet.	−	−	11	34
Mediomastus fragilis	11	86	46	34
Monticellina dorsobranchialis	−	71	126	343
Nephtys hombergi	−	29	23	−
Nereidae indt.	−	−	−	11
Ninoe armoricana	−	−	11	57
Notomastus latericeus	34	−	−	11
Onuphis quadricuspis	−	14	−	−
Ophiodromus flexuosus	−	−	11	−
Ophryotrocha sp.	−	−	−	11
Paradoneis lyra	11	−	11	−
Paradoneis sp.	−	−	−	23
Paraonidae indet.	−	-	23	137
Paraonidae indet. 1	−	14	−	−
Paraonidae indet. 2	−	171	−	−
Paraonis gracilis	57	−	−	−
Poecilochaetus serpens	11	29	−	11

			Station	
Sepcies	**1**	**2**	**8**	**10**
Polychaeta indet.	–	14	46	–
Polydora sp.	–	–	11	–
Polynoinae indet.	–	–	11	–
Prionospio fallax	937	214	457	549
Prionospio multibranchiata	57	–	46	–
Prionospio steenstrupii	194	43	114	411
Pseudocapitella sp.	–	–	11	–
Sabellidae indet.	–	–	–	11
Sphaerosyllis sp.	–	–	11	11
Spio sp.	–	–	11	11
Spionidae indet.	–	–	–	11
Sternaspis scutata	23	–	–	–
Sthenelais limicola	–	–	11	–
Syllidia armata	–	14	-	–
Terebellidae indet.	11	14	23	–
Terebellides stroemi	–	–	46	34
Molluscs				
Abra alba	–	–	23	23
Bivalva indet.	–	–	–	46
Nuculana fragilis	–	–	11	23
Opistobranchia indet.	–	–	11	–
Tellina fabula	23	–	–	–
Thyasira sp.	57	–	34	57
Venus striatula	23	–	–	–
Echinoderms				
Amphiuridae indet.	–	14	–	–
Cucumaria elongata	11	–	–	–
Leptosynapta sp.	–	–	11	–
Crustaceans				
Alpheus glaber	–	14	11	–
Ampelisca sp.	–	–	–	869
Anfípoda indet.	–	–	11	23
Eudorella truncatula	–	–	11	–
Harpinia sp.	–	–	–	11
Leucon siphonatus	–	–	–	23
Tanaidacea indet.	–	–	11	11
Others				
Golfingia vulgaris	–	–	114	–
Nemertina indet.	126	43	34	80
Oligochaeta indet.	194	–	46	–
Onchnesoma steenstrupii	–	–	–	34
Sipunculida indet.	–	29	–	–

Table A4.5. Position of hyperbenthic sampling stations (initial and final trawl), depth and trawl time.

		Initial trawl			Final trawl			
Station	**Date**	**Latitude N**	**Longitude W**	**Depth(m)**	**Latitude N**	**Longitude W**	**Depth(m)**	**Trawl time**
15	15/01/03	43º26,90'	8º29,48'	97	43º26.97'	8º29,62'	97	2'
16	16/01/03	43º35,96'	8º31,24'	150	43º35,85'	8º31,45'	148	2'
17	16/01/03	43º42,59'	8º43,45'	290	43º42,67	8º43,50'	290	2'
19	17/01/03	43º27,44'	8º48,79'	150	43º27,42'	8º48,89'	150	3'

Table A4.6. The most abundance species by area and stratum in decreased biomass average (B = gr tow^{-1}).

Total area			**Stratum A**		
Species	**Group**	**B**	**Species**	**Group**	**B**
Turritela communis	Molluscs	77183.8	*Turritela communis*	Molluscs	9645.6
Arnoglossus laterna	Fishes	22094.2	*Arnoglossus laterna*	Fishes	1779.8
Eledone cirrhosa	Molluscs	20906.7	*Octopus vulgaris*	Molluscs	757.5
Microchirus variegatus	Fishes	8120.0	*Neptunea contraria*	Molluscs	525.4
Neptunea contraria	Molluscs	8106.0	*Ophiocomina nigra*	Echinoderms	486.9
Lepidorhombus boscii	Fishes	7960.8	*Callionymus lyra*	Fishes	440.4
Octopus vulgaris	Molluscs	6060.0	*Microchirus variegatus*	Fishes	291.0
Plesionika heterocarpus	Crustaceans	5932.0	*Phascoliom strombi*	Sipunculids	264.0
Munida intermedia	Crustaceans	5666.6	*Hinia reticulata*	Molluscs	240.3
Ophiocomina nigra	Echinoderms	3895.3	*Liocarcinus depurator*	Crustaceans	188.5
Stratum B			**Stratum C**		
Species	**Group**	**B**	**Species**	**Group**	**B**
Eledone cirrhosa	Molluscs	980.9	*Eledone cirrhosa*	Molluscs	1266.8
Arnoglossus laterna	Fishes	839.9	*Munida intermedia*	Crustaceans	628.2
Microchirus variegatus	Fishes	608.5	*Plesionika heterocarpus*	Crustaceans	587.6
Lepidorhombus boscii	Fishes	349.7	*Lepidorhombus boscii*	Fishes	534.8
Neptunea contraria	Molluscs	229.6	*Munida sarsi*	Crustaceans	362.8
Charonia lampax	Molluscs	204.7	*Gaidropsarus macroph.*	Fishes	213.3
Gaidropsarus macroph..	Fishes	161.4	*Lophius budegassa*	Fishes	204.9
Solenocera membranacea	Crustaceans	147.0	*Neptunea contraria*	Molluscs	204.1
Callionymus maculatus	Fishes	117.9	*Solenocera membranacea*	Crustaceans	88.9
Astropecten irregularis	Echinoderms	93.0	*Astropecten irregularis*	Echinoderms	60.4

Table A4.7. Main values and standard error (SE) of richness (K), biomass (B) and biomass diversity (HB') by sector-stratum and by total area.

Sector-Stratum	K	SE_k	B (kg)	SE_B	HB'	$SE_{HB'}$
1A	45.00	21.15	20.41	17.69	2.38	1.25
2A	24.50	6.76	12.81	12.56	1.84	0.56
1B	42.33	9.45	5.29	2.00	3.15	0.37
2B	40.50	5.21	4.60	1.37	3.42	0.37
1C	26.00	4.97	3.46	1.48	2.54	0.40
2C	23.40	6.27	5.32	2.08	1.97	1.24
Total	33.42	12.87	8.34	9.73	2.57	0.95

ANNEX 5: TERMS OF REFERENCE FOR THE ICES STUDY GROUP ON THE NORTH SEA BENTHOS PROJECT 2000

- collect and harmonize data from stations sampled during the 2000 ICES North Sea Benthos Project;
- augment the NSBP 2000 data with information from other sources (principally from the period 1999–2001) in order to maximise coverage of the North Sea area;
- propose effective ways for ICES to interact with the NSBP database at the Flanders Marine Institute;
- prepare a programme of work to resolve problems affecting the compatibility of data sets from different sources;
- identify patterns in contemporary North Sea benthic assemblages and the causal influences, by reference to supporting environmental data from the NSBP 2000 and other sources;
- compare the outcome of the NSBP 2000 with that of 1986 and postulate causes for any observed differences, with reference to information on temporal changes in biotic and environmental factors, including human influences;
- provide a strategic evaluation of the utility of the collaborative exercise for sea-wide quality assessments;
- make recommendations for the timing and coordination of any future work.

These Terms of Reference cover the projected activities of the SG for the duration of its existence (predicted to be 4 years).

ANNEX 6: REVIEW OF DRAFT TEXT OF SECTION 5 OF THE 2003 WGECO REPORT

Comments by Eike Rachor and Karel Essink.

EcoQO (Ecological Quality Objective) elements:

(o) density of sensitive (e.g., fragile) species
(p) density of opportunistic species

Scavengers are introduced as opportunistic species. This is not completely true. These are species that may show an opportunistic response in the case of availability of, e.g., damaged benthos (due to trawling) and discards from fisheries.

List of fragile benthic species (Table 5.2.1):

- Questions to BEWG: species missing? Species to be skipped (e.g., *Aporrhais*)?

List of sensitive benthic species (Table 5.2.2):

- Sensitive to what (kind of human influence)?
- Why are no polychaetes mentioned? Any suggestions?
- Missing information: sensitive to what? (e.g., fishing with bottom gear, pollution, oxygen deficiency -> deep-burrowing species).

List of opportunistic benthic species (Table 5.2.3):

- Is *Echiurus* correctly placed on the list?
- Can *Echinocardium cordatum* be regarded opportunistic?
- Missing information: to what specific human disturbance do the respective species show an opportunistic response?
- Missing information: what natural disturbances may cause opportunistic response?
- And how/whether to discriminate between natural and human disturbance? Important for making this EcoQO operational.

List of benthic scavenger species (Table 5.2.):

- Are *Amphiura chiajei* and *Ophiotrix gracilis* correctly placed on this list?
- Same question for *Neptunea antiqua*.

List of habitat-forming benthic species (5.2.5):

- Which species/groups are lacking (e.g., callianassids, barnacles)?

Scenarios for application of EcoQOs

- Suggestion to leave opportunistic species out unless a clear distinction can be made between opportunistic responses to human and natural disturbance. Moreover, opportunistic responses are often bound to be relatively short; they will fade away as soon as a new (or the old) situation has developed (but then they may be regarded as indicators (by their reduction)).

EcoQO element (b) presence and extent of threatened and declining species in the North Sea

Procedure of four steps is considered practical. Why not use this approach also to sensitive and opportunistic species?

Preliminary OSPAR list (Table 5.4.1):

- More invertebrate species to be added??!
- Specify what threat(s) is (are) especially active for the species listed?
- To be added: *Lophelia pertusa* (cold-water reefs), deep-burrowing or habitat-forming animals. (?)

General conclusion (not clearly formulated):

How to proceed?

- This remains rather open.
- To enlarge the OSPAR list (for the North Sea as a "pilot area").
- Attention is needed for the potential to operationalize the few EcoQOs that seem to remain.

ANNEX 7: THE APPLICATION OF AQC CRITERIA, AT THE FIELD SAMPLING, LABORATORY ANALYSIS AND DATA ENTRY STAGES, FOR EVALUATING THE ACCEPTABILITY OF BIOLOGICAL DATA IN MONITORING PROGRAMMES (UPDATED DRAFT, 1.5.03)

A sub-group comprising SGQAB and SGQAE members discussed the topic on four levels, i.e., site criteria, sample criteria, laboratory data criteria and data bank criteria. The group expressed concern that Z-scores, which are an appropriate instrument in chemical QA, may not be suited to compare biological community data.

Rejection is not the only way to deal with dubious data; another option is flagging and use of different levels of precision.

In preparing the following account, information was gleaned from five main sources, namely:

Field Operations Manual (1998) and Quality Assurance Manual (1998). Southern California Bight 1998 Regional Marine Monitoring Survey (Bight '98). (See: http://www.sccwrp.org/regional/98bight)

ICES TIMES Report No. 16 (1991). (Benthic communities: Use in monitoring point-source discharges).

NMMP "Green Book" (UK National Marine Monitoring Programme, 2001).

Rumohr (1999). (ICES TIMES report No. 27) and BEQUALM CD-ROM.

UK NMBAQC Annual Report (Year 7): 2000/2001.

In general, there was an encouraging degree of consistency in the advice provided in these documents.

We are also grateful to Hasse Kautsky, Stockholm, for providing advice regarding phytobenthos sampling.

This updated document incorporates comments of the ICES BEWG, at their meeting of 28 April–1 May, 2003.

A. Site criteria

(i) New/random/single sampling sites:

Site Acceptability Criteria (subtidal remote sampling using grabs/cores)

Subtidal sampling with the use of remotely operated grabs or cores may not be possible at some stations for a variety of reasons (e.g., the presence of kelp beds, rocky bottoms and inappropriate water depths). The suitability of a station should be examined by reference to the output from acoustic sounders, and (with care) trial deployment of sampling gear. Stations should, where feasible, be located at the centre rather than at the margins of strong signals which indicate homogeneity in habitat type. If unsuitable, a station may, in a typical local sampling design, be moved no more than 100 m from any assigned coordinate site and ± 10 % of the nominal depth. Clearly, the scope for relocation will depend upon the distance from adjacent stations, and the objectives of the survey. If, after three attempts to locate a suitable station, the station still falls in an area unsuitable for sampling, the station may be abandoned and the reasons for station abandonment will be recorded.

Site Acceptability Criteria (small trawls and towed dredges)

Subtidal sampling with such devices may not be suitable because of uneven/rocky terrain which may yield unreliable samples or result in damage or loss of sampling gear. The suitability of a station should be examined by reference to the output from acoustic sounders, and (with care) trial deployment of sampling gear. Tow lengths/duration may vary depending on location and survey objectives; for small (e.g., 2 m) beam trawls, tow lengths may typically be 0.5 km to 1 km. The scope for relocation of sites if the initial location is unsatisfactory must be determined on the basis of information on substratum type and therefore it is not possible to specify precise distances for relocation; circumstances which dictate abandonment of the site will depend upon the distance between adjacent sampling stations in the planned survey design and the overall goals of the project.

Site Acceptability Criteria (phytobenthos)

- A site (transect) should incorporate the photic zone. Deeper sites are rejected if no hard-substratum animal communities are included in the study;

- The starting point of a transect may be moved to the nearest shore when rejected if beyond the photic zone or in the case of being on land;
- A transect may have the starting point on hard substratum and then may be extended into deeper water until other substrata occur.

Site Rejection Strategy (general)

A sampling site may be rejected if any of the following occurs:

- If the location places the site on land or in an obviously unsuitable location;
- If the site exceeds the depth boundaries (± 10 %) established for the project;
- For benthic subtidal sites sampled by grab or core, if a suitable substratum is not found after three attempts at the nominal location, and up to three attempts at two other locations;
- For trawl sites, if the acoustic survey identifies unsuitable substrata at three locations, if any equipment is lost or damaged, or if the site is deemed unsuitable by the Chief Scientist, or their designate, for a valid reason.

Site Rejection Strategy (phytobenthos)

A sampling site may be rejected if any of the following occurs:

- If relevant (e.g., scope is to only investigate hard, stable substrates), the transect should be rejected if it stops before the major part of the photic zone is incorporated. Then, a site should be chosen which may incorporate the whole photic zone; alternatively the transect is divided into suitable sub-distances so that the entire photic zone is incorporated (e.g., on extremely shallow coasts);
- For "reference" (unimpacted) locations, the site clearly has to be rejected when it is under obvious anthropogenic influence (pier, harbour, major outlet, public bath, etc.). Typically, the site may then be moved a maximum of 200 m;
- The transect may be rejected if it consists of other substrata than set by the scope of the investigation, e.g., if hard substrates are investigated, all sites with substrate fractions less than large stones (high instability) may be rejected;
- In the case where substratum type is a major criterion, the transect is interrupted at the depth where unsuitable substratum is reached, even if it is above the limit of the photic zone.

(ii) Routine/long-term sampling site:

Generally, the site must be suited for the chosen sampling method (thus, for example, a grab sampler is clearly not suited for boulder fields and steep rock walls). The site should be located within an area of relative homogeneity, and should not be subject to variation as a result of demonstrable localised gradients of change, the detection of which is outside the scope of the study in question.

B. Sample criteria

For sampling using grabs or corers, samples should be rejected and sampling repeated (when possible) if:

- Less than 5 litres of sample volume is obtained by a 0.1 m^2 grab in soft sediments or less than 2.5 litres in hard-packed sand (for HAPS corers, less than 15 cm penetration)* ;
- Incomplete closure is noted;
- An obvious uneven bite is noted;
- Spillage during transferring of samples is observed;
- Samples clearly deviate from the other samples (e.g., there is an observed change from clean sand samples to *Mytilus* bank samples). The samples should nevertheless be kept, in order to record faunal patchiness, but another sample should be taken to replace it in calculating the mean for the station.

*The advice in the above-mentioned reports dealing with field sampling methods (from ICES, US and UK sources) is consistent in that, for a conventional 0.1 m^2 grab sampler, 5 l approximates to a depth of 7 cm, while 2.5 l approximates to a depth of 5 cm. Measures of sample depth are taken vertically at the centre of the closed grab buckets.

(For the collection of water samples, criteria for rejection may include: inadequate volume, inadequate amounts of added fixative, the presence of turbidity (e.g., mud arising from bottom contact), the presence of air bubbles in an oxygen sample, and so on.)

Criteria for rejection of samples (phytobenthos)

Samples should be rejected and sampling repeated (when possible) if:

- More than 20 % of the material within the frame is lost (as judged by the diver). Then the frame is re-sampled at the same site by tossing it once more (frame-bag is emptied first);
- When the sampling bag is torn and shows major holes through which portions of the sample can be lost;
- If there is too high wave action to secure sampling close to the surface without major loss, these samples are taken under calmer conditions at the site;
- If more than 2 % of sample is lost when transferring it to, e.g., a bag for conservation;
- When the description for the identification of the sample is lost or damaged and cannot be recovered.

C. Laboratory data criteria

Criteria for attention include:

- taxonomic outliers (new species/wrong determinations);
- poor QA/AQC performance.

An example of the application of laboratory AQC criteria is provided by the UK NMBAQC scheme. The criteria apply to the outcome of independent re-analysis of samples of the benthic macrofauna collected by individual laboratories (i.e., "own samples"). Information is also provided on approaches to the AQC of associated particle size analyses of sediments.

Benthic macrofauna

Extraction efficiency – total taxa target

To achieve a pass, the number of taxa extracted should be within ± 10% or ± 2 taxa (whichever is greater) of this total.

Extraction efficiency – total individuals target

The total should be within ± 10% or ± 2 individuals (whichever is greater) of the total resulting from re-analysis of the samples.

Total wet weight biomass target

The total value should be ± 20 % of the value obtained from re-analysis of the sample.

Bray-Curtis comparison

Comparison of the two untransformed data sets, arising from the work of the participating laboratory and from independent re-analysis, should result in a Bray-Curtis Similarity Index of ≥ 90 %.

Overall flag

An overall flag for the Scheme has been agreed and set by examining the flags for the individual components. To attain an overall "Pass" flag for the "own sample" exercise on which to base a filtering system for the UK National Marine Monitoring database, it is required that laboratories obtain passes for six of the nine individually flagged exercises conducted during a year, i.e., 3 samples × 3 flagged items (number of taxa, individuals, Bray-Curtis). Note: because of the considerable variation in the estimation of biomass the flag for this component is not presently included in the determination of the overall flag for the "own sample" exercises.

NB. The NMBAQC Committee has agreed to alter the pass/fail criteria for the "own sample" exercises in 2002. This will now be based solely on scores arising from the use of the Bray-Curtis Similarity Index (BCSI: see above), as follows:

100 % BCSI:	Excellent
95–<100 % BCSI:	Good
90–95 % BCSI:	Acceptable
85–90 % BCSI:	Poor – remedial action suggested
<85 % BCSI:	Fail – remedial action required

Particle size standards

In the UK, laboratories engaged in benthic monitoring are presently required to determine the silt/clay (<63 microns) fraction to within ± 10 % of the mean of the results from all laboratories. However, it is intended to extend this exercise in 2002 to include derived measures from the outcome of particle size analyses (e.g., median diameter, sorting coefficient), employing a "Z score" system in a comparable way to AQC practices for analytical chemistry. Thus an individual laboratory will be deemed to have failed if its estimate of a measure lies outside ± 2SD of the overall mean for that measure determined from all participating laboratories. The suitability of this approach is presently being retrospectively evaluated, using archived data from earlier AQC data.

In the case of laboratories using different particle sizing techniques (typically conventional mechanical sieving and weighing *versus* laser sizing) there is an important and fundamental need to establish the compatibility (and hence acceptability) of data deriving from the different methods.

D. Data bank criteria

Relevant considerations relating to quality control include:

- Incomplete data reporting, e.g., missing stations of species;
- Missing metadata. These may be essential (e.g., lat/long datum; mesh size) or desirable (e.g., meteorological conditions at the time of sampling). The existence of an "audit trail" may greatly assist in eliminating problems (i.e., how/by whom/why were data collected, edited or changed and quality controlled);
- Non-compliance with data format. This may be due to inappropriate or incompletely normalized data format;
- Non-compliance with international standards (e.g., conventions for taxonomic nomenclature, international dictionaries of parameters, ship codes) must also be considered;
- Flagging of doubtful or low quality data (i.e., plausibility control). Conflicting data or internal inconsistencies will be relevant considerations in deciding upon the need to flag data. Changes should only be made in cooperation with the data originator.

Although relating mainly to chemical determinands, the paper given in ACME (2001) concerning evaluations of the acceptability of data in environmental monitoring programmes is valuable in this context.

ANNEX 8: OFFSHORE WIND FARMS—CURRENT KNOWLEDGE CONCERNING THEIR EFFECTS ON FISHERIES AND FISH POPULATIONS

Summary of a report made in accordance with the governmental instructions to the National Board of Fisheries, Sweden, for the fiscal year 2002.

Since only a few studies of the effects on fish or fish communities have so far been made in this context, there are great gaps in the relevant scientific knowledge. The findings have moreover been confined to small installations, and are thus hardly transferable to the much larger projects that are now being proposed. One is thus reduced to leaning on indirect assessments of the possible effects.

It may be assumed, on the basis of common biological knowledge, that the following types of environmental disturbances could occur, and affect the fish community or certain fish species, during the construction and operation of the farms and their eventual dismantling:

- deterioration of water quality (by sediment or oil spills or through increased turbidity)
- changes in habitats
- noise and vibration
- unusual light and reflections
- electromagnetic fields from direct-current cables.

The three last mentioned physical disturbances act directly on the sense organs of fish and thus affect such vital functions as communication, spawning, migration, and foraging. There may also be synergistic effects, and in addition to the biological ones, some economic consequences in the way of bans on anchoring and fishing.

In view of the present insufficient knowledge of the effects on fish, the National Board of Fisheries advises against the location, for the time being, of offshore wind farms on fishing banks.

ANNEX 9: RECOMMENDATIONS

The Benthos Ecology Working Group [BEWG] (Chair: H. Rumohr, Germany) will meet at AZTI, San Sebastian, Spain from 19–22 April 2004 to:

a) review the report and activities of the ICES Study Group on the North Sea Benthos Project 2000;
b) review the outcome of the ICES ASC Theme Session concerning benthic community indicators, and make recommendations on future developmental work;
c) collate information/recommend biological criteria for selection of dredged material disposal sites;
d) develop guidelines for phytobenthos sampling with a view to publication in the ICES TIMES series;
e) update and finalise guidelines for sampling of the epibiota for publication in the ICES TIMES series;
f) review progress in environmental assessments of offshore wind farms in relation to the underpinning regulatory rationale, and make recommendations concerning the role of benthic community studies.

BEWG will report by 10 May 2004 for the attention of the Marine Habitat and Oceanography Committees, ACME and ACE.

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 and relation to Action Plan	a) The SGNSBP is a subgroup of the BEWG and the BEWG meeting is the forum for discussing and providing direction to the SG. b) It is necessary to evaluate the outcome of this theme session with a view to identifying possible controversies and gaps in knowledge. This is important to enable ICES to plan future activities of Working Groups. c) There are no coordinated criteria (identified, laid down) for the selection and monitoring of dredge spoil sites in the ICES region with respect to benthic communities. These reviews will allow informed justification of the development of appropriate criteria and selection of sites from a benthic viewpoint. d) As phytobenthos is an essential compartment of the areas that will fall under the coming water frame work directive valid and accepted method recommendations are of high common interest. e) Completion of this task will have important practical benefits for the future of epifaunal studies in the ICES area. f) It was recognised by the BEWG that EIAs are performed in most countries before permissions are given for windfarm construction, and that zoobenthos studies form a main part of these. It seems to be necessary to compare the efforts made in different countries and allow ICES to play an important role in harmonizing such efforts and consider possible necessities like large-scale (e.g., North Sea-wide) spatial planning.
Resource Requirements:	N/A
Participants:	Representatives from member Countries with experience in various aspects of benthic ecology.
Secretariat Facilities:	N/A
Financial:	None
Linkages To Advisory Committees:	ACME, ACE
Linkages To other Committees or Groups:	WGECO, WGEXT, WGITMO, WGSAEM, WGMHM, SGQAE, SGQAB
Linkages to other Organisations	OSPAR, HELCOM EEA
Cost Share	ICES 100%

RECOMMENDATIONS TO ICES:

i. Evidence from recent events (e.g., the "Prestige" oil spill) shows that there are still many important areas, especially offshore, where there is little or no knowledge of the benthic biota. It is recommended that there should be national and

international coordinated efforts to identify such areas, to rank them in order of perceived importance (especially in relation to their vulnerability to human impacts) and then to conduct appropriate investigations in order to fill such gaps in knowledge in a pro-active fashion**.**

ii. Proposals for future ICES Theme Sessions:

- Offshore wind power: ecological impacts on the marine system (ICES ASC 2005).

- Macrophytobenthic communities in a wider marine ecosystem context (Conveners: US, Canada, Sweden).

ANNEX 10: ACTION LIST

1. Dr Degraer to liaise with Hans Hillewaert regarding the feasibility of converting pre-2000 ICES BEWG reports to pdf format for inclusion on the BEWG website.
2. Santiago Parra to provide an up-date on studies off the Galician coast in relation to the "Prestige" oil spill.
3. All: to compile information regarding criteria for selection of dredged material disposal sites, with special emphasis on biological factors.
4. H Rees to liaise with D Connor regarding the scope for future collaboration between the ICES SGNSBP 2000 and the ICES WGMHM.
5. Dr Desroy to report on the final outcome of studies into the effects of *Phaeocystis* blooms on the benthos and sediments along the French coast.
6. H Rees to contact the Chair of WGSAEM intersessionally with a view to future collaborative work regarding the elucidation of trends in long-term data sets.
7. Alexander Schroeder (AWI) to contribute to the future evaluation of long-term data sets employing relevant data from German coastal waters.
8. H Rees/E Vanden Berghe to contact Paul Kingston regarding the scope for extracting long-term data series from the UKOOA initiative on the compilation of oil/gas benthos studies in the UK sector.
9. All: to provide specimen data sets from benthic community studies to ICES (Marilynn Sørensen) for incorporation into the ICES database as a pilot exercise.
10. All: provide information on projects concerning environmental assessments of offshore wind farms.
11. Hasse Kautsky to draft text concerning the importance of phytobenthos to the marine ecosystem, and approaches to their scientific study, to be published in the ICES TIMES series.
12. Les Watling to compile US/Canadian SOPs on macrophytobenthos sampling.
13. H Rees to compile European SOPs on macrophytobenthos sampling (including information from the HELCOM COMBINE manual).
14. Karel Essink to report on the outcome of recent evaluations of the cockle fishery and its environmental effects in the Dutch Wadden Sea.
15. Bjorn Tunberg to report on an ongoing ecological assessment of the Indian River Lagoon, Florida.
16. Bjorn Tunberg to report on habitat utilization by benthic fauna and fishes at dredge hole depressions in Lake Worth Lagoon, Florida.
17. Mike Robertson to report on progress with FRS benthic surveys in the North Sea and adjacent waters.
18. H Rees to up-date and finalise guidelines for epibenthos sampling (including intersessional contact with other contributors) for publication as an ICES TIMES report.
19. Les Watling to produce text on manned submersibles for the Epibiota Guidelines report.
20. Ingrid Kröncke/H Rees to produce text concerning the definition of epifauna, and approaches to describing assemblage types, for the Epibiota Guidelines report.
21. Heye Rumohr to produce text on the Kieler Kinderwagen and on the Gordeev sampler for the Epibiota Guidelines report.
22. Heye Rumohr to produce text on Sediment Profile Imagery for the Epibiota Guidelines report.
23. Hasse Kautsky to produce text on direct visual inspections along line profiles, and on diver-deployed gear for the Epibiota Guidelines report.
24. Jan Van Dalfsen to provide text/references on Canonical Correspondence Analysis for the Epibiota Guidelines report.
25. H Rees to add text on the Naturalist's dredge, and expand text on drop-frames for the Epibiota Guidelines report.
26. H Rees/others to produce a list of key taxonomic reference works for the Epibiota Guidelines report.
27. Heye Rumohr to finalise a report on the history of the BEWG (see also 1, above).