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WESTBANKS

BELGIAN SCIENCE POLICY

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Introduction

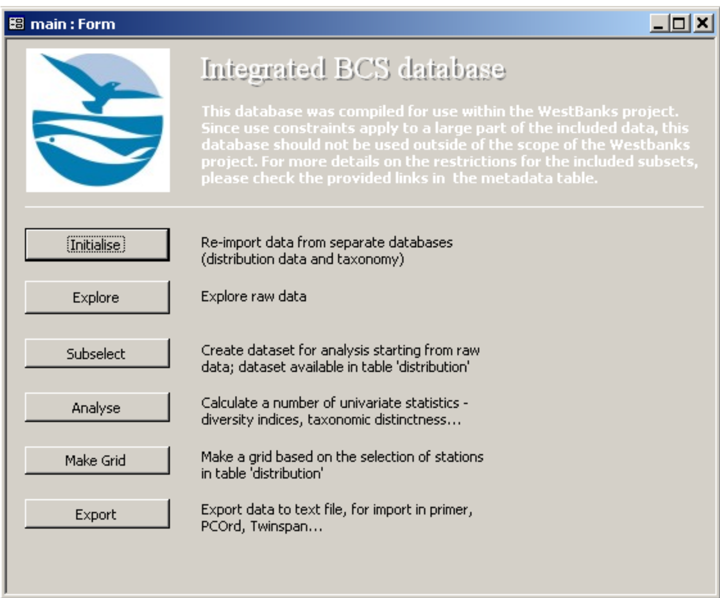
While designing the layout of the scientific programme of the WestBanks project, participants realised that WestBanks, if funded, would be the third network in which they would be cooperating. Indeed, since the start of the Belspo programme 'Sustainable Management of the North Sea – SPSD I', in 1997, this consortium gathered to investigate patterns and processes on the Belgian Continental Shelf (BCS). After completing a first project (Structural and Functional Biodiversity of North Sea ecosystems), the cooperation was continued during SPSD II within the project TROPHOS. This resulted in a massive amount of data, gathered on the BCS that have never been analysed in an overarching framework. This lead us to decide to compile all these data in a single database, and to add data from the public domain or from WestBanks scientists involved in earlier/other projects in a single WestBanks database. This database can serve as basis for tackling relevant scientific and/or policy related questions that can never be answered by a single scientist alone. The WestBanks database was build by VLIZ and once completed, scientists and end-users associated with the WestBanks project were invited to bring forward scientific issues that could possibly be tackled using the newly compiled WestBanks database. After compilation of questions and scientific hypotheses, a workshop (29/10/2008-31/10/2008 hosted by VLIZ in the IODE training facilities in Oostende, Belgium) was organised to start addressing these issues.

In what follows, we report on the progress made during the workshop and provide preliminary conclusions that not only have created challenging scientific hypotheses but have also provided very useful insights for policy makers wishing to evolve towards a science-based management of marine natural resources in the BCS.

The integrated WestBanks Database

The integrated WestBanks database consists of 730132 records containing information on sediment related variables (biology and environmental variables) and 72107 records with water column derived data. The bulk of the biological data holds information on the abundance of macrobenthos, hyperbenthos and meiobenthos Seabird data is stored as geographic grid files for the BCS in order to allow easy spatial linking to the other biological data. but the raw data files are part of the database as separate tables in case more detailed info is required..

The core of the data included was readily available from the SPSD projects "Structural and Functional Biodiversity of North Sea ecosystems" (1997-2001), "TROPHOS" (2002-2006) and from the "WestBanks" project itself. In addition, data was harvested from the public domain (e.g. IDOD, IMERS…) and from partners' private databases: EU JEEP project (Major biological processes in European tidal estuaries; 1990-1993), IMPULS (benthos in estuarine and coastal ecosystems; 1992-1996), BEACHES (Hyperbenthic communities of beaches; 1995-1997), Macrodat, Seabird distribution on the BCS. Data from the monthly VLIZ monitoring and Meetnet Vlaamse Banken was available as supporting data.



The integrated database was set up as a MS Access, allowing easy access, transport and data.operations. The structure of the database is similar to databases set up in the framework of the FP6 NoE MarBEF (e.g. MacroBEN, Manuela, Largenet, ..). Several built in functionalities allow the user to explore, subselect, export and analyse the data by calculating different indices such as: (1) the Shannon-Wiener and Hurlbert diversity index (ES50), (2) the Biotic Quality

Index, (3) the Borja's indices of habitat health and (4) taxonomic distinctness coefficients. Biological data was matched with the World Register of Marine Species (WORMS: http://www.marinespecies.org) in order to account for synonymy problems and to allow for lumping on higher taxonomic levels.

Policy related questions

Policy related topics and questions were submitted by the Federal Public Service, Marine Environment (WestBanks end-user). All topics were discussed in plenary sessions and some were selected for further investigation by a dedicated working group. For the purpose of this report, questions and answers are grouped per topic.

Topic 1: Questions related to reproductive capacity

Questions included (1) what data are available that can tell something on reproduction capacity (benthos, birds, fish)? (2) How can a stable reproduction capacity be defined/quantified and (3) what densities and diversity are needed to reach a stable reproduction capacity?

These questions are difficult to answer, since it is not defined what is meant by “reproductive capacity”. This could e.g. be the number of tern eggs but also the number of eggs reaching adulthood. In addition, and sticking to the sea bird example: there is a need on life-span integrated reproductive success per tern, however these data are not available. As similar difficulties were encountered for other taxa, it was decided that these set of questions could not be answered by the WestBanks scientists present.

We make the remark that questions/problems arising from the policy level cannot always be answered *ad hoc*. This is even clearer when an overarching framework is lacking. It is very easy to draft challenging research projects on the reproductive capacity of selected species or taxa, however at the moment it is not clear how results are applicable in management strategies for a sustainable use of the coastal seas.

Topic 2: Questions related to eutrophication

Questions included (1) Is there any evidence that benthos is significantly impacted by eutrophication in certain areas of the BCS; (2) what areas should be selected to address the possible impact of eutrophication; (3) how important is organic carbon in coastal waters and (4) to what extent is oxygen distribution in sediments a limiting factor for the benthic communities at the BCS?

We are not aware of any significant effect of eutrophication on the benthos at present. Earlier research showed a rich and diverse community of macrobenthos in the area of the Western Coastal Banks (Van Hoey et al. 2004). In this area, nematode communities reach very high densities, however diversity is rather low (Steyaert et al. 1999). Further offshore, macrobenthic densities and diversity decrease (Van Hoey et al. 2004) while this is the opposite for nematode communities (Vanaverbeke et al. 2002). These contrasting results indicate the importance of food (Organic Carbon) and oxygen for the benthos. When food supply from the water column to the sea floor is high, this results in increased oxygen stress (e.g. in the gullies in the Western Coastal Banks area) which decreases the diversity of nematodes in this area. This is not surprising given the interstitial life style and hence the intimate contacts with the environment nematodes are dealing with. The high food input, and the large size of the macrofauna however enables these organisms to change their sedimentary environment in such a way that food input is maximized while oxygen supply is guaranteed. Patterns observed at all well studied areas at the BCS indicate a dependence of the benthos on pelagically produced organic carbon (Steyaert 2003, Vanaverbeke et al. 2004, Van Oevelen et al. subm.), a time lag between deposition and mineralisation of organic matter in coastal, fine grained sediments resulting in oxygen stress from spring to late summer (Vanaverbeke et al. 2008), but negative effects have never been recorded. However, it should be mentioned that the most stressed sediments on the BCS, situated near the mouth of the Westerschelde have not been studied intensively so far.

A monitoring programme aimed at addressing a possible impact of eutrophication on the benthos should ideally include all areas of the BCS, thereby sampling all macrobenthic communities present on the BCS. Sampling should be replicated in time and space. Sampled environmental variables ideally include measures for labile OM (chl *a*) and oxygen stress in the sediment (location of RPD layer, oxygen profiles).

Topic 3: Seabirds-eutrophication

Questions addressed included: (1) are the foraging areas of self-feeding seabirds related to areas of eutrophication; (2) is primary production related to breeding success of birds and (3) is it possible to have accurate estimations of primary production in coastal waters?

Some species of seabirds (e.g.Common Tern *Sterna hirundo*) do prefer coastal zones with elevated nutrient concentration, but others do not. A preference for eutrophicated waters is probably driven by water clarity (visibility) and not by eutrophication per se. Optimal water characteristics for plunge-diving seabirds are species-specific and depend very much on the trade off between fish detectability by birds, the vertical distribution of the prey fish in the water column and the ability of the prey to detect (escape) the predator. As such, there is no clear preference for eutrophicated/non-eutrophicated waters for the self-feeding seabirds assemblage.

A relationship between primary production and the breeding success of plunge-diving seabirds was found in some seabird species foraging in stratified North Sea waters, but has not been studied in mixed waters here in the southern North Sea. A relationship with primary production was not further investigated during the workshop since data on primary production is virtually lacking from the integrated database and thus would require the involvement of other networks. Other fish-eating seabirds (non plunge-diving seabirds) might be indirectly affect by eutrophication through changes in the pelagic food chain, taking into account a time-lag of at least 1 year. However, this has never been investigated so far.

For an answer to the last question (3), we refer to the scientific results obtained in the AMORE network (coordinator: Prof. dr. Christiane Lancelot, ULB-ESA) and the MERIS project (coordinator: dr. Kevin Ruddick, MUMM).

Topic 4: *Phaeocystis* - benthos

Question: is there a quantity of Phaeocystis that can be assimilated through the benthos without causing disturbance to the system?

This question is difficult to answer since data on the possible cascading of *Phaeocystis* in the benthic food web are virtually lacking. TROPHOS data reveal that *Phaeocystis* can be mineralised in the benthic environment (Vanaverbeke et al. 2008) and we measured uptake of *Phaeocystis* derived carbon in nematodes (Franco et al. 2008). Recent research on the intertidal sediments of the Eastern English Channel showed an increased sediment oxygen demand and a simulation of nitrification during the arrival of *Phaeocystis* derived phytodetritus in the intertidal (Rauch et al. 2008). This shows that there is an effect of *Phaeocystis* on the benthic environment, both in relation to the food web and the ecosystem functioning. However, research on this topic is in its infancy and more results are needed before sound conclusions can be drawn.

Topic 5: *Lanice conchilega* related questions

Questions for this topic included (1) Is there a link between the distribution of Lanice and juvenile sole; (2) is the BEQI approach able to detect changes in Lanice patches after a beam trawl disturbance and (3) what is the extent and the frequency of the Lanice conchilega presence encountered so far.

Link *Lanice conchilega* and juvenile and larval sole

A possible link between the geographical distribution of *L. conchilega* and juvenile and larval sole was investigated by producing habitat suitability maps (HSMs) for both species by means of the software MaxEnt. MaxEnt creates “maximum entropy models” and is a general-purpose method of making predictions or inferences from incomplete information. The software estimates a target probability distribution by finding the probability distribution of maximum entropy (i.e. that is closest to uniform) under the condition that the expected value of each feature under this estimated distribution matches its empirical average. The concept is similar to general linear modelling (GLM) and general additive models (GAMs), but MaxEnt only uses presence data. It is important, however, to indicate that MaxEnt models a probability distribution over the pixels in the study region, and pixels without species records are not at all interpreted as absences. We used MaxEnt as this technique allows for a generative approach, which is very useful for small datasets, as opposed to the discriminative approaches of GLM and GAM. Generative approaches model probabilities of input variables (feature vectors) based on responses (probality of occurrence) while discriminative approaches model the probability of a response based on the available input vectors.

We have large datasets at our disposal with full coverage data on environmental variables. These are used as predictor variables to create habitat suitability for a specific species (group). The interpretation of the model is based on the output which generates heuristic estimates of relative contributions (i.e. percentages) of the different environmental variables. In the absence of interactions between the environmental variables, additivity of the model allows for interpreting the relation between environmental variable and habitat suitability.

We emphasize that there was some scientific discussion on the use of these models and we concluded that more analyses and interpretation will be needed if this modelling technique will be further used within the WestBanks project.

However, as a preliminary, exploratory exercise, habitat suitability maps were created for *L. conchilega* and *Solea solea* (all possible stages together; data on separate juvenile and larval stages were too scarce) (Fig. 1). The habitat suitability of *S. solea* mainly depends on total suspendend matter (32,7%), sand fraction (20,4%), tidal amplitude (15,4) and depth (11,4%). For *L. conchilega*, maximum chlorophyll (42,8%), total suspended matter (9,1% and 5,1%) and slope (7,9%) are important variables contributing to the HSM. Both species seem to prefer the Western Coastal Banks area as an optimal habitat, When using the HSM of *L. conchilega* as an environmental parameter in the HSM of *Solea solea*, this polychaete appears to be the most important parameter. The heuristic estimate of relative contributions of *L. conchilega* as environmental variable to the HSM is 37%. This does not imply a specific causal link since

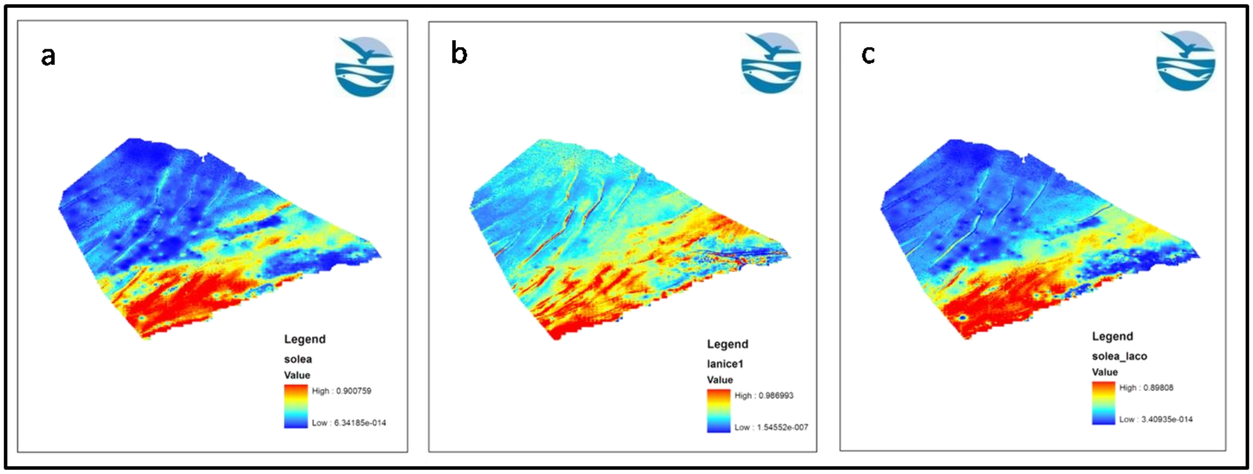


Figure 1 Habitat suitability maps (HSMs) created with MaxEnt; (a) HSM for *Solea solea*; (b) HSM for *Lanice conchilega*; (c) HSM for *S. solea*, with the *L. conchilega* included as predicting environmental variable.

species preferring the same habitat are likely to be an important heuristic estimate in each other's HSM. However, it indicates that the Western Coastal Banks area is a suitable habitat for both *L. conchilega* and *S. solea*, Hence, we state that it is likely to encounter both species together and we can expect ecological interactions between *Lanice* and sole.

What are the outputs of the BEQI applying it to the BACI design of the *Lanice* in situ beam-trawling disturbance experiment (Rabaut et al. 2008)? Is the BEQI-approach able to detect the changes as a significant effect?

Because of the small amount of samples and total surface of sampling of the reference data available in the *Lanice* experiment dataset (8 samples before disturbance, 8 samples after disturbance), the BEQI is not the most appropriate method to apply here. For a correct calculation of the BEQI, the reference dataset has to be large enough to represent the main factors of spatial and temporal variability (Van Hoey et al. 2007b). Furthermore, there was no biomass data available within the *Lanice* experiment dataset, Applying the BEQI to density data only decreases the reliability of the resulting overall Ecological Quality ratio (EQR).

However, merely as a test, the BEQI index based on densities only was calculated for the *Lanice* experiment dataset. This dataset was gathered during two beam trawling disturbance experiments (Rabaut et al. 2008). The intertidal experiment in Boulogne (France) was a quite small and focused experiment which yielded a database without any biomass data.

For the T0 or assessment situation, the BEQI output showed a significant drop in similarity versus the T-1 or reference situation. This resulted in a moderate status EQR as far as the parameter similarity was concerned. Although there were clear deviations for both density and species richness (total number of species), the status of the assessment situation was still classified as good. Averaging the EQR scores for the individual parameters density, species richness and similarity, resulted in a final EQR of 0.63 corresponding to a good overall status.

The preliminary result of this small test seems to indicate that the BEQI approach is able to detect these experiment related changes as a significant effect. However, it is difficult to make hard statements, since part of the assumptions where not fulfilled. Further testing and application on a larger dataset is therefore recommended. Moreover, some methodological uncertainties prevented us to draw clear conclusions on the use of the BEQI-tool. In the absence of an expanded dataset, we consider the use of BEQI as inappropriate for the analyses of targeted experiments. In such case, dedicated statistical tools are far more powerful in detecting possible impact. For the results and detailed description of these analyses, we refer to Rabaut et al. 2008.

Since there were questions raised concerning the applicability for the BEQI index for this case, we calculated the Benthic Quality Index (BQI) as developed by Rosenberg et al. (2004) in view of the implementation of the Water Framework Directive as an alternative method. This index is based on the fact that sensitive species tend to become dominant relative to tolerant species during secondary succession. Sensitive species thus tend to be dominant in undisturbed environments, whereas tolerant species dominate in disturbed areas. According to Rosenberg et al. (2004), the level of sensitivity/tolerance of a given species can differ between geographical areas. In BQI, the level of sensitivity/tolerance is based on the analysis of each studied data set through the concept of ES500.05 (Rosenberg et al. 2004). Analyzed data sets must thus be large enough to allow for the assessment of ES500.05 (Rosenberg et al. 2004, Labrune et al. 2006, Zettler et al. 2006). This constitutes a severe limitation to the spread of the use of BQI, which is thus currently restricted to large data sets (Labrune et al., 2006). This can be solved by computing ES500.05 for large sub areas (i.e. Arctic, Atlantic, North Sea and Mediterranean Sea). This was achieved by using the Macroben database of European soft-bottom macrofauna, built up by the NoE MarBEF. This resulted in the computation of ES500.05 of 767 species (corresponding 98.6% of total abundance) in the whole database. Corresponding number of species and % of abundance were 171 (70.1%), 465 (99.9 %), 78 (45.3%) and 278 (72.9%) in the Arctic, North Sea, Atlantic and Mediterranean Sea, respectively. These lists are available on the MARBEF website to compute BQI values in small datasets.

The integrated database assembled by VLIZ for the Westbanks workshop contains an easy tool to calculate the BQI index of samples. The MarBEF ES50_0.05 North Sea species list was integrated into the database and BQI index was calculated for the 16 stations that are part of the *Lanice* experiment. Only for a limited number of occurring species an ES50_0.05 was available in the list. The treatment effect of the *Lanice* experiment was detected by BQI but in view of the limitation of the dataset, no clear conclusions can be drawn.

Furthermore, converting the Benthic Quality Index into an Ecological Quality ratio is to be done on a local scale, based on the highest value of BQI found in the studied area Rosenberg et al. 2004. Further exploration and application of the BQI to a larger subset of the Westbanks database could point out what the appropriate conversion scale for the BCP should be.

What is the extent and the frequency of the *Lanice conchilega* presence encountered in the samples taken so far? Where has it been found and how many times in the same area?

The maps in Figure 1 indicate that *L. conchilega* occurs mainly in the coastal zone. As a first exercise, we focussed on the presence of *Lanice* in the Western Coastal Banks Area. This area is a relatively well sampled samples area, enabling for a longer term analysis. We emphasize that further analyses on the whole of the Belgian part of the North Sea is required in the future.

Although sampling location and intensity has not been constant at all throughout the last decades, Fig. 2 clearly shows that *L. conchilega* has been present in the Westbanks area for

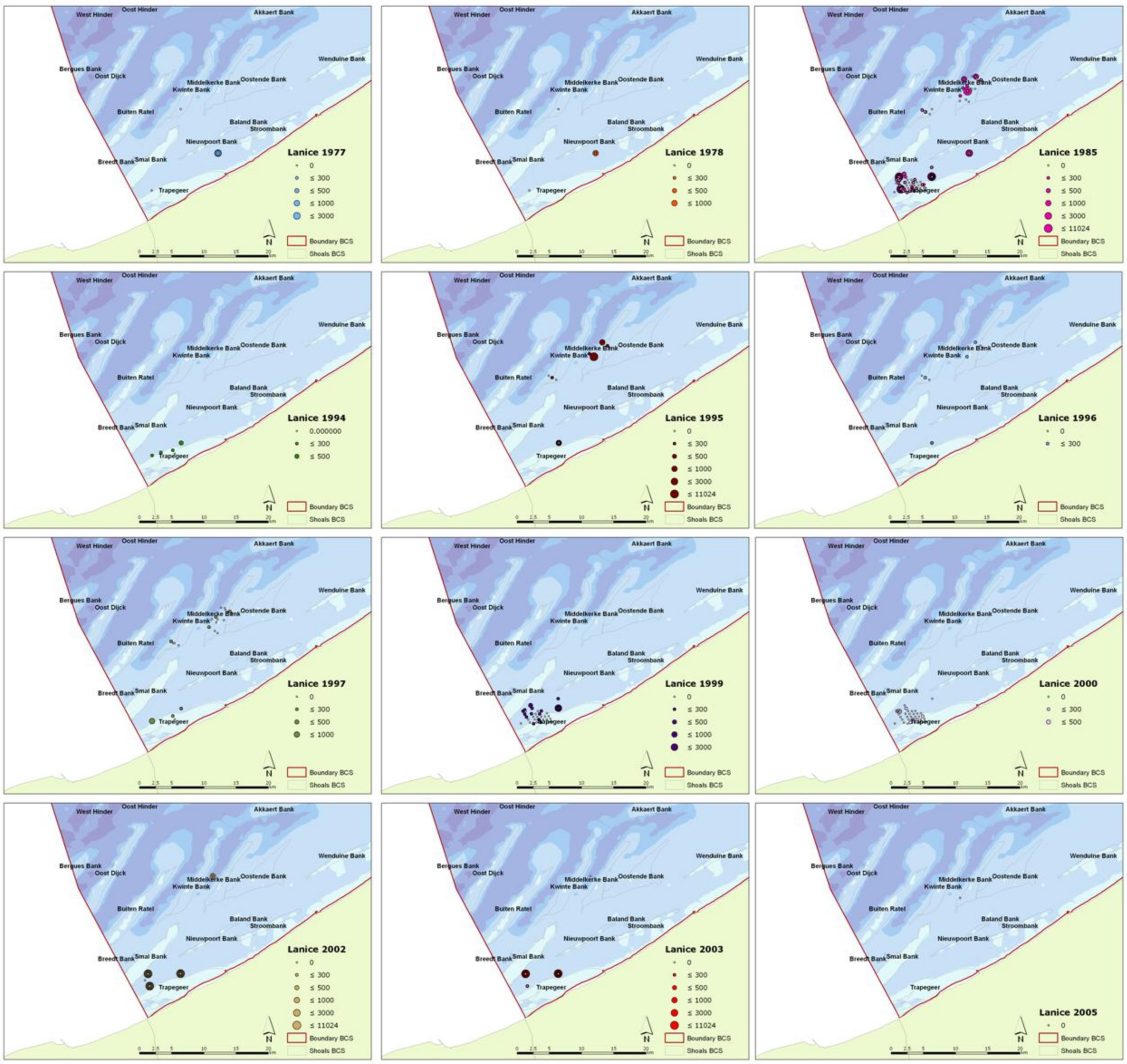


Figure 2: Occurrence of *L. conchilega* in the Western Coastal Banks area in the period 1977-2005.

almost 30 years (1977-2005). The species occurs in 343 samples of a total of 539 macrobenthos samples corresponding to 64% of all samples taken in the area. When in a particular year on a specific site *L. conchilega* is found, then, on average, we have found that in 91,65% of the samples taken at that place (in that year), the species is present. Analysing all samples per year, we calculated that the percentage of samples containing *L. conchilega* varies from 16% to 100%. However, its density cannot always be considered as a typical reef density (> 1000 ind.m^{-2}). It is impossible to follow individual reef systems over several years. The longevity of individual reefs can only be hypothesised but several mechanisms for a successful renewal of individual reefs have been described in literature. It is important to notice that the reef structures can be visualised with remote sensing techniques (Degraer et al. 2008). These techniques make it possible to monitor the location, extent and evolution of this particular reefy habitat.

In conclusion, the preliminary data analyses of this WestBanks workshop show that the Western coastal banks are a highly suitable area for *Lanice conchilega*. Moreover, this very same area seems to be of importance for Common sole (*Solea solea*) (with the heuristic estimate of relative contributions of *L. conchilega* to the HSM no less than 37%). When we link the persistent occurrence of this reef builder for almost 30 years in the WestBanks area with the current ecological knowledge, it goes without saying that this species is of importance when it comes to the sustainable management of this coastal area. We note that within the WestBanks project, results indicate that the reef system degrades as a consequence of bottom fisheries. We also advice to take advantage of new technologies to monitor this area in the future (in particular remote sensing techniques).

Global analysis of biodiversity on the BCS

Rationale

Many data on the macrobenthos (Van Hoey et al. 2004), meiobenthos (Vincx et al. 1991, Vanaverbeke et al. 2000,2002) and hyperbenthos (Dewicke et al. 2003) have been collected and analysed in order to unravel spatial differences in community patterns on the BCS. However, a global analysis including more than one size/ecological group has never been done before. Ongoing research, in the framework of the PhD of Bea Merckx revealed increased diversity of macrobenthic communities often coincides with rather low diversity for nematode communities. This suggests that both the macrobenthos and meiobenthos reflect different aspects of the biology of the sediments at the BCS. The aim of this topic is to further investigate the link the spatial patterns between the macrobenthos and meiobenthos. If this is successful, it would be large step in developing so called "umbrella species" or "umbrella communities" which could reduce the costs of monitoring programmes on the one hand, and increase our knowledge of interactions between different benthic components. In a further step, an attempt will be made to include the hyperbenthic communities in this global analysis.

Results

During the workshop, much time was spent in cleaning up the datasets in order to exclude uncertain identifications. This was especially needed for the database with the nematode data since taxonomical problems often results in identification to putative species. Putative species identified by Jan Vanaverbeke and Maaike Steyaert were kept in the database since these have been standardised in recent years. Putative species identified by Magda Vincx were also kept in the database since good descriptions are available for these species and hence there is no confusion with other putative species in the database. All other uncertain identifications were removed from the database. Seasonal data per station were pooled, as data from vertically distributed sediment columns. Replicates were averaged. This resulted in a database consisting of

724 species encountered in 76 stations. Macrobenthic data were retrieved from a subset of the WestBanks integrated database that was already checked for inconsistencies and consisted of 123 species encountered in 733 stations. This subset was used in a recent paper on habitat preference modeling (Degraer et al. 2008).

For both datasets, an MDS was carried out, based on presence/absence (Fig. 3). Median grain sizes per station were allocated to 50µm intervals. Communities per sediment catergory were compared using 1-Way ANOSIM. For both nematodes and macrobenthos, there were significant differences between the assemblages from different sediment categories, confirming the idea that sedimentological variables are important in structuring benthic community composition.

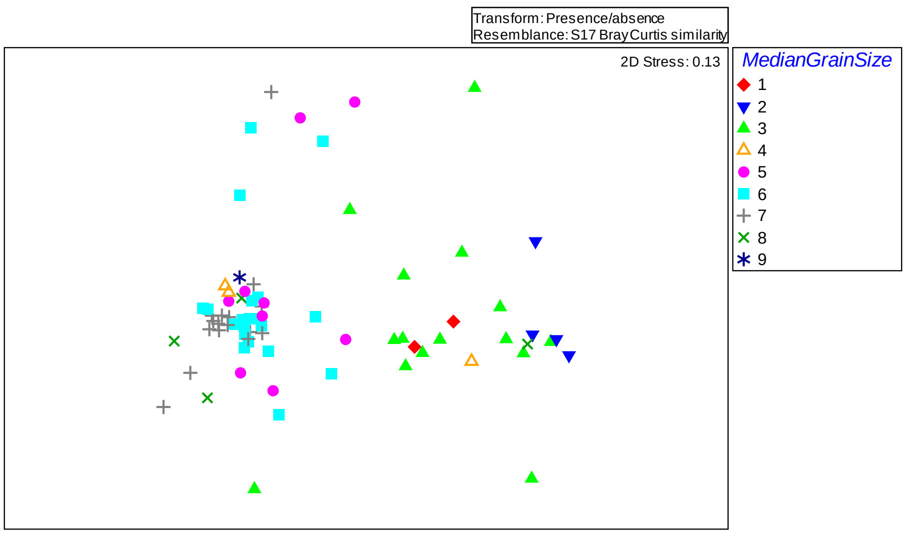


Figure 3. Example of MDS on nematode community data (presence/absence). Increasing numbers in legend indicate increasing median grain size.

These preliminary analyses allow for further detailed testing on the relation between macrobenthic and nematode community composition in different sediment categories.

Linking seabird distribution with macrobenthic distribution patterns

Scoters *Melanitta sp*. have shown a major change in wintering areas along the Belgian coast (Fig. 4, Fig. 5). The shift occurred around the winter 1999/2000 and coincided with a strong reduction in *Spisula* sp. (Van Hoey *et al.* 2007a) which is one of the preferred prey species of Scoters. Our aims were 1) to test if Scoter distribution prior to 1999/2000 was determined by the abundance and the availability of *Spisula* sp. and 2) to find out what prey might be important for Scoters nowadays. During the workshop, much time was spend on mapping the distribution of Scoters in ArcGis and finding relations with abiotic parameters that might restrict the availability of benthic prey, such as water depth and distance to the shoreline. In a next step, the main food items were selected based on literature and known densities of bivalves in our coastal waters. Habitat Suitability Maps (HSMs) were composed for 7 selected prey species. These HSMs were based on mud content , d50 and slope. As water depth determines food availability it was not used for generating the HSMs. We took a lot of time discussing the methodology for linking the HSMS with presence/absence data of Scoters and to discuss the usability of HSMs. It was agreed that the analysis will be carried on outside the scope of the workshop as we felt that it might lead to a scientific publication.

Figure 4. Distribution of Scoters *Melanitta sp.* between December 1996 and March 1999.

Figure 5. Distribution of Scoters *Melanitta sp.* between October 1999 and February 2008.

General conclusions

The **long-term funding** of **oriented basic scientific research** by the Belgian Science Policy (Belspo) enabled us to compile a database which makes it possible (1) to conduct targeted scientific analyses that can be of direct use for a sustainable management of the North Sea and provide answers to questions arising from international obligations and commitments (e.g. Water Framework Directive, Habitat Directive…). As such, it is imperative that a **continuous funding of high level oriented basic marine science** is maintained in Belgium.

There was **no obvious link** detected between eutrophication of the water column and the benthos on the BCS. **Targeted monitoring actions** in the near future are required to confirm this observation and should be designed in such a way that possible impacts on the benthic life can be observed.

The importance of *L. conchilega* for the ecosystem functioning of the Western Coastal Banks area has been emphasized before. At present, *L. conchilega* is recognised as reef building organism (Rabaut et al. in press) in the international literature and its protection is considered to be very important with respect to ecosystem functioning (Godet et al. 2008). In the Belgian coastal water, the presence of *Lanice* reefs should be considered as closely associated with the habitat type 1110 "Sandbanks which are slightly covered by sea water all the time". **International obligations in the framework of the Habitat Directive require the protection of this combination**. This is reinforced by the results obtained during this workshop since **a clear geographical link between the occurrence of *L. conchilega* and the common sole *Solea solea*** was demonstrated. Although it is at present still impossible to monitor individual subtidal *L. conchilega* reefs, our database revealed **the presence of this species in the Western Coastal Banks are for a period of about 30 years** suggesting a continuous contribution to habitat diversity and complexity in the area. However, monitoring using remote sensing techniques is required to increase our knowledge on the spatial and temporal scale of the presence of *L. conchilega* reefs.

Acknowledgements

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