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Weighing natural variability and anthropogenic impacts: a case study of demersal fish and epibenthic communities in the Belgian Part of the North Sea.

Annelies De Backer[1*], Sofie Vandendriessche[1], Jan Wittoeck[1], Kris Hostens[1]

1 *Institute for Agricultural and Fisheries Research-Fisheries, Bio-environmental Research Group, Ankerstraat 1, B-8400 Oostende, Belgium*
**Email: annelies.debacker@ilvo.vlaanderen.be*

EXTENDED ABSTRACT

Background

Anthropogenic activities such as sand extraction, fisheries, shipping, the construction of pipelines or windmill farms, dredging and dumping of dredged material, have been shown to result in varying effects on the marine ecosystem (Köller *et al.* 2006, Wilhelmsson *et al.* 2006, Barrio Froján *et al.* 2008, La Porta *et al.* 2009, Ware *et al.* 2009). Numerous monitoring programs have been set up to evaluate the extent and nature of these effects. However, the effects of anthropogenic activities on the benthic life are often difficult to detect against a background of small and large scale natural variability resulting from differences in environmental variables, especially in the highly dynamic sandbank-dominated habitats in the Belgian Part of the North Sea (BPNS).

The distribution of the macrobenthos in the BPNS is well studied, and four major species assemblages were defined (Van Hoey *et al.* 2004, Degraer *et al.* 2008). Each of these assemblages is determined by a number of indicator species and by typical density and diversity measures. The distributional patterns of the macrobenthic assemblages are mainly linked to sediment type (cf. average grain size and mud content). Based on that relation, a habitat suitability map for the four assemblages could be established for the BNPS (Degraer *et al.* 2009).

On the other hand, distributional patterns of the epibenthos and demersal fish in the BPNS are not yet thoroughly presented. In the framework of an ecosystem approach, knowledge on epibenthos and demersal fish communities, in addition to macrobenthos data, is imperative, and will allow for sound ecosystem-based management. Furthermore, knowledge on the natural variability of these communities will underpin a sound interpretation of the detection of any ecological change in the area.

A monitoring strategy based on medium-term data acquisition at fixed locations is used to define demersal fish and epibenthos communities and to evaluate their natural spatial and temporal variability in the BPNS. In total, 80 locations spread over the BPNS were sampled with an 8 m shrimp trawl during 1 to 9 (spring and autumn) campaigns between 2004 and 2009. Five tracks are located in sand extraction areas, five in dredge dumping sites and two in windmill areas, and could thus be defined as impact locations, while 68 tracks are regarded as reference locations. A number of environmental variables were used in the analysis of the spatial distribution of the encountered species.

Results

1) <u>Characterisation of the species assemblages and distributional patterns</u>

The coastal - offshore transition is the dominant structuring factor on a regional scale (BPNS), which is reflected by a shift from a coastal system characterised by shrimp, ophiuroids and crabs to an offshore system with lesser weever, hermit crabs and dab (Fig. 1). The transition between coastal samples and offshore samples was consistent over the years and seasons.

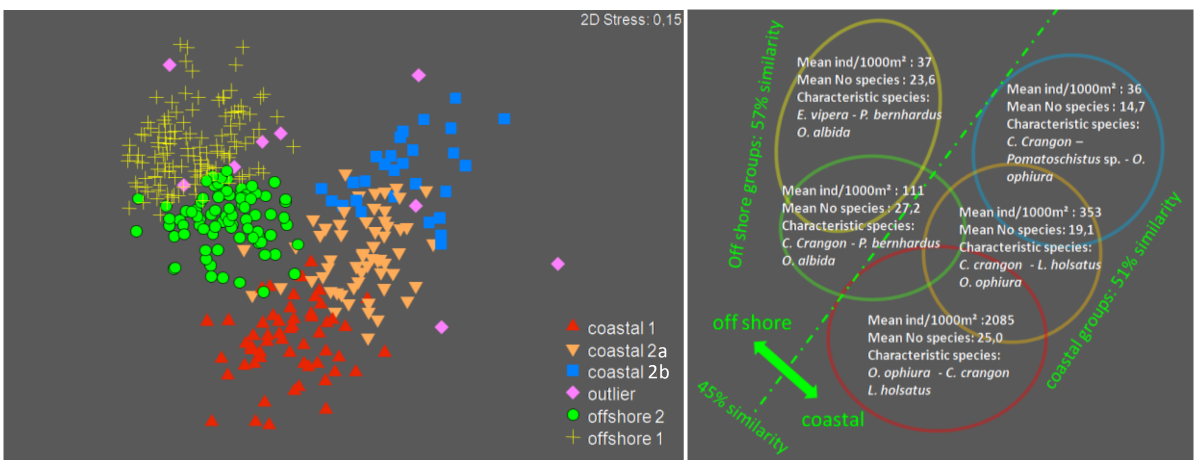

Figure 1: MDS plot with indication of the defined species assemblages (left) and characterisation of the species assemblages by average density, number of species and characteristic species (right)

Within the coastal zone, three groups could be distinguished based on a cluster analysis and visualised in an MDS plot (Fig. 1), which mainly differed in the occurrence and densities of *Ophiura ophiura*, *Ophiura albida*, *Crangon crangon*, *Liocarcinus holsatus* and *Nassarius reticulatus*:

<u>Coastal 1</u> is found in the western part of the coastal area and a bit more offshore at the eastern part (Fig. 2). This assemblage, characterized by the species *O. ophiura, C. crangon* and *L. holsatus*, showed the highest densities (mean 2085 ind./1000 m²) and a high diversity (mean N° of species

(S): 25; mean N1: 4.4) (Fig. 1). The spatial extent of this group was consistent over the years, and it coincides with the potential habitat of the diverse macrobenthic *Abra alba* community, which is characteristic for muddy fine sand (mean mud content 5.8% and mean median grain size 219 μm) (Fig. 2).

Coastal 2a is found between the harbour of Ostend and the Belgian-Dutch border (eastern coastal zone), extending offshore to the Vlakte van de Raan (Fig. 2). 'Coastal 2a' samples are predominantly spring samples exhibiting the lowest density values of the BPNS (mean density 36 ind./1000 m^2) and low diversity values (mean S: 14.7; mean N1: 3.7). The top characteristic species were *C. crangon, Pomatoschistus* sp. and *O. ophiura* (Fig. 1).

Coastal 2b has a similar spatial distribution as 'coastal 2a', although contributing samples are most frequently found closer to the shore. The samples constituting this group were characterized by the species *C. crangon, L. holsatus* and *O. ophiura*. This is mainly an autumn assemblage exhibiting intermediate values of density and low diversity values, similar to the ones of 'coastal 2a' (mean density 353 ind./1000 m^2; mean S: 19.1; mean N1: 3.6). Both 'coastal 2' assemblages overlap mainly with the potential habitat of the, likewise less diverse, *Macoma balthica* community occurring in muddy sediments (mean median grain size 95 μm) (Fig. 2).

Within the offshore samples, two subgroups are defined based on varying densities of *C. crangon*, *Echiichthys vipera* and *O. albida*. The offshore assemblages coincide with the macrobenthic *Nephtys cirrosa* and *Ophelia limacina* communities, both characterized by low densities and low species richness and respectively occurring in fine to medium sands (mean median grain size: 274 μm) and medium to coarse sands (mean median: 409 μm).

Offshore 1 samples are mostly found in the most remote parts of the BPNS (except in spring 2006, during which even the most remote stations are characterized by the 'offshore 2' community). The samples belonging to 'offshore 1' all exhibit low densities (mean density 37 ind./1000 m^2), but a relatively high species number and evenness (mean S: 23.6, mean N1: 7.3). The top characteristic species were *E. vipera, Pagurus bernhardus* and *O. albida.*

Offshore 2 is characterized by the species *C. crangon, P. bernhardus* and *O. albida,* and combines the higher densities found in coastal samples with the high diversity found in genuine offshore samples (mean density 111 ind./1000 m^2; mean S: 27.2; mean N1: 8.3). Several samples in the spatial range of the 'offshore 2' zone are inconsistently placed in one of the offshore assemblages over years and seasons. Part of this inconsistency is induced by yearly varying water temperatures influencing the species distribution, and part by differences between sandbank tops and gullies within the sandbank systems of the offshore region.

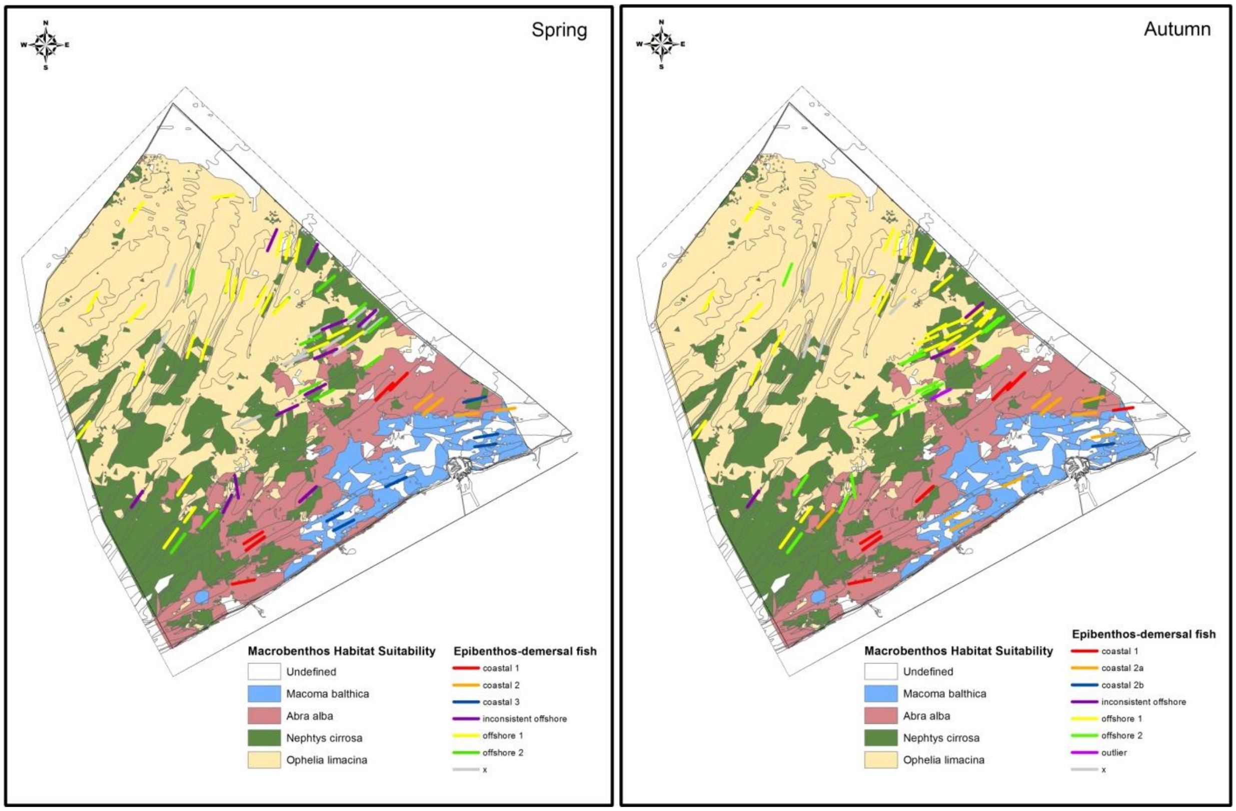

Figure 2: Overlay of demersal fish and epibenthos communities per sampling station on the macrobenthos habitat suitability map (from Degraer *et al.* 2009) of the BPNS for spring (left) and autumn (right).

2) <u>Main structuring variables</u>

The distLM results (based on BIC criterion and BEST selection) (Permanova +, Anderson *et al.* 2008) showed that 40.5% of the biological variation could be explained by a combination of the variables distance to the coast, temperature, depth, mud percentage, median grain size of the sand fraction and salinity (Fig. 3). In other words, both site specific and temporal conditions were identified as important structuring factors. Distance was the most important variable, accounting for 25.7% of the explained variation. This again indicates the importance of the coastal - offshore transition on the regional (BPNS) scale, whilst defining epibenthos – demersal fish assemblages. Distance was followed by temperature explaining 5.3%, emphasizing the differences between spring and autumn samples, which are separated per community on the second axis in the dbRDA plot (Fig. 3).

'Impact' was as well entered as a categorical variable, but was not retained as an explanatory variable for the distribution patterns of the epibenthos and fish assemblages of the whole BPNS. However, on small spatial and temporal scales, some differences between impact and reference zones were noted (Vandendriessche *et al.* in prep). These small scale differences need to be further investigated.

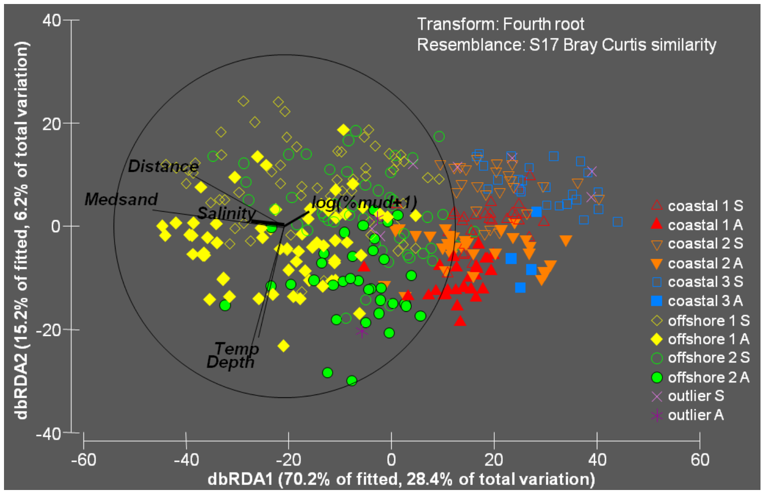

Figure 3: Distance based RDA showing the environmental variables explaining part of the variation observed in the epibenthos and demersal fish communities (S: spring samples; A: autumn samples).

Conclusion

Knowledge of the natural spatio-temporal dynamics of the reference conditions is a major advantage for future quantification of anthropogenic impacts and also for the evaluation of the relevance of these impacts. This study shows that to optimize the impact assessment and filter out the natural variability in the BPNS, it is imperative that both control and impact samples belong to the same epibenthic and demersal fish assemblage. Moreover, to exclude the observed seasonal variation, impact and control samples should be taken in the same period of the year to minimize temporal dynamics.

Furthermore, we find geographical evidence for close overlap between the macrobenthos and the epibenthos-demersal fish communities in the BPNS. To find out whether these ecosystem components react differently on the diverse human impacts, it is very valuable to assess the biological status of both ecosystem components and examine the impact of anthropogenic activities through different trophic levels of the ecosystem.

On the spatial scale of the BPNS, the small scale impact of human activities on epibenthic and demersal fish assemblages fades away into the background of natural variability. This is actually a good sign, since the anthropogenic impacts do not push the ecosystem outside the natural limits. However, to unravel the long term and small scale impacts, more detailed studies are needed, taking into account the above mentioned requisites.

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