ICES BEWG Report 2006

ICES Marine Habitat Committee
ICES CM 2006/MHC:09
REF. ACE

Report of the Benthos Ecology Working Group (BEWG)

15 May 2006

Heraklion, Crete, Greece

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

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

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2006. Report of the Benthos Ecology Working Group (BEWG), 15 May 2006, Heraklion, Crete, Greece. ICES CM 2006/MHC:09. 77 pp.

Contents

Executive Summary

The 25the meeting of the Benthos Ecology Working Group (Chair: Heye Rumohr, Germany) was held in the Hellenic Centre for Marine Research (HCMR) in Heraklion, Crete. The meeting was attended by 22 participants from twelve nations, two of which were new to the group (Russia and Latvia).

ToR a) The Agenda contained reports from ongoing and new benthos research projects in the ICES area and special reports from the hosting institute about the eastern Mediterranean. The Wikispecies project supported by the Wikimedia Foundation has a great potential. It is meant to become an open, free directory of species. This will cover Animalia, Plantae, Fungi, Bacteria, Archaea and Protista. Everyone has the possibility to add or adjust a page on species, or any higher taxon. Species will ideally have name references, synonymy and links to wikipedia pages in all languages. All the information, images included, is free of copyright. The peracarid order Cumacea was outlined as an example both on Wikispecies and on the Dutch Wikipedia on http://nl.wikipedia.org/wiki/Zeekomma%27s. (www.wikipedia.org and species.wikipedia.org)

ToR b) The group discussed the progress of the SGNSBP and the contents of the planned CRR which will be finished in 2006. The data will be integrated in the MarBEF database when all data providers have agreed.

ToR c) A subgroup formulated a text concerning benthos as eutrophication indicator where they addressed the topic regionally in estuaries, Baltic Sea and Lagoons, Fjords and the open waters. No simple, single species based system can be recommended for defining eutrophication effects on macrozoobenthos. An approach investigating whole community structure shifts must be adopted.

It was recommended that observations are to be carried out on changes in the ratio of species numbers to total individual numbers. Increases in opportunistic species, including increases in biomass, should be considered. Changes in the community diversity can then be followed and compared by the Rarefaction Method.

Pearson – Rosenberg (and related) models should be considered to identify species / groups important as local indicators. This should also include observed higher variability and even increased species numbers in the very early stages of enrichment. The group also recommends that consideration be given to shifts in feeding strategies in the benthic community (from suspension feeders to deposit feeders) The group recommends not only to consider infauna but also to consider hyper- and epibenthos which involves the application of different sampling methods such as dredging, imaging, etc.

ToR d) There is a possibility to form a consortium of researchers which have a common interest in the marine environmental implications of off-shore renewable energy generation. (www.cost.esf.org/opencall). An initial expression of interest to participate in this initiative was from Spain, Belgium, Germany, Poland and the UK. The end of May deadline may be difficult to attain, although the group is convinced that there would be enough interest from different countries and institutes. Therefore it was concluded that a mailing list of possible interested parties would be created.

ToR f) The outcome of Theme Session S (ASC 2005) was not very relevant for the question of long-term effects of oil-spills since it mainly dealt with short-term effects and clean-up methodologies.

Looking in the literature, however, we find that after oil spills many effects were no longer visible after one year, most of them disappeared after three years but in the case of Amoco Cadiz the *Ampelisca* spp. population recovery took more than ten years . Single remainders of

crude oil may be found even after 25 years as asphalt ‘pavements’. Kingston (2002) reports in his very comprehensive and up-to-date paper that the recovery in intertidal habitats is very much coupled to wave exposure and natural processes and that recovery is normally within 1–3 years after the spill depending on the latter ones and of the life span of the species in question

ToR g) The initial draft report on dredged spoil disposal produced by the sub-group illustrated examples from the work conducted in several countries including information from Belgium, Germany, Spain, Sweden, United Kingdom and the U.S.A. The group formulated a list of conclusions and recommendations on how to deal with the search for suitable disposal site. A final document will be published as a *Cooperative Research Report* (CRR), final draft ready by September 2006.

ToR j) To achieve a comprehensive list of existing metrics Hiscock 2004 shall be updated including newly developed metrics like e.g. tools developed under the WFD to assess the ecological status (i.e. multimetric tools or multivariate tools); Taxonomic distinctness and related indices; Any other new univariate indices.

The regional sections of the WGRED report were distributed to experts in the group asking for critical review and need for amendments. The group agreed that generally the major interest goes to oceanography and fishing and only very little to benthos, special amendmends can be found in the annexes.

ToR l) ICES Data Centre: The group agreed that geo-referenced fishing effort information is necessary. The importance of VMS data over information from ICES rectangles was emphasized. Sediment distribution data (geo-referenced) is also important. A metadata catalogue from the ICES Data Centre should be made readily available and accessible via the internet.

The working group website has been moved to a new address: www.bewg.be

.

1 Opening of the meeting

The Chair, Heye Rumohr, opened the meeting and welcomed the participants. The local host, Christos Arvanitidis gave some practical information about domestic issues. A list of participants is included at Annex 1.

Prof. A. Elefteriou gave an overview on the history of the IMBC and the research background of the recently founded Helenic Centre for Marine Research (HCMR).

Apologies were received from former Chair C. Heip, P. Kingston and K. Essink. Also from K. Howell, Alf Norkko, J. Davies, I. Kröncke, P. Taylor, H. Rees, T. Brattegard, E. Vanden Berghe, M. Guerra, F. Beuchel, J. Craeymeersch and R. Pitcher.

1.1 Appointment of Rapporteur

The Chair expressed his wish to have daily Rapporteurs, together with an editing Rapporteur who would bring the daily contributions together into the final report. H. Hillewaert was appointed editorial Rapporteur; daily Rapporteurs were H. Reiss, A. Borja, and I. Moulaert.

1.2 Terms of Reference

The Terms of Reference (ToR) for BEWG 2006 are listed at Annex 2. The respective TOR item is included in the headings of subsequent sections for information.

2 Adoption of the agenda

The agenda was agreed unanimously and is attached at Annex 3.

3 Report on ICES meetings and other meetings of interest

3.1 ASC, Aberdeen 2005

H. Rumohr reported briefly on the ASC (Annual Science Conference) in Aberdeen last autumn. He highlighted the high number of participants and mentioned the few sessions with benthos related topics, of which the modelling of trophic interactions (ELEFAN model) was a major one. E. Rachor mentioned that the ASC 09/2007 in Helsinki will include a benthic theme session based on the results of the North Sea Benthos Project 2000 (SGNSBP).

3.2 MHC, Aberdeen 2005

H. Rumohr reported briefly on the MHC (Marine Habitat Committee) in Aberdeen last autumn. The outcome was much more positive and promising than the former one in Vigo. The main point to improve the performance was the increased presence of WG chairs at the meetings of MHC. The conclusions of this meeting can be found on the CDROM of the ASC 2006 from ICES and also on the ICES web page www.ices.dk.

3.3 ACE, Aberdeen 2005

H. Rumohr reported briefly from ACE (Advisory Committee of Ecosystems) in Aberdeen last autumn.

3.4 ACME, Aberdeen 2005

H. Rumohr reported briefly from ACME in Aberdeen last autumn. There were few demands for advice from HELCOM and OSPAR.

3.5 SGQAB

H. Rumohr reported briefly on the SGQAB, which is the merger of the former SGQAE and SGQAB groups. The intersessional answer to a SGQAB will be dealt with under ToR k.

3.6 WGMHM, Galway 2006

S. Birchenough provided and updated on the existing marine habitat mapping programmes in the UK. The first project presented was the role of seabed mapping in environmental monitoring and management. This programme finished in March 2005. The programme tested different techniques and applications in marine aggregate extraction areas and in a dredged material disposal site. The final outcome of the programme was to develop electronic guidelines for the production of habitat maps (interactive CD). The report is currently *in press* and will be available in the next few weeks.

The second programme presented was the broad-scale mapping of the eastern English Channel. The eastern English Channel (EEC) contains a substantial area of potential aggregate resources and the UK aggregate industry has evaluated these for future development and exploitation through the Regional Environmental Assessment (REA). The main aim of this mapping study is to produce broad-scale marine habitat maps of the EEC area. This study conducted an initial geophysical survey in 2005 adopting an acoustic corridor approach. This strategy was employed to efficiently sample over a broad-scale area and the survey was designed to place this Regional Environmental Assessment (REA) into a wider context. The importance of this broad-scale-mapping programme was to provide a wider spatial context the environmental significance of any potential impacts from commercial aggregate extraction over the broader region of the EEC.

A geophysical survey grid provided ‘acoustic corridors’ of multibeam bathymetry data and side-scan sonar coverage over the survey area. The ground-truth survey was used to sample the areas where different habitats types were distributed based on existing geological information developed by British Geological Survey (BGS). There was a wide range of ground-truth techniques employed (i.e. grabs, trawls and video sledge transects) to corroborate, identify and describe features in the area. It is known that the area possesses a variety of vulnerable habitats, which will need protection to avoid damage resulting from extraction of aggregate resources. The preliminary results of this work were presented to the BEWG. The resulting habitat maps from this study will provide vital information to contribute to an effective and sustainable management of this environment.

The third programme presented was entitled “Best methods for identifying and evaluating biogenic and cobbly reef”. This programme is still ongoing. The main outcomes so far are as follows:

1) Different techniques, or combinations of techniques will be of value depending on the nature of the *Sabellaria* accumulation;
2) Side-scan and multibeam can detect certain forms of *Sabellaria*;
3) Varying survey vessel speed will affect acoustic image quality;
4) Orientation of side-scan lines will affect image quality.

Finally a quick up-date on the MESH was also mentioned as part of the Cefas involvement as part of the standards and protocol (Action 2).

S. Birchenough will forward the request of E. Rachor about why the eastern part of the North Sea was not included in the scope of the MESH project, to David Connor, Chair of WGMHM.

Two new Spanish habitat mapping projects have been initiated. The Spanish Institute of Oceanography works on the mapping of the Mediterranean coast and a Basque project managed by AZTI (San Sebastian) is mapping the continental shelf of the Basque country.

3.7 WGEXT, Cork 2006

H. Hillewaert reported on the meeting of WGEXT in Cork and briefly described the current activities of the working group. The new chairman of WGEXT is Gerry Sutton from CRMC, Cork, Ireland. The full report will be available on the ICES Website.

3.8 OSPAR

3.8.1 OSPAR Eutrophication Task Group (ETG)

L. Buhl-Mortensen gave a brief summary of the OSPAR Eutrophication Task Force meeting in London, October 2005.

The results of the Norwegian fjord project on eutrophication were presented, and a request to ICES was made on changes in zoobenthos (Category III).

It was noted that the requested advice from ICES in 2006 on a list of area-specific indicator species should be supplemented by exchange of information on national monitoring and assessment practice.

3.8.2 OSPAR Biodiversity Committee (BDC)

L. Buhl-Mortensen reported on the meeting of the OSPAR Biodiversity Committee in Trondheim, held in March 2006.

Norway will develop EcoQOs to restore and/or maintain the quality and extent of the threatened and/or declining habitats in the North Sea, as shown in the initial OSPAR list. *Lophelia* reefs will be chosen as an example. Norway will also draft guidelines on *in situ* research and bio-prospecting on cold-water coral reefs assisted by Iceland, Ireland, Portugal, Sweden and the United Kingdom.

3.9 MARBEF, Crete 2005

C. Arvanitidis reported on the autumn 2005 MARBEF Theme 1 workshop in Crete.

All reports related to this workshop are available on the website:
http://www.medobis.org/prope/creports.php

3.10 WGRED, Copenhagen 2006

H. Rumohr gave a brief account on the activities of the new Working Group of Regional Ecosystem Descriptions (WGRED) with the chairman Jake Rice. The working group was constituted to play a central role in facilitating the inclusion of more ecosystem and environmental information in the short term advisory task for ICES. Thus, the main objective of this working group is to describe the fauna, flora and the environmental health within the different advisory regions of ICES. The BEWG was asked to check and comment the overview documents in the WGRED-Report 2006. See http://www.ices.dk/reports/ACE/2006/WGRED06.pdf.

3.11 History and future of BEWG

H. Rumohr presented an updated PPT about the 25 years history of the BEWG since its installation in 1981. This presentation was especially for the many new BEWG members and focussed on the many work foci and long lasting efforts to consolidate the important role of this group within ICES. Recurring North Sea Benthos Sampling Programmes and their scientific evaluation used to be the central *raison d´être* of this group. This history of the Working Group is also displayed on the BEWG webpage www.bewg.be.

H. Rumohr mentioned letters of former BEWG chairmen C. Heip and K. Essink, which were sent to him by e-mail. Both pointed out the need for a better cooperation with the United States and Canada since ICES is the only trans-Atlantic marine scientific organization. The importance of an improved cooperation was discussed and agreed by the working group. C. Heip also suggested a closer cooperation with the MarBEF network of excellence.

4 Review and consider recent developments in ongoing benthos research in Europe (ToR a)

4.1 Benthic research projects in Greek waters and the wider Mediterranean

4.1.1 Trawling Impact Studies in Greece

C. Smith reported on fishing gear impact studies in Greece.

Since the mid-1990s, eight EU funded projects have been completed in Greece concerning some aspects of trawling impacts. These have ranged from traditional BACI experiments to monitoring, looking at faunal, physical and chemical impacts as well as methodological approaches. Overall results have not always been clear cut and in some cases contradictory. It is sometimes difficult to explain the results and show linkages between impact, impacted feature and relationship to other ecosystem process or group. There are still many gaps in the knowledge pertaining to trawling impacts and although these may be of high importance there is a lack of funding at national and international level to undertake the work. The activities of one recent EU project, Cost-Impact were highlighted. The work undertaken in Greece was aimed at parameterising an ERSEM model with faunal and process specific data relating to trawling impacts in Iraklion Bay (an oligotrophic soft-sediment system). The model was then run for scenario testing of different management scenarios (reduction of impact, reduction of effort, closed areas etc.). Data was collected concerning impacts on macrofauna, megafauna, sediment chemistry and nutrient fluxes. Future research efforts will concentrate towards the fishery perspective in particular the survival, fate and effects of discards but also towards stimulating model development for trawling impacts.

4.1.2 Aquaculture and fish farming

Y. Karakassis presented the results of the EU-project MERAMED. The project website can be consulted at http://www.akvaplan.niva.no/meramed/.

4.2 Cooperative studies

4.2.1 EPICATCH

H. Reiss reported briefly about the EPICATCH project. No new results compared to last years meeting could be added (see BEWG report 2005). The main results of the project will be published in the ICES Journal of Marine Research in the near future.

4.2.2 RESPONSE

A. Schröder reported on the EU-project RESPONSE, Response of benthic communities and sediment to different regimens of fishing disturbance in European coastal waters, which was finalised in 2005.

EU 5th framework project (Q5RS-2002-00787) within the informal EU-cluster INTERACT (www.interact-cluster-web.org) involving six partners from four countries (ICM-CSIC, IEO & MSM, Spain; CIBM, Italy; UWB, Wales; AWI, Germany). Basic informations have been

outlined in the last BEWG-report 2005, details can be found on the project's web site at www.icm.csic.es/rec/projectes/response.

The final report of the project is still in preparation and will be published soon. The presentation at the meeting therefore focussed on the final results from the North Sea study, comparing the protected area around the research platform FINO1 (www.fino-offshore.de) to the normally fished surroundings.

The local fishing intensity, its spatial distribution and temporal development was estimated by a combination of Dutch and German VMS satellite data representing most of the activity in the area. In addition trawl marks were recorded by side-scan sonar (SSS) mapping. Both data were used to calculate the trawling frequency. According to VMS-data each m² in the area was fished between two and seven times per year, primarily by large beam trawlers using 12m-beam trawls highest activities were recorded in June, when trawling intensity reached between 100 and 200% areal coverage per month. SSS revealed a dense mesh of tracks, but in the areas of highest intensity the tracks were not separable, leading to an underestimation. Correlation between SSS- and VMS-data indicated a visibility of track on the SSS of about one month on the fine sandy sediments. Within the protected area a few tracks were observed but overall only 2% of the area was trawled.

Sampling started before the platform installation and continued with five consecutive samplings up to 15 month, when the project ended. Beyond a strong seasonal variation, changes in the fauna of the protected area were observed. The biomass of in- and epifauna was more stable in the protected area, showing less seasonal variation than the in the fished areas. From three month after the construction onwards, the epifaunal community differences between protected and fished areas increased continuously, while the differences between reference areas remained at the same level. Densities of scavenger species like e.g. swimming crabs (*Liocarcinus holsatus*) were higher in the fished areas. Although significant differences were found after 15 month of closure in the in- and epifauna, differences were larger in the epifauna than in the infauna. Infaunal changes included higher abundances of several opportunistic species (*Phoronis* spp.; spionid polychaetes, several amphipods) in the protected area. The trend visible in the infauna started about one year after the construction of the platform. It is expected that more time is necessary to observe a recovery from fishing effects for a fauna strongly shaped by continuous anthropogenic impact. Sampling has been continued, but needs additional funding for further analyses.

A summary of the results of the complete project including all study areas will be reported at the next BEWG-meeting.

4.2.3 MAFCONS

H. Reiss reported on the EU-project MAFCONS (Managing fisheries to conserve groundfish and benthic invertebrate species diversity). This project extends from 2003 to 2006, and has several partners. The main objective is to provide scientific advising to fisheries managers with mathematical tools to quantify the consequences of fishing to groundfish and benthic invertebrate species diversity of achieving particular fisheries objectives e.g. increasing or decreasing the 'Total Allowable Catch' (TAC) of a given species (for details see BEWG-Report 2005). The main spatial scale on which the studies of MAFCONS are based on is the ICES statistical rectangle scale in the North Sea. Thus, infauna (van Veen grab), epifauna (2 m beam trawl) and fish (GOV) was sampled in the entire North Sea in summers 2003 and 2004. Secondary production and diversity for each compartment have been determined and compared. Up to now, several studies and reviews were carried out during the project: e.g. a review of theories of marine communities, a review of the ecological effects of fishing disturbance on fish and benthic communities and review of the relationship between catch and effort. All reports can be downloaded at the project web-site (http://www.mafcons.org). The

investigation of the relationship between fishing quota and fishing effort revealed no significant correlation for most species and gear types. This mismatch has to be taken into account in fisheries management, since the fishing quota is the managed parameter and the fishing effort is the parameter which effects the ecosystem most (especially the benthic fauna).

In order to additionally investigate the linkage between fishing disturbance and faunal community characteristics at a different spatial scale, a case study within the framework of MAFCONS was started in 2004 by the German project partners using micro-scale distribution of fishing effort (for details see BEWG-Report 2005). The same sampling strategy as for the North Sea wide study was applied to the small-scale study. Preliminary results of multivariate analyses indicate that sediment structure is the main environmental parameter determining the infaunal community structure. Whereas fishing effort seem to affect community structure in areas with similar sediment composition. However, further analysis of this case study will give an insight into the linkage between fishing disturbance and benthic communities on small-scale and different temporal scales and, thus, provide a separate fine scale model in combination with the main model based on the ICES statistical rectangle scale within MAFCONS.

4.2.4 SPEEK

I. Moulaert reported on the study of post-extraction ecological effects in the Kwintebank sand dredging area. To gain insight in the possible restoration of benthic life in the central depression of the Kwintebank after closure of that area in February 2003, three Belgian and one Spanish institute were involved in a multidisciplinary project SPEEK (Study of Post-Extraction Ecological effects in the Kwintebank sand dredging area), where data on the meiobenthos (nematodes by Marine Biology lab of the University of Gent, Belgium and harpactoids by AZTI, San Sebastian, Spain) and macrobenthos (ILVO, Oostende, Belgium) were supported by geological data (RCMG, Gent, Belgium). The project will be finishing in 2006. Only the results from the study by ILVO-Fisheries on the macrobenthic component are summarized in Annex 6.

4.2.5 MAREANO

L. Buhl-Mortensen reported that the area of the Norwegian Sea was previously surveyed by multibeam. Visual observation and sampling of sediments and biota will be undertaken in the near future. Norwegian seabed areas are insufficiently surveyed. This information is needed for an ecosystem-based approach for an effective management. The main products of the project are detailed topographical maps, bottom and habitat categories, environmental status of the sediments and benthic species richness/diversity. The project possesses the following components: mapping, a website to disseminate the outcomes of the project and R&D. 142,000 km^2 are to be covered. 18,000 km^2 have been completed in detail. 20,700 km^2 will be surveyed annually; multibeam surveys covered 980 km^2 in 2005.

Some of the information is provided by Russian colleagues. More information about the project can be found at Annex 7.

4.2.6 Benthic habitats in the Barents Sea (IMR)

L. Buhl-Mortensen provided a summary on occurrence and distribution of relevant sensitive species in relation to fisheries activities. These data were collected in collaboration with Russian colleagues of PINRO. The distribution of benthic habitats in the area is insufficiently known. Data are collected on occurrence and distribution of coldwater corals in the area. The distribution of bottom trawl fisheries and sponges in by-catches are investigated.

The joint Norwegian-Russian ecosystem survey of the Barents Sea will provide new information from the area. For more information see Annex 8.

4.2.7 The response of hyperbenthos to hypoxia in fjords: searching for indicator-organisms and controlling environmental factors.

The ongoing eutrophication on the Skagerrak coast is regarded as a large-scale experiment. The long term oxygen measurements conducted by Institute of Marine Research in the area provide an opportunity to study the fauna in fjords that are known to have experienced different oxygen history to detect effects of hypoxia. The zoobenthos, both infauna (collected by grab) and hyperbenthos (mainly crustaceans collected by epibenthic sled) were studied in 11 fjords. These fjords were divided into three categories of hypoxia defined by the historic minimum oxygen concentration in bottom-water: < 2 ml/l; 2–3 ml/l; and > 3 ml/l, and with 3, 3, and 5 basins within the categories. There was a very strong and significant relation between species richness of hyperbenthos and oxygen minimum during the last 5 years (R2 = 0.91) Number of species decreased from 48–56 in well-oxygenated basins, to 22–32 in the intermediate hypoxia situation, and 0–7 in the most hypoxic environment. Also for infauna the relation was clear, but weaker (R2 = 72).

The results show that it is possible, based on the relation between oxygen concentrations and species richness of zoobenthos estimate loss in diversity due to eutrophication and to predict effects of improvement in the eutrophication situation. Thus species richness of zoobenthos and in particular of mobile crustaceans (hyperbenthos) is a useful assessment parameters under category III, 2 zoobenthos. In particular it provides information of the eutrophication situation that naturally does not fluctuate seasonally or inter annually.

4.2.8 Research of benthos in the Russian part of the Baltic Sea (2001–2005)

M. Orlova reported on the Russian sector of the Baltic Sea. It covers the easternmost part of the Gulf of Finland (EGOF), identified as the extended estuary of the Neva River (Telesh, 2004) and the coastal waters in the Kaliningrad region along the Sambian Peninsula, Vistula and Curonian Spit and two shallow lagoons – Curonian and Vistula. Along with local peculiarities both the Lagoons and the Neva Estuary have common features such as low salinity and other natural gradients, and are directly and indirectly influenced by eutrophication, habitat deterioration, increasing cargo shipping, contamination (data on contamination of the Baltic Sea are available from HELCOM reports (HELCOM, 2003)) and other human activities.

An extensive summary can be found at Annex 9.

4.3 Benthos of soft sediments

4.3.1 Comprehensive Everglades Restoration Plan (CERP)

B. Tunberg reported on three projects in Florida.

Benthic Infaunal Monitoring of the St. Lucie Estuary (SLE) and the Southern Indian River Lagoon (IRL)

The main objectives of the project are: 1) to evaluate the present health status of the St Lucie Estuary (SLE) and the Indian River Lagoon (IRL) south as baseline data, 2) to record and follow long term changes in these ecosystems, 3) to attribute causative factors to observed changes (i.e., freshwater runoff/release, natural successions and oscillations, climate change, other anthropogenic impacts), 4) to pinpoint and evaluate anthropogenic disturbances, 5) to provide reference data for possible intensive short term local monitoring programs.

Quantitative macroinvertebrate sampling is performed at thirteen sites quarterly (three to four replicates per site). The samples are collected utilizing a 0.02 m^2 Ponar grab. After being extracted through a sieve with 0.5 mm mesh in the field, the samples are immediately

preserved in a solution of 4–7% buffered formalin, diluted in sea water. The samples are then stained with Rose Bengal. Bottom substrate samples for sediment analyses are being collected by means of an Ogeechee corer (Wildco Cooperation).

Project Status, March 2006

In late March 2006, 117 Ponar grab samples collected between February 2005 and July 2005 have been sorted, and the specimens have been identified to the lowest possible taxonomic level, with a total result of 254 taxa and 44,256 individuals. Only 5,648 (12.8%) of these individuals were collected in the St Lucie Estuary.

Both the number of taxa, individuals and diversity are much lower in the SLE than in the IRL. The reasons for extreme increases of certain taxa at some of the IRL sites between the sampling dates have not yet been analyzed.

The results clearly indicate severe ecological problems in the SLE. The low quantity and quality of infauna in the SLE may have a significant impact on the bottom dwelling animals (as a food source) and on the bioturbation of the SLE sediments. This in contrast to the much better conditions in the actual IRL.

Ecological Development in the Loxahatchee Estuary, Eastern Florida During the Period 1992-1999/2002, Elucidated by Means of Infaunal Monitoring.

Quantitative infaunal sampling was performed at nine estuarine and two fresh water sites by the Wildpine Ecological Laboratory, Loxahatchee River District. Sampling was performed twice per year (dry and wet season) with three to four replicates per site. The estuarine sites were sampled by box corer (0.0156 m^2) while the fresh water sites were collected by Hester Dendy samplers (3 at each site) each with a total area of 0.13 m^2 (deployed 28 days on each occasion). Multivariate techniques were primarily used to elucidate temporal changes and to illustrate the taxa that had the greatest influence for observed changes.

The stations were divided into three groups; coastal, intermediate, and fresh water, where the data were combined (transformed into standard deviation units). The data from both the coastal and intermediate sites indicated that high values for total abundance, taxa, and diversity in the dry season (winter) usually resulted in low values during the wet season (summer and fall) and vice versa (but not statistically significant according to cross correlation analyses). In spite of large yearly and seasonal differences no significant long term changes (total abundance, taxa, diversity) were recorded at any of the coastal and intermediate stations.

Significant oscillatory pattern (polynomial regression) was recorded at the fresh water stations (total abundance data combined), with high values in 1992, 1995, 1999 and 2002. The temporal (1992–2002) trend (linear regression) was significantly negative at the fresh water sites ($p=0.05$).

Pre-Dredge Benthic Infaunal Monitoring in the Sebastian River, Eastern Florida

The main objective of this project is:

To provide a description of the benthic environment within and around the suggested soft sediment removal area of the Sebastian River. This basic pre-dredge assessment will provide the basis for post-dredge assessment, including:

- Assessing any temporal and spatial changes that may be attributed to the effects of the soft sediment removal.
- Determining whether unacceptable impacts are occurring within and around the soft sediment removal sites.
- Establishing the nature and rate of recolonization by benthic invertebrates following cessation of the soft sediment removal.

Quantitative macroinvertebrate sampling is performed at 8 sites (4 sites that will be impacted by dredging and 4 reference sites) quarterly (three to four replicates per site). The samples are collected utilizing a 0.02 m^2 Ponar grab. After being extracted through a sieve with 0.5 mm mesh in the field, the samples are immediately preserved in a solution of 4–7% buffered formalin, diluted in sea water. The samples are then stained with Rose Bengal. Bottom substrate samples for sediment analyses are being collected by means of an Ogeechee corer.

In late March 2006, 160 Ponar grab samples collected between April 2004 and May 2005 have been sorted, and the specimens have been identified to the lowest possible taxonomic level, with a total result of 169 taxa and 30,949 individuals.

The preliminary data strongly indicate that the two 2004 hurricanes (Frances and Jeanne) had a devastating impact on the entire study area, wiping out large parts of the natural communities occurring here. Opportunistic species appeared very quickly after the storms and in high densities. The data from May 2005 indicate a slow recovery, but that the area still was significantly disturbed at this time. In spite of shallow water the River has a very strong and pronounced salt wedge reaching far into the system.

The data further confirm that the River basin between the old US1 peninsula and the railroad bridge (close to the Indian River Lagoon) is in general poor ecological shape due to soft sediment accumulation from the storm water canal C-54, but that the conditions are much better west of the bridge.

However, due to lack of funding dredging is now instead planned to start west of the railroad bridge, further into the main River. According to our findings this may have serious negative consequences for the entire Sebastian River ecosystem.

4.3.2 Monitoring programmes and long term data series on the Belgian continental shelf.

I. Moulaert reported on monitoring studies on the Belgian Continental Shelf.

For almost three decades the Institute for Agriculture and Fisheries Research in Belgium (formerly known as CLO-DVZ) has been collecting benthic samples to study the possible effects of anthropogenic activities on the marine environment (in particular the benthos). The main focus was on dredge disposal and on sand extraction, but also on the construction of pipelines and more recently on the placement of offshore wind farms.

Currently there are five disposal sites on the Belgian Continental Shelf (BCS). No base line studies were undertaken for any of these sites, although data have been collected since 1979. Until 2004 no conclusions could be made on the direct effects of dumping as the sampling strategy was not detailed enough. The few stations located close to the disposal sites did not show a negative evolution of the benthic communities. Since 2004 two locations were sampled at every disposal site; one in the centre and one on the border. Also in 2004 information came available on the spatial variation of the intensity of dumping inside the main disposal site S1. As a result, a more detailed sampling strategy was set up for this site. Lower densities and number of species were found, as well as higher variation, compared to a reference samples. Data from the disposal site for the port of Nieuwpoort were comparable to other stations in the surrounding area, except for some species that occurred in different densities (e.g. *Heteromastus filiformis*). Since 2006 a detailed sampling strategy is set up for all dump sites.

Regarding sand extraction activities on the BCS, currently four areas are open for exploitation and 1 area is designated for exploration. Until 2003 only a few stations located within the sand extraction zone were sampled on a regular basis. In 2003 the project SPEEK was set up and in 2004 and 2005 base line studies were undertaken for the two new exploitation zones

(Gootebank and Thornton bank) and for the new exploration zone (Hinderbanks). A clear correlation between density and species number with depth was apparent: higher numbers in the swale, lower numbers on top of the banks. A comparison between Van Veen grab and Hamon grab on the Hinderbanks did not yield a clear difference between the two devices. Since 2006 a more detailed sampling strategy is set up to monitor the sand extraction zones.

After almost 30 years of sampling, the spatial variation of the benthos on the Belgian Continental Shelf is relatively well known, and for some locations long data series are yielding information about temporal evolution. One of the main findings out of the spatial variation on the BCP is the high densities in the deeper swales in the offshore areas comparable to the densities found in the coastal area. A first attempt of putting together the long term data from different locations on the BCP shows no clear evolution and a lot of variation in density. Species number and diversity did increase slightly for some stations. A lot of factors will have to be taken into account before good results can be obtained from these series.

4.4 Benthos of hard substrates

4.4.1 BeoFINO II

Impacts of offshore wind farms on benthic ecology in the North and Baltic Sea (www.fino-offshore.de)

A. Schröder reported on a national research project funded by the German Ministry for the Environment (BMU), the first part was finished in Dec. 2004 and the final report in German was published in July 2005. The follow up project BeoFINO II runs until December 2007 continuing the research with some changes in focus. Basic information was outlined in the BEWG Report 2005.

In- and epifauna in the close vicinity of the pile are studied by grab samples (also used for sediment analyses) taken regularly from the platform. Additional sampling from ships is undertaken in the surroundings three times per year including beam trawls. The growth on the underwater construction of the platform is monitored regularly by a remotely operated digital camera/video system controlled online via the internet. The results of the photo analyses are backed up by annual quantitative sampling by divers.

Epifaunal studies of the FINO1 underwater structure showed a very quick complete colonisation by hydroids within few weeks, followed by a succession with a quickly increasing number of taxa. Over time a considerable amount of biomass has been build up, differentiated in different depth zones. High biomass values were found after one year (up to 2–3.5 $kg.m^{-2}$, ca. 3.6 t on the structure). Species composition and dominance is constantly changing, with a high dominance of amphipods (*Jassa falcata*) over prolonged periods. Lately the shallower areas are completely covered by mussels (*Mytilus edulis*) reaching up to 60 kg/m^2 in the upper 3–5 m. Large amounts of shells have accumulated in the scouring pit, which has reached a depth of approx 1.5 m. Infauna in the direct vicinity of the pile changed significantly with a clear increase of predatory species and scavengers (*Asterias*, *Cancer*, *Pagurus*, *Liocarcinus*, etc.) closer to the platform, while typical infauna species were strongly reduced.

The effect extends to at least 15 m from the base of the platform; the total extent will be assessed by additional fine scaled sampling in 2006. Aggregation of fishes around the platform (horse mackerel, small gadoids) was detected. A horizontal looking echosounder (100 m away) will be used to evaluate the behaviour and quantity of fishes. A video was presented.

There are 27 applications for wind farms in the German EEZ, 10 pilot farms have already been permitted. A first pilot farm will be constructed in 2007 close to FINO1. Studies will be extended to this area. Results will feed into a mathematical model of the ecological processes in the vicinity of the platform to asses the cumulative effects of the planned large offshore wind farms in the North Sea. (www.bsh.de)

A comparison of the epifauna of artificial substrates to that of natural hard substrates in Helgoland is underway. Studies in the Baltic Sea show that the vertical artificial walls are very impoverished compared with the natural bottoms. During the first 2-3 years only annual species occur and a change of predators. Similar processes are found in fish farms.

The structure will be removed after 10 years. Studies were undertaken by the IOW on the cable connections in the first part of BeoFINO. Experiments on effects of electromagnetic field could not prove any influence on mortality of the tested species and behavioural influences were only seen for Brown Shrimp (*Crangon crangon*). Effects depend on the depth of sediment over the cable and its construction.

4.4.2 ECOMARG

S. Parra reported on a multidisciplinary study of the continental margin ecosystem and the impact of its fisheries. The global objective of the ECOMARG project is the integrated study of the benthic-demersal ecosystem in the Galician and Cantabrian Sea continental margins (shelf and slope). It aims to investigate the structure, the components and the dynamic of the Deep-Sea ecosystem (100-1000 m), which is subjected in some measure to numerous human fishing extractive activities. The study has a multidisciplinary strategy that includes the abiotic scenario and the benthic and demersal communities. Concerning the abiotic scenario, the morphosedimentary and bathymetric characteristics and also the characteristics of the water column were analysed. Regarding communities, the main compartments of the benthic domain were studied using a multigear system. i) Demersal fish and larger epibenthic communities were sampled using an otter trawl (Porcupine Baca trawl and the rockhopper), ii) smaller epibenthos was sampled with a 3.5 m beam trawl, iii) suprabenthos was captured with a sled, iv) a box corer (0.25 m^{-2}) was used to sample endobenthos, and v) a WP2-type plankton net was used to collect near-bottom zooplankton. Sampling by trawling and dredges is complemented with visual techniques: photogrammetry sledges (TFS-1 and TFS-2) and remotely operated vehicles (ROV). This methodological approach offers a vision of the biodiversity of the ecosystem and its communities' structure and distribution. The trophic ecology of the dominant species of fish and crustaceans will be used to estimate of the energy flows, the consumption and niche overlap among high level trophic groups. All this information, together with the study of the impact of the fisheries working in the area, will be integrated in a trophodynamic mass-balance model (Ecopath) that will allow us to explain and to synthesize the characteristics of the ecosystem, to compare it with similar ones and to try to predict the consequences of the possible management measures that can be adopted in this remarkable area. More details about this project were provided in the webpage www.ecomarg.net. More information about the project can be found at Annex 10.

4.4.3 Mapping of offshore shallow reefs along the Swedish coast

H. Kautsky presented this project that was financed by the Swedish EPA and finished this spring. The purpose was to describe the ecosystem of the reefs and give background data to help to classify them whether they should be protected or not. There is an interest of placing windmill parks on the reefs. A for Swedish conditions extensive investigation of the reefs started in the year 2003, including geological mapping, hydrology and biological mapping and collecting of samples of the reefs. The biological investigations had a main purpose to present geographical distribution of the plant and animal species using GIS-applications. Areas were investigated by video-hanger and ROV (Swedish west coast), divers transects, specimen

collection and quantitative sampling. Based on video data from species depth distribution and coverage as well as the type of substrate GIS-maps were produced together with geological map and a wave exposure model. All data from the project will be stored in a database free for use for anyone and attainable via the homepage of the Swedish EPA.

In comparison to the coastal ecosystems the areas are all unique. The reefs on the west coast hold species not found anymore along the coast. The Baltic reefs constitute unstable substrate deriving from the last glaciation and in combination with the high wave exposure and are uniquely species poor. A low number of *Mytilus edulis* found at Hoburgs bank is probably caused by the grazing from diving ducks. This would then be one of few areas where biotic interactions influence the whole ecosystem composition.

4.4.4 Long-term monitoring of a benthic rocky-bottom community in a high-arctic fjord (Kongsfjorden, Svalbard)

F. Beuchel reported by e-mail on a benthic rocky-bottom community in Svalbard. More details can be found in Annex 11.

4.5 Other studies

4.5.1 Preparation of TIME report "The importance of the phytobenthic plant and animal communities to marine ecosystems and their scientific study"

H. Kautsky gave an account on the different methods that are employed for the study of phytobenthic communities.

The document will include a brief definition of the phytobenthic communities, emphasise the importance of phytobenthic system as a boundary land-sea, high biodiversity and briefly mention environmental hazards relevant for this part of the ecosystem. The report will describe frequently used and/or recommended methods and discuss their pros and cons (references) and their coupling to ICES Habitat group, UK SAC, water frame work directive (WFD), habitat mapping, EUNIS, etc.. Mainly the methods used in the Baltic Sea region, the North Atlantic and North Sea and the Mediterranean Sea will be described, but also relevant methods for these areas from other regions of the world will be presented. The methods described will be subdivided in the categories from remote- broad scale (satellite) down to the most precise quantitative, destructive sampling by scraping a unit area (Satellite; Areal photography (true colour, filtered etc); From ship: Echo-sounder, side scan sonar, Videohanger, ROV; From boat: Aquascope; (videohanger); pavane; Walking (intertidal, shallow water); Diver transects, frames and destructive sampling). Examples of relevant investigations will be cited.

4.5.2 ECASA (Ecosystem Approach for Sustainable Aquaculture)

A. Borja reported about the European 'Specific Targeted Research or Innovation Project' (Contract no.: 006540). It is composed of 16 partners and 12 countries, and extends from 1st Dec-2004 to 30th Nov-2007. The objectives are: (1) To identify quantitative and qualitative indicators of the effects of aquaculture on the environment and vice-versa, and to assess their applicability; (2) To develop operational tools, including models, to establish and describe the relationship between environmental conditions and aquaculture activities over a range of ecosystems and aquaculture production systems; and (3) To develop effective environmental impact assessment and site selection methods for coastal area management.

To achieve these there are 6 WP, being the most important tasks: (1) Identifying and quantifying the most relevant indicators of the interactions (positive and negative) of aquaculture on ecosystem considering physical, chemical and biological factors, and including

socio-economy (such as local fisheries) and secondary impacts (made in 2005); (2) Identifying and quantifying the main driving forces of ecosystem changes influencing the aquaculture sector and to develop the appropriate environmental indicators (made in 2005); (3) Assessing the applicability of such indicators (efficiency, cost effectiveness, robustness, practicality, feasibility, accuracy, precision, etc) and developing operational tools, e.g. models establishing the functional relationship between environment and aquaculture activities (to be made in 2006–2007); (4) Testing and validating these tools in order to include them in a methodology for Environment Impact Assessment (EIA) and effective site selection (to be made in 2006-2007: we have selected 16 locations for sampling, including fin-fish and shellfish aquaculture and different systems of aquaculture, covering the whole Europe); and (5) Dissemination to stakeholders and end-users (to be made in 2007).

4.5.3 Benthic intercalibration made by the Working Group for the implementation of the Water Framework Directive:

A. Borja reported. The European Water Framework Directive (WFD) establishes a framework for the protection and improvement of transitional and coastal waters; its final objective is to achieve at least 'good water status' for all waters, by 2015. The WFD requires Member States (MSs) to assess the Ecological Status (ES) of water bodies. This assessment will be based upon the status of the biological, hydromorphological and physico-chemical quality elements, by comparing data obtained from monitoring networks to reference (undisturbed) conditions, then deriving an Ecological Quality Ratio (EQR). One of the biological quality elements to be considered is the benthic invertebrate component and some structural parameters (composition, diversity and disturbance-sensitive taxa) must be included in the ES assessment. Following these criteria, several approaches to benthic invertebrate assessment have been proposed by MSs and the WFD requires to intercalibrate these approaches. At this moment the comparison of the different methodologies proposed by United Kingdom, Spain, Denmark and Norway, for coastal waters has been made, using a dataset of 589 benthic invertebrate abundance samples from different locations along the European Atlantic coasts: Belgium (132), Denmark (72), Germany (64), Republic of Ireland (RoI, 14), Norway (12), Spain (45), and United Kingdom (UK, 250). Results show a high consistency between the approaches, both with regard to determining the EQR and boundary settings for the ES, achieving 85% of agreement in the final classification.

4.5.4 Valued Ecosystem Components (VECs)

B. Tunberg reported that in the United States and Canada this approach is being used in environmental studies. According to the Port Hope Area Initiative, Canada, VECs, are parts of the local environment, valued because of their ecological, scientific, cultural, socio-economic or aesthetic importance. VECs can represent a class of species or a type of ecosystem. VECs are used in the assessment of potential environmental effects.

In South Florida, USA, VECs have recently been introduced as a potentially important approach for the evaluation of the estuarine environment, this with varying success. South Florida Water Management District has issued the following statement to defend/explain why VECs are being evaluated and partially used here: "Because much of the critical habitat in South Florida's estuaries is biotic (grass beds, oyster reefs, mangroves), management strategies to enhance or sustain the biotic integrity of estuaries have focused on providing a suitable environment for such dominant, habitat forming communities. These species have been identified as valued ecosystem components (VECs) and constitute the specific biotic resources for which an estuary is managed. The implied link between biotic integrity and VECs is that managing for VECs will sustain the biotic integrity of the whole system."

4.5.5 BWZee

The project on Biological Valuation of the Belgian Continental Shelf is currently in its final stages and will be reported on next year. For any information see http://www.vliz.be/projects/bwzee/

4.5.6 Recent developments in the use of the Internet for benthos ecologists

H. Hillewaert gave a presentation on Wikipedia and Wikispecies. The latter is project supported by the Wikimedia Foundation with a great potential. It is meant to become an open, free directory of species. This will cover Animalia, Plantae, Fungi, Bacteria, Archaea and Protista. Everyone has the possibility to add or adjust a page on species, or any higher taxon. Species will ideally have name references, synonymy and links to wikipedia pages in all languages. All the information, images included, is free of copyright. The peracarid order Cumacea was outlined as an example both on Wikispecies and on the Dutch Wikipedia on http://nl.wikipedia.org/wiki/Zeekomma%27s. (www.wikipedia.org and species.wikipedia.org)

Several online databases exist (delta, ITIS, Species 2000, Fishbase, Taxonomicon, etc.), but none are complete and none grow as fast as Wikispecies, where everybody can contribute. They are however very important as a source of information.

The working group website has been moved to a new address: www.bewg.be

5 Review the final meeting report of the SGNSBP and consider future joint activities in the North Sea (ToR b)

Considerable progress was made with the aim to finalize the Cooperative Research Report. Deadline for contributions was established at end of May 2006.

All SGNSBP data will be integrated in the MARBEF database by the end of this year, after all data providers have agreed. Progress on the project, can be consulted on the NSBP website at http://www.vliz.be/vmdcdata/nsbp

Following chapters were added/updated:

- Sections 1 & 2, Summary and introduction;
- Section 3, Data management;
- Section 4, North Sea environment;
  - Synopsis and human influences;
  - Sediment particle size;
  - Metal concentrations ;
- Section 5, patterns and changes in the benthos (1986–2000);
  - Structure, distribution and characterising species of macro-zoobenthos communities in 2000;
  - Changes in community structure (1986–2000) and causal influences;
  - Species distributions;
  - (Role of) biotic/diversity indices;
  - predictive modelling;
  - parallel studies;
- Section 6, Ecosystem interactions;
  - Links between infauna, epifauna and fish distributions;
  - Functional diversity;
  - Fishing practices;

- Benthic food web studies;
- Other human activities;
- Benthic community studies over relevant time-scales;

- Conclusions, recommendations, acknowledgements, references.

6 on request by OSPAR, develop a list of area-specific (groups of) benthic indicator species in relation to the development of the ecological quality objectives for changes in zoobenthos in relation to long-term eutrophication (ToR c)

A subgroup discussed the OSPAR request. Details and recommendations can be found in Annex 12.

7 Discuss the environmental implications of off-shore renewable energy generation (wind, wave, tide, etc.) (ToR d)

This ToR was discussed in a sub-group and was carried over from the previous BEWG. The sub-group discussed recent progress from existing developments across Europe. Although it was also highlighted that there were little additional developments from work reported previously.

A. Schroeder proposed the sub-group the potential collaborative opportunity of conforming a consortium of researchers which have a common interest in the marine environmental implications of off-shore renewable energy generation. (www.cost.esf.org/opencall) The sub-group discussed the formal development of a proposal under the Cost scheme. The sub-group agreed on the need to develop this initiative to allow exchanges of technologies, lessons learned and to further enhance common links under the existing developments of off-shore renewable energy. An initial expression of interest to participate in this initiative was from Spain, Belgium, Germany, Poland and the UK.

This concept note was further discussed widely among the participants of the BEWG to assess future ideas and wide collaboration from other countries:

It was highlighted that the project leader should be someone with a decent background on the subject, who is able to collate all the information and steer de group. For the UK it would be too early to take the lead. The main research in the UK is undertaken through universities. It was mentioned that different consultancies might be interested. Also the lack of knowledge on this subject in the US was mentioned.

The end of May deadline may be difficult to attain, although the group is convinced that there would be enough interest from different countries and institutes. Therefore it was concluded that a mailing list of possible interested parties would be created and A. Schröder will send a summary around.

8 Review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant. The data tables will be subject to thematic assessment to be undertaken at a REGNS thematic assessment workshop. (ToR e)

The group decided that last year's tables do not need updating at the moment. They can be found in the BEWG report 2005 on the ICES Website.

9 Based on the outcome of the ICES ASC Theme Session on Oil Spills in Marine Ecosystems, review progress on guidelines for the assessment of long-term impacts of oil spill (ToR f)

The outcome of Theme Session S was not very relevant for the question raised in ToR f) since it mainly dealt with short-term effects and clean-up methodologies.

Presentation S:08, however, stating "ten years of clean up after the Exxon Valdez oil spill in Alaska, a survey of 91 formerly oiled beaches in Prince William Sound found more than half the beaches still contained crude oil, often in quantity. Liquid crude oil was found in some 9,000 assessment pits; all subsurface oil was identified as Exxon Valdez crude oil by GC fingerprinting. Subsurface oil was most abundant at the mid tide level and was present as low as the zero tide level and well into the biological zone of mussels and clams. Bioavailability of the constituent PAH was limited to species that live or forage in the intertidal such as mussels, clams, harlequin ducks, and sea otters, all of which showed evidence of exposure and harm more than 10 years past the spill. Populations of sea otters appear to have recovered if total numbers are the criteria for recovery. Yet some bays with persistent oil still do not support use by sea otters, suggesting that lingering oil in the intertidal zone has resulted in long-term impacts on select populations. While the exposure was relatively universal in the western half of Prince William Sound at the time of the spill, present day exposures are very site specific and limited in space to specific patches of lingering oil.."

MCWG discussed this topic in 2005 and presented the paper S:13 at the ASC 05 which concluded the following: "Consideration of the impact assessments conducted following recent oil spill incidents in Europe has demonstrated a range of short-term effects, but studies have not been continued for more than a few years. In most cases, the assessment of both short- and long-term impacts of spilled oil is hampered by a lack of pre-spill data on marine resources, and of the pre-existing levels of hydrocarbon and PAH contamination (Shaw and Bader, 1996). The assessment of long-term impacts is further compromised by the difficulty of unambiguously assigning effects observed to the spilled oil rather than to either hydrocarbons and PAH deriving from other local sources and chronic inputs, or to other chemicals present in the local environment. High levels of natural variability in biological systems add further difficulties. As can be seen from the studies reported here, many investigative techniques can be effectively applied in oil spill impact assessment. It would be useful to develop a framework for this process, within which comparable methodologies could be applied to monitoring the most vulnerable and sensitive components of the ecosystem (Wells *et al*., 1995) and the food-chain. As has been suggested by others (Peterson *et al*., 2003), the development of an ecosystem-based toxicology is required if we are to be able to understand the chronic, delayed and indirect long-term risks and impacts of oil spills. This is in line with the holistic ecosystem-based approaches to monitoring and assessment currently being developed within ICES."

We may initially have to define two terms (as in Kingston, 2002): 'clean' and 'recovery':

- Clean, in the context of an oil spill, may be defined as the return to a level of petroleum hydrocarbons that has no detectable impact on the function of an ecosystem.
- Recovery of an ecosystem is characterized by the re-establishment of a biological community in which the plants and animals characteristic of that community are present and functioning normally.

Looking in the literature we find that after oil spills many effects were no longer visible after one year, most of them disappeared after three years (Sell *et al*., 1995) but in the case of Amoco Cadiz the *Ampelisca* spp. population recovery took more than ten years (Dauvin, 1998). Single remainders of crude oil may be found even after 25 years as asphalt 'pavements'. Kingston (2002) reports in his very comprehensive and up-to-date paper that the recovery in intertidal habitats is very much coupled to wave exposure and natural processes and that recovery is normally within 1–3 years after the spill depending on the latter ones and of the life span of the species in question (Elmgren *et al.*, 1983).

References

Dauvin, J.-C. 1998. The fine sand *Abra alba* community of the Bay of Morlaix twenty years after the *Amoco Cadiz* oil spill. Mar. Pollut. Bull., 36(9): 669–676.

Elmgren, R., Hansson, S., Larsson, U., Sundelin, B., and Boehm, P.D. 1983. The *Tsesis* oil spill: acute and long-term impact on the benthos. Mar. Biol., 73: 51–65.

Kingston, P.F. 2002. Long-term environmental impact of oil spills. *S*pill Science & Technology Bulletin, 7(1–2): 53–61.

Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., and Irons, D.B. 2003. Long-Term ecosystem response to the *Exxon Valdez* oil spill. Science, 302(5653): 2082–2086.

Sell, D., Conway, L., Clark, T., Picken, G.B., Baker, J.M., Dunnet, G.M., McIntry, A.D., and Clark, R.B. 1995. Scientific criteria to optimise oil spill cleanup. Proceedings of the 1995 Oil Spill Conference. American Petroleum Institute, Washington DC, pp 595–610.

Shaw, D.G., and Bader, H.R. 1996. Environmental science in a legal context: The *Exxon Valdez* experience. Ambio. Stockholm, 25(7): 430–434.

Wells, P.G., Butler, J.N., and Hughes, J.S. 1995. *Exxon Valdez* spill: Fate and effects in Alaskan waters. ASTM Spec. Tech. Pub., 1219.

10 Work intersessionally to produce a draft report on the use of benthic biological criteria for selecting dredging disposal sites (ToR g)

S. Birchenough acted as a co-ordinator of the sub-group collating and extracting available information from existing case studies providing an initial draft for discussions.

The structure and content of this overview document was drafted during the last ICES BEWG meeting in 2005. The sub-group of the BEWG worked through the year in the revision of available case studies. The initial draft report produced by the sub-group illustrated examples from the work conducted in several countries. This revision includes information from Belgium, Germany, Spain, Sweden, United Kingdom and the U.S.A.

S. Smith also mentioned the importance and the need to incorporate available information on the new enforcement of London protocol on the 24 March 2006 with 26 administrations. The London protocol possess ”Generic Guidelines and eight comprehensive “specific Guidelines” for all wastes such as dredged material, sewage sludge, fish wastes, vessels and platforms, inert inorganic material (i.e. mining wastes), organic material of natural origin and bulky items

(e.g. martial comprising iron, steel and concrete). The sub-group will incorporate an element related to the dredged disposal activities at sea in the existing draft overview. To access further information on the London protocol visit the web site: http://www.londonconvention.org .

OSPAR and Helcom have also guidelines built on the existing ICES dredging guidelines. For more information visit the web site: http://www.helcom.fi and the ICES: http://www.ices.dk

Participants of the sub-group also agreed the importance of incorporating information from The Netherlands. I. Moulaert kindly offered to establish contacts with colleagues working on dredged material disposal activities. The group also decided to incorporate existing information from the Netherlands into the existing draft report if the information is available.

Electronic copies of the initial draft were issued and circulated among participant of the sub-group for initial editorial comments and to up-date the existing information where necessary. Relevant references to support this work are currently being collated.

During this meeting the sub-group discussed the preliminary results obtained from the several study sites and agreed a list of initial conclusions and recommendations for the future development of this work. The sub-group also agreed to finish the final discussion/recommendation sections and to report the final outcomes under an *ICES Cooperative Research Report*. The final draft for consultation among the group members will be available during September 2006.

The preliminary list of conclusions and recommendations of this sub-group are as follows:The importance of a control programme supported by consistent robust data for a long-term comparison and characterisation was discussed. Some studies from Sweden currently undertake this assessment although the information is sometimes only supported by video observation in as part of a qualitative assessment. The sub-group participants recommended the need of the collection or robust scientific data in support of a sound scientific approach.

- The lack of available baseline survey data from studies conducted in many places was also discussed. The sub-group also recommended that the importance of the baseline information to support future monitoring programmes and long-term monitoring assessment should be a requirement of the license conditions to support the analysis of disposal sites.
- Recommendations were also indicated from existing studies in Spain and the UK. The development of a tiered approach and the integration of multi-disciplinary assessments were seemed to be efficient tools, which contributes to the development of sound robust science. These tools comprises the use of chemical assessment, bioassay work to test the toxicity of dredged material and the inclusion of physical, chemical and biological information to the analysis to established the signs and effects as a result of the disposal of dredged material activities.
- The costal processes of the site were also considered important to consider in conjunction with the existing measures. The nature of the area (i.e. currents, particle movement) was also important when planning and monitoring dredged material disposal sites.
- The sub-group also supported the use of beneficial schemes (re-use, re-cycling) to minimise open sea disposal activities.
- The sub-group also agreed the revision of action level from the different case studies to incorporate a comparison in the draft overview.
- The disposal of dredged material and the effects surrounding these disposal sites were considered to be highly important in the assessment of the site. The sub-group recommended this information to be considered as part of the monitoring activity of the disposal site.
- A. Borja also mentioned the use of ‘black boxes’ for controlling the exact location/releasing of dredged material in the licensed disposal sites in Spain.

- I. Moulaert also mentioned the possible adoption in Belgium of splitting the licensed disposal sites up in different parts. Through time these would then change when a certain amount of material has been disposed. I. Moulaert will report on any updates.
- Considerations of regarding alterations of the function of the ecosystem have to be mentioned as well as of the biodiversity. Depending on the nature of maintenance dredging, disposal activities contribute to eutrophication and silting of valuable habitats.
- S. Smith also expressed concern in areas where the dredged material disposal site can also be compromised by conflict of interests (i.e. fishery grounds). This example was specifically observed in Sweden.
- The sub-group also highlighted the importance of site selection criteria needs to consider an integration of combined economic, physical and biological effects rather than solely concentrate in one aspect which usually is the economic effects in isolation from the combine set of effects.

11 Relate a list of indicators to the impacts of human-induced activities and changes in ecological state. Assess the effectiveness of any potential performance indicators in identifying cause-effect relationships (ToR h)

The BEWG subgroup gathered to discuss the potential approaches to undertake the task proposed under this TOR. The group concluded that there is already a large amount of information available in several publications and reports. Participants of the group encountered this task as challenging; therefore there was an agreement to progress further this work intersessionally during 2006 with the final aim of a working session of testing different metrics during next year in BEWG. Discussions within the subgroup lead to the following approach to proceed toward the accomplishment of the ToR:

Firstly, an update of the existent reports from e.g. Hiscock *et al*. 2005 and ICES-SGSOBS, 2004 shall be compiled to achieve a comprehensive list of existing metrics including newly developed metrics like e.g.

- Any tool develop under the WFD to assess the ecological status (i.e. multimetric tools or multivariate tools);
- Taxonomic distinctness and related indices;
- Any other new univariate indices.

To relate the performance of these indices to different types of anthropogenic impacts, case studies shall be performed with various data sets e.g.:

- sewage sludge disposal;
- dredged material disposal;
- aggregate extraction;
- offshore constructions, e.g. windfarms;
- pollution by various substances;
- bottom trawling;
- aquaculture;
- eutrophication.

Preliminary results from these case studies will be presented and discussed during the next BEWG meeting in 2007, in order to present the final outcomes at the forthcoming indicator symposium in November 2007 in London, United Kingdom.

Hiscock, K., Langmead, O., Warwick, R., and Smith, A. 2005. Identification of seabed indicator species to support implementation of the EU Habitats and Water Framework Directives. Second edition. Report to the Joint Nature Conservation Committee and the Environment Agency from the Marine Biological Association. Plymouth: Marine Biological Association. JNCC Contract F90-01-705. 77 pp.

ICES. 2004. Report of the Study Group on Ecological Quality Objectives for Sensitive and for Opportunistic Benthos Species, 22–24 March 2004, Copenhagen, DK, ICES CM 2004/ACE:01, 41 pp.

12 Consider the outcome of a Workshop on statistical analysis with special emphasis on minimum sampling area and trend analysis in ecological studies (ToR i)

This ToR is based on a misunderstanding and the expression of a wish materialized in the present ToR. This workshop never took place. The WSAEM Chair offered cooperation but were not able to attend a BEWG meeting or have back-to-back meetings other than in ICES Headquarters.

13 Discuss and report on potential contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes (ToR j)

The regional sections of the WGRED report were distributed to experts in the group asking for critical review and need for amendments. The group agreed that generally the major interest goes to oceanography and fishing and only very little to benthos. Comments on the different regional overviews are presented in Annex 13.

14 Review and comment on the draft text on the application of AQC Criteria (Annex 8, SGQAE 2004). (The answer to this TOR demands intersessional work by BEWG) (ToR k)

The draft text was sent out by the Chair and critical remarks were received from the former Chair Karel Essink. The Chair discussed the remarks and altered the draft text in such a way that the amendments were covered. It was returned in time and obviously accepted by SGQAE. The Chair informed the group about the changes.

15 Specify and request an overview of database contents from ICES Data Centre (ToR i)

The group agrees that geo-referenced fishing effort information is necessary. The importance of VMS data over information from ICES rectangles was emphasized.

Sediment distribution data (geo-referenced) is also important.

A metadata catalogue from the ICES Data Centre should be made readily available and accessible via the internet.

16 Any other business

Professor A. Eleftheriou presented the recently published IBP handbook on benthos sampling methods (Eleftheriou and McIntyre (2005). Methods for the Study of Marine Benthos. Blackwells Publishing).

A. Eleftheriou presented an inspired outline of the Minoan perception of marine nature.

16.1 ASC Theme session proposal

The Benthos Ecology Working Group [BEWG] proposes a Theme Session for the 2007 or 2008 Annual Science Conference:

Title: Mapping marine benthic habitats distribution

Possible Theme Session conveners:

- David Limpenny (Cefas, UK);
- Siân Boyd/Silvana Birchenough (Cefas, UK);
- Hubert Rees (Cefas, UK);
- Ceri James (BGS, UK);
- Brian Todd (Canadian);
- Charlotte Johnson (JNCC, UK);
- Jon Davies (EN, UK);
- Leonie Robinson (University of Liverpool, UK).

Scientific Justification

Currently, there is a wide range of international policies and objectives under OSPAR and ICES highlighting the importance of marine benthic habitats distribution in support of an efficient marine spatial planning. At present multiple uses of the seabed (e.g. aggregate extraction, dredging, fisheries, windfarms) can affect the distribution of species and habitats Therefore, the development of habitat maps is needed as a tool to support the proper management of a sustainable use of the seabed.

Recent developments in acoustic technologies with a combination of ground-truth techniques offer valuable opportunities to explore and map the seafloor at high-resolution levels. This session will incorporate the used of techniques for collection of data, robust statistical procedures for the developing of habitat maps, and the significance of the maps.

ICES BEWG made a formal request to incorporate a habitat mapping session as part of ICES ASC to cover the marine benthic habitats distribution. This session will integrate members of ICES groups: BEWG, HMWG, WGECO, REGNS.

Participants

It is expected that responses to a call for contributions will reflect the wide interest and active research current in this subject area.

16.2 Upcoming symposia etc.

- ALSO meeting, session on indicators, British Columbia, Canada, 5–6 June 2006
- 41th EMBS, Cork, Ireland, 4–8 September 2006
- Iberian Symposium of Marine Biology, Barcelona, Spain, 12–15 September 2006

- ICES Annual Science Conference, Maastricht, Netherlands, 19–26 September
- Conference on offshore windfarms and the environment, Marienlyst, Denmark, 27–29 November 2006.

  http://eventus.trippus.se/finalresults/participants
- The Baltic Sea Science Congress (BSSC), Rostock, Denmark, 19–23 March 2007
- 42th EMBS, Kiel, Germany, August 2007
- Indicator symposium, Londen, UK, November 2007
- Estuarine Research Foundation (ERF) 2007, Providence, Rhode Island, USA, 4–8 November 2007

16.3 Proposed Draft Resolutions 2006

The preliminary Terms of Reference for 2007 and a draft resolution for an *ICES Cooperative Research Report* can be found at Annex 4.

17 Closing of the meeting

The Chair thanked the participants for their enthusiastic cooperation and thanked HCMR and its staff for hosting the meeting in their institute. He specially thanked the local host Dr C. Arvanitidis, S. Faulwetter and K. Vassileiadou from the Institute of Marine Biology and Genetics.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Christos Arvanitidis	Institute of Marine Biology and Genetics HCMR, Former americqn base of Gournes, 71003, Heraklion, Crete, Greece	+30 2810 337748 +30 2810 337822	arvanitidis@her.hcmr.gr
Silvana Birchenough	CEFAS Burnham Laboratory Remembrance Av. Burnham-on-Crouch Essex CMO 8HA UK	Phone: +44 1621 787211 Fax: +44 1621 784989	silvana.birchenough@cefas.co.uk
Ángel Borja	AZTI Herrera kaia, Portualde z/g 20110 Pasaia (Gipuzkoa) Spain	Phone: +34 943004800 Fax: +34 943004801	aborja@pas.azti.es
Hans Hillewaert	ILVO-Fisheries Ankerstraat 1 B-8400 Oostende Belgium	Phone: +32 59 569832 Fax: +32 59 330629	hans.hillewaert@ilvo.vlaanderen.be
Vadims Jermakov	Institute of Aquatic Ecology Latvian University Latvia	Phone: +371 7614840 Fax: +371 7601995	vadims@monit.lu.lv
Yannis Karakassis	Department of Biology, Faqulty of Science, University of Crete	Phone: +30 81 346860 Fax: +30 81 241882	jkarak@imbc.gr
Hans Kautsky	Department Systems Ecology Stockholm University 10691 Stockholm	Phone: +46 8 164244	hassek@ecology.su.se
Kerstin Mo	Swedish Board of Fisheries. Institute of Coastal Research Gamla Slipv. 19 74071 Oregrund Sweden	Phone: +4617346474	kerstin.mo@fiskeriverket.se
Lene Buhl-Mortensen	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	Phone: +47 55 236936 Fax: +47 55 238531	lenebu@imr.no
Ine Moulaert	ILVO-Fisheries Ankerstraat 1 B-8400 Oostende Belgium	Phone: +32 59 569847 Fax: +32 59 330629	ine.moulaert@ilvo.vlaanderen.be
Marina Orlova	ZIN RAS Universitetskaya embankment, 1 199034, St.Petersburg, Russia	Phone: +7 812 3280211 Fax: +7 812 3280921	marina_orlova@rambler.ru
Santiago Parra	Centro Oceanográfico de La Coruna Muelle de las Animas s/n Apdo 130 E-15001 La Coruña Spain	Phone: +34 981 205362 Fax: +34 981 229077	santiago.parra@co.ieo.es

NAME	ADDRESS	PHONE/FAX	EMAIL
Eike Rachor	Alfred-Wegener-Institut Foundation for Polar and Marine Research P.O. Box 12 0161 D-27515 Bremerhaven & BfN - Vilm Germany	Phone: +49 471 4831/1310	erachor@awi-bremerhaven.de
Henning Reiss	Forschungsinstitut Senckenberg Suedstrand 40 D-26382 Wilhelmshaven Germany	Phone: +49-4421 9475 267 Fax: +49 4421 9475 222	henning.reiss@senckenberg.de
Mike Robertson	Multispecies Interactions Group FRS Marine Laboratory PO Box 101 Aberdeen UK AB11 9DB	Phone: +44 1224 295433 Fax: +44 1224 295511	M.R.Robertson@marlab.ac.uk
Heye Rumohr (Chair)	Leibniz Institute for Marine Reseach IFM-GEOMAR Düsternbrooker Weg 20 D-24105 Kiel Germany	Phone: +49 431 600 4524 Fax: +49 431 600 1671	hrumohr@ifm-geomar.de
Alexander Schröder	Foundation Alfred Wegener Institute for Polar and Marine Research P.O. Box 120161 27515 Bremerhaven Germany	Phone: +49 471 4831 1734 Fax: +49 471 4831 1724	aschroeder@awi-bremerhaven.de
Susan Smith	Swedishl Board of Fisheries P.O. Box 423 SE-40126 Gothenburg Sweden	Phone: +46 31 7430 362 Fax: +46 31 7430 444	susan.smith@fiskeriverket.se
Jan Sørensen	Kaldbak Marine Biological Laboratorium Mjokagøta 3 FO-180 Kaldbak Faroe Islands		jan@havbotnur.fo
Bjorn Tunberg	Smithonian Marine Station 701 Seaway Drive Fort Pierce, FL 34949 USA	Phone: +1 772 465 6630 / 108 Mobile: +1 772 532 5758 Fax: +1 772 461 8154	tunberg@ si.edu
Jan Warzocha	Sea Fisheries Institute ul. Kollataja 1 PL-81-332 Gdynia Poland	+48 58 621 71 95 +48 58 620 28 31	janw@mir.gdynia.pl

Annex 2: BEWG Terms of Reference 2005

2005/2/MHC09 The **Benthos Ecology Working Group** [BEWG] (Chair: H. Rumohr, Germany) will meet at HCMB, Heraklion, Crete/Greece, from 1–5 May 2006 to:

a) review and consider recent developments in ongoing benthos research in Europe

b) review the final meeting report of the SGNSBP and consider future joint activities in the North Sea;

c) on request by OSPAR, develop a list of area-specific (groups of) benthic indicator species in relation to the development of the ecological quality objectives for changes in zoobenthos in relation to long-term eutrophication;

d) discuss the environmental implications of off-shore renewable energy generation (wind, wave, tide, etc.);

e) to review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant. The data tables will be subject to thematic assessment to be undertaken at a REGNS thematic assessment workshop.

f) based on the outcome of the ICES ASC session on Oil in Marine Systems, review progress on guidelines for the assessment of long-term impacts of oil spill

g) work intersessionally to produce a draft report on the use of benthic biological criteria for selecting dredging disposal sites;

h) relate a list of indicators to the impacts of human-induced activities and changes in ecological state. Assess the effectiveness of any potential performance indicators in identifying cause-effect relationships;

i) consider the outcome of a Workshop on statistical analysis with special emphasis on minimum sampling area and trend analysis in ecological studies.

j) discuss and report on potential contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes.

k) review and comment on the draft text on the application of AQC Criteria (Annex 8, SGQAE 2004). (The answer to this TOR demands intersessional work by BEWG).

l) specify and request an overview of database contents from ICES Data Centre.

BEWG will report by 15 May 2006 for the attention of the Marine Habitat Committee 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 forums, consequently these activities are considered to have a very high priority
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan. 1.2.1, 2.2.1, 2.13, 4.12, 2.11 a) This is a prerequisite for the scientific information status of the group b) The SGNSBP is a major research activity of the BEWG and the basis for future joint activities and c) This is in response to a request by OSPAR. d) There is a growing need for a harmonized approach to benthic studies in view of the rapid expansion of the interest in off-shore wind energy and other forms of energy generation off-shore. It will provide further advice in response to the OSPAR. e) This will be an important review of the Integrated Assessment Workshop in May 2006. f) This will be a basis for future OSPAR requests g) This is in response to a OSPAR request h) 2005 This is to continue important work on definition of benthic indicators in response to the ongoing requests from OSPAR. i) This is a continuation of the attempts to cooperate with WGSEAM j) This is in response to a request from ACME. ICES is moving towards providing scientific advice for the integrated management of all human activities that affect marine waters. Information on the quantity and quality of habitat and the health of marine ecosystems will be essential to the achievement of this goal. k) This is in response to a request from STGQAE. **Deadline 10 February.** l) This is in compliance with a request from the ICES Data Centre
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Group is normally attended by some 20-25 members and guests
SECRETARIAT FACILITIES:	None
FINANCIAL:	No financial implications
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It also is of close relevance to the Working Group on Ecosystem Effects of Fisheries.
LINKAGES TO OTHER ORGANISATIONS:	The work of this group is closely aligned with similar work in FAO and in the Census of Marine Life Programme
SECRETARIAT MARGINAL COST SHARE:	ICES:NASCO 80:20

Annex 3: Agenda

Opening & Local Organisation

Appointment of Rapporteur

Terms of Reference

Adoption of Agenda

Report on ICES meetings and other meetings of interest

ASC 2005 (Aberdeen) / ICES Annual Report for 2005

Marine Habitat Committee, Aberdeen 2005

ACE, Aberdeen 2005

ACME, Aberdeen 2005

STGQAB

WGMHM

WGEXT

MarBEF

WGECO

ToR a) review and consider recent developments in ongoing benthos research in Europe

Cooperative studies

Benthos and fisheries

Benthos of soft sediments

Benthos of rocky substrates

ToR b) review the final meeting report of the SGNSBP and consider future joint activities in the North Sea;

Report on SGNSBP meeting in Copenhagen 2005 and November 2005 in Ostende

ToR f) based on the outcome of the ICES ASC session on Oil in Marine Systems, review progress on guidelines for the assessment of long-term impacts of oil spill

ToR g) work intersessionally to produce a draft report on the use of benthic biological criteria for selecting dredging disposal sites;

ToR c) on request by OSPAR, develop a list of area-specific (groups of) benthic indicator species in relation to the development of the ecological quality objectives for changes in zoobenthos in relation to long-term eutrophication;

ToR i) consider the outcome of a Workshop on statistical analysis with special emphasis on minimum sampling area and trend analysis in ecological studies.

ToR h) relate a list of indicators to the impacts of human-induced activities and changes in ecological state. Assess the effectiveness of any potential performance indicators in identifying cause-effect relationships;

ToR e) to review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant. The data tables will be subject to thematic assessment to be undertaken at a REGNS thematic assessment workshop.

ToR j) discuss and report on potential contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes. See: WG Report WGRED

ToR d) discuss the environmental implications of off-shore renewable energy generation (wind, wave, tide, etc.);

ToR k) review and comment on the draft text on the application of AQC Criteria (Annex 8, SGQAE 2004). (The answer to this TOR demands intersessional work by BEWG). (done by Chair)

ToR l) specify and request an overview of database contents from ICES Data Centre.

Any other business

Theme Sessions

Upcoming symposia, etc.

Recommendations and Action List

Recommendations for next years meeting (2007)

Recommendations for Theme Sessions/ Symposia

Action List

Adoption of the report

Closing of the meeting

Annex 4: Draft Resolutions 2006

Draft Resolution for BEWG meeting in 2007

The **Benthos Ecology Working Group** [BEWG] (Chair: H. Rumohr) will meet in Wilhelmshaven in Germany from 23–27 April 2007 to:

a) review and consider recent developments in ongoing benthos research in the ICES area

b) assess the effectiveness of any potential performance indicators in identifying cause-effect relationships based on a list of indicators prepared by intersessional work

c) discuss and report on the role of benthos for monitoring under the WFD and the NATURA 2000 regimes

d) based on the final SGNSBP report discuss further plans for North Sea benthic surveys and

e) discuss recent developments in benthic sampling methodology with a view on updating the TIMES (1999) recommendations

f) report on the environmental implications of existing off-shore renewable energy generation installations (wind, wave, tide, etc.) and make proposals to minimize their negative effects

BEWG will report by 15 May 2006 to the attention of the MHC Committee.

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 forums, consequently these activities are considered to have a very high priority
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan. 1.2.1, 2.2.1, 2.13, 4.12, 2.11 a) This is a prerequisite for the scientific information status of the group b) This is in response to ongoing OSPAR requests and in perspective of the coming ICES Symposium on Indicators in November 2007. This is also in response to a request from ACME. ICES is moving towards providing scientific advice for the integrated management of all human activities that affect marine waters. Information on the quantity and quality of habitat and the health of marine ecosystems will be essential to the achievement of this goal. c) Benthos will be a major component in the monitoring regimes of the European WFD and the NATURA 2000 network of nature reserves. The BEWG is prepared to evaluate national plans of monitoring and especially how far the comparability is guaranteed to arrive a scientifically suited lon-term data sets. d) The SGNSBP is a major research activity of the BEWG and the basis for the discussion of future future joint activities in the BEWG e) This will is a needed update of the methods recommendations discussed and formulated 10 years ago. f) There is a growing need for a harmonized approach to benthic studies in view of the rapid expansion of the interest in off-shore wind energy and other forms of energy generation off-shore. It will provide further advice in response to the OSPAR.

RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Group is normally attended by some 20-25 members and guests
SECRETARIAT FACILITIES:	None
FINANCIAL:	No financial implications
LINKAGES TO ADVISORY COMMITTEES:	There are linkages to ACME and ACE
LINKAGES TO OTHER COMMITTEES OR GROUPS:	WGMHM, WGEXT, MHC
LINKAGES TO OTHER ORGANIZATIONS:	None
SECRETARIAT MARGINAL COST SHARE:	

BEWG draft resolution for a publication (Category 1)

The report on **Biological Criteria for dredged spoil disposal** as reviewed and approved by the Chair of the Marine Habitat Committee, will be published in the *ICES Cooperative Research Report* series. The estimated number of pages is 85.

The Working Group BEWG agrees to submit the final draft of the proposed publication by the end of 2006.

Supporting Information

PRIORITY:	This has a high priority for various reasons. For example in Ireland there is increased commercial interest in the potential of marine mining which may require the formulation of appropriate regulatory mechanisms and it is intended that this be based on the most recently reviewed scientific studies carried out in this respect.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 10.3 and 8.4. The forthcoming ICES Cooperative Research Report represents a synthesis of the most recent scientific work on Biological Criteria for dredged spoil disposal and is thus of Importance for managing agencies and ICES client organisations like EU, OSPAR and HELCOM.
RESOURCE REQUIREMENTS:	Publication of this material as a CRR will cost ca. 10 000 DKK. The material in the report is fairly straightforward, and therefore no specific additional costs are necessary.
PARTICIPANTS:	Approximately one month's work is required by the editor to finalise this draft.
SECRETARIAT FACILITIES:	About one month of the services of Secretariat Professional and General Staff will be required.
FINANCIAL:	Publication costs.
LINKAGES TO ADVISORY COMMITTEES:	
LINKAGES TO OTHER COMMITTEES OR GROUPS:	BEWG, WGEXT
LINKAGES TO OTHER ORGANIZATIONS:	
SECRETARIAT MARGINAL COST SHARE:	This part is normally added by the Secretariat and contains details of how the Secretariat's costs are to be divided between ICES and the Regulatory Commissions.

Annex 5: Recommendations and actions

RECOMMENDATION	ACTION
1. ICES to produce a Cooperative Research Report in 2007 on (tentative title) Biological Criteria for dredged spoil disposal.	Draft in 2006 (intersessionally)
2. To assess the effectiveness of any potential performance indicators in identifying cause-effect relationships based on a list of indicators prepared by intersessional work	

BEWG 07 Action list

- Henning, to report on MACFONS final report
- Alex, present final results of RESPONSE project
- Ine and Silvana, prepare short note about different performance pf Hamon and Van Veen grab in different sedimentary environments
- Bjoern, to update on monitoring programmes in Indian River Lagoon and lessons learned
- Alex, to present progress in BeoFINO II project
- All, intersessional work on TOR h with the
- Ine, to report on BWZEE final
- Mike, to report on HABMAP project
- Santiago, to report on final report of PRESTIGE oil spill and update on ECOMARG project
- Vadims, present final results of study on dynamics of benthos in the Baltic
- Marina, update on existing data in Russian estuaries and present data on non-indigenuous species.
- Jan, to inform about benthic work in the Faroe Islands
- Hasse, to present final draft for TIMES doc on Phytobenthos sampling
- Silvana and Hans , to update on Indicator Symposium 2007
- Hans to update on current computer tools for benthic research

Annex 6: SPEEK: Post-extractie studie van het Macrobenthos op de Kwintebank

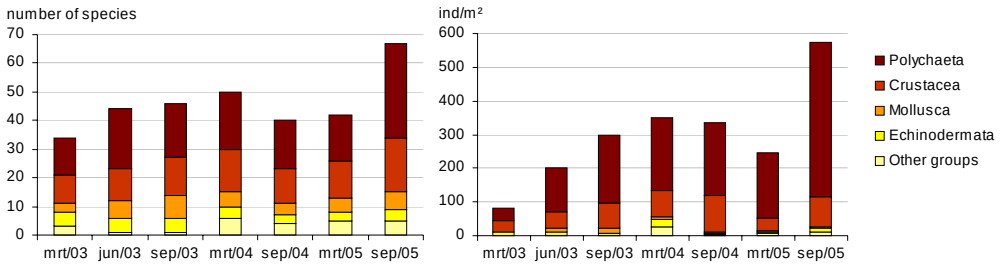
Ine Moulaert, Kris Hostens & Hans Hillewaert

ILVO – FISHERIES, Biological Environmental Monitoring

Ankerstraat 1, 8400 Oostende.

Contact ine.moulaert@ilvo.vlaanderen.be

Six stations located in the central depression of the Kwintebank were sampled seven times between 2003 and 2005 (sampling will be continued at least till 2008). At every locations 3 replicates were sampled with a Van Veen grab. Three other locations on the Kwintebank were used as a reference. Sediment data showed no clear evolution throughout the different sampling periods. The macrobenthic data revealed that one month after cessation of the extraction activities (March 2003) density, number of species and species diversity were generally low compared to the subsequent periods in the central depression. For this period the values were also lower in comparison to the reference zones to the south of the depression and in the northern part of the Kwintebank where low dredging activity occurred. A positive trend was found from 2003 towards 2005 as density and species number did increase in all sampling locations in the central depression of the Kwintebank. Consequently, the data for the central depression became more comparable with those from the surrounding reference stations, where no or limited dredging activity takes place.



The amphipod *Urothoe brevicornis* and the polychaetes *Hesionura elongata*, *Polygordius appendiculatus*, *Spiophanes bombyx*, *Scoloplos armiger* and *Nephtys cirrosa* (both juvenile and adult individuals) were the most important species from autumn 2003 onwards, with a generally increasing trend for all of these species. By means of multivariate analyses, a small change in community composition could be found, related to an increased density of the polychaetes over the whole sampling period. Also, the ratio between adult and juvenile *Nephtys cirrosa* individuals slightly changed over the sampling period in favour of the adults. However, due to the lack of baseline data, it remains unclear if this macrobenthic community matches the 'original' one or rather has evolved into a new community.

In general, it can be concluded that the poor macrobenthic community that was found in the central depression of the Kwintebank in early 2003, directly after the cessation of extraction, did evolve into a community more characteristic for a typical sandbank area on the Belgian Continental Shelf in less than one year.

Annex 7: Mareano

Explorers of the seabed (to be published in ICES Newsletter)

By Lene Buhl-Mortensen and Yvonne Robberstad

Norwegian waters cover a total of over 2 million km². As of today, the knowledge about the seabed in these waters is limited. In fact, we know more about the surface of the planet Mars than about the seabed right outside our coastline! In 2005, the Norwegian Government allocated NOK 5 million for the first phase of an interdisciplinary programme, MAREANO, which aims to map and study the seabed in Norwegian waters – initially focusing on environmentally sensitive areas of the Barents Sea. (Figure A7.1)

Indications have been given that the programme will be carried out as planned from 2006 until 2010, with a total cost of around NOK 235 million. The importance of MAREANO is specifically stressed in the Integrated Management Plan for the Barents Sea recently presented by the Norwegian Government. Extensive plans for exploitation of oil and gas reserves in Lofoten and the Barents Sea are being considered, and a sustainable management of the area is highly dependent on improved knowledge of the Arctic ecosystems. (Figure A7.2)

A management tool

What does the seabed consist of? What is the relationship between the physical environment, species diversity and biological resources? How are contaminants stored in seabed sediments? Where are the coral reefs located? Where can we find the best natural conditions for aquaculture? These are questions that will be addressed by MAREANO (Marine Area Database for Norwegian Coasts and Sea Areas).

In order to provide answers to these questions, the programme has been divided into three main components: mapping, research and dissemination.

1. Surveys

Surveys and basic studies of the physical, biological and chemical environment of the seabed will initially prioritise a number of environmentally sensitive areas of the Barents Sea and the Lofoten area in which offshore petroleum activities are being planned. Future areas to be surveyed will be selected on an annual basis in agreement with the government and relevant user groups.

2. Research

The research will focus on corals, biotopes, the effect of oil and gas spills on biotopes, and relationships between biotopes and sediments. By following up seabed mapping with sampling and video recordings of the benthic fauna, one result of the MAREANO research will be the ability to predict occurrences of bottom habitats based on seabed information (e.g. topography and acoustic backscatter). (Figure A7.3)

3. Public databases

As the name of the programme indicates, the information gathered through surveys and research will be collated in a database on Norway's coastal and marine regions.

This database will also be open to contributions from external sources of knowledge in the public and private sectors, such as local and regional government bodies and the offshore industry. A pilot version of the online MAREANO database currently covers information on selected topics and a limited interactive map service for parts of the Barents Sea (see www.mareano.no). The service will be developed to cover the totality of Norway's coastal and marine regions.

The ultimate aim of MAREANO is to provide a tool that will give users from the industry, the authorities, research and the general public direct access to neutral and reliable knowledge. An example of such knowledge will be charts that combine different types of data to display potential conflicts between vulnerable spawning grounds and planned offshore activities in the Barents Sea. Another is the possibility of combining data on types of seabed, currents and depth in order to identify optimal sites for fish farms in the coastal zone.

Complex topography

The seabed off the Norwegian coast is characterised by deep fjords and shelf areas (deeper than 200 m) and the habitats are complex and not easily documented using only standard sampling gears. That is why a video-platform has been built, with a high-resolution video camera and sensors enabling quantitative estimates of epibenthic megafauna. (Figure A7.4)

In the deeper parts of the Norwegian coast and shelf, coral- and sponge-communities are quite abundant. The distribution of these and other habitats, and observed effects of fisheries are examples of valuable information that will be obtained by this new equipment. (Figure A7.5)

Joint effort

MAREANO is a multi-disciplinary programme, bringing together biologists from the Institute of Marine Research and geologists from the Geological Survey of Norway, and the Hydrographic Service. A number of other partners will also participate in the field work and contribute to the MAREANO database.

Financing is provided by the ministries of the Environment, Fisheries and Coastal Affairs, Trade and Industry and by the Research Council of Norway through the new Marine and Coastal Programme.

More about MAREANO:

www.mareano.no (Norwegian website)

www.imr.no/english/activities/mareano

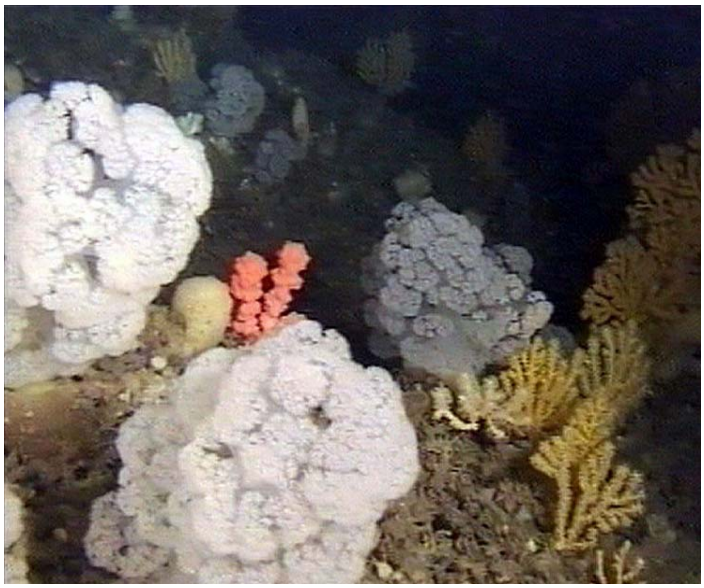


Figure A7.1: Previous mappings of the seabed by IMR have resulted in discoveries of large cold-water coral reefs off the Norwegian coast. The corals constitute a rich habitat for a number of other species.

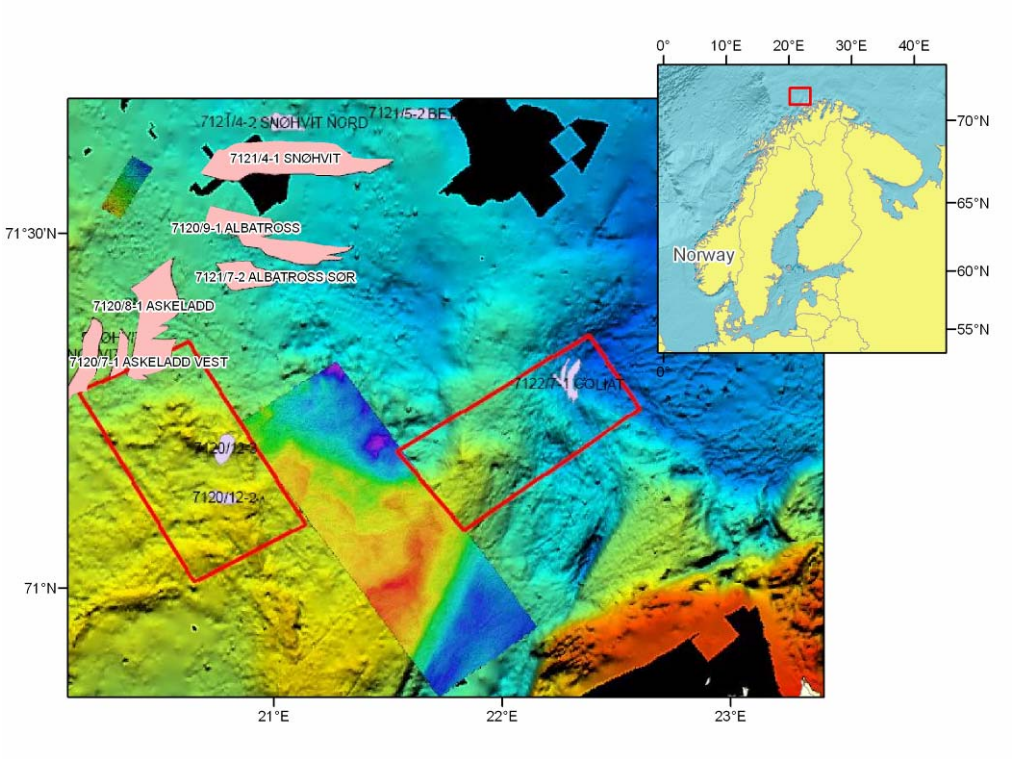


Figure A7.2: In 2006 MAREANO will map bottom fauna and habitats within the area mapped with multibeam echosounder in 2005 (middle rectangle with strong colours). The red rectangles on either side have been mapped with multibeam echosounder this spring and will be part of the 2007 programme for fauna and habitat mapping.

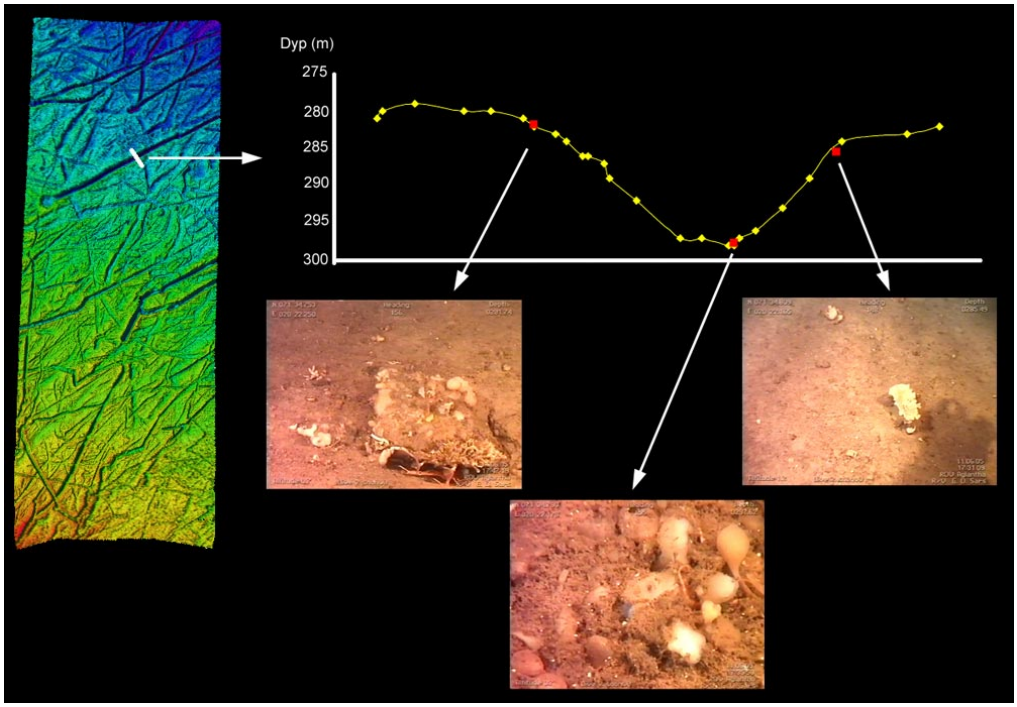


Figure A7.3: Map made by multibeam echosounder in the Snøhvit area (left). It shows a web of ~15 m deep iceberg furrows. The white line indicates the locations of a transect where observations were made using video. The depth-profile of the transect is shown to the right with photos taken at the sites marked in red beneath. On the sides of the furrow sponges are common while dense occurrences of brachiopods are found in the bottom.

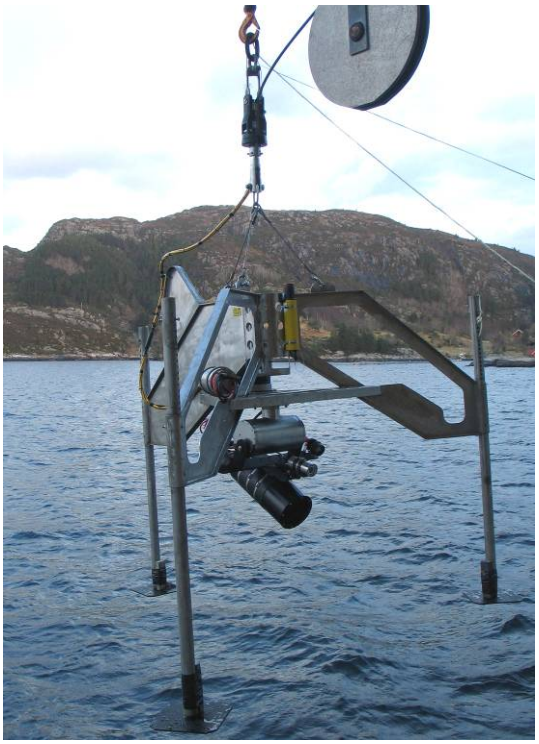


Figure A7.4: Video-platform with high resolution video camera and sensors enabling quantitative estimates of seabed substrates and abundance of epibenthic megafauna.

Figure A7.5: Remains of a Lophelia reef that has been heavily trawled, leaving it as a pile of rubble.

Annex 8: Barents Sea Data

By L. Buhl-Mortensen.

The Institute of Marine Resources has been collecting benthic samples in the Barents Sea on the yearly survey (see Figure A8.1) this is done in close collaboration with the Russian institute PINRO. The samples collected in 2005 are listed in the table. In 2006 the plan is to sample 12 stations with grab and video. At present only bottom-trawl by-catches have been analysed (Figure A8.2). This joint sampling program together with PINRO will, together with the habitat mapping programme MAREANO, produce new information from the area in the years to come.

Table A8.1 Overview of samples collected with different gear used onboard the five research vessels involved in the ecosystem survey. Number of replicates is given in parenthes

	VESSELS				
Equipment	*GO Sars*	*Johan Hjort*	*Jan Mayen*	*Fritjof Nansen*	*Smolensk*
Grab (0.1m²)				58(282)	
Grab (0.25m²)	12 (50)				
RP sledge	11				
Video rig	23				
Sigsby trawl				60	
Beam trawl	18				
Campelen trawl	122	80	20	90	154

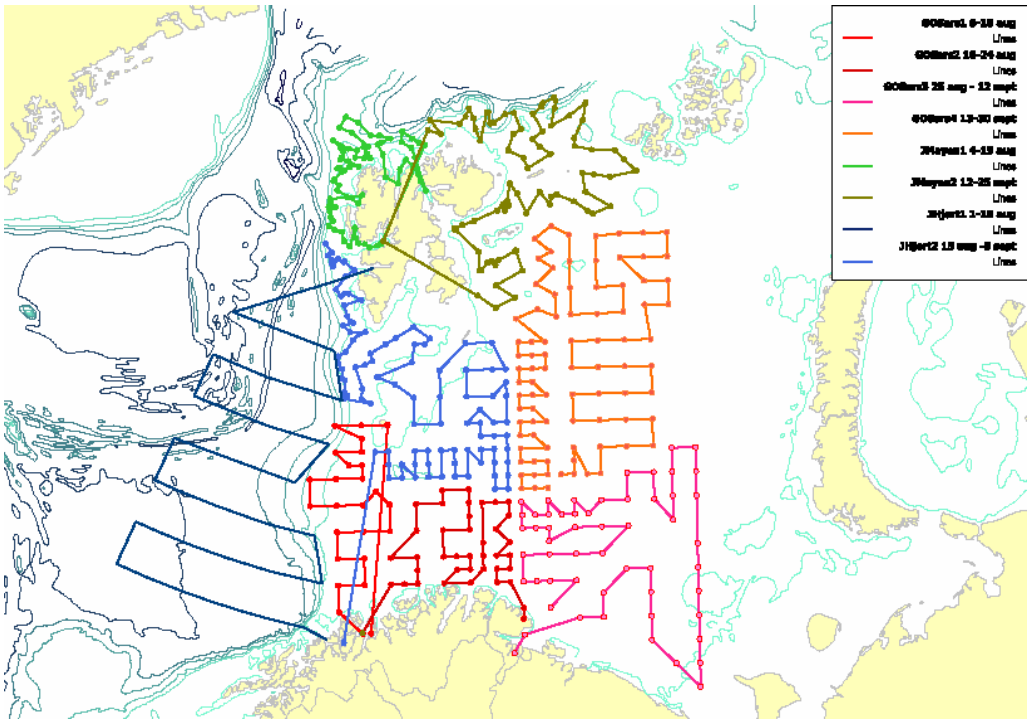


Figure A8.1: Cruises in the Barents Sea in 2005 arranged by Institute of Marine Research in collaboration with PINRO.

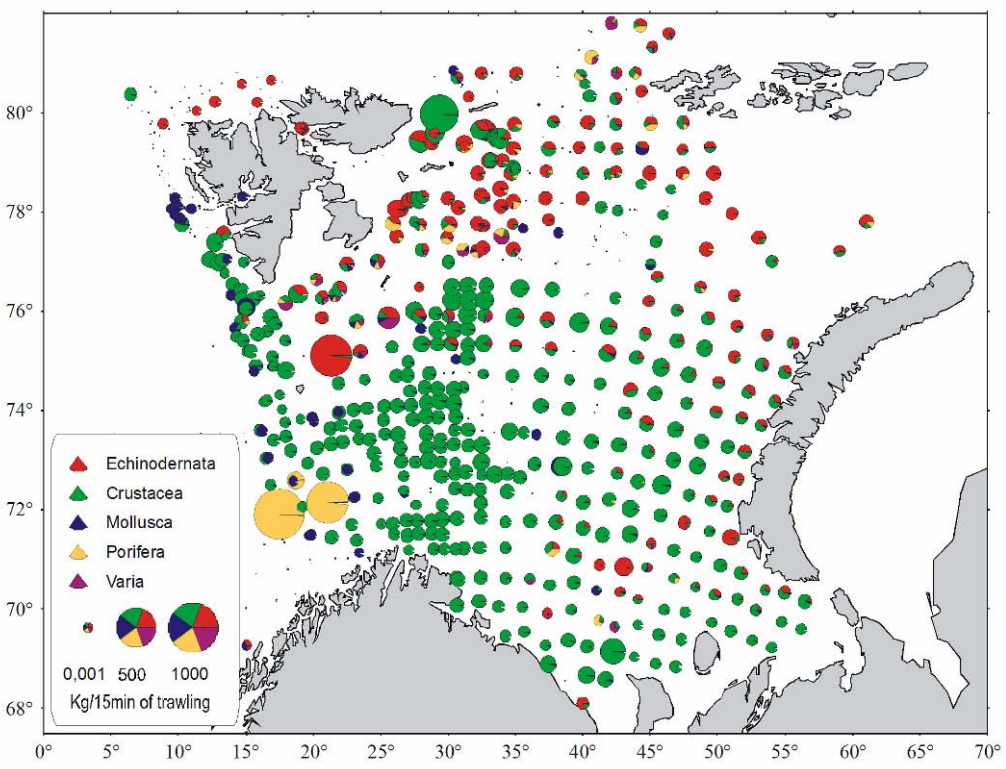


Figure A8.2: Composition of bottom organisms in by-catch from bottom-trawl in the Barents Sea.

Annex 9: Recent benthic research in the Russian part of the Baltic Sea

by Marina Orlova, Elena Ezhova and Nikolai Kovaltchouk

The eastern part of the Gulf of Finland

Natural gradients and their impacts on benthos.

The water regime and life in the Neva Estuary are strongly dependent on discharge of three major Rivers. Of them the Neva River is the largest one with catchment area exceeding 280,000 km^2. EGOF shows significant variations in abiotic and biotic conditions both in space and time (Davidan and Savchuk 1997). The freshwater Neva Bay is separated from other regions of the estuary by storm-surge barrier since 1980s. Salinity varies from fresh water conditions in the Neva Bay to 2–4 PSU on the surface and up to 5–6 PSU at the bottom to the west and south. The area is non-tidal, but water level fluctuations (about 1 m) induced by wind actions, seiches and changes of the Neva River runoff are common. Ice usually covers the area from December to April and its thickness reaches 70–80 cm. Deep part of the EGOF is stratified, hypoxia is not expressed as strong as in other parts of the Gulf of Finland. Inflows salt water happen every several years cause temporary decrease of oxygen concentration with following rapid decrease (till extinction) of biomass of benthic organisms (MERI, 2005)

More then 80% of species in seaweed associations and in macrozoobenthos are freshwater. Number of marine and brackishwater species increases to the west following increase of salinity of water Figure A9.1). Littoral zone (0–1.5 m depth) is covered by plant vegetation (Koreliakova, 1987; Back *et al*., 2001), macrozoobenthos here harbors the highest number of species (Figure A9.2) due to insect larvae, which dominate communities together with Oligochaeta and gammarid amphipods. The latter group impacts strongly the variations in community structure through the warm season ((Berezina *et al*., 2005). At depth of 2–7 m at hard and mixed bottoms sessile filter-feeders (bivalve *Dreissena polymorpha* (zebra mussel) and barnacle *Balanus improvisus*) dominate communities, playing a role of habitat engineers (Orlova *et al*., 2006). At deep parts in brackishwaters in favorable oxygen conditions, the communities are consisting of few opportunistic species (Davidan, Savtchuk, 1997; Maximov, 2006 in press). Of them crustaceans *Pontoporeia affinis* and *Saduria entomon*, had dominant position before 1980s, like in other parts of the Gulf of Finland and in Bothnian Sea (MERI, 2005; 2006)

Increasing shipping and associated problems.

Increased cargo shipping in the EGOF is considered as effective vector of non-indigenous species (NIS) introductions (in ballast waters and ship fouling), like in other parts of the Baltic Sea (Leppakoski *et al*., 2002). The xenodiversity in benthic macrofauna is the highest in comparison to other living associations (Orlova *et al*., 2006, see also Table 1). Many of NIS are established due to both their biological peculiarities and long-term transformations occurring in communities and induced by human (Krylov *et al*., 2004). Several non-indigenous species, including zebra mussel (*Dreissena popymorpha*) impact species diversity and community functioning (Orlova *et al*., 2006). Construction and exploitation and seaports and harbors is expected to cause destroy of benthic habitat and suggested decrease of diversity and abundance in communities due to dredging and deposition and other effects and becomes one more reason for concern at the area (Figure A9.3).

Eutrophication

This is contributed from various outer sources (Basova, 2006) and is facilitated by some physical (Rybalko *et al.*, 2006) and biological processes (e. g. nutrient release from zebra

mussel populations (Orlova *et al*., 2004)) occurring at the bottom. Observed high biomass of sessile filter-feeders (Figure A9.4) at areas referred as eutrophicated (Basova, 2006) is, probably, one of ecosystem responses to this process. More rapid response is massive development of filamentous algae in littoral zone (Back *et al*., 2001). Decline in populations of important soft bottom species - *Monoporeia affinis* and *Saduria entomon* and decrease of total abundance of macrozoobenthos at soft bottoms over time (Figure A9.5) may be addressed to accumulation of organic matter in bottom sediments combined with other effects (e.g. oxygen deficit, establishment of invasive species).

Extraction of mineral resources can be considered as one more source of disturbance of benthic habiatat. Experimental extraction of ferro-manganese concretes has demonstrated complete destroy of benthic community benthos with successive recover of taxonomic content (Filippov *et al*., 2006).

South-East Baltic Sea (Russian sector).

Open Coast

Open coast is characterized by rather stable salinity condition (6-8 PSU), soft sandy bottoms prevail, hard bottoms located along the northern coast of the Sambian Peninsula. Area is exposed to moderate eutrofication, amber mining and coastline restoration. Benthos is represented by four typical communities - *Mytilus edulis, Macoma baltica, Mya arenaria* and community dominated by spionid polychaetes (Figure A9.6).

Lagoons

The *Curonian Lagoon* is shallow and hypereutrophic in its Russian part. Dramatic changes in the macrozoobenthos (exctinction of long-living species, decrease of species richness and biomass, displacement of four major associations by association of Oligochaeta+Chironomida) occur since mid part of 20 century. Vistula Lagoon is also shallow water body, eutrophic, and under strong impact of non-indigenous species. Of them north American polychaete worm *Marenzelleria neglecta* has colonized entire lagoon and plays now an important role in transformation of benthic habitats and communities (Ezhova *et al*., 2003) (see also Figure A9.7). Also important record of new parasites of has been recently done in North American gammarid *Gammarus tigrinus* (Dr. G. Rodjuk, pers.comm.)

References

Back, S., Orlova, M., Anokhina, L., Panov, V., Telesh, I., Ignatieva, N., and Dernjatin, M., 2001. Finnish–Russian Co-operative Research on Littoral Ecology in the Neva Estuary. Finnish Environmental Institute, Helsinki, Finland, 56 p.

Basova, S.L. 2006 Monitoring of the Gulf of Finland in 2005 year. VII international environmental forum Baltic Sea Day, St. Petersburg, 22–23 March 2006. Book of abstracts.

Berezina N, Golubkov S. and Gubelit J. 2005. Grazing Effect of alien Amphipods on macroalgae in the littoral zone of the Neva Estuary (eastern Gulf of Finland, Baltic Sea). Oceanological and Hydrobiological Studies, 34 (1): 63–82.

Davidan, I.N., and Savchuk, O.G. 1997. International project ‘‘Baltica’’. Problems of research and mathematical modelling of the Baltic Sea ecosystem. Issue 5, Ecosystem models. Assessment for the modern state of the Gulf of Finland, part 2 (in Russian). Hydrometeisdat Publishers, St-Petersburg, Russia 206 p (in Russian).

Ezhova, E.E., Rudinskaya, L.V., and Pavlenko-Liatun, M.V. 2003.Structure and functioning of estuarine ecosystems. 4.2.3. Macrozoobenthos. Ed. by A.F. Alimov M.B. Ivanova. *In* Regularities of hydrobiological regime in water-bodies of different types. Moskow, “Scientific world”, 146–163 (in Russian).

Filippov, A.A., Namiatov, A.A., Lange, E.K., Stogov, I.A., Chivilev, C.M. 2006 Transformation of plankton and benthos in the eastern Gulf of Finland under influence of extraction of ferro-manganese concretes. VII international environmental forum Baltic Sea Day, St.Petersburg, 22–23 March 2006. Book of abstracts.

HELCOM. 2004. Dioxins in the Baltic Sea. Helsinki Commission, Helsinki, Finnland. Available at www.helcom.fi.

Koreliakova, I.L. 1987 Macrophyte vegetation in the eastern Gulf of Finland. Leningrad, Gosniorch, 158 p. (in Russian).

Krylov, P.I., Bolshagin, P.V., Panov, V.E., Bychenkov, D.E., Naumenko, E.N., and Polunina, J.Y. 2004. Invasions of predaceous planktonic Cladocera and causes of their success. Ed. by A.F. Alimov and N.G. Bogutskaya. *In* Biological invasions in aquatic and terrestrial ecosystems/ Moskow, KMK Scientific press Ltd., 100–129 (in Russian)

Leppakoski, E., Gollasch, S., Olenin, S. 2002. Invasive Aquatic Species of Europe.Distribution, Impacts and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Maximov, A.A. 2006. (in press). Modern state of macrozoobenthos in the eastern Gulf of Finland. Annual reports of ZIN RAS. St-Petersburg, Russia.

MERI, 2005a. State of the Gulf of Finland in 2003 year, FIMR, #53.

MERI, 2005b. State of the Gulf of Finland in 2004 year, FIMR, #55.

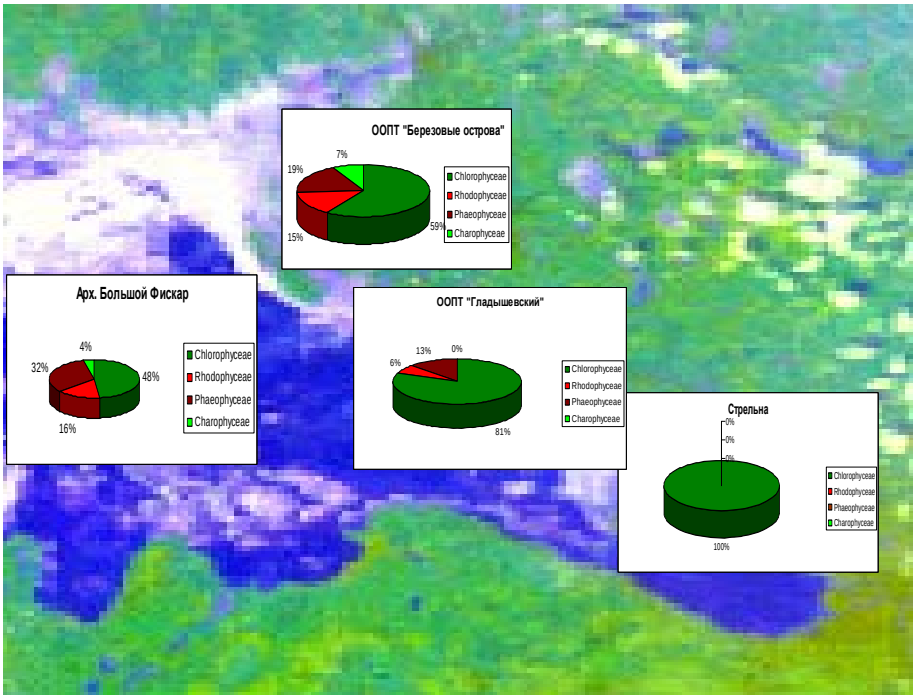
Orlova, M.I., Telesh, I.V., Berezina, N.A., Antsulevich, A.E., Maximov, A.A., and Litvinchuk LF. 2006. Effects of nonindigenous species on diversity and community functioning in the eastern Gulf of Finland (Baltic Sea). Helgol Mar Res (2006), DOI 10.1007/s10152-006-0026-7

Rybalko, A.E., Korbeev, O.Y., Fedorova, N.K., Subetto, D.A. 2006 Dynamics of bottom sediments' and upper bottom waters' quality in the estarn Gulf of Finland for the period of 2000–2005 by state geological monitoring. VII international environmental forum Baltic Sea Day, St. Petersburg, 22–23 March 2006. Book of abstracts.

Telesh, I.V. 2004. Plankton of the Baltic estuarine ecosystems with emphasis on Neva Estuary: a review of present knowledge and research perspectives Mar. Poll. Bull. 49: 206–219.

Table A9.1. Non-indigenous free-living species (NIS) contribution into species diversity at the study area by the results for 2004–2005.

LIVING ASSOCIATION	TOTAL NUMBER OF SPECIES	NUMBER AND % OF NIS
Phytoplankton	147	0 (0)
Macrophyte vegetation in littoral zone)	69	3(4)
Zooplankton (with no larvae of benthic NIS)	186	4(2)
The same with pelagic larvae of benthic NIS	190	7(3)
Macrozoobenthos (to include fouling and necto-benthic organisms)	210	22 (9)



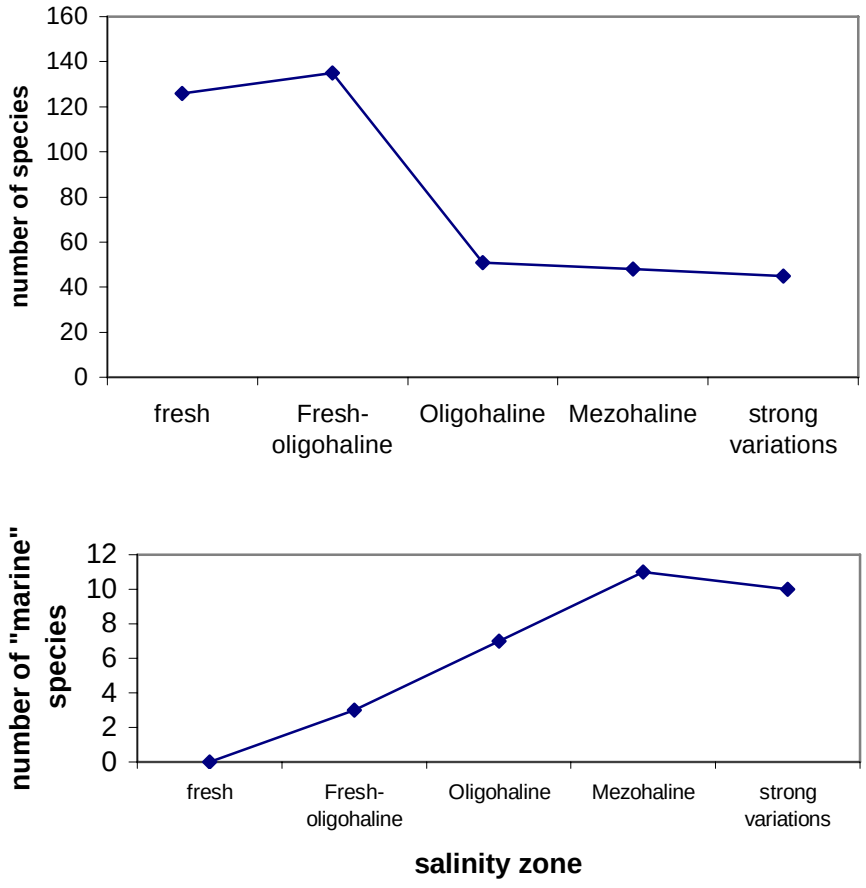


Figure A9.1: Salinity and taxonomic composition of benthos (upper panel: seaweeds; below: macrozoobenthos) by data of 2004–2005 years.

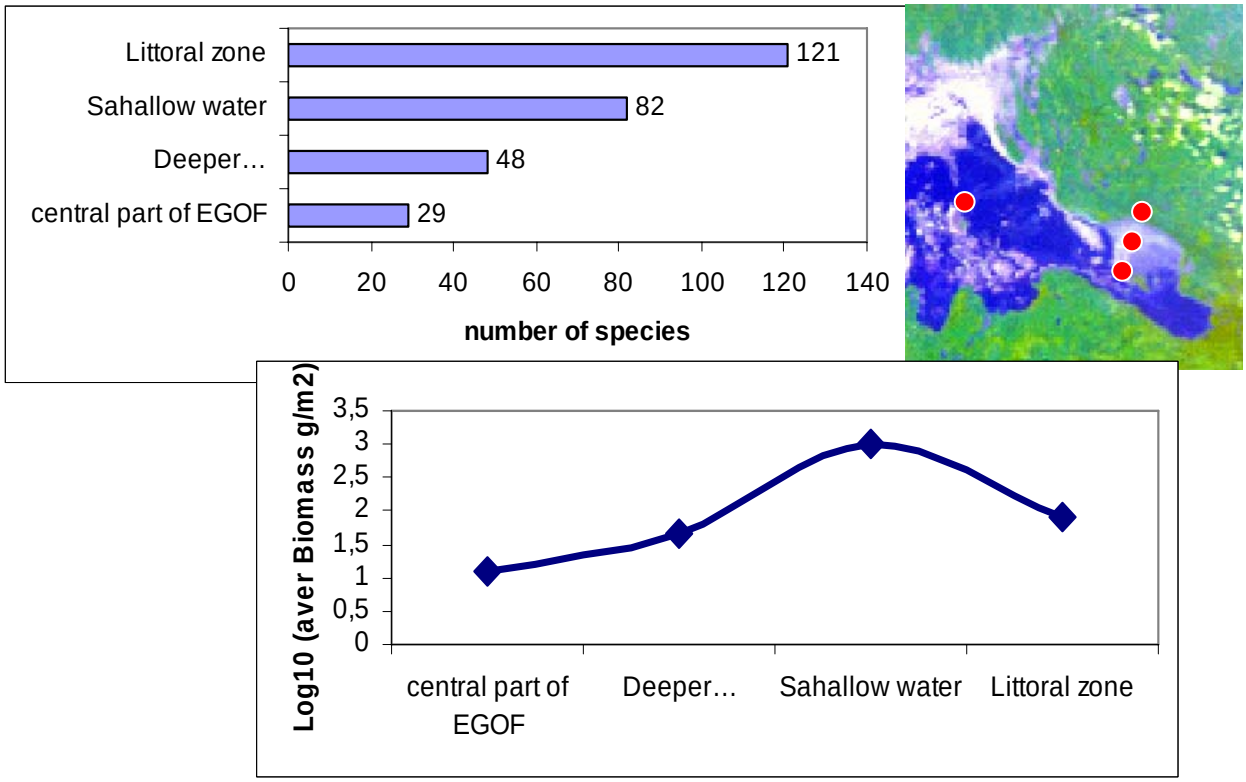


Figure A9.2: Vertical distribution of species number and biomass (log10) of macrozoobenthos in EGOF (2004-2005).

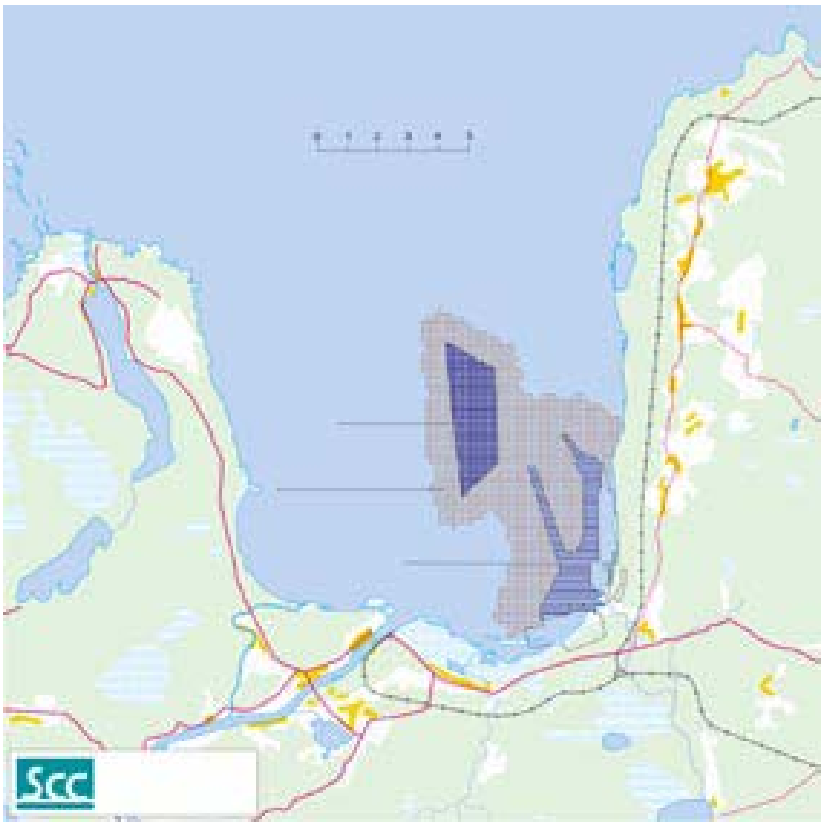


Figure A9.3: Dredging, deposition areas (blue dark) and areas with increased turbidity of water (grey) – at area of construction of Ust-Luga terminal (Project, June 2003).

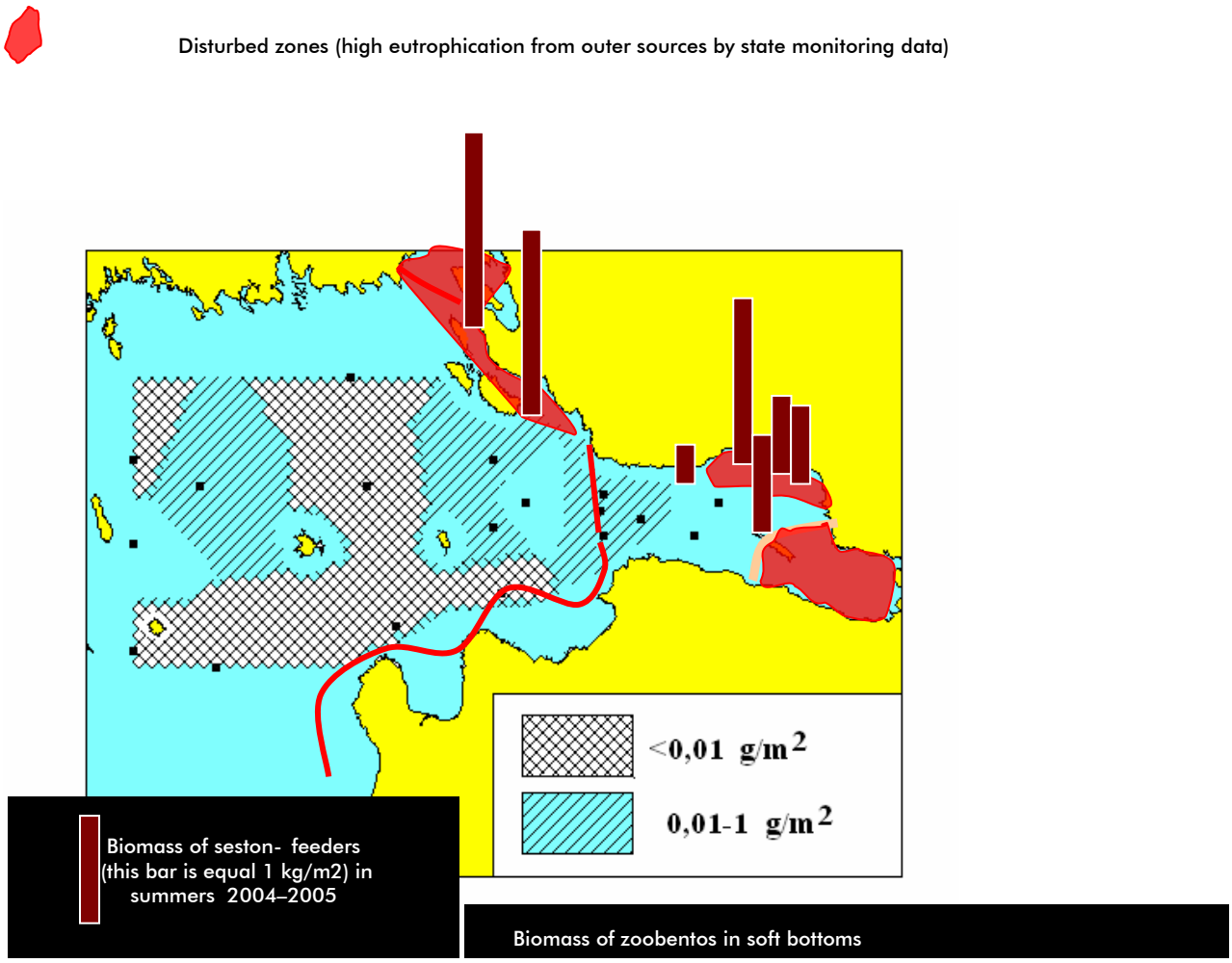
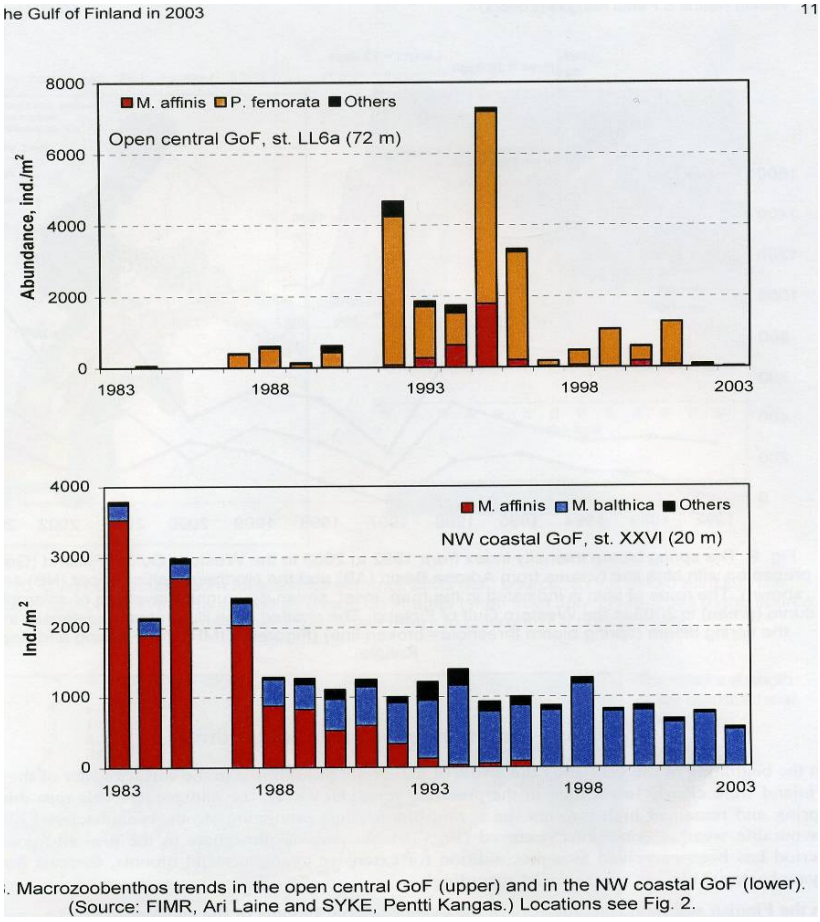


Figure A9.4. Eutrophied areas (in red) and biomass of filter feeders – *Dreissena polymoprha* (in fresh to oligohaline conditions) in *Balanus improvisus* (in areas with salinity > 2 PSU).



. Macrozoobenthos trends in the open central GoF (upper) and in the NW coastal GoF (lower). (Source: FIMR, Ari Laine and SYKE, Pentti Kangas.) Locations see Fig. 2.

Figure A9.5: (MERI, 2005).

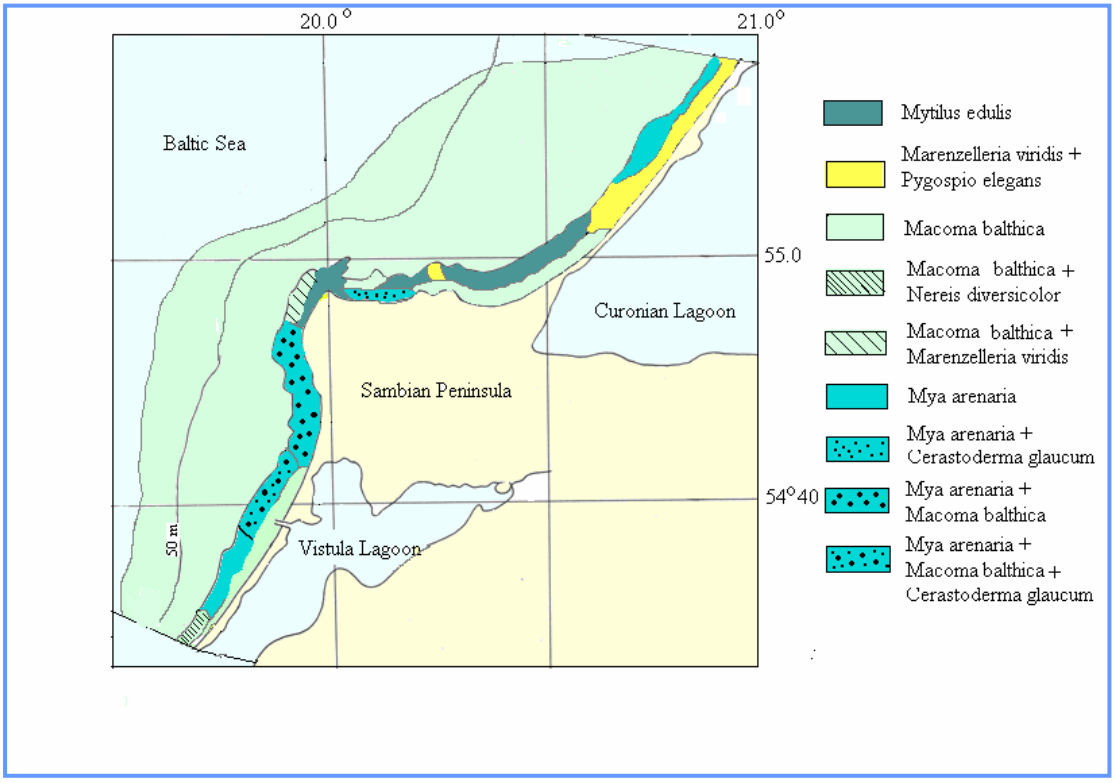


Figure A9.6: Distribution of four major benthic communities along the Kaliningrad coast of the Baltic Sea.

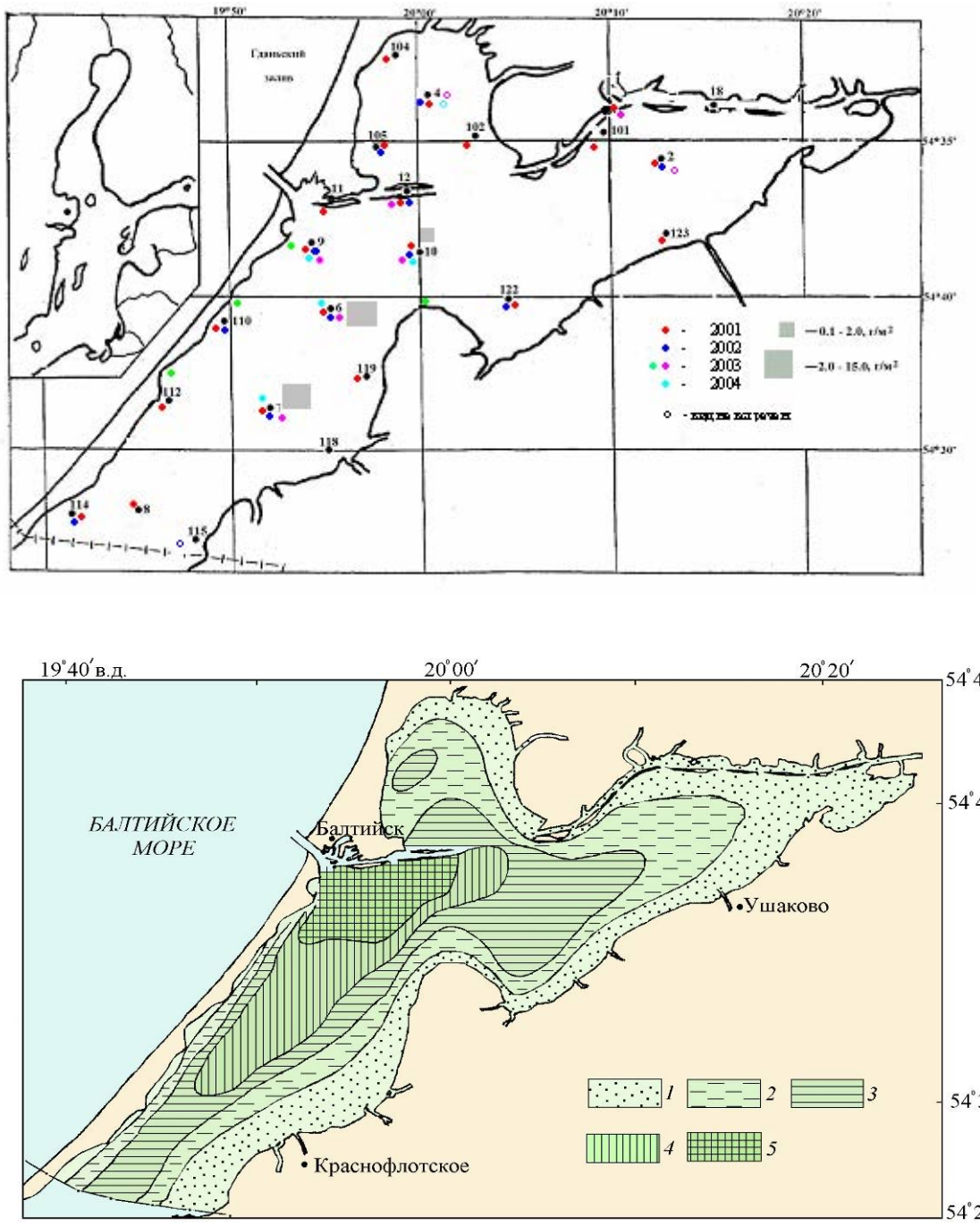


Figure A9.7: Distribution (upper picture) and bioturbation by *Marenzelleria neglecta* in Vistula Lagoon (below pictures, 1-5 scores of bioturbation activity) (Ezhova *et al.*, unpubl.).

Annex 10: ECOMARG PROJECT

ICES Benthos Ecology
Working Group Herakleion,
Crete (Greece), May 2006

- ECOMARG PROJECT
- A multidisciplinary study of the continental margin ecosystem and the impact of its fisheries

Sánchez[1], F., A. Serrano[1], S. Parra[2], M. Gómez[3], A. Muñoz[4], J. E. Cartes[5], J.C. Sorbe[6], I. Preciado[1], J. Acosta[3], I. Frutos[2], C. Pola[7], F. Velasco[1], I. Olaso[1] & A. Punzón[1].

[1]Instituto Español de Oceanografía, Centro Oceanográfico de Santander, 39080 Santander, Spain

[2]Instituto Español de Oceanografía, Centro Oceanográfico de La Coruña, 15001 La Coruña, Spain

[3]Instituto Español de Oceanografía, Sedes Centrales, Corazón de María, 28002 Madrid, Spain

[4]MAPA, Secretaría General de Pesca Marítima, MAP, 28071 Madrid, Spain

[5]CSIC, Centre Mediterrani d'Estudis Marins i Mediambiental, 08003 Barcelona, Spain

[6]CNRS, 75794 Paris Cedex 16, France

[7]Instituto Español de Oceanografía, Centro Oceanográfico de Gijón, 33212 Gijón, Spain

KEY WORDS: Continental margin, Le Danois Bank, Cantabrian Sea, Deep-Sea ecosystem, biodiversity, fisheries impact, trophodynamic model, benthos, suprabenthos.

INTRODUCTION

The study of the effects of fishing activities on marine ecosystems has gained a considerable importance during the last years. Indeed, fisheries management has become an essential tool to maximize the productivity of resources under exploitation, and the direct and indirect effects of these extractive activities on other components of the ecosystem (benthos, non-commercial species, marine birds and mammals) have begun to be considered in global management strategies. Knowledge of the structure and dynamics of marine ecosystems is essential for future resource management if, as recommended by the principles of Sustainable Development, a balance between nature conservation and fisheries economical profit is to be maintained.

The global objective of the ECOMARG project is the integrated study of the benthic-demersal ecosystem in the Galician and Cantabrian Sea continental margins (shelf and slope). It aims to investigate the structure, the components and the dynamic of the Deep-Sea ecosystem (100-1000 m), which is subjected in some measure to numerous human extractive activities. It is also framed within the urgent need to identify, study, and describe vulnerable marine habitats, which are currently more accessible due to the new fishing technologies. These habitats are typically extremely important as a refuge for sensitive species or are essential for juveniles or reproducing individuals of species which are exploited in adjacent areas. At a biological level, the ECOMARG project is mainly aimed at the study of the fauna which is associated with the

sea floor (demersal and benthic), in detriment of the pelagic system, since it is more representative of the particular characteristics of the ecosystem under investigation.

The project envisions a multidisciplinary approach in which all activities proposed by the different research groups will be designed to inter-relate and complement each other, yielding a characterization of the benthic-demersal ecosystem and its synthesized description using trophodynamic metamodels. The results of this project intend to generate data and knowledge databases which are essential to bring into operation the integral management models which will become an indispensable tool to implement a sustainable development of fisheries in the marine ecosystem.

STUDY AREAS

The main working field of the ECOMARG project is the northern shelf of the Iberian Peninsula (Figure A10.1). Its special characteristics, with high values of primary production and consequently important fisheries, are a priority scenary for the research lines of the project. In particular, the continental margin of the Cantabrian Sea presents a set of physiographic and geomorphologic distinctive features that provide it with high biodiversity indices. Namely, it has a very narrow continental shelf (20–40 km), a steep slope (10–12% inclination), extremely narrow and tight submarine canyons which are often arranged obliquely to the general direction of the margin (Avilés, Lastres and Llanes canyons) and marginal shelves (Le Danois Bank, Santander and Ortegal promontories).

Le Danois Bank ("The Cachucho")

As a result of his investigations on board of the oceanographic vessel Président Thédore Tissier between 1934 and 1939, the French researcher Edouard Le Danois discovered the Bank now bearing his name to the scientific community. Since then, the Le Danois Bank, locally known as "The Cachucho" fishing ground, has remained virtually unexplored, in spite of belonging to the Exclusive Economical Spanish Zone, being located at only 30 miles off the Asturian coast and of the fact that it is subjected to important fishing activities. Its origin is related to compressive processes, which caused imbricated over thrusts which in turn produced the rising of the Le Danois Bank, during the Paleogene (Low Tertiary). It is located in the Cantabrian Sea (North of Spain, 5ºW longitude), and has an elongated E-W disposition, with depths on the plain ranging between 450 and 600 m.

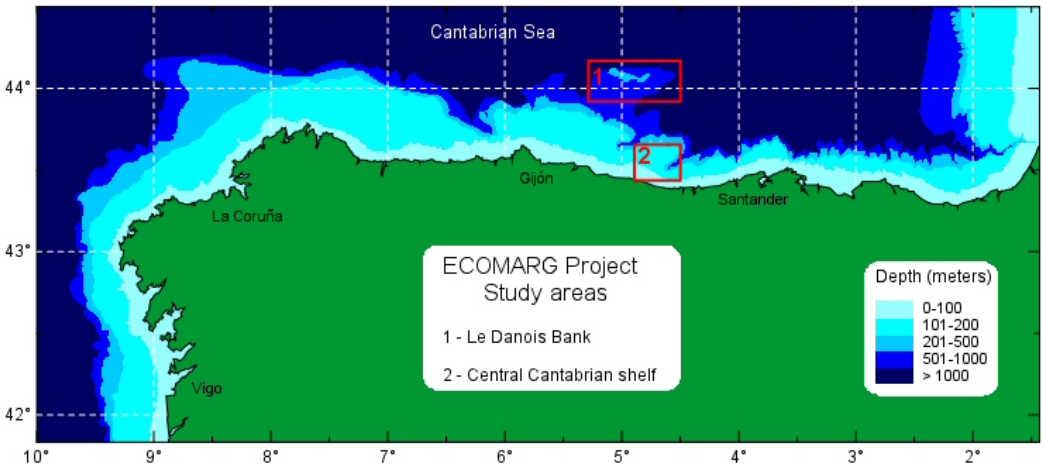


Figure A10.1: Study areas.

The ECOMARG project is achieving important results regarding the geomorphology and physiography of the Le Danois Bank and its adjacent areas, obtaining a detailed cartography of the area, digital terrain models, seismic reflection profiles, etc. The bank presents a noticeable dissymmetry of its Northern and Southern flanks. The Northern façade shows a pronounced slope (the steepest in the Northern Atlantic), which goes from 500 m at the top to more than 4000 m in the abyssal plain, which lies only 5 miles north of it. Its southern façade is softly linked to the inner Asturian basin through a saddle threshold, with depths that exceed 850 m. The general appearance of the top of the bank is a sub horizontal plain with local irregularities, presenting two geomorphologic groups: one with a clear irregular morphology and slight sediment coverage, and another having a more homogeneous appearance, corresponding with typical sedimentary bottoms (Figure A10.2).

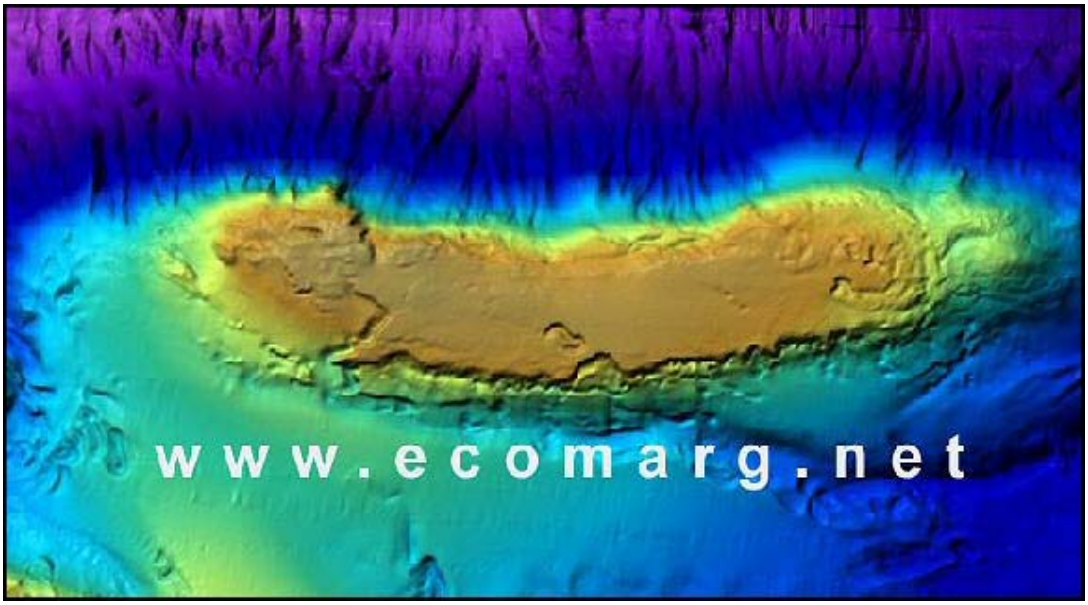


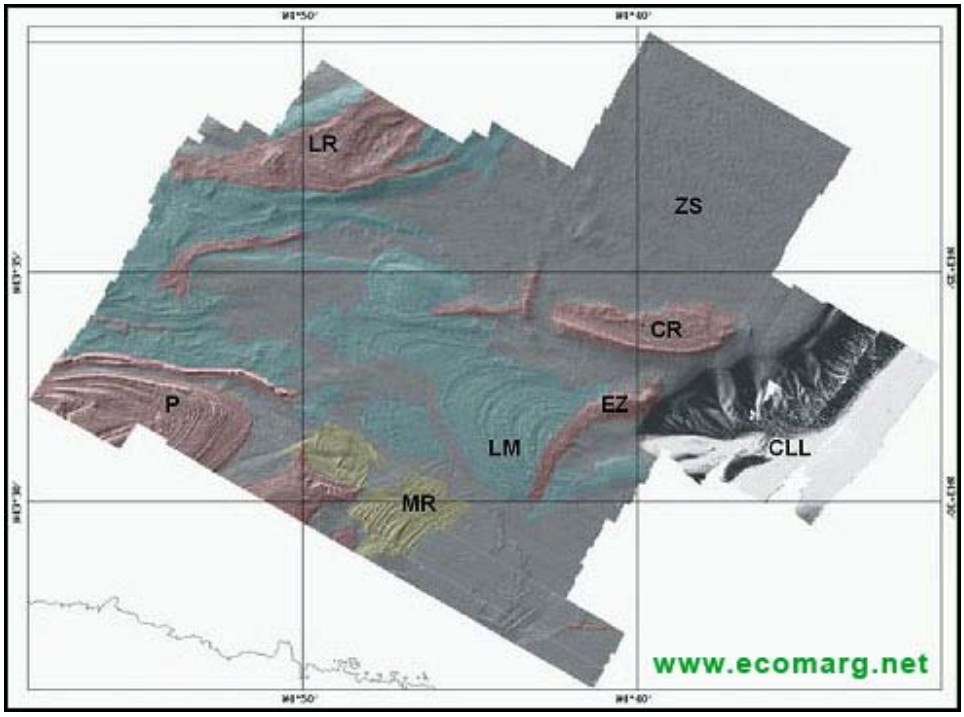
Figure A10.2: Bathymetric map of the Le Danois Bank area.

Cantabrian Sea central shelf

The part of the shelf under study, located facing the village of Llanes, is delimited by two important submarine canyons; the Lastres one to the northwest and the Llanes one to the southeast. These canyons, which are controlled by faults, are the main elements of sediment transference from the continent to the continental shelf and to the deep basins, especially during the Quaternary glacial periods. They are also probably responsible for the slight sediment covering of the area, since they are an important drain of the sediment flowing from the shelf to the great bottoms. In this area of the shelf there are outcrops of Cretacean materials from the inner shelf, which give way to tertiary materials in the middle shelf, and local Cretacean outcrops as the anticline located in the northern margin of the Lastres Canyon.

The geomorphology of this area of the shelf, studied by the ECOMARG project, is represented in the Digital Terrain Model (DTM), and corresponds to a surface of 616 km2. The shelf shows the existence of four main geomorphologic groups (Figure A10.3):

- Rocky outcrops with important relieves (red color)
  - Hard material alternating lithologies (P)
  - Massive rocky outcrops (LR, EZ , CR)
- Low relief rocky outcrops and slight sedimentary covering (LM, blue color)
- Sedimentary bottoms and forms
- Submarine canyons (CLL)
  - Flat bottoms with unconsolidated sediments (ZS, gray color)
  - Mega ripples and sand dorsals (MR, yellow color)



FigureA10.3: Digital model of the central continental shelf of the Cantabrian Sea.

RESEARCH

The ECOMARG project envisions multidisciplinary studies in the selected areas in which all proposed activities for the different research teams are designed to inter-relate and complement each other, resulting in a characterization of the benthic-demersal ecosystem, including habitat description, biodiversity, structure and dynamic and synthesized description using meta-models.

In a first phase, the project studies the morpho-sedimentary and bathymetric characteristics of the study area. Further on, it aims at the integrated study of the communities of the three main components of the benthic domain (infauna, epifauna and suprabenthos) and demersal fish, based on the systematic determination of the involved taxa, and the joint analysis of abundance and biomass quantitative data and abiotic factors of the water column and the sediment, as determinants of its variability.

This methodological approach offers an overview of the biodiversity of the ecosystem and the structure and distribution of its communities. The trophic ecology of the dominant fish and crustacean species is used to estimate the energy fluxes, the consumption, and niche overlap between higher trophic groups. All this information, together with the analysis of the impact of the fisheries being carried out in the area, are integrated in a mass balance trophodynamic model (Ecopath) which allows explanation and synthesis of the characteristics of the ecosystem, comparison with other similar ones and prediction of the consequences of the putative management measures which may be adopted in each particular area.

The main objectives of the project can be summarized as follows:

Morpho-sedimentary study of the continental margin

The morpho-sedimentary study is carried out using bathymetric prospecting with 100% covering of the sea floor by means of a high-resolution multibeam echosounder to provide cartography (digital terrain models) and identification of the morphological elements of the study area. To identify the units and thickness of recent unconsolidated sediment sequences we use a high-resolution parametric reflection continuous seismic profiling system. We also

construct sonographic mosaics of the area based on acoustic reflexion, which are complemented with direct data as visual sampling (photo and video). The application of automatic texture classification programs of the sea floor is an important methodological improvement since it includes direct data (trawl sampling, photogrammetry, ROV, etc) of the different types of sea floor, allowing calibration and supervision of the system.

Dynamic and characteristics of the water masses in the study areas

The hydrographic study includes acquiring knowledge of the topographic effects produced by the continental shelf and the slope over the general current dynamics, which are predominantly W-E directed (Christmas current, slope current, Mediterranean water vein, etc…) and whose flux alterations may generate vertical transport phenomena and a mixture of the previously described water masses, hence conditioning the productivity of the area and its surroundings. Since this project is aimed at the benthic ecosystem, we will focus on the characteristics of the water which is close to the sea bed (Benthic Boundary Layer) as determinant of the communities inhabiting these areas and possible cause of their variability.

Characterization of benthic and demersal communities

The analyses of the communities that inhabit the study areas are undertaken according to the information provided by the geophysical studies, and are mainly directed to benthic megafauna and demersal fish. In the first case we include the study of the three principal compartments of the benthic domain: the endobenthic communities of sediment bottoms and the epibenthic and suprabenthic communities, both of soft and rocky bottoms. This study will be based in the systematic determination of taxa accessible with different sampling methods and at common stations, and the joint quantitative analysis of abundance and biomass together with abiotic factors from the water column and the sediment. The integrated data treatment will allow us to obtain an overview of biodiversity of the benthic ecosystem and determine the putative environmental factors responsible for the distribution and structuring of the different community types.

Trophic ecology of fish and crustaceans

Predator-prey relations play a fundamental role in defining the dynamics of the ecosystem, since they condition the energy transfer cycles among the different trophic groups present in the area and are necessary for the design of trophodynamic models. The study will be tackled using stomach content analysis of the main demersal fish occupying the top of the trophic chain, and decapod crustaceans dominating the community with an important role as scavengers or predators.

Study of the impact of fisheries working in the area

Knowledge of the impact of fisheries on bottom communities is essential to explain current biomass and energy flux balance between the different compartments (particularly the upper levels), of the trophic chain. The project attempts to unravel which fishing activities operated in the past, which take place nowadays, and which species are exploited or discarded by the commercial fleets, in order to be able to interpret the impact they may be causing on each particular ecosystem. In this context, we perform experiments to discern the impact of certain trawling modes such as the rock-hopper, which may operate in vulnerable or sensitive bottoms.

Generate trophodynamic models of the ecosystem

The integrating objective of the results obtained by the ECOMARG project is the general description of the ecosystem by means of a trophodynamic model. The use of mass balance metamodels, such as ECOPATH, has produced a considerable advance in understanding the

cascading dynamic processes through the different trophic levels in many ecosystems. It has also permitted the generation of indices and descriptive parameters that characterize these ecosystems, allowing comparisons among them. At the same time these models provide estimations of the complexity of internal fluxes and niche overlap that may be correlated with stability and maturity of the ecosystem. These models allow integration of the information from fisheries which in turn permits quantification of their direct and indirect impact on each of the components of the ecosystem (Sánchez & Olaso, 2004). These impacts may be modeled in space (ECOSPACE) and time (ECOSIM) to estimate the consequences of particular management measures or environmental changes. Due to all these features, models are used in environmental impact evaluation both from fisheries and contaminating spills, using the strategy of comparing between previous and after disturbance trophodynamic structures and analysing the evolution of the relative importance of the biomass of the various trophic compartments after the disturbance.

Writing proposals for sustainable development

The final objective of the ECOMARG project is to provide realistic scientific advice regarding the status of the ecosystems under exploitation, taking into account a responsible use of resources. This means taking into consideration the principles adopted by FAO in 2002, in the Reykjavik declaration, and which in summary imply that fisheries management must contemplate:

- Incorporate ecosystem considerations
- Take into account the impacts of fisheries on the marine ecosystem
- Take into account the impact of the marine ecosystem on fisheries
- Contribute to the effective conservation of the ecosystem and its resources

The failure to consider these simple principles during decades has led a considerable number of fisheries to an appalling state, with very bad consequences both for the marine ecosystem and for the economy of coastal populations. The ECOMARG project attempts, by studying and identifying:

- The role of habitat
- The structure, components and functioning of the marine ecosystem
- Species interactions and predator-prey relationships
- The relevant biological, physical and oceanographic factors

In combination with the available information from the systematic monitoring of natural variability, ecosystem productivity and data from the fisheries (landings, by-catch and discards); to propose management measures directed to the establishment of marine protected areas (MPAs), limitations on effort (in those cases in which it surpasses the ecosystem´s production capacities) and/or changes in the exploitation strategies (more in accordance with the real possibilities of each ecosystem).

The project includes important technological innovations, which are necessary to tackle the study of deep hard bottoms. Among them, the use of digital photogrammetry aided by laser should be highlighted. Another important achievement of this project is that the first deep immersions using a ROV were undertaken. This allowed us to reach rocky bottoms down to 620 m, which are difficult to access using conventional quantitative samplers, and hence become acquainted with the communities present in these areas.

GENERAL SAMPLING METHODS

The great variability of habitats in the study area causes a wide variety of morphologies and behaviours of the species inhabiting them. Therefore, it is essential that different sampling systems are used so that all the information needed to understand the functioning of the ecosystem can be accessed. The methodology used by ECOMARG contemplates sampling the

different compartments of the benthic domain. Epibenthos and demersal fauna are sampled using three different trawling gears: the Porcupine Baca trawl, the rockhopper and the beam trawl. The former two are characterized by a high efficiency in capturing large-sized demersal swimming species, and a lower one for epibenthic species. The Porcupine Baca trawl is used in soft bottoms, while the rockhopper is used in rocky ones. The beam trawler is more efficient for epibenthic fauna: flat fish and occasional swimmers, sessile species and small invertebrates. In rocky ledge areas qualitative sampling is conducted using a rock dredge. Endobenthos is sampled using a megabox-corer, while suprabenthos is sampled using an Arcachon type sledge. The benthopelagic plankton is captured with a WP2 type net. Sampling by trawling and dredges is complemented with visual techniques: photogrammetry sledges (TFS-1 and TFS-2) and remotely operated vehicles (ROV). Once on board samples are classified at the lowest taxonomical level possible, size distributions are obtained and the stomach contents analysed.

INFORMATION ANALYSIS

The inventories from the biological treatment of the samples are stored in a database from which precise matrices will be extracted for each statistical analysis. The importance of species is expressed as a function of their frequency and relative abundance in number or biomass (number of individuals or biomass per surface unit for the epibenthos and demersal fauna, and per volume unit for the endobenthos, suprabenthos and benthopelagic plankton). The different ecological indices are obtained from the ecological matrices per haul. The ECOMARG philosophy consists of integrated analysis of the biological and physical elements of the ecosystem. Thus, statistical analyses are aimed at interpreting the faunistic variability in relation to environmental data. Community structure is investigated using hierarchical ordination techniques and its relation to environmental data using canonical analysis. The spatial distribution of the communities and its relation to environmental variables will also be analysed using geostatistical techniques. The final aim of the project is integration of all this information into a trophodynamic model.

The Galician and Cantabrian Sea shelves ecosystems have been studied and catalogued by the Instituto Español de Oceanografía (IEO) since 1983 by means of bottom trawling surveys. We have temporal series of georeferenced data of species richness and diversity. Transition ecosystems between the shelf and the slope have received less attention even if with the ECOMARG project a new research line has been started. The multidisciplinary methodological approach which characterizes the project is providing valuable information regarding the endobenthic, epibenthic and suprabenthic communities. The lists linked in http://www.ecomarg.net/biodiversidad_en.html enumerate all catalogued species to date in the study areas.

RELATED PUBLICATIONS

Cantabrian sea shelf:

Olaso, I., Velasco, F. & Pérez, N. 1998. Importance of discarded blue whiting (*Micromesistius poutassou*) in the diet of lesser spotted dogfish (*Scyliorhinus canicula*) in the Cantabrian Sea. *ICES Journal of Marine Science*, 55: 331-341.

Olaso, I., F. Sánchez, C. Rodriguez-Cabello & F. Velasco, 2002. The feeding behaviour of some demersal fish species in response to artificial discarding. *Scientia Marina*, 66: 301-311.

Olaso, I., F. Velasco, F. Sánchez, A. Serrano, C. Rodriguez-Cabello and O. Cendrero, 2004. Trophic Relations of Lesser-Spotted Catsherk (*Sciliorhinus canicula*) and Blackmouth Catshark (*Galeus melastomus*) in the Cantabrian Sea. Journal of Northwest Atlantic Fisheries Science, Vol 35: 481-494.

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

Sánchez, F., N. Pérez y J. Landa, 1998. Distribution and abundance of megrim (*Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*) on the northern Spanish shelf. *ICES Journal of Marine Science,* 55: 494-514.

Sánchez, F. y J. Gil, 2000. Hydrographic mesoscale structures and Poleward Current as a determinant of hake (*Merluccius merluccius*) recruitment in southern Bay of Biscay. *ICES Journal of Marine Science*, 57: 152-170.

Sánchez, F. and A. Serrano, 2003. Variability of groundfish communities of the Cantabrian Sea during the 1990s. Hydrobiological Variability in the ICES Area, 1990–1999. *ICES Marine Science Symposia,* 219: 249-260.

Sánchez, R., F. Sánchez and J. Gil, 2003. The Optimal Environmental Window that controls hake (*Merluccius merluccius*) recruitment in the Cantabrian Sea. Hydrobiological Variability in the ICES Area, 1990–1999. *ICES Marine Science Symposia*, 219: 415-417.

Sánchez, F., M. Blanco & R. Gancedo, 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. *Ed. CYAN (Inst. Esp. Oceanogr.):* 158 pp.

Sánchez, F., F. Velasco, J.E. Cartes, I. OLaso, I. Preciado, E. Fanelli, A. Serrano and J.L. Zabala, 2005. Monitoring the *Prestige* Oil Spill Impacts on some Key Species of the Northern Iberian Shelf. *Marine Pollution Bulletin*, Prestige special issue (in press).

Serrano, A., F. Velasco, I. Olaso & F. Sánchez, 2003. Macrobenthic crustaceans in the diet of demersal fish in the Bay of Biscay in relation to abundance in the environment. *Sarsia* 88: 36-48.

Serrano, A.; Velasco, F. & Olaso, I., 2003. Polychaete annelids in the diet of demersal fish from the southern shelf of the Bay of Biscay. *J. Mar. Biol. Ass. U.K.*, 83: 619-623.

Serrano, A., F. Sánchez and G. García-Castrillo, 2004. Epibenthic communities of trawlable grounds of the Cantabrian Sea. *Scientia Marina* (in press).

Serrano, A., F. Sánchez, I. Preciado, S. Parra and I. Frutos, 2005. Spatial and Temporal Changes in Benthic and Demersal Communities of the Galician Continental Shelf After the *Prestige* Oil Spill. *Marine Pollution Bulletin*, Prestige *special issue* (in press).

Velasco, F and Olaso, I. 1998. European hake *Merluccius merluccius* (L., 1758) feeding in the Cantabrian Sea: seasonal, bathymetric and length variations. *Fisheries Research*, 38: 33-44.

Velasco, F. and Olaso, I. 1998. Gadoids and clupeoids in John Dory, *Zeus faber* (L., 1758), feeding off Galicia and in the Cantabrian Sea (Northern Spain), *Bol. Inst. Esp. Oceanogr.* 14: 69-79.

Velasco, F., I. Olaso and F. Sánchez, 2001. The role of cephalopods as forage for the demersal fish community in the southern Bay of Biscay. *Fisheries Research*, Vol 52: (2001), 65-77 pp.

Velasco, F., I. Olaso and F. Sánchez, 2003. Annual Variations in the prey of demersal fish in the Cantabrian Sea and their implications for food web dynamics. Hydrobiological Variability in the ICES Area, 1990–1999. *ICES Marine Science Symposia*, 219: 408-410.

Le Danois Bank:

Ballesteros, M., A. Muñoz, J. Acosta & J. Rivera, 2004. Bathymetry of "El Cachucho" (Le Danois bank) area besed on multibeam data. ECOMARG project. *IX Colloquio Internacional del Golfo de Vizcaya* (Pau).

Frutos, I. & J.C. Sorbe, 2004. First observations on the suprabenthic communities from the "Le Danois" bank (caladero "El Cachucho), southern Bay of Biscay. *IX Colloquio Internacional del Golfo de Vizcaya* (Pau).

Guerra-García, J.M., J.C. Sorbe & I. Frutos, (2006). A new species of /Liropus/ (Crustacea, Amphipoda, Caprellidae) from the Le Danois bank (southern Bay of Biscay). *Organisms, Diversity & Evolution*, (accepted April 2006).

Sánchez & Serrano 2004. Rediscovering Le Danois Bank. The epibenthic communities from "El Cachucho", sixty years after the survey of "Président Théodore Tissier. *IX Colloquio Internacional del Golfo de Vizcaya* (Pau).

Serrano, A., F. Sánchez, J. E. Cartes, J.C. Sorbe, S. Parra, I. Frutos, I. Olaso, F. Velasco, A. Punzón, A. Muñoz, M. Gómez, C. Pola & I. Preciado, 2005. ECOMARG Project: A multidisciplinary study of Le Danois Bank (Cantabrian Sea, N Spain*). ICES CM 2005/P*:11, 17 pp.

Sorbe J.C. & I. Frutos, 2004. Primeras observaciones sobre las comunidades suprabentónicas batiales del banco "Le Danois", norte del margen Cantábrico. *XIII Simposio Ibérico de Estudios del Bentos Marino* (Las Palmas de Gran Canaria).

Marine ecosystem modelling:

Sánchez, F. and I. Olaso, 2004. Effects of fisheries on the Cantabrian Sea shelf ecosystem. *Ecological Modelling* 172: 151-174.

Sánchez, F., C. Rodríguez-Cabello & I. Olaso, 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them*. J. Northw. Atl. Fish. Sci.*, Vol. 35: 467-480.

Annex 11: Long-term monitoring of a benthic rocky-bottom community in a high-arctic fjord (Kongsfjorden, Svalbard)

Results from an ongoing long-term monitoring project on benthic rocky-bottom fauna in Kongsfjorden/ Svalbard are presented. The project started in 1980, when a photographical monitoring station at Kvadehuken (78° 58,6' N, 11° 30,1' E) at the southern entrance of Kongsfjorden was established. The monitoring area consists of ten 0.50 x 0.50 cm squares that are located about 300m from the shore in 15m depth. From halve of the squares, all fauna was removed at the beginning of the project, while five squares remained undisturbed. Since then, pictures have been taken annually in the end of august.

The objective in this study is to reveal inter-annual variations in composition of an arctic macrobenthic community on a rocky bottom habitat and the study of succession in an area where all fauna was removed. Further, co-variations between faunal patterns and environmental factors were tested.

Although the sample design looks relatively simple, the great value of the data is the presence of a now 25-year continuous long time-series for benthic fauna that is unique for such high latitudes.

In the succession experiment, after eight years the treated (scraped) areas were for the first time not significant different from the undisturbed areas (control). Stable non-significant values are obtained after 1993. Therefore the succession time for group treatment to reach a climax community is suggested to be 8–13 years for this locality.

The inter-annual differences are not even distributed during the observation period. Minor changes are observed in the middle of the 1980s especially for group control, followed by a very period with low changes from 1990–1993 for both groups. Then, increasing changes occur in both groups, after 1999 these changes decrease again. The periods of large changes are mainly characterized by high concentrations of brown-algae and a rapid decline in the actinian- population.

The inter-annual changes in the faunal pattern showed significant positive correlation with the NAO-index (lag 1-year) and temperature in the adjacent West-Spitzbergen current.

Annex 12: Area-specific (groups of) benthic indicator species in relation to the development of the ecological quality objectives for changes in zoobenthos in relation to long-term eutrophication

Introduction

OSPAR has demonstrated a need to develop methods to identify changes in macrozoobenthos communities brought about by the effects of organic and / or nutrient enrichment. Several proposals and models already exist which address these problems, for example the Pearson and Rosenberg model, see Figure A12.1 (here, this includes models adapted for specific seas such as the Baltic). In this Baltic model, the high variability and increases in species richness in the benthos in the early stages of enrichment are stressed. Information on the effects of eutrophication on specific species can also be found in websites such as MARLIN (hosted by the MBA, UK)

There is at present a further need for development of EcoQOs for zoobenthos changes related to eutrophication (see OSPAR Commission 2005 background documents on eutrophication detailed below). In the harmonised assessment parameters in the Common Procedure, changes in zoobenthos are related to eutrophication, a category III parameter: indirect effects of nutrient enrichment.

Nutrient, chlorophyll a, and phytoplankton concentrations vary both inter- and intra- annually and the registered levels of these parameters are strongly affected by the time of assessment. Phytobenthos may also be a good early indicator of changes in the trophic system. Zoobenthos however is more stable in time and can provide an integrated picture of changes in the eutrophication situation.

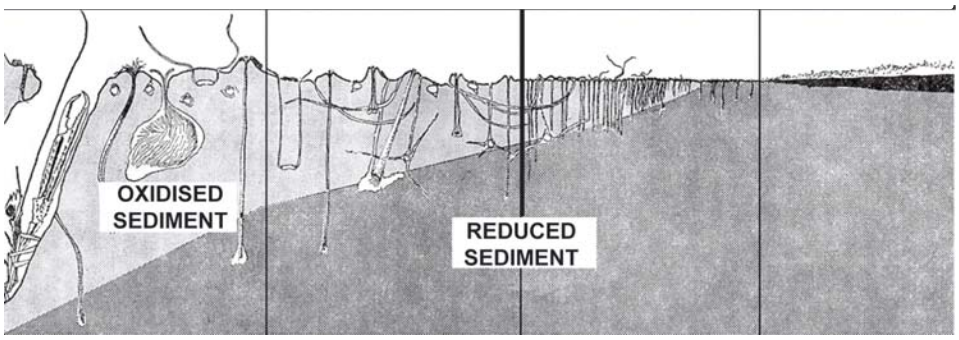


Figure A12.1: Changes to bottom-fauna along a gradient in organic load from healthy sediments under good oxygen conditions to sediments affected by sever hypoxia (from Pearson and Rosenberg 1978).

In addition to these eutrophication effects we have to consider water stratification and water exchange events which can have similar impacts as organic enrichment on benthic communities. However, it is difficult to demonstrate clear gradients in open waters and in fjords.

Four main areas were addressed

Estuaries

In the shallow non-stratified waters of the Neva River estuary (the Gulf of Finland, Baltic Sea) which are exposed to eutrophication and other man-mediated impacts and where increased production of phytoplankton as well as a high input of allochtonous organic matter from river discharge occur dense populations of the non-indigenous filter-feeders, *Dreissena polymoprha* (Bivalvia) and *Balanus improvisus* (Cirripedia) have developed over the last fifteen to twenty years (Figure A12.2). The first species was previously described as preferring mesotrophic to eutrophic conditions (Lyakhnovich, 1994).

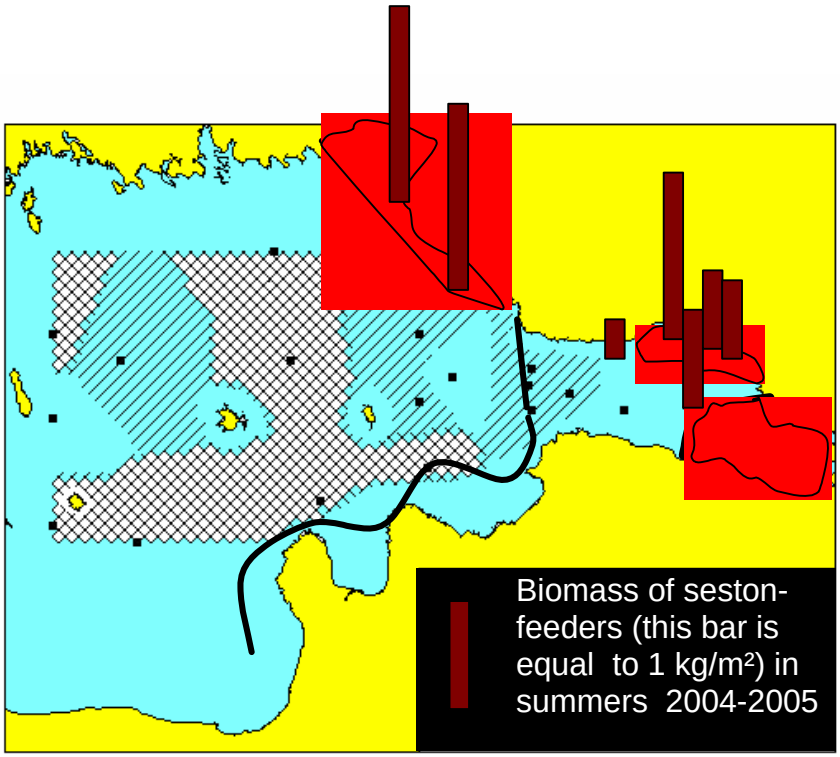


Figure A12.2: Areas exposed to eutrophication (in red, after Basova, 2006) and biomass of filter-feeders (kg of total/m²) in the Neva Estuary.

To the west, in the soft bottom communities at a depth of 20 m, the contribution from the previously common crustacean *Monoporeia affinis* to the abundance of the community decreased until the end of 1980's, while the contribution from the bivalve *Macoma baltica* has been increasing since the 1990s (Figure A12.3). The latter feeds both as a filter- feeder and as a deposit-feeder, collecting the fine, enriched sediment fraction from the surface of the sea bed.

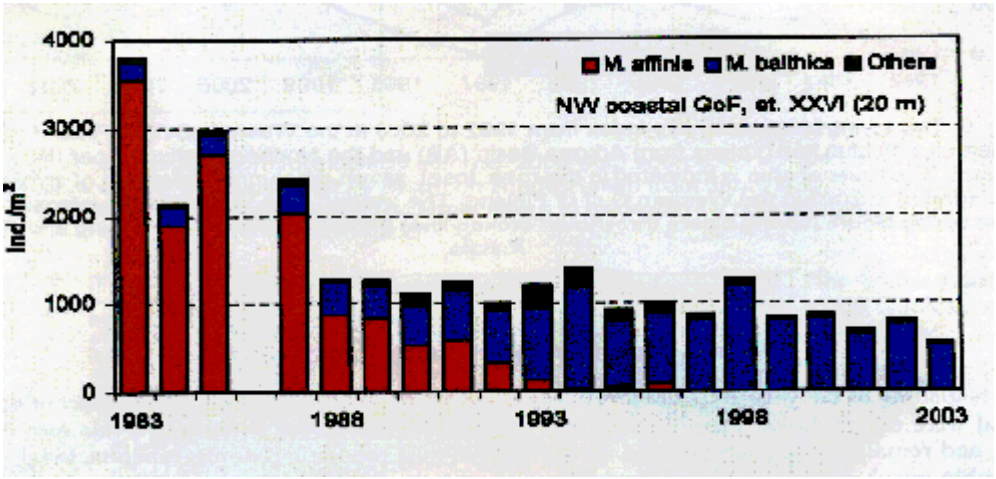


Figure A12.3: Macrozoobenthos trend on North-West coast of the Gulf of Finland (MERI, #51, 2005)

In deeper stratified areas of the Gulf of Finland, hypoxia, as result of eutrophication and other processes, can be considered as one of the possible reasons for the decrease and often the complete disappearance of macrozoobenthos at many localities (MERI, ## 51, 2005; MERI # 53, 2006)

Baltic Sea Lagoons and Enclosed Bays

From the shallow Russian areas of the South-East Baltic (the Curonia and Vistula Lagoons) with no permanent water stratification, the disappearance of long-lived large species and the development of short-lived opportunistic species such as Chironimidae (including *Chirinomus plumosus*) and Oligochaeta in macrozoobenthos at the most polluted and enriched sites can be demonstrated. Eutrophication therefore has led to a decrease in the total biomass of the macrozoobenthos, to a further decrease in the number of species in the communities and to a growth in the area dominated by Oligochaeta / Chironomidae. Similar trends are seen in the Florida lagoons and in the enclosed (by storm-surge barrier) areas of Neva Bay (The Gulf of Finland).

In the Vistula lagoon the establishment of the non-indigenous polychaete *Marenzelleria neglecta* has been observed. This event is considered as one ecosystem response to eutrophication. This species can both suspension feed and deposit feed unlike many local benthic species and is able to survive anoxic/hypoxic conditions due to peculiarities in it's metabolism and even dig down by 30cm in sediments poor in oxygen (Schiedek, Eshova *et al*). This species is also characteristic of disturbed areas in other parts of the Baltic Sea.

Fjords

The effects of eutrophication depend to a large extent on the local hydrographic conditions. In areas were bottom-water is frequently exchanged and sufficient amount of oxygen is available for decomposition of organic matter, even high loads may not result in any substantial changes to the benthic-fauna. Thus local circulation patterns are important in deciding the response of the benthos. For that reason we have divided fjords into three categories based on the criterion of sill depth which is the most important factor influencing bottom-water exchange in the fjords:

1) No sill: This kind of fjord would normally not experience large-scale effects of eutrophication on benthos. The advection of oxygenated bottom-water and export of organic matter is large and thus effects on the oxygen conditions are not common. Locally at point sources the response to organic matter would follow the Rosenberg, Pearson model. This is based on experience from the Norwegian and Faeroe Islands coast.

2) Shallow (20–40 m) sill: If the basin is deeper than about 100m the exchange of bottom-water is often so restricted that increased load of organic matter would lead to hypoxia that will affect the bottom-fauna. Initially this could result in increased diversity and biomass of bottom-fauna (see Figure A12.4). Decline in oxygen minimum concentration below 3.5 ml/l will lead to a clear and linear decrease in the diversity of bottom fauna with further decrease in oxygen concentration. Recent studies indicate that the decrease in hyperbenthos (crustacean fauna) is stronger than for infauna. For values of oxygen concentration in bottom-water between 2 and 3 ml/l studies indicate that 50% of the diversity can be lost and below 2 ml/l very few species are left.

3) Deep sill (50–300 m): Fjords with very deep sills >200m will seldom experience periods with stagnant bottom-water and hypoxia rarely occur. Shallower sills combined with deep basins may together with a high load of organic matter result in hypoxia. This has seldom been observed in Norway were those fjords are common.

The response to hypoxia would most likely follow the same pattern as for group 2.

Open Waters

It is extremely difficult to describe effects in open waters as water exchange rates are high and stratification events seldom occur. Nevertheless, regarding the infauna as described by the Pearson and Rosenberg model, shifts can be identified in the infaunal communities. One should also consider shifts in the distribution patterns in communities for example the *Amphiura* community in the German Bight. The German Bight is regarded as an open system where the waters only exhibit stratification during periods of very calm weather or in the deepest parts of the Bight. If plankton blooms then occur, massive “kills” of benthic fauna can occur. However these events are sporadic and occur less often than in enclosed or fjordic waters.

To detect changes in the benthic communities encountered in open waters, the more mobile crustacean fauna (hyperbenthos) should be monitored by video inspection while the larger organisms can be monitored by dredging and imaging techniques.

Conclusions

The Group cannot recommend a simple, single species based system for defining eutrophication effects on macrozoobenthos. An approach investigating whole community structure shifts must be adopted.

As a first quick approach, we recommend observations are carried out on changes in the ratio of species numbers to total individual numbers. Increases in opportunistic species, including increases in biomass, should be considered. Changes in the community diversity can then be followed and compared by the Rarefaction Method. It is also strongly recommended that investigations into changes in the burrowing fauna are carried out.

Pearson – Rosenberg (and related) models should be considered to identify species / groups important as indicators. This should also include observed higher variability and even increased species numbers in the very early stages of enrichment.

Further to the above, the Group strongly recommends that changes in Crustacean diversity be adopted as an early indicator of eutrophication as reported by, for example, Norwegian researchers. While changes in bivalve and echinoderm numbers should also be included in these observations

The Group also recommends that consideration be given to shifts in feeding strategies in the benthic community (from suspension feeders to deposit feeders)

The Group recommends not only to consider infauna but also to consider hyper and epibenthos which involves the application of different sampling methods such as dredging, imaging etc.

OSPAR Document 1

Relation between oxygen minimum in bottom-water of fjords and the species-richness of zoobenthos along the Norwegian Skagerrak coast.

In a report evaluating the eutrophication situation along the Norwegian Skagerrak coast it was concluded that a marked decrease in oxygen has occurred after 1975 (Aure *et al*., 1996). Calculations relating the decrease in oxygen to organic input indicate an increase of 50–100% after 1975 for fjord-basins in this area. Recently several fjord-basins along the Skagerrak coast have experienced oxygen levels below 2 ml l^{-1} which is the level at which most marine invertebrates are significantly affected (Diaz and Rosenberg 1995). The long time oxygen measurements conducted by IMR in this area provide an opportunity to study the fauna in fjords that are known to have experienced different oxygen history to detect effects of hypoxia. The zoobenthos, both infauna (collected by grab) and hyperbenthos (mainly crustaceans collected by epibenthic sled) were studied in 11 fjords. These fjords were divided into three categories of hypoxia defined by the historic minimum oxygen concentration in bottom-water: < 2 ml/l; 2-3 ml/l; and > 3 ml/l, and with 3, 3, and 5 basins within the categories. There was a very strong and significant relation between species richness of hyperbenthos and oxygen minimum during the last 5 years ($R^2 = 0.91$) (see Figures A12.1 and A12.2). Number of species decreased from 48–56 in well-oxygenated basins, to 22–32 in the intermediate hypoxia situation, and 0-7 in the most hypoxic environment. Also for infauna the relation was clear, but weaker ($R^2 = 72$).

The results show that it is possible, based on the relation between oxygen concentrations and species richness of zoobenthos estimate loss in diversity due to eutrophication and to predict effects of improvement in the eutrophication situation. Thus species richness of zoobenthos and in particular of mobile crustaceans (hyperbenthos) is a useful assessment parameters under category III, 2 zoobenthos. In particular it provides information of the eutrophication situation that naturally does not fluctuate seasonally or inter annually.

OSPAR Document 2

The OSPAR classification scheme

The assessment is based on the OSPAR common assessment criteria, which is summarised in Table A12.1.

Table A12.1: The Agreed Harmonised Assessment Criteria and their respective assessment levels of the Comprehensive Procedure (from OSPAR 2002).

ASSESSMENT PARAMETERS		
Category I	**Degree of Nutrient Enrichment**	
	1	Riverine total N and total P inputs and direct discharges (RID)
		Elevated inputs and/or increased trends
		(compared with previous years)
	2	Winter DIN- and/or DIP concentrations
		Elevated level(s) (defined as concentration >50% above salinity related and/or region specific background concentration)
	3	Increased winter N/P ratio (Redfield N/P = 16)
		Elevated cf. Redfield (>25)
Category II	**Direct Effects of Nutrient Enrichment (during growing season)**	
	1	Maximum and mean Chlorophyll a concentration
		Elevated level (defined as concentration > 50% above spatial (offshore) / historical background concentrations)
	2	Region/area specific phytoplankton indicator species
		Elevated levels (and increased duration)
	3	Macrophytes including macroalgae (region specific)
		Shift from long-lived to short-lived nuisance species (e.g. *Ulva*)
Category III	**Indirect Effects of Nutrient Enrichment (during growing season)**	
	1	Degree of oxygen deficiency
		Decreased levels (< 2 mg/l: acute toxicity; 2 - 6 mg/l: deficiency)
	2	Changes/kills in Zoobenthos and fish kills
		Kills (in relation to oxygen deficiency and/or toxic algae) Long term changes in zoobenthos biomass and species composition
	3	Organic Carbon/Organic Matter Elevated levels (in relation to III.1) (relevant in sedimentation areas)
Category IV	**Other Possible Effects of Nutrient Enrichment (during growing season)**	
	1	Algal toxins (DSP/PSP mussel infection events)

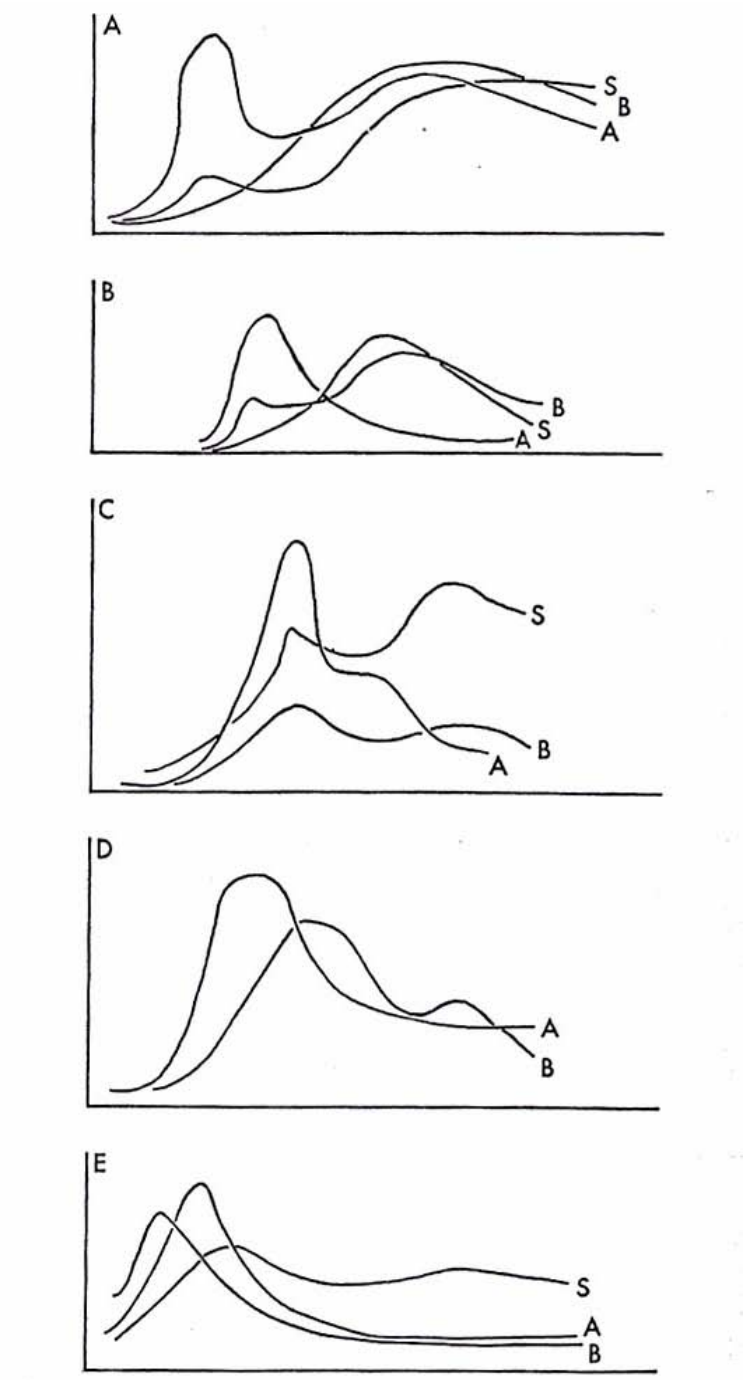


Fig. 1.—Species—abundance—biomass (SAB) curves along a decreasing gradient of organic enrichment from left to right: based on data given for A, Saltkällefjord, Sweden (Rosenberg, 1976a); B, Loch Creran, Scotland (Pearson & Stanley, in prep.); C, Fraser River Estuary, British Columbia (Otte & Levings, 1975); D, Cortiou, France (Bellan & Bellan-Santini, 1972); E, Kiel Bay, Germany (Anger, 1975a).

Figure A12.4: Macro-benthic succession in relation to organic enrichment and pollution of the marine environment (copied from Pearson and Rosenberg, 1978).

Annex 13: Contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem

Bay of Biscay and Iberian Seas

Ecosystem Components

Circulation

Most of the water masses are of North Atlantic origin, including those that have been transformed after mixing with the Mediterranean water. The region is affected by both the subpolar and subtropical gyres depending on latitude, but the general circulation in the area mainly follows the subtropical anti-cyclonic gyre in a relatively weak manner (1–2 $cm.s^{-1}$). A synthetic view of the water masses in the southern part of the Bay of Biscay, including seasonal and long-term changes, can be seen in Valencia *et al*. (2004).

Off France, at the slope of the Bay of Biscay, the mean residual current flows towards the north, although at slope depth (below ca 500 m) it goes down the slope (Pingree & Le Cann, 1990). In the Cantabrian Sea the surface currents generally flow eastwards during winter and spring and change westwards in the summer following the wind forcing (González *et al*., 2004; Lavin *et al*, 2006).

These changes in the currents direction produce seasonal coastal upwellings. The circulation of the west coast of the Iberian Peninsula is characterized by a complex current system subject to strong seasonality and mesoscale variability, showing reversing patterns between summer and winter in the upper layers of the slope and outer shelf (e.g., Barton, 1998; Peliz *et al.*, 2005, Ruiz-Villareal *et al.*, in press). During spring and summer northerly winds along the coast are dominant causing coastal upwelling and producing a southward flowing at the surface and a northward undercurrent at the slope (Fiúza *et al.*, 1982; Haynes and Barton, 1990; Peliz *et al*., 2005; Mason *et al.*, 2006). This environmental pattern has been related to the recruitment of some species, such as anchovy in the southern French coast (Borja *et al.*, 1996, 1998). In the autumn and winter, the surface circulation is predominantly northward, partially driven by meridional alongshore density gradients (Peliz *et al.*, 2003a,b), and transporting higher salinity and warmer (subtropical) waters over the slope and shelf break (Frouin *et al.*, 1990; Haynes and Barton, 1990; Pingree and Le Cann, 1990) - the Iberian Poleward Current (Peliz *et al.*, 2003b). These waters are nutrient poor and contribute to fronts which determine the distribution of plankton, fish eggs and larvae (Fernández *et al.*, 1993; González-Quirós *et al.*, 2003). Strong subtropical water intrusions in the Cantabrian Sea may be a feature strongly influenced by wind events (Villamor *et al.*, 2005). Another important feature of the upper layer is the Western Iberia Buoyant Plume (WIBP) (Peliz *et al.*, 2002), which is a low salinity surface water body fed by winter-intensified runoff from several rivers from the northwest coast of Portugal and the Galician Rias. The WIBP could play an important role in the survival of fish larvae (Santos *et al.*, 2004).

The intermediate layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which tends to contour the south-western slope of the Iberia (Ambar and Howe, 1979; Valencia *et al*., 2004), generating mesoscale features called Meddies (e.g., Serra and Ambar, 2002), which can transport salty and warm MW over great distance. The exchange of water masses through the Gibraltar Straits is driven by the deep highly saline (S>37) and warm Mediterranean Outflow Water (MOW) that flows into the Gulf of Cadiz and the less saline, cool water mass of the Atlantic Intermediate Water (AIW) at the surface.

Physical and chemical Oceanography (temperature, salinity, nutrients)

Most important features enhancing primary production are coastal upwelling, coastal run-off and river plumes, seasonal currents and internal waves and tidal fronts.

Upwelling events are a common feature in Portugal, Galicia and western Cantabrian Sea, especially in summer (Fraga, 1981, Fiuza *et al.*, 1982, Blanton *et al.*, 1984). The occurrence of upwelling pulses during summer is important since the upwelling process injects nutrients in the surface layer that fuel primary production. Under conditions of moderate upwelling, the innermost coastal 25 km are about 10 times more productive than offshore waters and the upwelling centres about 20 times more. However upwelling events in the northern Iberian Shelf are generally restricted to a narrow band near the coast in the western Cantabrian Sea (Botas *et al.*, 1990; OSPAR, 2000), but some events similar to upwelling have been described in the southern French coast (Borja *et al*., 1996, 1998). In northeast Bay of Biscay, mainly in summer, weak upwelling events occur off South Brittany and the Landes coastline. The wind-speed during the 1990s was greater by 1 $m.s^{-1}$ than over the previous decades. Since the 1940s annual mean speed has tended to decrease in the south of the Bay of Biscay while it has increased in the north. However, these trends are small in comparison with the degree of inter-annual variability at each station (Planque *et al.*, 2003). Regarding off northwest Iberian a notable shift in the winds has occurred during the last two decades, resulting in a reduction in the spring-summer upwelling (Cabanas *et al.*, 2003). In the south-eastern part of the Bay of Biscay there is a significant negative tendency to increase downwelling and reducing turbulence from the 1960s (Valencia *et al*., 2004).

Water temperature is highest to the south, where it is influenced by the MW. For example, the yearly mean temperature at 100m depth is 11.2 °C to the North of the advisory region, 48°N, and 15.6 to the South, 36°N (Levitus, 2001).

Mean surface water temperatures increased 1.4ºC in the southeast Bay of Biscay for the period 1972–1993 (0.6ºC per decade), and. 1.03°C over the last Century (Koutsikopoulos *et al*., 1998 ; Planque *et al.*, 2003). However, these results depend on the length of the series, because, although temperature is increasing since the 1970s, when studying longer series in the south-eastern part of the Bay of Biscay the trend is negative since the 1940s (Borja *et al*., 2000; Usabiaga *et al.*, 2004). Heat stored in central waters below the mixed layer underwent an important increase in the last decade. ENACW (Eastern North Atlantic Current Water) increased at rates of 0.032ºC yr^{-1} and Mediterranean water about 0.020ºC yr yr^{-1}, linked to a density compensating salinity increase. These warming rates are from two to six times greater than those accepted for the North Atlantic in the course of the 20th century. The overall result is a net warming of 0.24 ºC for this water column in the period 1992–2003 (Gonzalez-Pola and Lavin, 2003; Gonzalez-Pola *et al*., 2005). Alternatively, changes in the SST observed in the south-eastern Bay of Biscay may result from changes in heat content, driven by advective transport of warmer water (Valencia *et al*., 2004). On the continental shelf, bottom salinity is close to 35. At slope depth, high salinities are found due to the MW (values around 37.0 in the Gulf of Cadiz and above 35.5 in the Bay of Biscay). Low salinity lens from rivers is an important feature in the inner Bay of Biscay (Lavín *et al*, 2006). On yearly average, the French region received 27000 $m^3\ s^{-1}$ of run-off from the major rivers. The major indicators show that flows for 2002 and 2003 are slightly below the long-term average from 1952–2003 and the last 10 years average and preliminary data indicate that in 2004 is close to the long term average. In the northern Spanish coast, rivers flowing into the Cantabrian Sea are of short length and with smaller importance (30% of the total flow to the Bay, after Valencia *et al*., 2003) compared with those of the French coast, as Garonne or Loire. In the northwest Spanish coast the rias constitute an important sediment and fresh water source.

Some long-term data of optical properties, chlorophyll and nutrients, in the south-eastern part of the Bay can be seen in Valencia and Franco (2004).

Broad- scale climate & Oceanographic features & and drivers:

Large positive values of the NAO index are associated with higher dominance of the middle latitude easterly wind flow during winter that can lead to increased winter upwelling episodes. Dickson *et al*. (1988) related the decline in zooplankton and phytoplankton in the North Atlantic and in the catch of sardines off Portugal with the increase in northerly winds during the 1970s. These increased winter upwelling episodes related with large positive NAO indices were also observed during the 1990s (Borges, *et.al*. 2003). Over recent years the Hurrell NAO index was close to long-term (100 years) average. A discussion on the changes of NAO over the bay, together with associated changes in upwelling-downwelling, turbulence and temperature can be seen in Usabiaga *et al*. (2004) and Valencia *et al.* (2004).

Zooplankton

Zooplankton blooms follow the pulse of phytoplanktonic production. In coastal zones, mesozooplankton abundance presents a seasonal variation with absolute values rarely over 3000 ind/m³ in spring. In winter values are 250 ind/m³. The oceanic area off Iberia is oligotrophic and zooplankton biomass varies little throughout the year with a peak in April. Regarding the whole Bay of Biscay, since 1992, temporal and spatial biomass distribution of mesozooplankton (200–2000 m) show the same patterns described for phytoplankton with biomass (values of ~70 mgDW m^{-3}) closely after the phytoplankton spring bloom. After the spring bloom, zooplankton decreases showing a patchy distribution with some hot spots in coincidence with upwelling regions and freshwater plumes.

In summer, due to the upwelling, the regional zooplankton biomass production is highest off Galicia where it is often over 30 mg DW m^{-3} (60 mg DW m^{-3} peak are frequent) (Bode *et al.*, 1998). Along the Cantabrian Sea the biomass decreases towards the east (Llope *et al*., 2003).

Zooplankton in the Iberian coastal and shelf waters is very rich in terms of taxonomic groups and species. Copepods account for 60–85% of total zooplankton abundance off the north coast of Spain, and are present all the year round, whereas other holoplankton and meroplankton groups have a marked seasonal distribution. Extensive data of species composition and long-term variations within the Bay of Biscay were studied by Villate *et al.* (2004).

Benthos

In the Cantabrian Sea, and most probably in the whole region, the depth is the main factor of the distribution of both epibenthic an endobenthic communities, a second factor is the sediment characteristics (grain size and organic contents). The main communities over the continental shelf, in the south-eastern part of the Bay, have been studied by Borja *et al.* (2004). These authors provide useful ranges of different structural parameters. The mean fish species richness shows a progressive decrease with depth (Sánchez, 1993) while the inverse phenomena appears in invertebrates (Olaso, 1990), which prefer deeper water and muddy substrates due to their predominantly detritivorous feeding habits. Mediterranean species occur in the south of the advisory region, their occurrence decrease eastwards in the Cantabrian Sea at least for shallow species (Borja *et al*., 2004). The dominant mobile invertebrates on the soft grounds on the shelf are detritivorous crustaceans and molluscs, while the same type of grounds in deeper areas are dominated by filter feeders such as sponges and cnidarians. These later are abundant on rocky bottoms together with echinoderms (Serrano *et al*. in. press). Bioherm such as maerl beds in shallow waters and *Lophelia* reefs on the slope occur in some areas.

The main exploited invertebrates in the advisory region are: red shrimp (*Aristeus antennatus*) rose shrimp (*Parapeneus longirostris*), Nephrops and Cephalopods (*Octopus vulgaris*, *Sepia officinalis*, *Loligo* spp., and others). Smaller fisheries exist for rocklobster (*Palinurus elephas*), red crab (*Chaceon affinis*) and *Liocarcinus puber* (Borja *et al*., 2004). *Nephrops* occurs in

almost all the advisory region it is exploited from coastal water (e.g. south of Brittany) to the upper slope as in the Gulf of Cadiz.

Various bivalves species are exploited on the coastal shelf and in the intertidal area (eg Scallops *Pecten maximus* but also clam *Ruditapes decussatu*s, cockle *Cerastoderma edule*, telline *Donax truncates*) (for some management data on molluscs, see Borja *et al*., 2004). Some species were introduced for aquaculture purposes and some settled as wild populations (eg *Ruditapes phillipinarum*) now exploited. The introduced slipper limpet (*Crepidula fornicata*) is locally abundant. It may be a competitor of exploited filter feeders and has a negative effect on the substrate availability to juvenile sole in their nurseries (Le Pape *et al*., 2003c). This advisory region is locally suitable for shellfish aquaculture, e.g. more than 200.000 tons per year of mussels from raft aquaculture are produced off Galicia. Other exploited species, along the coasts of France, Spain and Portugal, are the algae, being the most important the red algae *Gelidium sesquipedale*. This species has been extensively studied, and some remarks on management and monitoring over the past 20 years are shown in Borja *et al*. (2004).

Fish community

Species composition and diversity

Fish diversity is quite high in relation to the co-occurrence of sub-tropical, temperate and boreal species which relative abundances follow latitudinal gradients.

The main pelagic species are sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*) and blue whiting (*Micromesistius poutassou*). To the south west of the Iberian Peninsula, other mackerels and horse mackerels such as the chub mackerel (*Scomber japonicus*), the Mediterranean horse mackerel (*Trachurus mediterraneus*) and the blue jack mackerel (*T. picturatus*) are also common. Seasonally, albacore (*Thunnus alalunga*) occur along the shelf break. To the south, northern bluefin tuna (*Thunnus thynnus*) is caught in the Gulf of Cadiz during its migratory way (in or out) to the Mediterranean.

Throughout the advisory region, the demersal fish community is organised according to depth, bottom and latitude and is stable over time despite species abundance variations and trends (Souissi *et al.*, 2001, Poulard *et al.*, 2003 Gomes, *et. al*., 2001; Sousa, *et al*, 2005). In general, the same species composition and population structures occur on the French and the Cantabrian shelves (ICES, 2005). However, some differences were found in the shelf off the Gironde estuary, which seems to be the southern limit of cold water species, such as the herring (*Clupea harengus*), haddock (*P. virens*), Norway pout (*T. esmarkii*), dab (*L. limanda*), sprat (*S. sprattus*) and whiting (*M. merlangus*).

The composition of catches and the values are some different. Hence, in the Basque Country (southeastern part of the Bay), the most catched species is albacore (46% of the captures), then anchovy (27%) and mackerel (22%). However, the incomes are 67%, 28% and 2%, respectively (Arregi *et al*., 2004).

More than 200 species occur in the northeast Bay of Biscay (Bertrand *et al.*, 2004). Only 5 species make up more than 50% of the total biomass and abundance of demersal fish (Blanchard, 2001). Species richness is highest in coastal shallow waters, down to 50 m (Blanchard, 2001). Strong environmental gradients occur in the Cantabrian Sea and affect the fish distribution. Due to the narrow and steep shelf, depth is the most influential factor determining the assemblages observed in this area. The physical and faunal variability are larger in both the coastal and shelf break strata. Regarding trends in species richness and diversity both have remained quite stable during the 1990s (Sánchez and Serrano, 2003).

Off Portugal horse mackerel (*Trachurus trachurus*) is more important in autumn assemblages whereas the boarfish (*Capros aper*) dominates in summer. On the upper slope the fish community is dominated by blue whiting (*Micromesistius poutassou*). The importance of Sparids in the fish community increases to the south (Gomes *et al*., 2001).The shallow fish community of the Gulf of Cadiz has some affinities with subtropical and tropical fish communities, due to the occurrence of species such as *Umbrina canariensis, Pomadasys incisus, Spicara flexuosa, Diplodus bellottii, Pagelus bellottii bellottii, Halobratrachus didactylus, Caranx rhonchus, Pomatomus saltatrix, Dentex* spp. and *Epinephelus* spp**.** (Fernández-Delgado, 1987). Some of these species also occur in part of the Mediterranean Sea. Deeper, the scabbardfish *Lepidopus caudatus* is abundant.

The main Elasmobranch species in the region are the rays, *Raja clavata, R. montagui,* and *R. miraletus* and the catsharks, *Scyliorhinus canicula* and *Galeus melastomus* at the coast and on the inner and outer shelf respectively (Sánchez *et al*., 2005a; Rodríguez-Cabello *et al.* 2005). Several deepwater sharks and chimaeroids are also found (Sánchez and Serrano, 2003; Lorance *et al.* 2000). Widely migratory sharks occur in this region such as blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrnchus*), porbeagle (*Lamna nasus*), tope (*Galeorhinus galeus*) and spurdog (*Squalus acanthias*). Some are taken in mixed demersal and pelagic (especially for tuna and swordfish) fisheries.

The main commercial demersal species caught by the trawl are hake, megrims (*Lepidorhombus boscii* and *L. whiffiagonis*), monkfishes and sole. Most of these species are distributed all through the advisory region, although not evenly.

Birds

The Iberian Peninsula gives rise to large seabird populations due to its strategic geographical position regarding their migratory pattern. Seabirds are grouped in terms of pelagic species (e.g. yelkouan shearwater (*Puffinus puffinus*), Leach s petrel (*Oceanodroma leucorhoa*), northern gannet (*Morus bassanus*) and razorbill (*Alca torda*), coastal species (e.g. shag (*Phalacrocorax aristotelis*), terns (*Sterna* spp.) and common scoter (*Melanitta nigra*) and gulls. The seabird community is dominated by the yellow-legged gull (*Larus cachinnans*) which makes up 70% of the total number of seabirds. Its feeding habits (fish discards and rubbish dumps) together with the protection of their colonies explains their strong demographic growth in recent decades. Other nesting seabirds of importance are the very similar lesser black-backed gull (*L. fuscus*), the shag, European storm-petrel (*Hydrobates pelagicus*), black legged kittiwake (*Rissa tridactyla*) and guillemot (*Uria aalge*) (OSPAR, 2000). More detailed information of some of these species, for the southeastern part of the Bay, can be seen in Franco *et al*. (2004).

Turtles

Two marine turtles species the loggerhead (*Caretta caretta* and the leatherback *Dermochelys coriacea*) occur year round in the south of the advisory region. Seasonal variations in abundance in the Gulf of Cádiz are related to a migration pattern through the Gibraltar Straits (Camiñas and Valeiras, 2001). As a consequence of the long migrations undertaken by the oceanic marine turtles using the Gulf Stream some occasional occurrences of *C. Caretta*, *D. coriacea*, *Chelonia mydas*, *Eretmochelys imbricate* and *Lepidochelys kempii* are also reported throughout the advisory region (Castro *et al*., 2004).

The major effects of the ecosystem on fisheries

Upwelling intensity, and to lesser extent other factors such as water stability, retention areas produced by local or general current fields and other mesoscale features like river plumes and eddies affect biological processes, recruitment, mortality and food availability to the small pelagic fish community (Borja *et al*., 1996, 1998 ; Bode *et al.* 2001; Allain *et al.* 2001).

Indices of the strength of upwelling have been used to improve environmental-stock-recruitment relationships in some pelagic species (Borja *et al*., 1996, 1998; Carrera and Porteiro 2003, Villamor *et al*., 2005). Subtropical water intrusions in the Cantabrian Sea and/or early spring extreme wind forcing events are of great importance for the pelagic ecosystem understanding. Hence, the turbulence is of great importance in the recruitment of mackerel (Borja *et al.,* 2002) and may be linked to important failures in its recruitment (Villamor *et al.* 2005). Also in relation with the strength of the upwellings and the Navidad current optimal environmental windows have been defined for some demersal species such as hake and megrims (Sánchez and Gil, 2000; Sánchez *et al.*, 2003a, b).

At the coast, sole recruitment was shown to be related to river output, higher fluvial discharge in winter-spring increasing the estuarine nurseries size (Le Pape *et al*. 2003a,b). Borges *et al.*, (2003) showed that a NAO positive phase, increased the winter upwelling events and constrained the productivity to a low recruitment period of sardine, whereas a NAO negative phase favoured the occurrence of high recruitment years. There is circumstantial evidence of a relation between low NAO values and high recruitment levels/CPUE in the Spanish swordfish fishery (Mejuto, 1998). Relationships between NAO and recruitment or captures have been described over the area by Drinkwater *et al.* (2002). Also, the strength of upwelling and its indexes have been used to improve environmental-stock-recruitment relationships in some pelagic species (Borja *et al*., 1996, 1998; Carrera and Porteiro 2003, Villamor *et al.,* 2005). Temperature increase has been related with changes on the distribution of several species (Quéro *et al.* 1998) that are progressively increasing their northernmost distribution limits. Some species may be favoured by warming (Blanchard and Vandermeirsch, 2005) and recently, species from North Africa were reported in the Algarve (Brander *et al.* 2003).

References

Allain, G., Petitgas, P., and Lazure, P. 2001. The influence of mesoscale ocean processes on anchovy (*Engraulis encrasicolus*) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodinamic model. Fish. Oceanogr., 10(2): 151–163.

Ambar, I., and Howe, M. R. 1979. Observations of the Mediterranean outflow - I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535–554.

Arregi, L., Puente, E., Lucio, P., Sagarmínaga, Y., Castro, R., and Uriarte, A. 2004. Coastal fisheries and demersal estuarine fauna. Ed. by A. Borja and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 493–513.

Barton, E.D. 1998. Eastern boundary of the North Atlantic: Northwest Africa and Iberia coastal segment. *In* The Sea. Ed. by A.R. Robinson and K.H. Brink. John Wiley & Sons, Inc., pp 633–658.

Bertrand J.A. 2004. L'état des communautés exploitées au large des côtes de France. Application d indicateurs à l'évaluation de l impact de la pêche. IFREMER report, DRV/RH/RST/04-001, 170 pp.

Blanchard, F., and Vandermeirsch, F. 2005. Warming and exponential abundance increase of the subtropical fish *Capros aper* in the Bay of Biscay (1973–2002). Comptes-rendus de l'académie des sciences, 328: 505–509.

Blanton, J.O., Atkinson, L.P., Castillejo, F.F., and Lavín, A. 1984. Coastal upwelling off the Rias Bajas, Galicia, northwest Spain I: hydrographic studies, 45: 497–511.

Bode, A., Varela, M., Barquero, S., Alvarez-Ossorio, M.T., and González, N. 1998. Preliminary studies on the export of organic matter during phytoplankton blooms off La Coruña (North Western Spain). J Mar Biol Assoc UK, 78: 1–15.

Bode, A., Varela, M., Canle, M., and González, N. 2001. Dissolved and particulate organic nitrogen in shelf waters of northern Spain during spring. Mar Ecol Prog Ser, 214: 43–54.

Borges, M.F., Santos, A.M.P., Crato, N., Mendes, H., Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. Ed by O. Ulltang and G. Blom. *In* Fish Stock Assessments and predictions: Integrating Relevant Knowledge. Scientia Marina, 67(1), April 2003.

Borja, A., Uriarte, A., Valencia, V., Motos, L., and Uriarte, A. 1996. Relationships between anchovy (*Engraulis encrasicholus*) recruitment and the environment in the Bay of Biscay. Scientia Marina, 60(2): 179–192.

Borja, A., Uriarte, A., Egaña, J., Motos, L., and Valencia, V. 1998. Relationships between anchovy (*Engraulis encrasicolus*) recruitment and environment in the Bay of Biscay (1967–1996). Fisheries Oceanography, 7(3–4): 375–380.

Borja, A., Egaña, J., Valencia, Franco, J., and Castro, R. 2000. 1947–1997, estudio y validación de una serie de datos diarios de temperatura del agua del mar en San Sebastián, procedente de su Aquarium. Ozeanografika, 3: 139–152.

Borja, A., Uriarte, A., and Egaña, J. 2002. Environmental factors and recruitment of mackerel, *Scomber scombrus* L. 1758, along the north-east Atlantic coasts of Europe. Fisheries Oceanography, 11(2): 1–12.

Borja, A., Aguirrezabalaga, F., Martínez, J., Sola, J.C., García-Arberas, L., and Gorostiaga, J.M. 2004. Benthic communities, biogeography and resources management. Ed. by A. Borja. and M. Collins. *In* Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, Elsevier, Amsterdam, 70: 455–492.

Botas, J.A., Fernández, E., Bode, A., and Anadón, R. 1990. A Persistent Upwelling off the Central Cantabrian Coast (Bay of Biscay). Estuarine Coastal and Shelf Science, 30: 185–199.

Brander, K., Blom, G., Borges, M.F., Erzini, K., Hendersen, G., MacKenzie, B.R., Mendes, H., Santos, A.M.P., and Toresen, R. 2003. Changes in fish distribution in the Eastern North Atlantic; are we seeing a coherent response to changing temperature? *ICES Marine Science Symposia*, 219: 261–270.

Cabanas, J.M., Lavín, A., García, M.J., González-Pola, C., and Pérez, E. 2003. Oceanographic variability in the northern shelf of the Iberian Peninsula 1990–1999. *ICES Marine Science Symposia*, 219: 71–79.

Camiñas, J.A., and Valeiras, J. 2001. Critical areas for loggerhead and leatherback marine turtles in the western Mediterranean Sea and the Gibraltar Strait region. Proceedings First Mediterranean Conference on Marine Turtles. Rome.

Carrera, P., and Porteiro, C. 2003. Stock dynamic of Iberian sardine (*Sardina pilchardus*, W.) and its implication on the fishery off Galicia (NW Spain). Sci. Mar., 67(1): 245–258.

Castro, R., Uriarte, A., Martínez de Murguía, A., and Borja, Á. 2004. Biodiversity and conservation of wildlife and natural habitats. Ed. by A. Borja, and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, Elsevier, Amsterdam, 70: 531–547.

Dickson, R.R., Kelly, P.M., Colebrook, J.M., Wooster, W.S., Cushing, D.H. 1988. North winds and production in the eastern North Atlantic. J. Plankton Res., 10(1): 151–169.

Drinkwater, K.F., Belgrano, A., Borja, A., Conversi, A., Edwards, M., Greene, C.H., Ottersen, G., Pershing, A.J., and Walker, H. 2002. The response of marine ecosystems to climate variability associated with the North Atlantic Oscillation. *In* The North Atlantic Oscillation: climatic significance and environmental impact, American Geophysical Union, Edited by J. Hurrell, Y. Kushnir, M. Visbeck, and G. Ottersen. Geophysical Monograph Series, 134: 211–234.

Fernández, E., Cabal, J., Acuña, J.L., Bode, A., Botas, A., and García-Soto, C. 1993. Plankton distribution across a slope current-induced front in the southern Bay of Biscay. Journal of Plankton Research, 15: 619–641.

Fernández-Delgado, C. 1987. Ictiofauna del estuario del Guadalquivir: su distribución biología de las especies sedentarias. Ph. D. Dissertation, Univ. Córdoba, 152 pp.

Fiúza, A.F.G., de Macedo, M.E. and Guerreiro, M.R. 1982. Climatological space and time variation of the portuguese coastal upwelling. Oceanologica Acta, 5: 31–40.

Fraga, 1981. Upwelling off the Galician coast, Northwest Spain. *In* Coastal and Estuarine Sciences 1. Coastal upwellings, Ed. by F.A. Richards. American Geophysical Union, Washington DC, pp 176–182.

Franco, J., Etxezarreta, J., Galarza, A., Gorospe, G., and Hidalgo, J. 2004. Seabird populations. Ed. by A. Borja and M. Collins. *In* Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 515–529.

Frouin, R., Fiúza, A.F.G., Ambar, I., and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. J. Geophys. Res., 95: 679–691.

Gomes, M., Serrâo, E., and Borges, M.F. 2001. Spatial patterns of groundfish assemblages on the continental shelf of Portugal. *ICES Journal of Marine Science*, 58(3): 633–647.

González-Pola, C., and Lavín, A. 2003. Seasonal cycle and interanual variability of the heat content on a hydrographic section off Santandert (Southern Bay of Biscay), 1991–2000. *ICES Journal of Marine Science*, 219: 343–345.

González, M., Uriarte, A., Fontán, A., Mader, J., and Gyssels, P. 2004. Marine dynamics. Ed. by A. Borja and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 133–157.

González-Pola, C., Lavín, A., and Vargas-Yánez, M. 2005. Intense warming and salinity modification of intermediate water masses in the southeastern corner of the Bay of Biscay for the period 1992–2003. Journal of Geophysical Research, 110, C5 *C05020*, doi:10.1029/2004JC002367.

González-Quirós, R., Cabal, J., Alvarez-Marqués, F. and Isla, A. 2003. Ichthyoplankton distribution and plankton production related to the shelf break front at the Avilés Canyon. *ICES Journal of Marine Science*, 60(2): 198–210.

Haynes, R., and Barton, E.D. 1990. A poleward flow along the Atlantic coast of the Iberian Peninsula. Journal of Geophysical Research, 95, 11425–11441.

ICES. 2005. Report of the Working Group on Fish Ecology (WGFE). ICES CM 2005/G:05, 214 pp.

Koutsikopoulos, C., Beillois, P., Leroy, C., and Taillefer, F. 1998. Temporal trends and spatial structures of the sea surface temperature in the Bay of Biscay. Oceanologica Acta, 21(2) : 335–344.

Lavin, A., Valdes, L., Sanchez, F., Abaunza, P., Forest, J., Boucher, P., Lazure, P., and Jegou, A.M. 2006. Chapter 24. The Bay of Biscay: The encountering of the ocean and the shelf. Ed. by A.R. Robinson and K.H. Brink. *In* The Global Coastal Ocean: Interdisciplinary Regional Studies and Syntheses. The Sea, 14: 933–1001.

Le Pape, O., Chauvet, F., Mahevas, S., Lazure, P., Guerault, D., Desaunay, Y. 2003a. Quantitative description of habitat suitability for the juvenile common sole (*Solea solea*, L.) in the Bay of Biscay (France) and the contribution of different habitats to the adult population. Journal of Sea Research, 50, 2–3, 139–149.

Le Pape, O., Chauvet, F., Désaunay, Y., and Guérault, D. 2003b. Relationship between interannual variations of the river plume and the extent of nursery grounds for the common sole (*Solea solea*, L.) in Vilaine Bay. Effects on recruitment variability. Journal of Sea Research, 50, 2–3,177–185.

Le Pape, O., Guerault, D., and Desaunay, Y. 2003c. Effect of an invasive mollusc, American slipper limpet, *Crepidula fornicata*, on habitat suitability for juvenile sommon sole *Solea solea* in the Bay of Biscay. Mar. Ecol. Prog. Series, 277, 107–115.

Levitus, S. 2001. World Ocean Atlas 2001. Objective Analyses, Data Statistics and Figures CD-ROM Documentation Ocean Climate Laboratory NOAA/NODC. September 2002. (3 CR-ROMs).

Llope, M., Anadón, R., Alvarez-Ossorio, M., Valdés, L., and Varela, M. 2003. Zooplankton biomass timing with temperature in South Bay of Biscay. Third International Zooplankton Production Symposium, Gijón (May 2003).

Lorance, P., Latrouite, D., and Seret, B. 2000. Observations of chondrichthyan fishes (sharks, rays and chimaeras) in the Bay of Biscay (North-eastern Atlantic) from submersibles. Proc. Third European Elasmobranch Association Meeting, Boulogne-sur-Mer, 27–29 May 1999, 29–45.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M., and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar., Série Cooperação, 51 pp.

Mejuto, J. 1998. A possible relationship between the NAO index and the swordfish (*Xiphias gladius*) recruitment index in the North Atlantic: Hypothesis of reproduction and possible effects on recruitment levels. ICCAT Doc. SCR/98/111.

OSPAR, C. 2000. Quality Status Report 2000. Region IV - Bay of Biscay and Iberian Coast. OSPAR Commission, London, 134 pp.

Peliz, A., Rosa, T.L., Santos, A.M.P., and Pissarra, J.L. 2002. Fronts, jets, and counter-flows in the Western Iberian upwelling system. Journal of Marine Systems, 35, 1–2, 61–77.

Peliz, A., Dubert, J., and Haidvogel, D.B. 2003a. Subinertial Response of a Density-Driven Eastern Boundary Poleward Current to Wind Forcing. August 2003.J. Phys. Oceanogr., 33(8): 1633–1650.

Peliz, A., Dubert, J., Haidvogel, D.B., Le Cann, B. 2003b. Generation and unstable evolution of a density-driven eastern poleward current: The Iberian poleward current. Journal of Geophysical Research. C. Oceans, 108, C8.

Peliz, A., Dubert, J., Santos, A.M.P., Oliveira, P.B., and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin - Fronts, Eddies and Poleward Flows: an overview, Deep-Sea Research Part I-Oceanographic Research Papers, 52(4), 621–646.

Pingree, R.D., and Le Cann, B. 1990. Structure, strength and seasonality of the slope currents in the Bay of Biscay region. Journal of the Marine Biological Association of the United Kingdom, 70: 857–885.

Planque, B., Beillois, P., Jégou, A.M., Lazure, P., Petitgas, P., and Puillat, I. 2003. Large-scale hydroclimatic variability in the Bay of Biscay: the 1990s in the context of interdecadal changes. *ICES Marine Science Symposia*, 219: 61–70.

Poulard, J.C., Blanchard, F., Boucher, J., and Souissi, S. 2003. Variability in the demersal assemblages of the Bay of Biscay during the 1990s. *ICES Marine Science Symposia*, 219: 411–414.

Quéro, J.C., and Cendrero, O. 1996. Incidence de la pêche sur la biodiversité ichthyologique marine: le bassin d'Arcachon et le plateau continental sud Gascogne. Cybium, 20(4): 323–356.

Rodríguez-Cabello, C., Fernández, A., Olaso, I., Sánchez, F., Gancedo, R., Punzón, A. and Cendrero, O. 2005. Overview of continental shelf elasmobranch fisheries in the Cantabrian Sea. J. Northw. Atl. Fish. Sci., 35: 375–385. http://journal.nafo.int/35/16-rodriguezcabello.html

Ruiz-Villareal, M., Gonzalez-Pola, C., Diaz del Rio, G., Lavin, A., Otero, P, Piedracoba, S., and Cabanas, J. M. In press. Oceanographic conditions in North and Northwest Iberia and their influence on the Prestige oil spill. Mar. Pollut. Bull.

Sánchez, F., and Gil, J. 2000. Hydrographic mesoscale structures and Poleward Current as a determinant of hake (*Merluccius merluccius*) recruitment in southern Bay of Biscay. *ICES Journal of Marine Science*, 57: 152–170.

Sánchez, F., and Serrano, A. 2003. Variability of groundfish communities of the Cantabrian Sea during the 1990s. *ICES Marine Science Symposia*, 219: 249–260.

Sánchez, R., Sánchez, F., Landa, J., and Fernández, A. 2003a. Influence of ocenographic parameters on recruitment of megrim (*Lepidorhombus whiffiagonis*) and four-spot megrim (*L. boscii*) on the Northern Spanish continental shelf (ICES Division VIIIc). *ICES Marine Science Symposia*, 219: 400–402.

Sánchez, R., Sánchez, F., and Gil, J. 2003b. The optimal environmental window that controls hake (Merluccius merluccius) recruitments in the Cantabrian Sea. *ICES Marine Science Symposia*, 219: 415-417.

Sánchez, F., Rodríguez-Cabello, C., and Olaso, I. 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them. J. Northw. Atl. Fish. Sci., 35: 467–480.

Santos, A.M.P., Peliz, Á., Dubert, J., Oliveira, P. B., Angélico, M.M., and Ré, P. 2004. Impact of a winter upwelling event on the distribution and transport of sardine (*Sardina pilchardus*) eggs and larvae off Western Iberia: a retention mechanism. Continental Shelf Research, 24(2):149–165.

Serra, N., and Ambar, I. 2002. Eddy generation in the Mediterranean undercurrent. Deep-Sea Research (Part II, Topical Studies in Oceanography), 49, 19, 4225–4243.

Serrano, A., Sánchez, F., and García-Castrillo, G. In press [a]. Epibenthic communities of trawlable grounds of the Cantabrian Sea. Scientia Marina.

Serrano, A., Sánchez, F., Preciado, I., Parra, S., and Frutos, I. In press [b]. Spatial and Temporal Changes in Benthic Communities of the Galician continental Shelf after the Prestige Oil Spill. Marine Pollution Bulletin.

Sousa, P., Azevedo, M., and Gomes, M.C., 2005. Demersal assemblages off Portugal: Mapping, seasonal, and temporal patterns. Fisheries Research, 75(2005): 120–137.

Souissi, S., Ibanez, F., Ben Hamadou, R., Boucher, J., Cathelineau, A.C., Blanchard, F., and Poulard, J.C. 2001. A new multivariate mapping method for studying species assemblages and their habitats: example using bottom trawl surveys in the Bay of Biscay (France). Sarsia, 86, 527–542.

Usabiaga, J.I., Sáenz Aguirre, J., Valencia, V., and Borja, Á. 2004. Climate and Meteorology, variability and its influence on the Ocean. Ed. by A. Borja and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 75–95, Elsevier, Amsterdam.

Valencia, V., and Franco, J. 2004. Main characteristics of the water masses. Ed. by A. Borja and M. Collins. *In* Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 197–232.

Valencia, V., Borja, A., Fontán, A., Pérez, F.F., and Ríos, A.F. 2003. Temperature and salinity fluctuations in the Basque Coast (Southeastern Bay of Biscay), from 1986 to 2000, related to the climatic factors. *ICES Marine Science Symposia*, 219: 340–342.

Valencia, V., Franco, J., Borja, Á., and Fontán, A. 2004. Hydrography of the southeastern Bay of Biscay. Ed.by A. Borja and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 159–194, Elsevier, Amsterdam.

Villamor, B., Gonzalez-Pola, C., Lavín, A., Valdés, L., Lago de Lanzós, A., Franco, C., Cabanas, J.M., Bernal, M., Hernandez, C., Carrera, P., Porteiro, C., and Alvarez, E. 2005. Distribution and survival of larvae of mackerel (*Scomber scombrus*) in the North and Northwest of the Iberian Peninsula, in relation to environmental conditions during spring 2000. ICES CM 2004/Session J:07.

Villate, F., Uriarte, I., Irigoien, X., Beaugrand, G., and Cotano, U. 2004. Zooplankton communities. Ed. by A. Borja and M. Collins. Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 395–423.

Barents Sea and Norwegian Sea

Benthos in the Barents Sea

Several Russian institutes have sampled the benthos in the Barents Sea for many years and reports on the distribution have been published in Russian but several compilations are available also in English (e.g. Pogrebov (1994).

Benthos in the Norwegian Sea

This description provides information only on megabenthos (> 5 cm), focusing on corals. However, there has been made several studies in the area both of soft-bottom infauna and hyperbenthos. Thus the description does not provide a correct picture of the existing information of benthos in the Norwegian Sea.

Annex 14: Update on the effects of the *Prestige* oil spill on the benthic and demersal communities of the Continental Shelf off Galicia and in the Cantabrian Sea

S. Parra, F. Sánchez, A. Serrano, F. Velasco, and I. Frutos

After the oil spill there was no evidence of any temporal changes in the granulometric characteristics or increase in the organic content of the sediment in any of the zones under study along the Galician continental shelf.

In the zone exhibiting the greatest impact from the spill, in Galician waters, the total infaunal abundance underwent a steady decrease in medium strata (121-200 m). The abundance of the polychaete group decreased, while the group "others" (nemerteans, sipunculids, etc.) increased in one station at a lower stratum. From a trophic standpoint, the abundance of the surface deposit feeders diminished gradually in all the stations and the subsurface deposit feeders grew only in one station in the lower stratum. The temporal variation in the infaunal total biomass after the spill was characterized by a progressive increase in the stations along the Muxía area (Costa de la Muerte, La Coruña). After the spill, infaunal species richness dropped in all the stations of the deep stratum and no clear pattern was seen in the variation of infaunal diversity.

Total suprabenthic abundance values for each station decreased from the shallowest to the deepest site, while temporal variation showed a general increase in total abundance at each station. Euphausids, amphipods and mysids are the main zoological groups responsible for this trend

On the Galician and Cantabrian continental shelf, no significant correlations between tar aggregates and species richness, biomass and diversity of epibenthic communities were found. Selected key components of the continental shelf epibenthic and demersal communities were monitored to identify the possible ecological effects of the oil. Significant reductions in the abundance of *Nephrops norvegicus*, *Plesionika heterocarpus* and four-spot megrim were detected in the *Prestige* oil spill maximum impact area. No significant effects on the abundance or distribution of hake juveniles were detected even though the tar aggregates were bound by the same oceanographic drift events as the hake recruits in different water column layers of the Cantabrian Sea. Feeding patterns of the four demersal species analyzed do not present any apparent modifications that can be related to the *Prestige* oil spill.