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# Report of the Benthos Ecology Working Group (BEWG)

19–23 April 2010

Edgewater, MD, USA

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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## Contents

## Executive summary

Because of the eruptions of the Icelandic Eyjafjallajökull volcano, the BEWG organized a multi-venue 2010 meeting, with one group meeting at SERC in Edgewater, MD, USA (8 participants), a second group at ILVO-Fisheries in Oostende, Belgium (7 participants) and a third group, scattered all over Europe (7 participants). Collaboration and interaction between all three groups was maximized through daily web conferences, facilitated by ICES HQ. The group represented a total of 10 countries.

Next to reporting on ongoing benthos research within the North Atlantic region (ToR d) and complying with its parent's Science Steering Group on Ecosystem Functioning organisational requests (ToRs g and h), participants worked on the BEWG 2010 agenda, as grouped under three main themes: benthos and climate change (ToRs a, b, c), benthos-related quality assessment (ToR e, WGBEC request) and marine habitat modelling and mapping (ToR f).

Benthos and climate change is a core theme of the BEWG agenda already since 2008, when a first overview of benthos in relation to climate change was reported. This literature review served as a basis for the BEWG contribution to the ICES Position Paper on Climate Change (ToR a). The benthos chapter was drafted intersessionally with the help of many BEWG members and was presented for internal review during the meeting. Based on the outcome of the BEWG review, the benthos chapter will be revised and submitted for publication to the Science Strategic Initiative on Climate Change (SSICC) by mid May 2010. The BEWG further discussed the conclusions from the Study Group on Climate related Benthic processes in the North Sea (SGCBNS) (ToR c), aiming at initiating future research activities concerning benthic ecosystem processes related to changes in the climate regime and to establish a network of benthic long-term series. The latter was discussed in depth and lead to the establishment of BELTS, the Benthic Ecology Long Term Series network, aiming at facilitating joint analyses of and publications on long-term series without the need of sharing raw data. To promote this initiative, a website will be built with the technical support of VLIZ, but logistic support from ICES HQ would be welcomed. The intersessional work on long-term series (ToR b), facilitating the assessment of wider patterns in relation to climate and in which data from Germany, UK, Belgium and the Netherlands was complied, can be considered a first BELTS initiative. Given the long-term data sets currently having a rather European focus, the American BEWG colleagues will try to discover the existence of American long-term series on marine benthos.

Benthos-related quality assessment is a second core theme, which is on the BEWG agenda for many years now. During this year's BEWG meeting we focused on reviewing the intersessionally drafted BEWG view point paper "The use of benthic indicators in Europe: from the Water Framework Directive to the Marine Strategy Framework Directive" (ToR e). Content and structure of the document were discussed amongst BEWG members and incorporated into the text. It was agreed to finalise and submit the manuscript for publication by the end of June 2010. The view point paper will be presented at the ICES Annual Science Conference (20–24 September 2010, Nantes, France), Session H: Benthic indicators: responding to different human pressures and assessing integrative quality status. This theme session, organized by the BEWG and convened by Ángel Borja (Spanish BEWG member), Daniel Dauer (USA) and Antoine Grémare (France) (Topic h: Indicators) will consist of 20 oral and 17 poster presentations. The BEWG further responded to the WGBEC request to review the evidence for benthic community structure as a suitable method for monitor-

ing effects of contaminants, by (1) evaluating to what extent the benthic community structure is affected by sediment contaminant levels compared to other environmental factors, (2) listing the existence of monitoring data from across contamination gradients, (3) evidencing low levels of contaminants to affect benthic community structure by adverse effects on particular sensitive species and (4) providing relevant references concerning the consideration of contaminant levels which have been taken into account in assessment of national benthos monitoring data across the ICES area.

Given the positive intersessional responses on the BEWG request to consider collaboration between BEWG and WGMHM on marine habitat suitability modelling and mapping (ToR f), the necessity to properly discuss this initiative was highlighted. It was recommended to organize a joint BEWG/WGMHM side-meeting during the ICES Annual Science Conference, aiming at agreeing on the most appropriate aims of and format for collaboration.

The next meeting of the Benthos Ecology Working Group will take place in Fort Pierce, FL, USA, on 2–6 May 2011.

# 1 Preface

Due to the unfortunate eruptions under the Eyjafjallajökull volcano in Iceland, most of the European BEWG members could not reach the venue in the USA, resulting in a multi-venue meeting: one group met at SERC in Edgewater (8 participants), USA and another group met at ILVO-Fisheries in Oostende, Belgium (7 participants). A third group, scattered all over Europe, participated through web conferences (7 participants).

The group agreed to adapt the agenda to allow for parallel breakout group and plenary work in Edgewater and Oostende, taking account of the 6 hours time zone difference. As such, a daily WebEx conference, facilitated by the ICES Secretariat, was set up, enabling participants to communicate over the internet (i.e. plenary work). The daily WebEx conferences started at 9h00 (Edgewater) and 15h00 (Oostende). During the WebEx conferences, participants concluded the various points on the agenda, as handled during the previous breakout group work, and introduced the work for the following breakout group session.

# 2 Opening of the meeting

The Chair, Steven Degraer, opened the meeting over a WebEx link. 22 participants from ten countries attended the meeting (Belgium, Canada, Germany, Italy, the Netherlands, Norway, Spain, Sweden, United Kingdom and United States of America) (Annex 1). Apologies were received from G. Duineveld, R. Diaz, M. Guerra, I. Kröncke, K. Mo, A. Norkko, F. O'Beirn, E. Rachor, M. Robertson, L. Robinson, H. Rumohr, J. Warzocha and M. Zettler. H. Hillewaert was appointed Editorial Rapporteur.

# 3 Adoption of the agenda

The adjusted agenda (due to the unforeseen volcanic eruption event) was unanimously adopted. The annotated Agenda is in Annex 2.

# 4 Benthos and climate change

## 4.1 Climate change effects on benthic communities

### 4.1.1 Introductory presentations

#### 4.1.1.1 Recent findings on long-term data series analyses: Studies on *Gelidium corneum* macroalgae, in relation to climate change, within the Basque Country (1983–2009)

**By Angel Borja of AZTI - Tecnalia, Marine Research Division (Spain)**

*Gelidium corneum* is a macroalgae structuring sublittoral benthic communities, between 0 and 15–20 m water depth, within the northern coast of Spain. It is used for agar-agar extraction, both from casts-off collected at beaches or from direct exploitation in rocky substrata. Within the Basque Country there exists a monitoring program to assess the situation of this important macroalgae. An extensive annual sampling is undertaken in an area extending 30 km, in the eastern part of this region. A total of 100 samples are taken annually, determining macroalgae cover and total biomass. The dataset covers 1983, 1986 and 1993 onwards.

Environmental data, such as daily sun hours, temperature, wave height and wave energy, and some teleconnection patterns (i.e. Eastern Atlantic, North Atlantic Oscillation), were also obtained and studied for the period 1983–2009. The most important factors explaining *Gelidium* summer biomass were sun hours, in previous winter-spring period, and waves in the same period.

Currently we are working with Bayesian networks in order to predict future changes in biomass depending on predicted changes in the abovementioned factors, described in the literature or derived by us in a project on the impacts on climate change within the Basque coast.

#### 4.1.1.2 Application of the biogeochemical flux model (BFM) to a shallow water lagoon and possible links with SGCBNS activities"

**P. Magni of CNR - National Research Council (Italy) reported**

At the CNR-IAMC of Oristano (Sardinia, Italy), in addition to the experimental part (e.g. sedimentology, benthic ecology, and fish ecophysiology), we developed a shallow water hydrodynamic model based on finite elements, fully coupled with ecosystem model (biogeochemical flux model, BFM), and applied it to a microtidal Mediterranean lagoon system. One of the major applications of our model is the energetics of grey mullets (*Mugil cephalus*). *M. cephalus* is a detrivore benthopelagic species which feeds on benthic organisms and swims in the water column in large aggregations, and therefore it represents a fundamental trophic link between the benthic and pelagic environments.

The coupled hydrodynamic-ecological model was calibrated for reproducing the environmental variability (water temperature, salinity, dissolved oxygen, ammonia, nitrate, orthophosphates and chlorophyll-a) in two adjacent Mediterranean shallow water environments: the Cabras lagoon and the Gulf of Oristano (Italy). This type of environments is particularly interesting as the physico-chemical characteristics of the water are widely fluctuating. The model was used to reproduce the temporal and spatial variation in the Metabolic Scope (MS) of a *M. cephalus* fish population in order to investigate the relationship between changes in MS and the observed seasonal migration pattern between the gulf and lagoon. Results from numerical simulations show that during the spring and beginning of summer period, the Cabras lagoon provides a higher MS for *M. cephalus* than the gulf of Oristano. During the rest of the year, apart from some transitional phases, the Gulf provides more suitable conditions (i.e. higher MS) for *M. cephalus*. Results were compared to fisheries data, showing that *M. cephalus* catches are highest during the end-July to August period, coinciding with the period of MS drop in the lagoon, when fish are caught migrating from the lagoon into the gulf. By modelling their metabolic scope (i.e. scope for activity), we developed a tool that allows to potentially forecast the distribution of grey mullets in Mediterranean coastal areas.

This is a first step towards a more comprehensive coupling between ecosystem modelling and benthic processes. A further step will be to include in the model the benthic components, such nutrient flux from sediments and benthic macroinvertebrates. Therefore, we could support the activities of SGCBNS by testing the “new” functional groups modules in a different environment from the North Sea, e.g. a Mediterranean coastal lagoon, which differs with respect to the North Sea both from latitude and geomorphology stand point.

#### 4.1.1.3 Long-term (1995–2008) environmental, anthropogenic and climatic factors affecting soft-bottom benthic communities within the Basque estuaries

**Angel Borja of AZTI - Tecnalia, Marine Research Division (Spain) reported**

Estuarine and coastal seas have been used for human settlement and marine resources exploitation through the history. Centuries of overexploitation, habitat transformation and pollution have contributed to estuarine degradation and biodiversity loss. Hence, there is an increasing need to restore degraded estuarine and coastal ecosystems. In this way, the Water Framework Directive emphasises the need of implementing monitoring programmes, providing a new view of water resources management in Europe, which is based mainly upon ecological elements (phytoplankton, macroalgae, benthos and fishes). Due to the huge industrial development that took place in the 19th century in the Basque Country, human activities highly damaged the ecological status of the Basque estuaries. After many decades of discharges of industrial and urban waste waters into the estuaries, water treatment schemes have been implemented in most of them. Moreover, the Littoral Quality Monitoring Network has monitored the Basque coastal and estuarine water quality since 1995.

The objective of this study is to determine the variability in Basque estuarine soft-bottom macrofaunal communities explained by anthropogenic, climatic and sedimentological factors. Moreover, time trends in these variables were analysed, using data provided by the LQM since 1995. Multivariate analysis revealed that anthropogenic variables explained the variability in the densities of the species in a higher extent (16.4%) than the climatic variables (15.4%). It also revealed that the general physicochemical characteristics are of special relevance (17.2%). Thus, some estuaries have communities with presence of pollution indicator species as a result of the low percentage of oxygen saturation and, in some cases, the high levels of heavy metals. Moreover, in estuaries in which the structural parameters of the communities were explained by anthropogenic variables, general improvement trends in the quality of the benthic community status and sediment quality were observed. Although the water treatment in the Basque estuaries, and the closure of major industries, have led to a gradual recovery of the benthic communities, there is still some work to be done, in order to achieve a "good water status for all water bodies for 2015", as required by the WFD.

### 4.1.2 Intersessional BEWG work on long-term data series analyses with special attention to climate change and future actions (ToR b)

#### 4.1.2.1 Long-term data series analyses with special attention to climate change

This initiative was discussed and established last year to enable benthic scientists to interrogate available benthic time-series for single areas and also to facilitate assessments of wider patterns in relation to climate. In principle all the information needed to be assessed to see the level of synchronicity of benthic information available. There was a protocol with information developed to assess the initial data sets available (see details presented in Annex 5). Data available from Germany, UK, Belgium and Netherlands was complied. Silvana Birchenough volunteered to assess the existing data trends and seek advice on alternatives way of analysing time-series data sets with Cefas Senior Statistician (Dr Jon Barry). Jon developed a series of 'scenario testing' options and these documents and papers with supporting information were circulated among BEWG remembers for their consideration (via share point this year). There was another invitation extended to all BEWG members that wanted to join this

initiative and the provision of the protocol to Silvana Birchenough was extended until June 2010. The work for this initiative needs to be pursued/agreed on sub-groups

Intersessional work on long term data series analyses with special attention to climate change will have to be conducted once all the relevant benthic time-series information is collated. American colleagues will try to discover existence of American long-term series.

#### 4.1.2.2 Benthic Ecology Long Term Series network (BELTS)

##### Discussion of the network initiative

The BEWG agreed on the name "Benthic Ecology Long Term Series network" (BELTS) to reflects all important aspects of the initiative. It was acknowledged that although the general idea is to facilitate joint analyses and publications without the need of sharing raw data, this may well be done if the contributors of a specific study decide to do so if needed. The BEWG reviewed and amended the draft description of the proposed network. The revised version can be found in Annex 6. This text will be the basis for the website, which will be distributed once a draft has been put together by A. Schröder in cooperation with technical support by VLIZ. After consensus by the group, it will be put online. All members are encouraged to supply ideas for a logo and possible pictures/figures to illustrate the website. A. Schröder and B. Tunberg were designated as chair and co-chair for the first period. The progress of this initiative shall be reported during the next BEWG-meeting in 2011.

The BEWG would like to ask the ICES for support the network logistically by supplying a share-point site, the possibility for WebEx meetings and by supporting case study meetings.

## 4.2 Outcome of the Study Group on Climate-Related Processes within the Benthos of the North Sea and recommendations regarding its future actions (ToR c)

The Study Group on Climate related Benthic processes in the North Sea (SGCBNS) was initiated by the ICES Benthos Ecology Working Group (BEWG) as a follow up initiative of former North Sea Benthos Surveys (NSBS 1986; NSBP 2000) and is partly based on the outcomes of a eponymous workshop held in 2008 (see WKCBNS report). The aim was to discuss and initiate future research activities concerning benthic ecosystem processes related to changes in the climate regime and to establish a network of benthic long-term series. The meeting took place in Lowestoft, UK, 1–4 March 2010.

Initial discussions were focused on the pros and cons of a reduced spatial coverage (i.e. box or small scale approach) for the study of benthic processes in the North Sea. Examples of representativity of benthic habitats, sampling effort and comparable areas were covered at length. As previously discussed a series of benthic hypotheses in relation to benthic communities and the effects of climate change were identified as key questions at the study group meeting at Wilhelmshaven in 2008 (ToR a). From these initial discussions it was mainly acknowledged of the importance of ecosystem processes which are driven by the hypotheses previously discussed. Further discussions were mainly focused on the key processes, parameters, drivers and methodology to be considered in helping to identify specific benthic processes affected by climate change.

To facilitate the study of relevant key ecosystem processes, it was decided that two case studies on bioturbation would be undertaken (ToR d). The objectives are to

evaluate the spatial (North Sea wide) and temporal (intra-annual) variation of the potential for community level and species level bioturbation. A follow-up workshop will be organised in Plymouth in November 2010 to work on case study 1 (intra-annual variation of bioturbation) and case study 2 will be started during next year's meeting (2011). In addition, another three case studies were discussed which will be further developed and carried out within the life span of the SG.

Ecosystem modelling was highlighted as an important tool for understanding benthic processes and the prediction of ecosystem changes (ToRs b and e). Nevertheless, benthic components in current ecosystem models are not sufficient. Therefore, the SG will initiate a cooperative approach to test current ecosystem models with existing benthos time-series data. The North Sea will be used as a study region, but the approaches used should be of general importance for the understanding of benthic processes. A closer cooperation between ecosystem modellers and this SG is also planned.

The establishment of a network for long-term benthos data was initiated during the SG meeting (ToR c). The intention of the network is to facilitate joint analyses of marine benthic long term series by collaborative work of scientists and to make existing information (e.g. publications, reports) available. The aim is NOT to collect data. The network will be finally discussed during the meeting of the BEWG. The Flanders Marine Institute (VLIZ) agreed to contribute in three ways to the SGCBNS. Firstly, by making a link with the European Marine Observation and Data Network (EMODNET). EMODNET will assemble fragmented biological data and information into one portal, which can help the SGCBNS in their search for suitable long-term data. Secondly, VLIZ will develop the website for the Benthos Network. Finally, VLIZ will act as data managers of the planned case studies.

The main recommendations were:

- Support from ICES for the long-term network (e.g. facilitating network interactions and providing data contributions )
- The BEWG to develop the network further via facilitating and disseminating current and future initiatives
- ICES to support intersessional work on the case studies (detailed work provided in the report for case studies 1–5)
- Facilitate the links between SGCBNS and Modelling group (WGPBI), WGBIODIV, BEWG
- ICES to actively feedback research needs and scientific priorities for the next FP7 call
- VLIZ to assist in preparing data for case study 2 and to develop the website for the Benthos Network
- The SG to support an additional workshop in Plymouth for case study 1

### 4.3 BEWG contribution to the ICES Position Paper on Climate Change (ToR a)

The ICES Position Paper on Climate Change was initiated by the Science Steering Group (SSGCC on Climate Change (now: Science Strategic Initiative on Climate Change, SSICC), considering the issue of climate change as an ICES Expert Group overarching theme. The Position Paper will contain 13 chapters, going from the physical aspects of climate change to the integrated ecosystem effects, and will be published by late 2010 or early 2011.

The BEWG was asked to compile a chapter on the effects of climate change onto the benthos. During her 2009 meeting, the BEWG agreed to contribute based on the BEWG 2008 meeting report, in which a first overview of benthos in relation to climate change is given, and allocated writing tasks to her members. Input from various authors was expected by late 2009 to be fine tuned and compiled during an ICES Editorial Workshop (25–27/01/2010, Copenhagen), for which BEWG delegated Silvana Birchenough, Henning Reiss and Steven Degraer as the editorial team for the BEWG contribution.

A final draft was sent out for internal review by Philip C. Reid (Plymouth, UK) in March 2010. Furthermore the BEWG 2010 participants were asked to review the final draft during the BEWG 2010 meeting, with special focus on the need for specifically added expertise (e.g. hypoxia, deep sea benthos) and the need for illustrations. Silvana Birchenough, Henning Reiss and Steven Degraer agreed to consider the review comments both from the internal review process as well as from the BEWG 2010 participants and revise the BEWG contribution accordingly by mid May 2010.

# 5 Benthos-related quality assessment

## 5.1 Recent developments in environmental quality assessment covering phytobenthic and zoobenthic topics

### 5.1.1 The use of M-AMBI in assessing benthic quality, within the Water Framework Directive and proposal for the Marine Strategy Directive

**By Angel Borja of AZTI - Tecnalia, Marine Research Division (Spain)**

The European Water Framework Directive (WFD) establishes a framework for the protection and improvement of estuarine and coastal waters, trying to achieve 'Good water status' for all waters, by 2015, in different biological elements. One of the elements is the benthos and, as such, the WFD normative definitions describe the aspects of the benthic communities that must be included in the ecological status assessment of a water body. Therefore, it is essential to include, in the assessment, the different metrics that address those parameters identified in the normative definitions for each of the ecological status classes e.g. diversity, richness, abundance and opportunistic and sensitive species.

To face this assessment problem the AZTI's Marine Biotic Index (AMBI) was develop to determine the ratio between opportunistic and sensitive species. Later the Multivariate AMBI (M-AMBI) was developed, including AMBI, richness and diversity in a Factor Analysis. M-AMBI requires reference conditions from each water type/habitat, in order to compare monitoring data to reference data and assess the status. Both methods are increasingly used worldwide (Europe, North and South America, Africa and Asia), and have been tested under different human pressures, including eutrophication, waste water and sludge discharge (and clean-up), dredging and sediment disposal, oil-platforms (drill cuttings), aquaculture, engineering works (marina and dyke construction), land reclamation (and restoration), priority substances (metals, organics) pollution, mine tailings, etc. However, M-AMBI needs to be tested with sand extraction and fishing. This and other methods are being used in Europe, after intercalibration, in assessing the ecological status within the WFD.

Now, the new European Marine Strategy Framework Directive (MSFD) tries to achieve good environmental status, by 2020. One of the 11 descriptors within the MSFD is "sea-floor integrity", which should be at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in par-

ticular, are not adversely affected. Hence, 'sea-floor' includes abiotic and biotic attributes; 'integrity' is related to spatial connectedness, ecosystem processes and functioning, and resilience to perturbations; and 'no affection' must be related to human uses and sustainability (the perturbations do not degrade ecosystem structure, function, goods and services, and recovery would be "rapid and secure" when the pressure is removed).

Within this context, the use of the same methods than in the WFD, together with other complementary (e.g. habitat mapping, habitat suitability, goods and services valuation, etc.), can be very useful in assessing the environmental status of the seafloor.

### 5.1.2 Benthic Infaunal Monitoring in the St. Lucie Estuary and the Indian River Lagoon. Ecological Disturbances Elucidated by using the Indices AMBI and M-AMBI

**Work done by Bjorn G. Tunberg, Angel Borja, Michelle Stephens**

The Indian River lagoon (IRL) and the St. Lucie Estuary (SLE) are affected by a variety of anthropogenic pressures. This benthic sampling program is a fixed site monitoring effort directed at identifying trends in benthic macrofaunal condition. It involves sampling at 15 sites, 13 of which have been sampled since the program's inception in February 2005, with two inner estuary sites added in July 2007 (Figure 1 and 2). Each site is visited 4 times per year, twice (January and April) during months that typically fall into Florida's dry season (November–April) and twice (July and October) during months that typically fall into Florida's wet season (May–October).

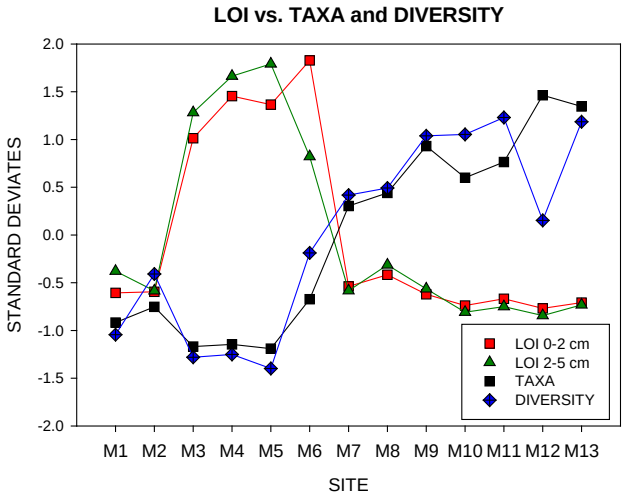


**Figure 1. The 13 monitoring sites, and the correlation between organic content in the sediment, and the number of taxa and diversity at each site. SLE= St. Lucie Estuary, IRL= Indian River Lagoon.**

These sites span all salinity regimes within the St. Lucie Estuary and the Southern Indian River Lagoon (SLE/IRL-S) and cover the watershed in such a way that benthic responses to hydrologic events stemming from the system's tributaries can be detected and analyzed. Statistical treatment of the faunal and environmental data has indicated that large parts of the investigated areas (especially the St. Lucie Estuary basin) are heavily disturbed by polluted freshwater releases. However, no biotic index has earlier been initiated to elucidate these disturbances for a better overview of the severity and extension of these disturbances.

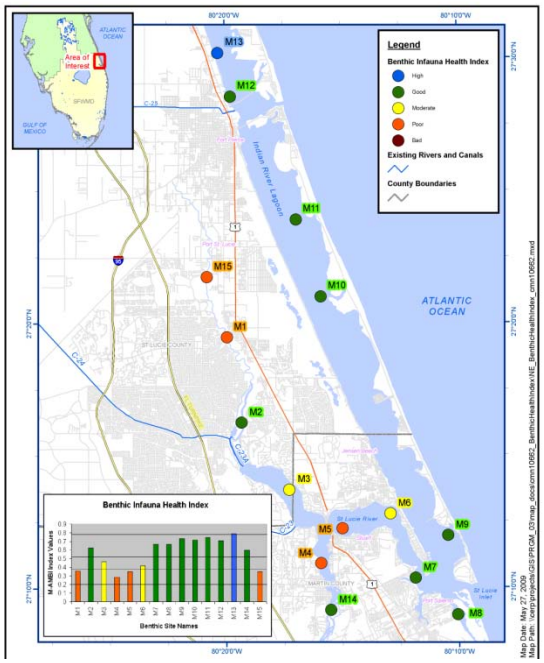


**Figure 2. Results of the M-AMBI analyses at the 15 monitored sites.**

This contribution investigates the application of the AZTI's Marine Biotic Index (AMBI) and multivariate-AMBI (M-AMBI), to assess the ecological status of these estuaries. AMBI was firstly calculated after assigning most of the previously unassigned species to each of the five ecological groups. Three main benthic assemblages, associated to oligohaline, meso-polyhaline and euhaline stretches, have been identified. Reference conditions of richness, Shannon's diversity and AMBI have been derived for these assemblages; M-AMBI has then been calculated (Figure 2). Both methods show that the inner part of the SLE is affected by anthropogenic pressures (increased freshwater inflow, elevated nutrient input, and sedimentation), whilst the IRL is less affected. We have demonstrated that AMBI is insensitive to the dramatic seasonal changes occurring in the SLE/IRL. At some of the sites, a significant positive trend has been identified, linked to the water discharges. The use of both tools seems to be promising in assessing benthic health in this area.

## 5.2 Status of the BEWG viewpoint paper on benthic indicators and evaluation of ongoing developments on ecological quality assessment (ToR e)

The draft version 2 of the view point paper entitled "The use of benthic indicators in Europe: from the Water Framework Directive to the Marine Strategy Framework Directive" was distributed to the members prior to the meeting. Content, structure of the document and further comments were discussed amongst BEWG members and incorporated into the text.

Some major points during the discussion were:

- More attention is needed concerning the use of terminology related to WFD and MSFD (e.g. good ecological and good environmental status), to avoid confusion in their use.
- A separate text box, instead of a mentioning in the introduction, may be handy to explain the content of both directives, offering overall information for non-involved readers.

- A summarizing table is important and worthwhile, but has to be linked from within the text.
- MSFD implementations have evolved in the last year. As such the latest steps in the MSFD process have to be included.
- The topic on monitoring effort has to be reworked and references have to be added.

During the meeting it was agreed to finish a final draft version by the end of May. The text will be reworked based on comments and member's contributions. The group can comment on it until half June, finalizing it for submission to *Marine Pollution Bulletin* by the end of June.

The content of the paper will be presented at the ICES Annual Science meeting in Nantes (Topic H: Indicators). An alternative path to publication, in the case of declined submission to *Marine Pollution Bulletin*, will be submission to the special issue of *Ecological Indicators* referring to topic H: Indicators.

## 5.3 WGBEC request: Benthic community structure and its relationship to contaminants

### 5.3.1 Introductory presentation: An empirical approach to the determination of metal regional Sediment Quality Guidelines, in marine waters, within the European Water Framework Directive

**Work done by I. Menchaca, A. Borja, M.J. Belzunce-Segarra, J. Franco, J.M. Garmendia, J. Larreta, J.G. Rodríguez at AZTI - Tecnalia, Marine Research Division (Spain)**

Regional Sediment Quality Guidelines (SQG) for metals from the Basque Country (northern Spain) were determined. These SQG are proposed to be used for management purposes, within the Water Framework Directive (WFD), in assessing chemical and physico-chemical status. Two approaches, based upon sediment chemistry, toxicity (Microtox, amphipod bioassays and larvae survival of sea-urchin) and AMBI, were carried out with 961 estuarine and coastal samples. They were applied using percentile calculations (biological effect and non-effect data), following normalization on the fine-grained sediment content and with non-normalization. The feasibility of SQG was quantified by the incidence of adverse effects of metal concentration. The study proposes the following formula to calculate SQG: $SQG_{metal} = {}^{*}SQG_{metal}\ \mu g.\ g^{-1} / FC.\ 10^{-2}$ (FC: Fine Content; *SQG: normalized SGQ). The *SQG were 13.5 $\mu g.g^{-1}$ for As, 1 $\mu g.g^{-1}$ for Cd, 39 $\mu g.g^{-1}$ for Cr, 55 $\mu g.g^{-1}$ for Cu, 0.53 $\mu g.g^{-1}$ for Hg, 23 $\mu g.g^{-1}$ for Ni, 78 $\mu g.g^{-1}$ for Pb, and 249 $\mu g.g^{-1}$ for Zn.

### 5.3.2 BEWG response to the WGBEC request

The BEWG responded to a request of the WGBEC to review the evidence for benthic community structure as a suitable method for monitoring effects of contaminants. Four questions were answered and comprehensively referenced:

1 ) Comprehensive literature is available and references are provided addressing the question to what extent benthic community structure is affected by sediment contaminant levels compared to other environmental factors

2 ) The WFD is providing monitoring data from across contamination gradients in the field on European level. Comprehensive and extensive monitoring is also carried out in the US.

3 ) Low levels of contaminants are thought to affect benthic community structure by adverse effects on particular sensitive species.

4 ) Relevant references are provided concerning the consideration of contaminant levels which have been taken into account in assessment of national benthos monitoring data across the ICES area.

The full document is given in Annex 7.

### 5.4 BEWG Theme Session at ICES Annual Science Conference (Nantes, France; 20–24 September 2010) "Benthic indicators: responding to different human pressures and assessing integrative quality status: State of the Art

**Conveners: Angel Borja (Spain), Daniel Dauer (USA) and Antoine Grémare (France)**

The deadline for abstract submission for the ICES Annual Science Conference 2010 was 15/04. The theme session has been well received by potential contributors, with 37 abstracts from 16 countries from Europe, North America, Oceania and Asia. From these abstracts, 20 have been retained for oral presentation and 17 abstracts for poster presentations. The abstracts covered various aspects of benthic indicators, with a focus on new indicators and methods, response of existing methods to human pressures and comparison of different methodologies. However, also some investigations on indices validation, reference conditions determination, biomarkers and climate change, will be presented. A selection of papers will be published in a special issue of the a1 journal *Ecological Indicators.*

## 6 Ongoing benthos-related initiatives

### 6.1 Exciting developments in ongoing phyto- and zoobenthic research in the ICES area, with special attention to North-American activities (ToR d)

#### 6.1.1 Mobilizing Marine Biodiversity Research: The Canadian Healthy Oceans Network

**Work done by Snelgrove, P. V. R., Archambault, P., Juniper, S. K., Lawton, P., Metaxas, A., McKindsey, C., Pepin, P., and Tunnicliffe, V.**

The Census of Marine Life has provided a framework for collaborative research in marine biodiversity. Here we present a model for academic and government partnership that has created the Canadian Healthy Oceans Network (CHONe), a national research program that is uniting researchers to provide new insights into marine biodiversity and provide scientific guidelines for policy in conservation and sustainable use of marine biodiversity resources in Canada's three oceans. This initiative is structured around three interlinking themes. Theme Marine Biodiversity addresses the relationships between biodiversity and habitat diversity by testing hypotheses that link functional and species biodiversity to habitat complexity. Theme Ecosystem Function addresses how ecosystem function and health are linked to biodiversity and natural and anthropogenic disturbances. Theme Population Connectivity addresses how dispersal of marine organisms, typically by early life stages, influences patterns of diversity, resilience, and source/sink dynamics of species and biological communities using source-sink studies of existing management areas as model systems, and comparative studies of different dispersal metrics to estimate metapopulation connectivity. We will synthesize the outcomes of these themes across the Network to identify approaches to bridge science and policy, and communicate these results to the complex networks of user groups who ultimately influence policy application.

Keywords: biodiversity, ecosystem function, baseline, connectivity, policy

Contact: P.V.R. Snelgrove, Ocean Sciences Centre & Biology Department, Memorial University of Newfoundland, St. John's, NL A1C 5S7 Canada. psnelgro@mun.ca

### 6.1.2 Infaunal macrobenthic communities in the Northern Galician Rias and in the adjacent continental shelf (NW Iberian Peninsula): preliminary studies

**Work done by S. Parra1, E., J. Valencia1, J. Fernández1, C. Vázquez1, M. Varela1 & R. Prego2**

**1 Instituto Español de Oceanografía (IEO), Oceanographic Center of A Coruña, Spain**
**2 Instituto de Investigacións Mariñas (CSIC), Vigo, Spain**

Benthic samples for study of sediment parameters and the infaunal subtidal community were collected at 22 stations in three embayment, locally called "ría", in the North-West of the Iberian Peninsula: Ría de Ortigueira, Ría de Barqueiro and Ría de Viveiro. This preliminary study examines the linkages between the marine sediment composition and the spatial distribution with the inhabit macroinfaunal communities.

Surface sediments are mainly composed of sand, mixed with gravel in the shelf due to the high energetic hydrodynamic conditions, whereas muddy sediments, with moderate organic matter content, are located in the innermost protected parts of the embayment. Ortigueira sediments are dominated by the presence of medium sands with low organic content, while Barqueiro sediments are composed of fine sands or very fine, with low to moderate organic content. By contrast, we found a great heterogeneity in the sediments of the Viveiro estuary, we observed from mud with high organic content to coarse sands with low organic matter content.

In all sampling stations, the Infaunal communities are dominated by polychaetes, followed by crustaceans, which reach high densities in Ortigueira bay. The polychaete *Magelona filiformis* is the most abundant species throughout the deep zone of study, while *Mediomastus fragilis* dominates the shallow areas and bathymetry. *Paradonesis armata* showed similar deals but mainly in the estuaries of the Barqueiro and Vivero bays. Different species of polychaetes of the genus *Aricidia* are highly abundant in all deeper zones of the three embayment studied. The amphipods crustaceans *Bathyporeia* spp. and *Ampelisca* spp. are the dominant species in areas of the continental shelf adjacent to the Ortigueira bay, where they are moderately abundant. As for the population parameters, the total abundance reaches its highest values in the inner zone of the estuary of Vivero, while the highest values of diversity, richness and evenness are reached in the deepest areas of the three estuaries, in the adjacent continental shelf.

### 6.1.3 Long-term variation in fish community composition: a Chesapeake Bay model system

**Work done by Robert Aguilar, Anson H. Hines, Margaret A. Kramer and Michael R. Goodison from the Smithsonian Environmental Research Center**

Long-term measures of species composition and population dynamics provide important indicators of ecosystem function, the status of biotic resources, and possible anthropogenic impacts on community structure. Our 28 year (1980–2007) data set provides long-term analysis of variation in the nearshore fish community in Rhode River, Maryland, a mesohaline subestuary of the upper Chesapeake Bay. Fifty-two fish species were caught and enumerated during yearly seine sampling (June–September) at 13 stations distributed throughout the Rhode River. Multivariate statistical analysis indicated a shift in assemblage structure from the 1980s to 1990s. This shift was generally characterized by declines in spot *Leiostomus xanthurus* and menhaden *Brevoortia tyrannus* and marked increases in white perch *Morone americana* and striped bass *Morone saxatilis*. Multivariate statistical analysis also indicated spatially distinct assemblages (i.e., creek vs. main stem stations) that occurred throughout the

entire study period. These assemblages were characterized by increased numbers of freshwater and marsh associated fish at creek sites and greater numbers of pelagic and transient species at main stem sites. Little correlation between and assemblage structure and environmental variable was noted, except at the most upstream sites, which receive the majority of freshwater flow. This relationship was primarily driven by higher abundances of freshwater fish during periods of low salinity, compared with increasing abundances of estuarine species during periods of higher salinity. These data further illustrate the importance of long-term sampling programs, since it is often necessary to sample at large time scales (e.g., decadal) to adequately assess change in community structure and ecosystem dynamics.

### 6.1.4 Pre- and Post Dredge Benthic Infaunal Monitoring in Sebastian River, Eastern Florida, USA

**Work done by Bjorn G. Tunberg, Michelle Stephens**

Dredging large parts of the Sebastian River was considered a necessity, since significant accumulation by soft sediments in the River (estuary) made navigation complicated here. In some areas the soft sediment also caused low oxygen values in the bottom water, with negative impacts on the bottom biological environment.

Benthic monitoring is required to document both pre- and post-dredge conditions and to determine whether intended environmental impacts (desirable or undesirable) are occurring. The outcome of this type of monitoring programs could therefore usefully contribute to judgments on the acceptability of continued dredging in the Sebastian River, and in other similar areas. The outcome of these monitoring programs can therefore also usefully contribute to decisions about continued dredging as designed or with design modifications to prevent negative impacts.

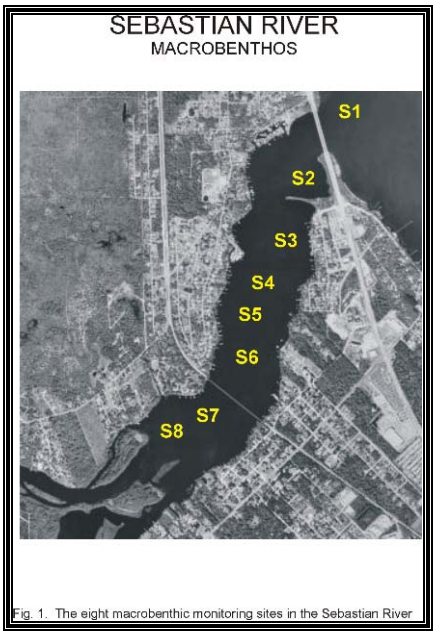

Fig. 1. The eight macrobenthic monitoring sites in the Sebastian River

Quantitative benthic infaunal sampling (with replication), sediment analyses and water quality measurements are being performed quarterly at eight sites (Figure 1) in the Sebastian River since April 2004. The study covers the area from the IRL (east and close to the US Highway1 bridge) to the west of the railroad trestle. The pre dredge data indicated that the ecological conditions were poor from the US1 bridge west to the railroad trestle, but good in large areas west of the trestle, with a rich infaunal

community and high bottom oxygen and salinity concentrations. The preliminary conclusion from these studies was that dredging could be performed from the US1 bridge and west to the railroad trestle without any serious ecological consequences, provided a minimal release of suspended matter into the water column. Because of the large areas with good environmental conditions west of the trestle, dredging should have been performed with the greatest caution here and also be as limited as possible. However, significant dredging has now been performed west of the railroad trestle and into the South Prong.

The decrease in abundance and species richness detected in October 2004 throughout the system was most likely caused by hurricanes Frances and Jeanne. These effects are documented in a manuscript in preparation for publication. Large freshwater discharges to the Sebastian River continued for a duration of approximately six weeks. This event significantly impacted the benthic environment, inducing hypoxia and low salinities that resulted in a rapid drop in benthic taxa and diversity. However, recovery was fairly rapid as indicated by the data from January and May 2005.

After the dredging at sites S3, S4, and S5 in 2007 these areas were completely defaunated. Recovery of individuals and taxa were fairly rapid, though multivariate analyses indicated that differences in community structure existed between the assemblages prior to and after the dredging occurred. The poor conditions that existed in these areas prior to dredging hampered further analysis until a longer time-series could be generated as infaunal abundance and diversity were very low prior to dredging at these sites.

However, the 2004 powerful hurricanes (mentioned above) that hit this area had a serious impact on the Sebastian River entire ecosystem, which complicated the evaluation of the infaunal temporal changes.

### 6.1.5 Fouling community recruitment - local vs. regional species pools

**Work done by João Canning Clode at the Smithsonian Environmental Research Center**

The relationship between local and regional richness in marine fouling assemblages was investigated using an expanded and globally replicated approach by incorporating two dimensions of diversity (taxonomic and functional) and different successional stages. In eight different biogeographic regions (Australia, Brazil, Chile, England, Italy, Japan, Portugal and Sweden) 68 polyvinylchloride (PVC) panels (15 x 15 x 0.3 cm) were deployed for colonization. Communities colonizing panels were analyzed by measuring percent cover at each of the four different successional ages: 2, 4, 6 and 8 months. Local richness was assessed as the average number of species and functional groups (FG) per panel and regional richness was evaluated as the estimated (Jack2) asymptote of the sample-accumulation curves for species and FG on experimental panels. The shape of the relationship between local and regional richness was found to depend on successional stage, and the type of richness considered, i.e. taxonomical or functional richness. Hardly any relationship was detectable between local taxonomic richness and regional taxonomic richness at any successional stage. In contrast, the relation between local functional and regional functional richness shows a unimodal pattern of change during succession, passing through the stages 'independent', 'unsaturated rising', 'saturated rising', and once again 'independent'. It can be concluded that the relationship between local and regional richness, whether taxonomic or functional, frequently displays independence of the 2 scales, particularly in early and late phases of the successional process.

## 6.2 State of the Art of the TIMES "Phytobenthos monitoring guidelines"

Hasse Kautsky drafted a TIMES manuscript on phytobenthis monitoring guidelines.

Paul Keizer reviewed the manuscript. He had some excellent editorial comments and pinpointed some inconsistencies, illogical statements, and offered suggestions for the reorganization of some parts of the text. His comments will now be incorporated in the text and the identified problems resolved after which the updated document will be returned to P. Keizer for an external referee round for further input to the contents.

# 7 Marine habitat modelling and mapping: Where BEWG and WGMHM meet

## 7.1 Introductory presentations

### 7.1.1 Modelling the distribution of macrozoobenthos in the Baltic Sea in response to selected environmental factors

**Work done by Mayya Gogina, Michael L. Zettler, Michael Glockzin, Ralf Bochert and Alexander Darr at the IOW WG Ecology of Benthic Organisms**

Generation of potential habitat distribution maps is stated to be among the goals of predictive modelling. The patterns in the spatial distribution of macrofaunal communities and exemplary species of the Baltic Sea are linked to patterns in nearbottom environmental parameters, based on the data for two various spatial extents. Conditional to the scale, various factors define the variations in distribution. For brackish ecosystem of the Baltic Sea salinity is regarded as a major driving factor that determines benthic biodiversity. The first case study is focused on the limited area in the western Baltic Sea. Preliminary investigation revealed characteristic species to indicate the most well-defined responses to depth and sediment parameters as total organic content, median grain size and sorting. The technique for predictive modelling of species distribution in response to abiotic variables, based on single-factor logistic regression models (that describe the occurrence of species along single environmental variable) combined with the use of AIC and Akaike weights for the multimodel inference was developed. Using the defined method, probabilities of occurrence were modelled and mapped for selected species. The response surfaces obtained indicate fairly high degree of success. Water depth that represents a type of integral parameter remained the key factor determining the species distribution among the parameters considered within the study scale. The similar method was applied in the Pomeranian Bight where e.g. for *Bathyporeia pilosa* total organic content explained most of variability in regional distribution. Based on an inventory dataset that compiled the information on macrozoobenthos distribution in the whole Baltic Sea including historical data the discriminating ability of salinity, bathymetry and substrate types as predictors for probability of species occurrence was tested. Simple empirical (logistic regression based) habitat suitability models allow to satisfactorily predict the potential distribution of exemplary macrofaunal species (background). Yet this exercise was only a first step. Clearly, implementation of other variables (e.g. characterizing oxygen and temperature fluctuations, total organic content, and nutrient supply) would obviously increase the model accuracy and applicability. Thus the suitable and sufficient data covering the distribution patterns for these environmental variables is highly demanded.

### 7.1.2 Species distribution modelling of North Sea Benthos

**Work done by Henning Reiss, Konstantin König, Sarah Cunze, Hermann Neumann, and Ingrid Kröncke**

The knowledge of the spatial distribution of species and communities in ecosystems is an essential prerequisite for the understanding of ecosystem functioning and processes as well as for conservation and spatial planning issues. Especially in the marine environment, where the fauna is much more difficult to access and to monitor than in terrestrial system, the requirements for spatial planning and ecosystem management are often confronted with fragmentary spatial information about the species and habitats. Therefore, predictive methods became more and more important as tools to overcome these problems.

In this study we have applied several niche modelling techniques to predict the distribution of benthos species in the North Sea. The benthos data were extracted from the databases of the North Sea Benthos Project 2000 and the EU-Project MAFCONS. Environmental variables on a North Sea wide scale were derived by a variety of sources (modelled, measured and satellite data) and processed to an identical GIS format. The performance of the following distribution model algorithms were test by using the software Maxent, OpenModeller and Biomod in R: GLM, GAM, GBM, MBA, SVM, RF, NNA, Maxent, GARP, MARS. The AUC values revealed a good or a very good performance of most of the tested algorithms. Nevertheless, the predicted distribution patterns varied remarkably depending on the algorithm used. The long-term objective is to apply these models for predicting the future distribution of benthos species in response to climate change by using IPCC scenarios.

## 7.2 Explore the feasibility and added value of a Study Group on Habitat Suitability Modelling as an "interface" between BEWG and WGMHM and recommend future actions (ToR f)

As agreed during the BEWG 2009 meeting, Jacques Populus, chair of WGMHM, was contacted regarding the BEWG intention to explore the feasibility and added value of a close collaboration of both ICES expert groups on habitat suitability modeling. Given the clear possibilities and need for interaction between both expert groups, their members were asked for their suggestions on the possibilities of the format of such interaction, as well as the way forward. BEWG and WGMHM members were highly supportive to build on such an initiative, though different views on its format existed. From the various reactions from both expert groups, the necessity to properly discuss this initiative was evident. Since a Web Conference was only supported partly, it was decided to organize a side-meeting during the ICES Annual Science Conference (20–24 September 2010, Nantes, France) with hopefully a good representation from both expert groups. The aim of this meeting is to agree on the most appropriate aims of and format for collaboration.

# 8 ICES matters

ToR g): Report by 15 March on potential contributions to the high priority topics of ICES Science Plan by completing the document named "SSGEF_workplan.doc" on the SharePoint site. Consider your current expertise and rank the contributions by High, Low or Medium importance

Since the implementation of the ICES Science Plan 2009–2013, the BEWG resorts under the Science Steering Group on Ecosystem Functioning (SSGEF). To search for opportunities for SSGEF-wide initiatives, all ICES Expert Groups under SSGEF were asked to prioritise the topics of the Science Plan 2009–2013, according to their rele-

vance for the respective Expert Groups. All BEWG members were invited to contribute to this exercise and based on the response of several BEWG members, the BEWG prioritization of the topics of the Science Plan 2009–2013 was compiled and sent to Pierre Petitgas (chair SSGEF) on 14/03/2010.

# 9 Any other business

## 9.1 BEWG Acknowledgement

To raise the visibility of the BEWG work, a standard phrase to be added to the acknowledgements of any publication, that was initiated or facilitated by the BEWG, was drafted:

"This publication was initiated and facilitated by members of the Benthos Ecology Working Group (BEWG), which is an expert group of the International Council for the Exploration of the Sea (ICES)."

## 9.2 New Biodiversity Group

During the meeting, Paul Snelgrove reported that discussions are underway to assemble a Strategic Initiative on Biodiversity for ICES. A Webex discussion is planned for 25 June 2010 with Mark Tasker, Simon Jennings, Jake Rice, Manuel Barange, Mike Sissenwine and Paul Snelgrove to define the specific needs and strategy for such an initiative and why it is needed by ICES at this time. The group hopes to report on their discussions at the 2010 ICES meeting in Nantes. The BEWG agreed that there was strong potential for synergy with this SI should it move forward and noted they would like to be informed of new developments.

## 9.3 Next year's BEWG meeting

The BEWG 2011 meeting will take place on 2–6 May 2011 in Fort Pierce (FL, USA) (Annex 3). The meeting will be hosted by B. Tunberg.

# 10 Closing of the meeting

The Chair thanked the organizers at the two venues (Edgewater and Oostende) for hosting the meeting. A special word of thanks went to M. Lifentseva, Assisting Secretary at ICES, for facilitating the daily WebEx conferences. He also thanked the participants in Edgewater, the BEWG members who travelled to Oostende on short notice and the people who joined remotely every day. Rapporteurs were duly acknowledged and the meeting was closed on Friday, 17:15 hours.

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## Annex 2: Agenda

**ICES-BEWG MEETING 2010**
**AGENDA**
Edgewater, Maryland (USA) – Oostende, Belgium, 19/04/2010 – 23/04/2010

IMPORTANT!!!

- As to assure a maximum overlap between the Edgewater and Oostende/Europe group, the following (minor) change in working hours are suggested:
  - Edgewater: 8h00 – 17h00 (Edgewater time, ET)
  - Oostende/Europe: 10h00 – 19h00 (Brussels time, BT)
- Daily WebEx conferences at 9h00 (ET; 15h00 (BT))

**Monday 19/04**

- 08h00 (ET; 14h00 (BT)):
  - Preparatory telephone contact between Bjorn, Tuck and Steven.
- 08h30 (ET; 14h30 (BT)):
  - First contact between the whole group by email and further instructions on how to join the first WebEx conference
- 09h00 (ET; 15h00 (BT)): First WebEx conference
  - Round table
  - Adoption of updated work plan and fully revised time schedule
  - Agreement on working format
  - Any further clarifications needed?
  - Editorial rapporteur: Hans Hillewaert
- 10h00 (ET; 16h00 (BT)):
  - Contributions (all)
    - All contributors (any Issue…): Upload as much PPTs as possible onto the BEWG 2010 SharePoint site [1]. Please, make sure to copy your PPT to the correct folder (cf. workplan Themes and Issues)
    - All contributors: Prepare and submit presentation abstracts (0.5 pp. max. for case study presentations) to be incorporated into the BEWG 2010 meeting report to hans.hillewaert@ilvo.vlaanderen.be and steven.degraer@mumm.ac.be.
    - Everybody: Have a closer look at the PPTs as to ensure the incorporation of their content into the following work/discussions.
  - Theme/Issue coordinators to prepare a revised work plan and post a summary of that revised work plan onto the sharepoint site (check for folders…)
    - Angel Borja, Gert Van Hoey:
      - Theme 2, Issues B (Viewpoint paper) & D (WGBEC request)
    - Silvana Birchenough, Henning Reiss, Alex Schröder:
      - Theme 1, Issue A (intersessional work)
    - Silvana Birchenough, Henning Reiss:
      - Theme 1, Issue B (SGCBNS Outcome)
    - Steven Degraer, Silvana Birchenough, Henning Reiss:
      - Theme 1, Issue C (ICES Position Paper on CC)

[1] http://groupnet.ices.dk/BEWG2010/default.aspx: Username: ices\last name); Password: initials from first name and last name or your personalised password; Please note that your last name and also your password should be written in lower case.

**Tuesday 20/04**

- 08h00 (ET; 14h00 (BT)):
  - Consider Theme/Issue coordination reports (see sharepoint)
- 09h00 (ET; 15h00 (BT)): Second WebEx conference
  - Theme/Issue coordinators to present the respective work plans: Work plan discussion, sub groups, how to move forward and task delegation
  - Further discussion and delegation of tasks on Theme 2, Issues B (Viewpoint paper) & D (WGBEC request)
- 10h00 (ET; 15h00 (BT)):
  - Theme 2, Issues B (Viewpoint paper) & D (WGBEC request)

**Wednesday 21/04**

- 08h00 (ET; 14h00 (BT)):
  - Consider Theme/Issue coordination reports (see sharepoint)
- 09h00 (ET; 15h00 (BT)): Third WebEx conference
  - Finalisation of Theme 2, Issues B (Viewpoint paper) & D (WGBEC request)
  - Further discussion and delegation of tasks on Theme 1, Issue A (intersessional work) & Issue B (SGCBNS)
- 10h00 (ET; 15h00 (BT)):
  - Theme 1, Issue A (intersessional work) & Issue B (SGCBNS)

**Thursday 22/04**

- 08h00 (ET; 14h00 (BT)):
  - Consider Theme/Issue coordination reports (see sharepoint)
- 09h00 (ET; 15h00 (BT)): Fourth WebEx conference
  - Finalisation of Theme 1, Issue A (intersessional work) & Issue B (SGCBNS)
  - Further discussion and delegation of tasks on Theme 1, Issue C (ICES Position Paper on CC)
- 10h00 (ET; 15h00 (BT)):
  - Theme 1, Issue C (ICES Position Paper on CC)

**Friday 23/04**

- 08h00 (ET; 14h00 (BT)):
  - Consider Theme/Issue coordination reports (see sharepoint)
- 09h00 (ET; 15h00 (BT)): Fourth WebEx conference
  - Finalisation of Theme 1, Issue C (ICES Position Paper on CC)
- 10h00 (ET; 15h00 (BT)):
  - Theme 2, Issue C (Theme Session at ASC)
    - Angel Borja: Upload PPT/Report onto the BEWG 2010 sharepoint .
    - Everybody: Consider and comment by email on SoA ASC Theme Session "Benthic indicators"
  - Theme 4 (BEWG/WGMHM interaction)
    - Steven Degraer: Upload PPT/Report onto the BEWG 2010 sharepoint.
    - Everybody: Consider and comment by email.
  - Theme 5 (ICES matters)
    - Steven Degraer: Upload PPT/Report onto the BEWG 2010 sharepoint site.
    - Everybody: Consider and comment by email.
- 12h30 (ET; 18h30 (BT)): Closure of the meeting
  - SoA on reporting

- Overview Action points, Recommendations and ToRs for BEWG 2011 meeting

## Annex 3: BEWG terms of reference for the meeting in 2011

The **Benthos Ecology Working Group** (BEWG), chaired by Steven Degraer, Belgium, will meet in Fort Pierce, Florida, USA, on 2–6 May 2011 to:

a ) consider the status of the intersessional BEWG work on long-term data series analyses with special attention to climate change and to decide on future actions

b ) explore the availability of long term benthos datasets in US and Canada

c ) report on exciting developments in ongoing phyto- and zoobenthic research in the ICES area, with special attention to North-American activities

d ) consider the 2010–2011 work of the Study Group on Climate-Related Processes within the Benthos of the North Sea and to formulate recommendations regarding its future actions

e ) consider the outcome of the intersessional meeting between BEWG and WGMHM and the format of future collaboration

f ) broaden the geographic scope of the BEWG work on benthic indicators to North American waters.

BEWG will report 31 May 2011 (via SSGEF) for the attention of SCICOM.

### Supporting Information

| | |
|---|---|
| Priority: | The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority. |
| Scientific justification and relation to action plan: | ICES Science Plan, Priority 1 "Understanding ecosystem functioning"<br>Research topic "Climate change processes and prediction of impacts"<br>Term of Reference a) and b)<br>Evaluating the intercessional analyses of long-term data series will help identifying major ecosystem regime shifts, including their geographical spread, as starting point for further consideration of the impact of climate change onto the benthos.<br>Term of Reference d)<br>To ensure a proper follow-up of the SGCBNS by the BEWG, there is a need to attract scientists from outside the North Sea bordering countries to get involved in this initiative. SGCBNS focuses on climate-related processes in relation to climate change, taking the North Sea only as a case-study.<br><br>ICES Science Plan, Priority 2: "Understanding interactions of human activities with ecosystems"<br>Various Research topics<br>Term of Reference c)<br>This is a prerequisite for the scientific information status of the group<br>Term of Reference f)<br>Broadening the geographic scope of the BEWG work on benthic indicators will help to strengthen our knowledge on interactions of human activities with ecosystems.<br><br>ICES Science Plan, Priority 3: "Development of options for sustainable use of ecosystems"<br>Various Research topics |

| | |
|---|---|
| | Term of Reference e)<br>Habitat suitability modelling (HSM) helps understanding the distribution of species and communities. As such, it helps elaborating a scientifically-sound management of the marine ecosystem. Two EGs are currently embracing HSM, namely the BEWG and the WGMHM. To maximize the use of human resources in HSM, clear agreements between both EGs are needed. |
| Resource requirements: | The research programmes which provide the main input to this group are already underway, and resources are 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 ACOM. |
| Linkages to other committees or groups: | There is a close working relationship with WGMHM, WGECO, WGEXT, MHC |
| Linkages to other organizations: | |

## Annex 4: Recommendations

| RECOMMENDATION | FOR FOLLOW UP BY: |
|---|---|
| 1. To support the Benthic Ecology Long Term Series network (BELTS) developed by the BEWG and SGCBNS logistically (by supplying a sharepoint site, a possibility for WebEx meetings and by supporting case study meetings.) | ICES Secretariate, SCICOM |
| 2. To support intersessional work on the SGCBNS case studies | SCICOM |
| 3. BEWG and WGMHM to organise a face to face side-meeting in Nantes at the ASC 2010 to outline the possibilities for future collaboration. | BEWG, WGMHM, SCICOM |
| 4. To explore the integration of regular ICES-wide benthos surveys into the large-scale fish surveys, e.g. IBTS, to support the ICES Science Plan 2009–2013 | SCICOM |

**Actions:**

Silvana, Henning and Steven: to finalise the Position Paper on Benthos and Climate Change and submit for publication in ICES CRR according to the SSICC timeline.

Bjorn and Paul: to collate a list of metadata on long-term time series from West-Atlantic waters.

Alex and Bjorn: to report on the progress on BELTS (Benthic Ecology Long Term Series network) at the BEWG 2011 meeting.

Gert: to finalise and submit the Viewpoint Paper on Indicators for publication (July 2010).

Bjorn: to contact US/Canadian benthologist colleagues for further BEWG work on benthic indicators.

Steven (and Jacques Populus, chair WGMHM): to organise a face to face side-meeting in Nantes at the ASC 2010 to outline the possibilities for future collaboration.

Paul: to report on the "new biodiversity group".

BEWG (all): update on exciting ongoing benthos research.

# Annex 5: Long-term data series analyses with special attention to climate change

Last Year requirements:

- Clarify the initiative (2 initiatives discussed)
- Requirements: document with information (2 pages document with methods, results for assessing macrobenthic patterns)
- Way forward (Cefas document)

Contributors:

- Silvana Birchenough (UK)
- Henning Reiss (Germany)
- Alex Schroeder (Germany)-still need document
- M. L. Zettler & A. Darr (Germany)
- Johan Craymeerch (The Netherlands)-document in Dutch!
- Carl Van Colen and Gert Van Hoey (Belgium)

## BEWG INITIATIVE-Belgian part of the North Sea (example of required case studies in similar format)

### Materials and methods

Long-term variation of the macrobenthos community at station 120 in the Belgian Part of the North Sea (51°11'10''; 02°42'07'') was assessed. This station was chosen because (1) it is relatively unaffected by anthropogenic activities in comparison with other monitoring stations and (2) the sediment characteristics remained relatively stable; i.e. the average median grain size over the entire time series was 200 μm, fluctuating between 115 and 286 μm, and the mud content (% < 63 μm) varied between 2 and 10 %.

A dataset was compiled using data gathered by the Department of Fisheries (ILVO, DVZ) and the Marine Biology Section (UGent, Marbiol), resulting in a long-term dataset (1979–2008) which consist of both spring and autumn data of each year (Wittoeck *et al*., 2005). No data were available for the periods 1987–1988, 1992–1993 and also the information for spring 1984 and autumn 2007 was lacking.

All macrobenthos samples were taken with a Van Veen Grab (sampling surface 0.10 $m^2$) in triplicate, except for spring 2005 (n = 5), spring 1991 (no replicates; samples pooled prior to laboratory analysis) and autumn 2008 (no replicates). The samples were sieved after fixation on a 1mm sieve. Non benthic species (e.g. Mysida, crabs) or species which were not adequately sampled (Nematoda, Nemertea, Oligochaeta) were excluded for the analysis.

The Ash-Free Dry Weight (AFDW) was calculated by converting the blotted wet weight according to Rumohr *et al*. (1987) and Ricciardi & Bourget (1998). Replicate samples were analyzed separately but were pooled afterwards for the statistical analyses. Analyses were performed in accordance with the guidelines agreed upon at the last BEWG meeting in Askö and the results are presented below in Figures 1 and 2.

### Results and the potential for further analyses of benthic patterns

Long-term trends were consistent for spring and autumn with, overall, higher species densities, abundances and biomasses in autumn. Over time the community at station 120 became clearly more diverse and consisted of a higher total biomass while a more erratic pattern was found for the abundance. The Warwick statistic increased over time which indicates that the community evolved from a community dominated by a few small-sized species towards a community where the biomass is dominated by a few, large long-lived species, represented by rather few individuals. The increase during the mid-eighties relates to the biomass increases of *Abra alba* and *Tellina fabula*, while the increase during the nineties is due to the increase in biomass of *Ensis spp*. and *Spisula subtruncata* (second half nineties). Massive recruitment was observed in summer 1991 for *Ensis spp*. and in summer 1995 for *Spisula subtruncata*.

A steep drop in species density, evenness, diversity and species richness occurred in spring after the severe winter of 1995/1996. Further, in comparison with the autumn of 1979, a steep decrease in species density, species richness, diversity and evenness was noticed in autumn 1980 which suggest a severe effect of the very cold winter of 1979/1980. Following these events, clear drops in interannual similarity for both spring and autumn communities occurred in the periods 1981–1983 and 1996–1998. Further, steep drops in community interannual similarity were present in 1990–1991 and 2001–2003 (only for spring samples). As regime shifts, at least in the marine environment, have been defined by de Young *et al*. (2004, 2008) as 'a change between contrasting persisting states' these periods should be a prime target for further detailed analysis of possible regime shifts in the Belgian Part of the North Sea and the ICES region.

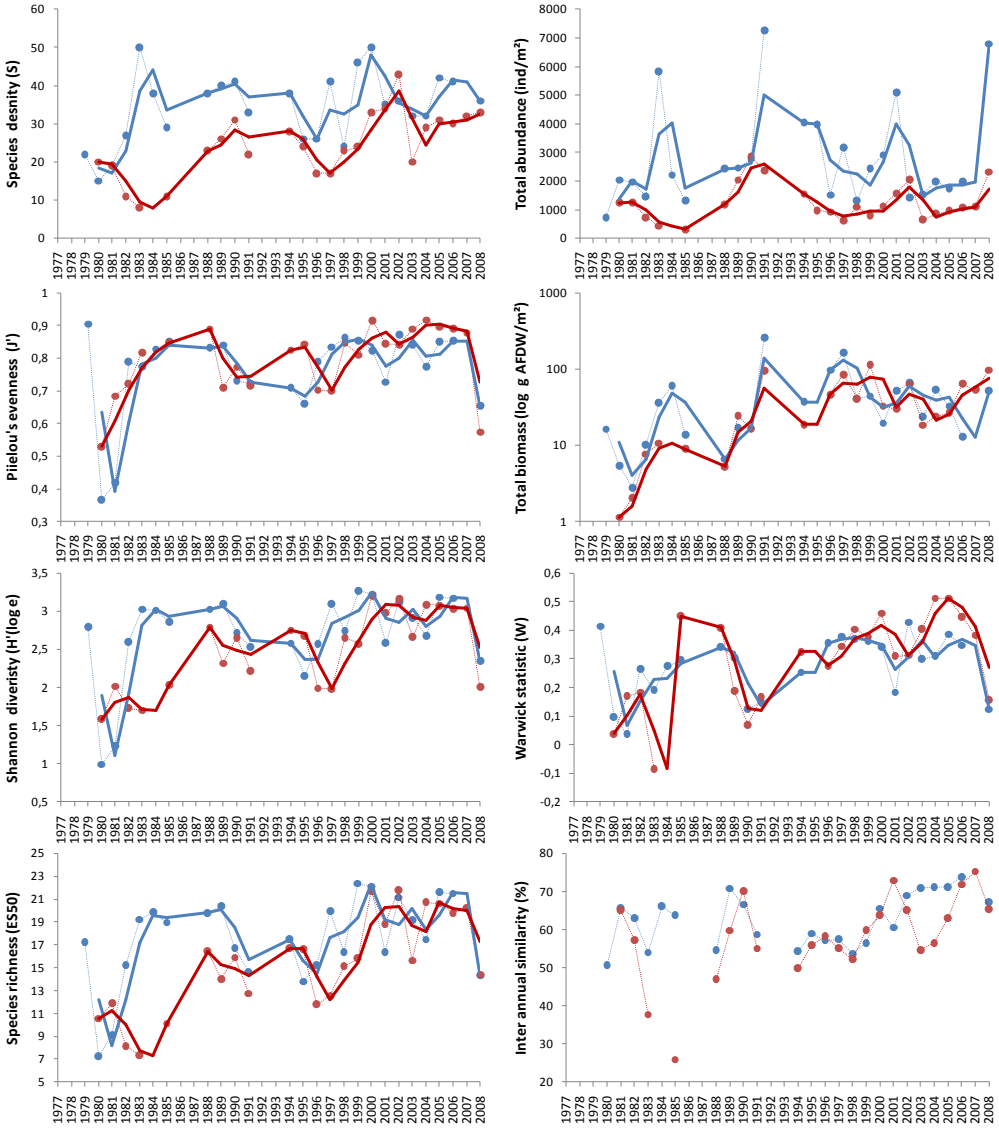


**Figure 1. Long-term spring (red) and autumn (blue) variation in species density (total n° of species/sample), Pielou's evenness, Shannon-Wiener diversity ($\log_e$), species richness ($ES_{50}$), abundance (ind./m²), biomass (log g ash-free dry weight/m²), the Warwick statistic and the interannual similarity (bray-curtis similarity between two subsequent sampling occasions based on 4th root transformed community abundance data ) between 1979 and 2008 at station 120 in the Belgian Part of the North Sea. Trendlines are running averages (period = 2 sampling occasions).**

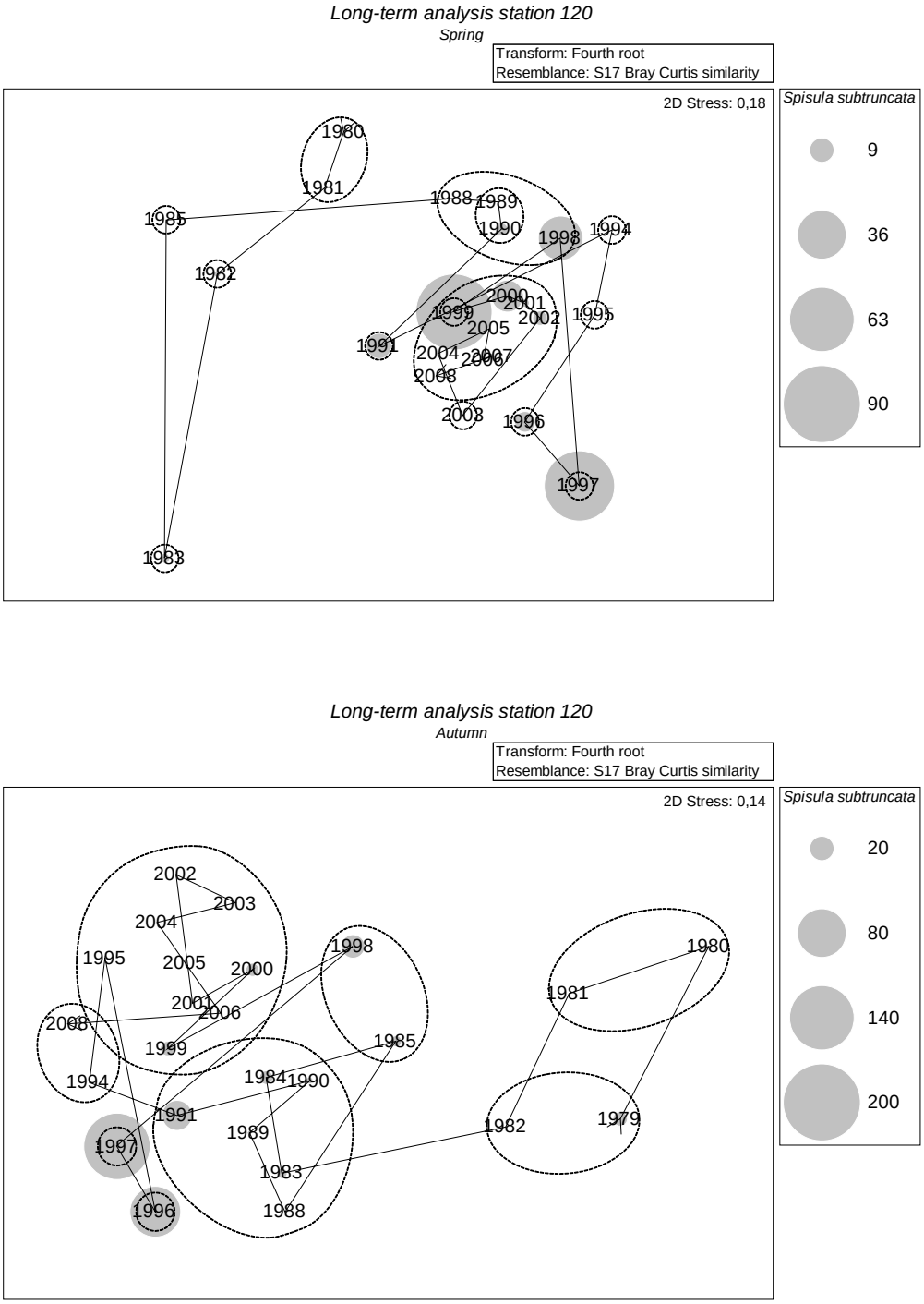


**Figure 2. Non-metric multidimensional (MDS) ordination of species assemblages at station 120 over time in spring (upper panel) and autumn (lower panel). Dashed lines represent 60% similarity clusters. Biomasses of Spisula subtruncata are superimposed using grey circles which sizes reflect the magnitude of the total biomass (g AFDW/m²) of this species.**

### References

de Young B, Harris R, Alheit J, Beaugrand G, Mantua N, Shannon LJ (2004) Detecting regime shifts in the ocean:Data considerations. Progress in Oceanography 60:143-164

de Younge B, Barange M, Beaugrand G, Harris R, Perry RI, Scheffer M, Werner F (2008) Regime shifts in marine ecosystems: detection, prediction and management. Trends in Ecology and Evolution 23:402-409

Ricciardi A, Bourget E (1998) Weight-to-weight conversion factors for marine benthic invertebrates. Marine ecology progress series 163: 215-245

Rumohr H, Brey T, Ankar S (1987) A compilation of biometric conversion factors for benthic invertebrates of the Balthic Sea. The Baltic Marine Biologists Publications No.9.

Wittoeck J., Hostens K., Hillewaert H., Cooreman K., Vandenberghe E., Mees J., Deprez T., Vincx M. & Degraer S. (2005) Long-term trends of the macrobenthos of the Belgian Continental Shelf (MACROBEL): final report. Belgian Federal Science Policy Office, 66p.

### What next:

- Suggestions provided by Dr Jon Barry Senior Cefas statistician (document in share point with additional references of for this work - 3 papers)
- Other contributors (time series via SG or BEWG network)
- Need to discuss in small subgroups the way forward

# Annex 6: BELTS - Benthic Ecology Long Term Series network

**Description based on discussions during SGCBNS and BEWG meetings 2010.**

## Aims - targets

The intention of the Network is to facilitate joint analyses of marine benthic long term series by collaborative work of scientists and by making existing information widely available. Unlike other initiatives, the aim is NOT to collect data. Instead it is meant to bring scientists together to jointly analyse long term data series to further the understanding of temporal changes in marine ecosystems over larger scales and the effects of climate change. This will allow general results about climatic effects beyond regional results from single data series.

## Development

The Network started as an initiative developed by the ICES BEWG and was further developed by the SGCBNS. However it is open to all scientists interested in joint long term analyses.

## General idea - concept

Long-term series analyses are valuable tools that enable scientists to assess environmental change (Hardman-Mountford *et al.* 2005). Temporal changes of benthic fauna may indicate climatic as well as anthropogenic Influences. Today the importance of time series for numerous aspects of marine ecology is widely acknowledged (Ducklow *et al.* 2009), However, analyses of single benthic time series often reflect local phenomena, while a joint analysis of several time series may detect more general pattern of climate influences.

To facilitate the analysis of benthic time series data on a large spatial scale, the BELTS network intends to connect scientists and promote the production of joint publications.

Instead of collating data, results will be produced by the data owner, keeping the data sets separate, but joining the results and expertise. This way, also inconsistencies between data sets can be overcome as long as they are considered in the separate analyses and results are formulated accordingly. The point of the Network is to circumvent data problems by working together without necessarily sharing raw data.

The Network will be able to produce results that can only be achieved by joining information and expertise, generating overarching insights based on group contributions. End products from the Network shall be peer-reviewed publications. This scientific activity should attract the participation of a wide range of colleagues to collate a diverse expertise on an international scale.

## Comparison and relations to other projects

Large scale projects that intend to collect, harmonise and manage actual data already exist (e.g. EMODNet, LargeNet, OBIS,…) and the initiative presented here does NOT intend to duplicate these efforts.

Large collections of data are valuable tools for the future, but are notoriously difficult in various aspects. First, the ownership and intellectual rights of the data supplier need to be assured and procedures are needed to avoid unauthorised use of the data. Second, an extensive harmonisation of these data sets is necessary to assure compa-

rability and data quality before any analyses can begin. Third, the producers of the respective data sets know best the potentials and restrictions as well as interesting observations.

Although the technical problems can be overcome with some effort - as has been successfully demonstrated in some projects (e.g. MARBEF, NSBP, …) - still a considerable and understandable reluctance exists for many scientists to make raw data available from valuable long term series data.

For a joint analysis, however, this is not really necessary as a *cooperative approach* will overcome all of the above mentioned problems and at the same time spark productive discussions between the participating experts.

The afore-mentioned data collections in other initiatives will be used where possible, but are not a prerequisite for the Network initiatives for joint analyses.

### Procedures

Communication will be facilitated by a Network web site and associated mailing lists. There will be a main list advertising general news and new studies and specific lists for each study.

Every member can put questions (objectives) forward and suggest required analyses, ask for necessary contributions (data, results & expertise), which then are open for discussion.

The initiative shall tackle specific questions by asking contributions of specified results from the partners. All contributors will get other existing contributions when they submit their results. They then are put on a distribution list to receive all further contributions to come. Contributions can be data or expertise, offering the opportunity for contributors to justify their inclusion – like a research consortium: What can people bring to this collaborative project?

To allow a productive outcome within adequate time, each study should fix appropriate deadlines for

1 ) discussions of questions, analytic methods & type of output and

2 ) delivery of contributions.

With the specific objective well defined, tasks will be distributed to construct a joint manuscript. All contributors will be co-authors.

After some initial joint analyses an informal meeting may be organised to develop the final publication, with a possibility to use an ICES SharePoint site and/or WebEx conferences.

This procedure needs a general element of trust of the collaborators. For each study a specific agreement or "declaration of mutual understanding of sharing unpublished information" shall be defined by the respective groups.

A website for the Network will be hosted by VLIZ (organising all technical requirements and if necessary assisting in data management) to spread the idea and invite contributions. It will contain a forum and/or generate email addresses for study subgroups. A scientific coordinator will run the general organisation for defined time periods, as a general contact person for questions regarding the Network. Each study is coordinated by the initiator.

### Status

Participants of the BEWG meeting 2009 agreed on developing collaborative work, which will contain further analyses/results (on published or unpublished records), using standardised analyses. Intersessional work continued by means of interrogating the long-term datasets with an agreed set of parameters to enable further comparisons. Two initiatives have already been started in BEWG for joint analyses of long term data:

1 ) Latitudinal shifts of species

2 ) Regime shifts in benthic communities across the North Sea.

The development of the Network was further discussed during the SGCBNS and BEWG-meetings 2010. The results of this discussion are summarised in this text, describing the intended setup of the Network initiative. This text will be the basis for the website hosted by VLIZ. After consent of the BEWG to a draft version, the web site will be published.

### Links to other initiatives and references

- Similar initiative in the UK: ***MECN*** (http://www.mba.ac.uk/mecn/index.htm)
- ***EMODNet***: European marine observation and data network incl. Metadata (http://bio.emodnet.eu).
- ***LargeNet***: Large scale and long term networking on the observation of Global Change and its impact on Marine Biodiversity
- (http://www.marbef.org/projects/largenet/index.php)
- ***PANGAEA***: Publishing Network for Geoscientific & Environmental Data (http://www.pangaea.de/)
- ***OBIS***: Ocean Biogeographic Information System (http://www.iobis.org/)
- ***ILTER***-Networks: International Long Term Ecological Research network
- (http://www.ilternet.edu/; Europe: http://www.lter-europe.net/)
- ***NEPTUNE*** Canada: a cabled deep-sea observatory adjacent to British Columbia Canada that will archive a wide range of oceanographic data relevant to seafloor processes (www.neptunecanada.ca)

Ducklow, H.W.; Doney, S.C. & Steinberg, D.K. (2009): Contributions of long-term research and time-series observations to marine ecology and biogeochemistry. *Ann. Rev. Mar. Sci.* **1**: 279-302.

Hardman-Mountford ,N.J.; Allen J.I,; Frost M.T.; Hawkins S.J.;. Kendall M.A; Mieszkowska , N.; Richardson, K.A.; Somerfield, P.J. (2005): Diagnostic monitoring of a changing environment: An alternative UK perspective. Mar. Poll. Bull. 50: 1463–1471

## Annex 7: Questions from ICES WGBEC to BEWG upon "Benthic community structure and its relationship to contaminants"

**Author: Angel Borja**

**Contributors: Johan Craeymeersch, Alex Schröder, Henning Reiss, Silvana Birchenough**

The WGBEC would like to review the links between contaminant exposure and effects on benthic community structure. Although not a new area of interest to the group, WGBEC would like to resolve some outstanding areas of uncertainty. Benthic community analysis is a recommended technique for biological effects, however there has been little formal consideration by the group of the evidence for the causal links. WGBEC would like to ask BEWG to review this issue at their 2010 meeting so that it can be considered by the group. As a recommendation WGBEC requests that BEWG review the evidence for benthic community structure as a suitable method for monitoring effects of contaminants, taking into account the considerations above and provide WGBEC with a report (or presentation) to consider at their meeting in March 2011.

Regarding these issues, there is increasing information on this topic. As an example a new book, edited by F. Sánchez-Bayo, P. van den Brink and R.M. Mann ('Ecological Impacts of Toxic Chemicals') is being to be published this year by Bentham Science Publishers Ltd. Within this book, Chapter 9 is focusing on 'Impact of pollutants on coastal and benthic marine communities' (authors A. Borja, M.J. Belzunce, J.M. Garmendia, J.G. Rodríguez, O. Solaun, I. Zorita). Some ideas for this report have been extracted from the draft of that chapter. There is also an established annual monitoring work conducted by The Centre for the Environment, Fisheries and Aquaculture Science (Cefas) which annually sample dredge material disposal sites in support of FEPA (Food Environmental Protection Act). There is a suite of parameters (contaminants: PAH's, PCB's; sediments, benthic infauna, metal and organics which are conducted routinely in support of regulator activities (see Bolam *et al*. 2009).

Some of the key issues, requested by the WGBEC, are outlined below.

### 1) To what extent is benthic community structure affected by sediment contaminant levels compared to other environmental factors (sediment structure, organic material etc.)?

Factors such as grain-size, organic matter content, dissolved oxygen concentration, water depth or hydrodynamics, are the main variables explaining most of the variability of benthic communities. Following the paradigm of Pearson and Rosenberg (1978), factors such as organic enrichment are very important in explaining the composition and structure of benthic communities affected by human pressures. Sometimes, these factors (confounding factors, such as dissolved oxygen, organic matter or nutrients load) can affect more the structure of benthic communities than contaminants in the sediments, masking their responses. In highly human-affected environments it has been described that dissolved oxygen is the primary factor affecting benthic structure, contaminants being a second (or even third) factor of impact (Borja *et al.*, 2006). However, the extent of the effects of contaminants on benthic communities have been described elsewhere, since long (Read *et al.*, 1978; Gray, 1982; Gray *et al.*, 1988; Gray *et al.*, 1990).

Biological effects of contaminants, at different levels of biological organisation, have been suggested by several authors (Allen and Moore, 2004; Broeg *et al.*, 2005), from cell and tissue level, organism level, to population and community level (ICES, 2006).

There are clear examples from the UK annual monitoring practices that are useful insight on specific benthic responses , when sources of chemical stressors are present (Bolam *et al*., 2009)

After Borja *et al.* (in press), a review of the effects of pollutants on aquatic ecosystems in different parts of the world can be seen in Islam and Tanaka (2004). These authors describe a decrease in species diversity, changes in community structure, degradation of habitats, decline in abundance and biomass, diminishing in yield of marine resources, etc. Hence, some authors (e.g. Wolfe, 1992) have systematized the bioindicators of pollution for marine monitoring programmes, at community and ecosystem levels. These approaches include abundance, biomass, richness, dominance, similarity, ratio opportunistic/sensitive species, age-size spectra, trophic interactions, energy flow, productivity, and the loss of goods and services.

Borja *et al*. (in press) review in detail the effects of pollutants on richness, diversity, evenness, ratio opportunistic/sensitive species, and trophic interactions. As an example, in a recent review, Johnston and Roberts (2009) make a meta-analysis of 216 papers, in which the most frequently used measures of diversity and evenness were species richness (number of species per unit area), the Shannon–Wiener index and Pielou evenness (Margalef's richness and Simpson's diversity were used occasionally). The vast majority of the contributions concluded that there were significant negative effects of pollution upon species richness, with occasional increases in species richness and diversity associated to nutrient enrichment. Only 20 % of the papers did not detect the effects of contamination, upon diversity.

The use of benthic indicators, in assessing the ecological status in marine waters, has increased dramatically in recent years, especially in Europe, after the Water Framework Directive (WFD; see methods used in Borja *et al.* (2009a)).

In the contribution of Borja *et al.* (in press) it can be seen that, from the extensive publications using these indices (and, especially, from that of AMBI), it can be observed that increases in metals (Marín-Guirao *et al.*, 2005; Carvalho *et al.*, 2006; Josefson *et al.*, 2008), organic compounds and TBTs (Muniz *et al.*, 2005; Muxika *et al.*, 2005; Martínez-Lladó *et al.*, 2007) produce a decrease in benthic community quality, detected by the index. Hence, a primary mechanism driving these changes, as a result of exposure to contaminants, is the elimination of sensitive species and the subsequent monopolization of resources, by tolerant and opportunistic species (Johnston and Roberts, 2009).

In some cases, such as at Restronguet Creek in the Fal estuary system (Matthiessen and Law, 2002), copper and zinc pollution from mining is strongly suspected to have caused the exclusion or restriction of several species of bivalves, including *Cerastoderma edule, Macoma balthica, Mytilus edulis* and *Scrobicularia plana*, as well as the changes in nematode metal tolerance. However, some species (such as *Nereis diversicolor*) are able to adapt to pollution. Birchenough *et al*., (2006) mapped the benthic distribution of habitats in an area used as a dredged material disposal site, there were clear reduction in number in the areas adjacent and in the centre of the disposal activity. Normally, in these extreme situations of metal pollution, infaunal communities are dominated typically by metal-tolerant opportunistic deposit-feeding polychaetes (Johnston and Roberts, 2009). In fact, sediment metal chemistry and benthic infauna surveys, undertaken over 33 years with sampling before, within and after tailings deposition from a metal (Pb, Zn) mine in Greenland (Josefson *et al.*, 2008) have shown dramatic changes of benthic fauna composition. Faunal recolonisation, 15 years after closure of the mine, was slow. Of the heavy metals Pb had the greatest impact, with deterioration of benthic communities above a threshold of 200 mg $kg^{-1}$, decreasing

diversity and dominance of sensitive species, and increasing tolerant and opportunistic species, i.e. long-lasting effects on the biological system.

In turn, from the relatively few data on hard-bottom substrata communities, it has been suggested that macroalgal communities are relatively resilient to pollution (Johnston and Roberts, 2009; Borja *et al.*, in press). However, some research has shown metal- and nutrient-impacted rocky shores to contain degraded communities of macroalgae. Likewise, to be dominated by opportunistic algal species with rapid growth rates, including *Ulva* and *Enteromorpha,* replacing relatively diverse communities of large perennial algae and sessile filter feeders seen in more pristine areas (Díez *et al.*, 1999; Orfanidis *et al.*, 2001; Bricker *et al.*, 2007; Guinda *et al.*, 2008; Díez *et al.*, 2009).

**2) What monitoring data is available from across contamination gradients in the field to support the use of this method as an indicator for contaminant effects (taking confounding factors such as change in sediment composition across the same gradient into account).**

Currently, the WFD has implemented monitoring networks all around Europe, in transitional and coastal waters (De Jonge *et al.*, 2006; Ferreira *et al.*, 2007). Some, of these networks are producing results over a long-term series, related in all cases to anthropogenic pressures (Borja *et al.*, 2009b). In most cases there are examples of spatial and/or temporal gradients of pressure, allowing the investigation of contaminant effects. Moreover, many monitoring networks in Europe are dealing with specific pressures, such as oil-platforms (drill cuttings) (Frascari *et al.*, 1992; Kröncke *et al.*, 1992; Daan *et al.*, 1994; Daan *et al.*, 1996; Breuer *et al.*, 2004), cage aquaculture (Kalantzi and Karakassis, 2006; Giles, 2008; Borja *et al.*, 2009c), sewage sludge disposal (Rees *et al.*, 1990; Rees *et al.*, 1992; Birchenough and Frid, 2009), etc.

In the case of USA, comprehensive and extensive monitoring is undertaken since long time, including different compartments of the ecosystem, both at national and states level (Macauley *et al.*, 1999; Hyland *et al.*, 2003; Llansó *et al.*, 2004; O'Connor and Lauenstein, 2006; Bricker *et al.*, 2007; Stein and Cadien, 2009).

**3) To what extent are changes in benthic community structure in offshore environments influenced by lower levels of contaminant exposure?**

The effects of low background levels of contaminants on benthic communities are difficult to disentangle from the multiple pressures and environmental drivers in offshore benthic systems (see above). Trace metal concentrations in offshore North Sea sediments were measured during the ICES North Sea Benthos Project 2000 (Rees *et al.*, 2007). None of the trace metals used in the analyses showed any correlation with the spatial patterns seen in the biota. Therefore, even though there are measured elevations in trace metal concentrations, these are not deemed to be responsible for the observed differences in large-scale community structure. However, the spatial scale and resolution of benthos sampling of this study was probably not sufficient to explicitly test for contaminant effects on large-scale community structure.

On a local scale, significant effects of contaminants were found to effect benthic communities e.g. by contamination during oil drilling (e.g. (Gray *et al.*, 1990; Kingston, 1992; Daan and Mulder, 1996; Daan *et al.*, 2006).

However, on larger spatial scales low levels of contaminants most probably affect benthic community structure by adverse effects on particular sensitive species. For example, even the relatively low levels of TBT in offshore waters have contributed to the decline and even local extinction of some gastropod species (e.g. *Buccinum unda-*

*tum, Neptunea antiqua, Nucella lapillus*) (Cadée *et al.*, 1995; Ten Hallers Tjabbes *et al.*, 1996; Ten Hallers Tjabbes *et al.*, 2003) and intertidal species *littorina littorea* in UK areas (Birchenough *et al.*, 2002a). These species are large predatory and scavenging species that shape benthic community structure by top down control. The decline of predatory species can lead to a shift of community structure towards a dominance of small opportunistic species (Spence *et al.*, 1990) and may have contributed to the observed North Sea wide trend in community structure towards the dominance of small opportunistic species (Frid *et al.*, 2000; Kröncke and Bergfeld, 2001; Wieking and Kröncke, 2003). Although in UK waters there was observed a shift and recovery of populations of dogwhelks *Nucella lapillus* on shores formerly subject to severe TBT contamination (Birchenough *et al.*, 2002b).

#### 4) What consideration of contaminant levels has been taken into account in assessment of national benthos monitoring data across the ICES area?

Regarding levels of concentration the Directive 2008/105/EC of the European Parliament and the Council, of 16 December 2008, on environmental quality standards (EQS) in the field of water policy, amending and subsequently repealing Directives 82/7172/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC and amending Directive 2000/60/EC, provides some values which should not be exceeded. Most of these values referred to waters and only some of them refer to sediments. In this case, some countries have produced their own normative EQS values, such as Norway (Bakke *et al.*, 2010), Italy (Maggi *et al.*, 2008). In other cases, some countries/regions have proposed Sediment Quality Guidelines (SQG), which have only regulatory effects. Examples for some European countries can be found in the literature (Burton, 2002; Casado-Martínez *et al.*, 2006; Alvarez-Guerra *et al.*, 2007; Hübner *et al.*, 2009).

The methods proposed to derive EQS, within the WFD, are those recommended by Lepper (2004), although others are being also used (McCauley *et al.*, 2000; Bjørgesæter and Gray, 2008).

In the case of USA and Canada, there exists a long history in deriving both EQS and SQG, by the environmental agencies (Long, 1992; Long *et al.*, 1995; Burton, 2002; EPA, 2002; Scrimshaw *et al.*, 2007; Keller and Cavallaro, 2008; Hübner *et al.*, 2009).

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