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Estimating the biological value of soft-bottom sediments with sediment profile imaging and grab sampling

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ABSTRACT

Biological value estimation is based on a set of assessment questions and several thresholds to delineate areas of ecological importance (e.g. biodiversity). An existing framework, that was specifically designed to assess the ecosystem biodiversity, was expanded by adding new questions on the productivity, functionality and biogeochemical status of benthic habitats. The additional ecological and sedimentological information was collected by using sediment profile imagery (SPI) and grab sampling. Additionally, information on the performance and comparability of both techniques is provided in this study. The research idea was tested at a site near the harbor of Zeebrugge, an area under consideration as a new disposal site for dredged material from the harbor entrance.

The sedimentology of the area can be adequately described based on the information from both SPI and Van Veen grab samples, but only the SPI revealed structural information on the physical habitat (layering, a-RPD). The latter information represented the current status of the benthic habitat, which was confirmed by the Van Veen grab samples. All information was summarized through the biological valuation framework, and provided clear evidence of the differences in biological value for the different sediment types within the area. We concluded that the installation of a new dredged material disposal site in this area was not in conflict with the benthic ecology. This area has a low biological value and the benthic system is adapted to changing conditions, which was signaled by the dominance of mobile, short living and opportunistic species.

This study showed that suitable sedimentological and ecological information can be gathered by these traditional and complementary techniques, to estimate the biological value of an area in the light of marine spatial planning and environmental impact assessments.

1. Introduction

Robust and meaningful ecological information (e.g. on biodiversity) is a pre-requisite to design a sustainable management plan and to minimize the effects of a given human activity. The biological value assessment is not trivial, and it is mostly linked to the objectives behind the valuation process itself (e.g. conservation, sustainable use, preservation of biodiversity) (Derous et al., 2007b). A wide range of definitions can be found in the literature, although these definitions are mostly linked to the socio-economic value of biodiversity. For example, important attributes like high number of rare/endemic species or high species richness should be assessed to delineate 'hotspot' areas. Most efforts on the identification of valuable marine areas are conducted at habitat level, with particular emphasis on structural properties (e.g. bottom topography, wave exposure, depth and substrate type), mainly because these are the most easily observed and highly documented features in marine environments. The assessment of different aspects at the benthic community or population level (e.g. indicator species, species diversity, functional groups) is much more challenging (Zacharias and Roff, 2001).

Benthic macro-invertebrates are a well-studied ecosystem component, especially from soft-bottom sediments in the Southern Bight of the North Sea (Reiss et al., 2010; Van Hoey et al., 2013). Macrobenthos is generally accepted as a good indicator of ecosystem status, due to its direct link with the conditions in and above the sediment surface (Van Hoey et al., 2010). The combined knowledge of substrate type and benthic ecology is considered to be a good proxy to estimate the biological value or potential of an area.

The site west of Zeebrugge harbor (Wandelaar area) in the Belgian Part of the North Sea (BPNS) is currently considered by the Belgian government as location for a new dredged material disposal site (diameter of approximately 1.5 km) (Fig. 1). Prior to determining the exact location, the government has requested an evaluation of the biological value of the whole area. This assessment will provide the scientific information necessary to minimize ecological conflicts or to predict possible consequences when this new site is in operation. Despite the detailed monitoring of the soft-sediment substrates in the BPNS, there is a lack of information on benthic and sediment data available for the Wandelaar area (Degraer et al., 2008; Van Hoey et al.,

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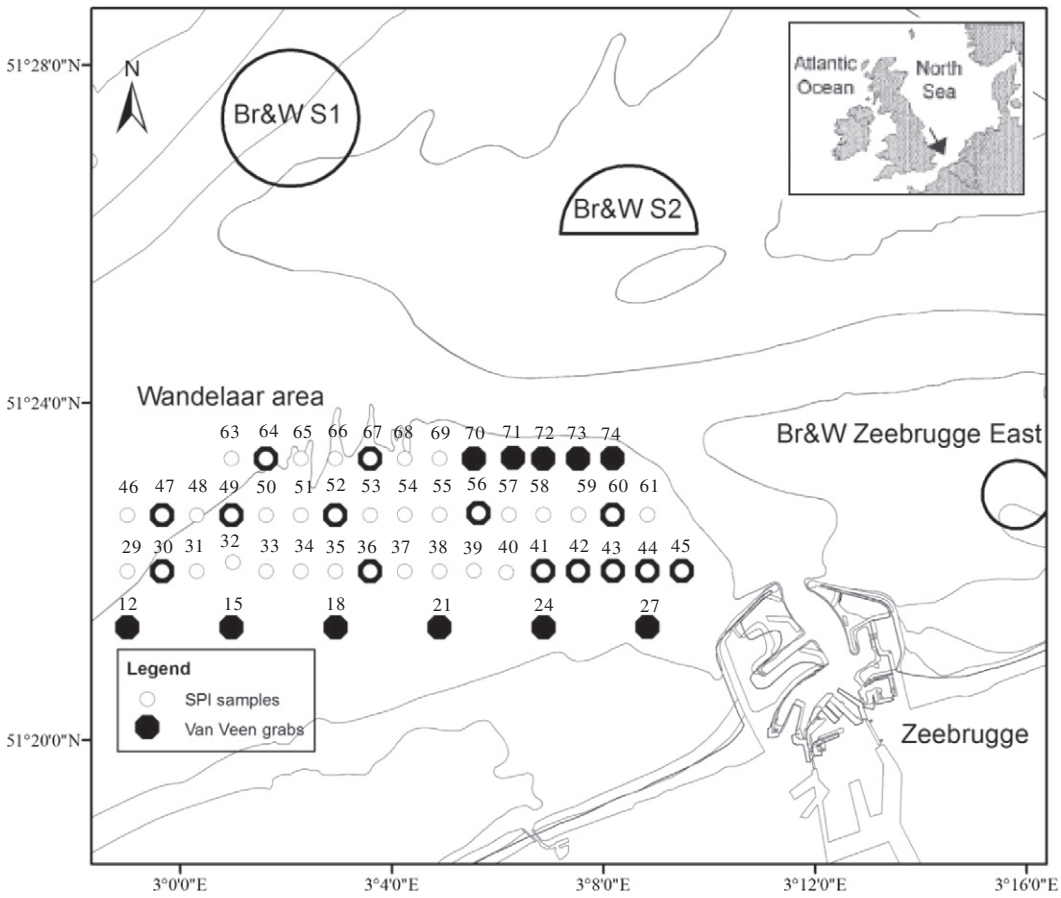

Fig. 1. Study area showing sampling points (numbers used to denote station names), where SPI images and Van Veen grab samples were taken. Also, the three current dredge disposal areas in the vicinity of Zeebrugge are indicated.

2013). To start the biological valuation assessment of this area, it was necessary to collect baseline information via existing monitoring activities. In this study, we focused on the benthos of soft-bottom sediments, which is classically monitored with Van Veen grab samples. The application of optical complementary techniques in benthic assessments has been proven to be appropriate (Germano et al., 2011). One of the optical techniques, also applicable in more turbid areas, is the sediment profile imagery camera (SPI), which provides a rapid assessment of the environment (sediment characteristics and associated fauna) and potential impacts (Birchenough et al., 2006, 2012a, 2012b; Germano et al., 2011; Nilsson and Rosenberg, 2000; Rhoads and Germano, 1982; Wilson et al., 2009). The SPI camera has a clear advantage over conventional sampling devices, as it is a quick tool delivering an undisturbed image of the sediment and presence/absence of biotic structures (e.g. burrows, tubes) with limited time needed for analysis (Germano et al., 2011). In contrast, grab samples (which are also quickly taken) enable a quantitative estimation of the biological data (e.g. species, densities, biomass) and the sediment characteristics, but these analyses are labor intensive and costly. Each technique can provide a different, yet complementary perspective on the benthic community condition (Wilson et al., 2009).

The onset of a new activity in the Wandelaar area, and the poor ecological and sedimentological knowledge within this area, provided an excellent case study to apply the biological value framework. The characteristics of sediment and biota gathered with SPI and grabs were used to answer the assessment questions within this framework. Knowledge on the biological value of an area supports the development of a sustainable management plan to allocate new activities (e.g. a dredged material disposal site) and the incorporation of this information in Environmental Impact Assessment (EIA) processes.

The specific aims of this study, based on information gathered with SPI and grab sampling, were: (1) to compare and integrate the quantitative and qualitative information on the sediment characteristics; (2) to produce sediment maps of the area with an indication of the benthic habitat potential; (3) to describe the biological (e.g. density, diversity, species composition) and functional (biological traits) characteristics of the area; and (4) to apply valuation criteria (biodiversity, productivity and functioning) and biological valuation thresholds to designate an appropriate area for dredged material disposal.

2. Materials and method

2.1. Study area

The BPNS is a small area (~3600 km^2) within the Southern Bight of the North Sea characterized by a complex system of sand banks (Van Hoey et al., 2004). It contains four principal benthic habitat types, i.e. the *Macoma balthica*, *Abra alba*, *Nephtys cirrosa* and *Ophelia borealis* habitats (Degraer et al., 2008; Van Hoey et al., 2004). The area located on the west side of Zeebrugge harbor (Wandelaar area) (Fig. 1) was an area with limited information on the benthos and sediment characteristics in the coastal area of the BPNS (Van Hoey et al., 2013). This area is currently considered by the Belgian government as a location for a new dredged material disposal site, in replacement of the current dredge disposal site Br&W Zeebrugge-oost (located at the east side of the harbor, Fig. 1). The reason for this replacement is that sediment particle movement models predicted that the recirculation of mud