Intensive Evaluation of the Evolution of a Protected Benthic Habitat

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Introduction

The area of the western Coastal Banks includes some Coastal Banks (Trapegeer, Broersbank, and Den Oever), as well as two swales (Potje and Westdiep) and is characterised by water depths of –15 m to 0 m MLLWS. Because of the geomorphological diversity in combination with the presence of several shallow sites (Broersbank), the area has been proposed as a special area within the EC-Habitat Directive. The geomorphological structure, being the most diverse along the Belgian coast, is directly responsible for the high biological diversity and richness of the area. Being a food resource for several seabird and demersal fish species, the macrobenthos is an important component within the ecosystem functioning of the western Coastal Banks.

Due to the crucial role of the macrobenthos within the coastal ecosystem, the distribution of macrobenthic communities in relation to bathymetrical, sedimentological, and hydrodynamical characteristics is determined. This relation is used for the development of time- and cost-efficient evaluation tools, including monitoring strategies for the follow-up of a management plan of the future MPA.

Regional Presentation Of The Macrobenthos And Its Physico-Chemical Environment

REVIEW OF THE BENTHIC HABITAT

In a first phase, maps were drawn on the basis of existing data, both from literature and reports. This included a compilation and integration of bathymetrical, morphological, sedimentological, hydrodynamical and macrobenthos data and provided a better characterisation of the benthic habitat of the study area.

Each presentation (map) is the result of a compilation of the available information, structured in a database. Through the possibility to integrate and superpose newly gathered data, a tool is provided to visualize the natural evolution of the area which can be of direct use when defining the present situation of the ecosystem of the western Coastal Banks.

A bathymetrical-morphological map was set-up comprising the occurrences of bedforms and their relative asymmetry. A digital very-high resolution side-scan sonar reconnaissance survey confirmed the presence of those bedforms and gave evidence of the highly diverse and complex nature of the seafloor.

The distribution of the surficial sediments was evaluated on the basis of existing sedimentological data. The surficial sediments are dominated by fine to medium sands with a coarsening of sediments towards the top of the bathymetric highs. The sand bank areas are generally coarsest, often characterised by coarse shell hash; the surficial sediments of the swales can have high percentages of the silt-clay fraction.

Semi-diurnal tides of macrotidal range (5.4 m) dominate the area. The tidal currents are higly rectilinear with a dominance of the flood current (NE-ENE) that can amount up to 1.32 m/s in the Westdiep swale. Numerical modeling (mu-BCZ) showed the highest current velocities in the Westdiep swale and near the foot of the slope of the Trapegeer. From sediment transport calculations it was shown that the surficial sediments are mainly mobile during Spring and Mid tide, from generally 1 hour before up to 1 hour after High Water. In the Westdiep swale and the Noordpas swale the ebb tidal current is also able to resuspend sediments.

Only little information about the macrobenthos of the Western Coastal Banks from the period before 1999 is available. The historical data are restricted to the Trapegeer, Broersbank, Den Oever and Potje. Almost no information about the Westdiep swale was available. Three macrobenthic communities, spread over the area were distinguished. The macrobenthos-rich *Abra alba – Mysella bidentata* community (syn. *Lanice conchilega* community) is mainly found in the deeper parts of the Potje swale and along the northern slope of the sandbank Trapegeer, while the *Ophelia limacina – Glycera lapidum* community (syn. *Mytilus edulis* community) prefers the shallowest sites (e.g. top of the Broersbank). On top of the sandbank Trapegeer and in the area of the Broersbank, the *Nephtys cirrosa* community was found. Although these data provide a first view on the community structure and macrobenthic spatial distribution within the area of the Western Coastal Banks, they should be interpreted with caution. For a bathymetric-geomorphological very diversified area as the Western Coastal Banks, the data, derived from only 32 stations, should be regarded as 'point data': spatial extrapolation of any macrobenthic characteristic was impossible.

MACROBENTHIC HABITAT: SPATIAL DISTRIBUTION

To study the spatial variation of the macrobenthic habitat, three subareas, with a maximum geomorphological diversity, were intensively investigated for their physico-chemical habitat and their macrobenthos.

Within the subareas, full-coverage very-high resolution side-scan sonar imagery was obtained that allowed to study the intrinsic nature of the seafloor in relation to the large-scale morphology. The combination of reflectivity, texture and patterns could be translated into specific acoustic facies that could be primarily interpreted in terms of the small-scale morphology and bedform occurrences, distribution of sediments and their relative compaction superimposed with hydrodynamical effects.

Sediment samples confirmed the highly variable nature of the sediments and this often on very short intervals. On the sandbanks, the distribution of the surficial sediments is hydrodynamically determined: the currents are strong enough to distribute the sediments. In the swales, a variety of sediments is deposited. This is mainly due to the high availability of fine-grained sediments that can settle out during slack water. On the contrary, the Westdiep swale is generally characterised by coarser sediments. As confirmed by side-scan sonar imagery, this swale should be regarded a high-energy depositional environment.

Along the foot of the slope of the Trapegeer sandbank, acoustic doppler current meter results confirmed the highly rectilinear nature of the tidal currents with a predominance of the flood current. Yet, the correlation between the high spatial variability and the hydrodynamical numerical model results still needs further investigation.

The knowledge on the macrobenthic community structure, based on historical data (see above), was confirmed by the detailed investigation. Next to one transitional species association (*Magelona mirabilis* transitional species association), three of a total of four subtidal macrobenthic communities discerned at the BCS (Van Hoey et al., in prep.) were found within the area of the Western Coastal Banks: *A. alba – M. bidentata*, *N. cirrosa* and *O. limacina – G. lapidum* community. Each community or species association is restricted to a very specific physico-chemically defined habitat. Although the communities were spread all over the area, zonation, mainly related to depth, was demonstrated. As already shown by Degraer et al. (1999a) and Van Hoey et al. (in prep.), the *A. alba – M. bidentata* community is an ecologically highly valuable macrobenthic community on the BCS. The community is characterised by the highest macrobenthic densities and diversity. Furthermore, most bivalve species (e.g. *A. alba*, *Fabulina fabula* and *Spisula subtruncata*) are found in high densities within the community. These bivalves are known to be an important food resource for larger epibenthic predators (e.g. cod *Gadus morus*, and sole *Solea solea*) and benthos-eating diving seaducks (e.g. common scoter *Melanitta nigra*). Primarily within the *A. alba - M. bidentata* community, the tube-building polychaete *Lanice conchilega* fulfills an important habitat-structuring role. Both other communities and the transitional species association contribute substantially to the overall macrobenthic diversity of the Western Coastal Banks: 74 % of all macrobenthic species, recently found on the BCS, were detected within the study area.

MACROBENTHIC HABITAT: TEMPORAL VARIATION

To study the seasonal variability within the macrobenthic habitat of the Western Coastal Banks, the multi-disciplinary study of October 1999 was repeated in March 2000. On a sedimentological level, the temporal variability was minimal and generally, the differences were within the error imposed by the analysis.

The side-scan sonar imagery shows more variability as it reflects the upper seafloor characteristics. Most striking was the presence of white reflectivity bands in the deepest parts of the swales that could be interpreted as fluid mud layers superimposed on fine sandy sediments. Still, in terms of an interpretation towards an acoustic facies, hardly any differences were appararent which indicates that a standardised side-scan sonar interpretation is valid on a temporal basis.

Although the community structure changed within all macrobenthic communities, the communities, detected in October 1999, were still present in 2000. Because of the relative low temporal variation of the structure of the three communities, the temporal variation does not overrule the "basic" structure of each community. The temporal variation was most obvious in the *A. alba – M. bidentata* community, while only minor changes were detected within the *N. cirrosa* and *O. Limacina – G. lapidum* community and the *M. mirabilis* species association. Because of the expected stability of the ecologically relevant physico-chemical environment (e.g. sedimentology and depth) at the sampling stations, most of the stations harboured the same community in October 1999 and 2000. A high spatial distributional stability was found within the area of the western Coastal Banks.

Development of Methodologies Aiming at the Creation ff Time- and Cost-Efficient Monitoring Tools for the Future Mpa

HABITAT MODEL

The HABITAT model, consisting of eight classification function sets derived from multiple discriminant analysis, allows to predict the presence or distribution of macrobenthic communities, based on knowledge of the physico-chemical environment. The model thus allows to evaluate the 'macrobenthic potentials' of non-studied places within the protected area on an time- and cost-efficient base. Based on the macrobenthos data of October 1999 and March 2000 (three communities and one transitional species association), 78 % of the classification functions revealed a community specific and overall *a posteriori* and *a priori* accuracy higher than 70 %. These accuracies can be drastically improved if only the three macrobenthic communities are taken into account, rather than using the *M. mirabilis* species association as well. Comparing the community specific accuracy of each classification function set, no set can be put forward as superior to the other sets. Further testing and refinement of the models is advised.

STANDARDIZED MACROBENTHIC INTERPRETATION OF SIDE-SCAN SONAR IMAGES (MSSSI)

Two approaches were followed in the interpretation of side-scan sonar imagery in terms of the occurrence of macrobenthic communities.

The first approach was based on a direct correlation of high abundances of macrobenthos with a specific acoustic facies. A medium to high reflectivity patchy to mottled texture was correlated with the presence of dense fields of the tube-building polychaete *Lanice conchilega.* If the density of this polychaete worm is indeed high enough, local sediment accumulations, detectable by side-scan sonar technology, can be formed. Interestingly, the occurrence of this acoustic facies is highly correlated with slope environments leading to the assumption that these environments have a high input of suspended matter.

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

HABITAT STRUCTURE MAP

A Habitat structure was set-up as an integration of the available data and interpretations and reflecting information on the bathymetry, sediment nature, the acoustic facies and the occurrence of the macrobenthic communities. This approach visualises the interactions between the physical environment and the macrobenthos and is a tool for a scientifically sustained evaluation of this unique ecosystem. Together with the other maps, the habitat structure map reflects the situation of the ecosystem before the effectiveness of a support plan. Knowledge on the t_0-situation is of primary importance for the evaluation of the effects of the policy decisions.

Implications for Future Management and Monitoring

Both models developed during the project (e.g. HABITAT model and Macrobenthic Side-Scan Sonar Interpretation) allow a time- and cost-efficient, full-coverage spatial extrapolation of point-data. The latter also proved to be useful for the delineation of ecological relevant strata, necessary to set up a stratified random sampling design for the follow-up of a future management plan. Three steps are proposed for the monitoring of the Western Coastal Banks: (1) selection of strata, (2) monitoring of the macrobenthic habitat, following a stratified random sampling design, and (3) full-coverage monitoring of the macrobenthic habitat, using very-high resolution acoustic techniques.