

Adaptation of the reference level for sand extraction: feasible or not?

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Introduction

The sand and gravel extraction in the Belgian part of the North Sea (BPNS) is limited to 5 m below the reference level determined by the Fund for sand extraction (Royal Decree of September 1, 2004 Art. 31). However, the sand extraction industry and the scientific institutes involved in the monitoring of the impact are demanding to adapt this arbitrarily defined reference surface based on clear scientific criteria. To optimally use the available sand reserves in the near future, taking into account a number of key projects (such as the master plan coastal safety), this project is indispensable.

Based on a detailed seismic study, a three-dimensional map of the sand extraction areas in the BPNS will be made. This allows an accurate evaluation of the available sand reserves and the economic potential. On this basis, a new reference surface regarding the maximum extraction depth will be proposed. First, the existing and available seismic data in control zones 1, 2 and 4 will be investigated and evaluated based on quality, density and detail. If necessary, additional seismic measurements will be scheduled. Next, several possible reference surfaces will be calculated using all the seismic data combined with the bathymetric models and the available sedimentological data. Finally, these surfaces will be further analysed taking into account both economic and environmental arguments.

Material and methods

For this study the existing seismic dataset from the Renard Centre of Marine Geology (Department of Geology and Soil Science, Ghent University) will be used. This dataset has been fully analysed and interpreted within the framework of the doctoral thesis of Mieke Mathys. More than 16.000 km of high-resolution seismic profiles have been acquired on the BPNS since the end of the '70's within the framework of several national and international projects. About 4.000 km of these old high-resolution single-channel reflection seismic profiles were digitised and integrated with 1.300 km of recent seismic data. These data were obtained between September 1980 and April 2007 on board of the research vessels Belgica, Mechelen, Sepia II, Spa and Bellini with different types of seismic tools (Mathys, 2009).

In addition, the results of the seismic investigation of the Hinder Banks will be incorporated. This study has been performed in 2008 by the Coastal Division (Agency for Maritime and Coastal Services, Flemish Government) in order to investigate the distribution and characteristics of the sediment for the future exploitation in exploration zone 4 (Mathys et al., 2009).

Besides the already available data, new seismic profiles were needed in control zone 2 on the Buiten Ratel and Oostdyck due to the low density and the low quality of the existing data in the area. In June-July 2014 more than 160 km of 2D high-resolution reflection seismic data were acquired in a study by the Continental Shelf Service, using the SIG sparker 1200 seismic source of the RCMG. This source

has a frequency range of 800-900 Hz allowing a penetration depth up to 100 m in sandy sediments with a vertical resolution of 50 cm.

All seismic data were integrated and analysed with the IHS Kingdom 2d/3dPAK software package.

Results and discussion

Two major geological boundaries are of great importance on the BPNS, namely the top of the Paleogene or the basis of the Quaternary and the top of the Eemian. As a case study the Hinder Banks area has been used (Figure 1).

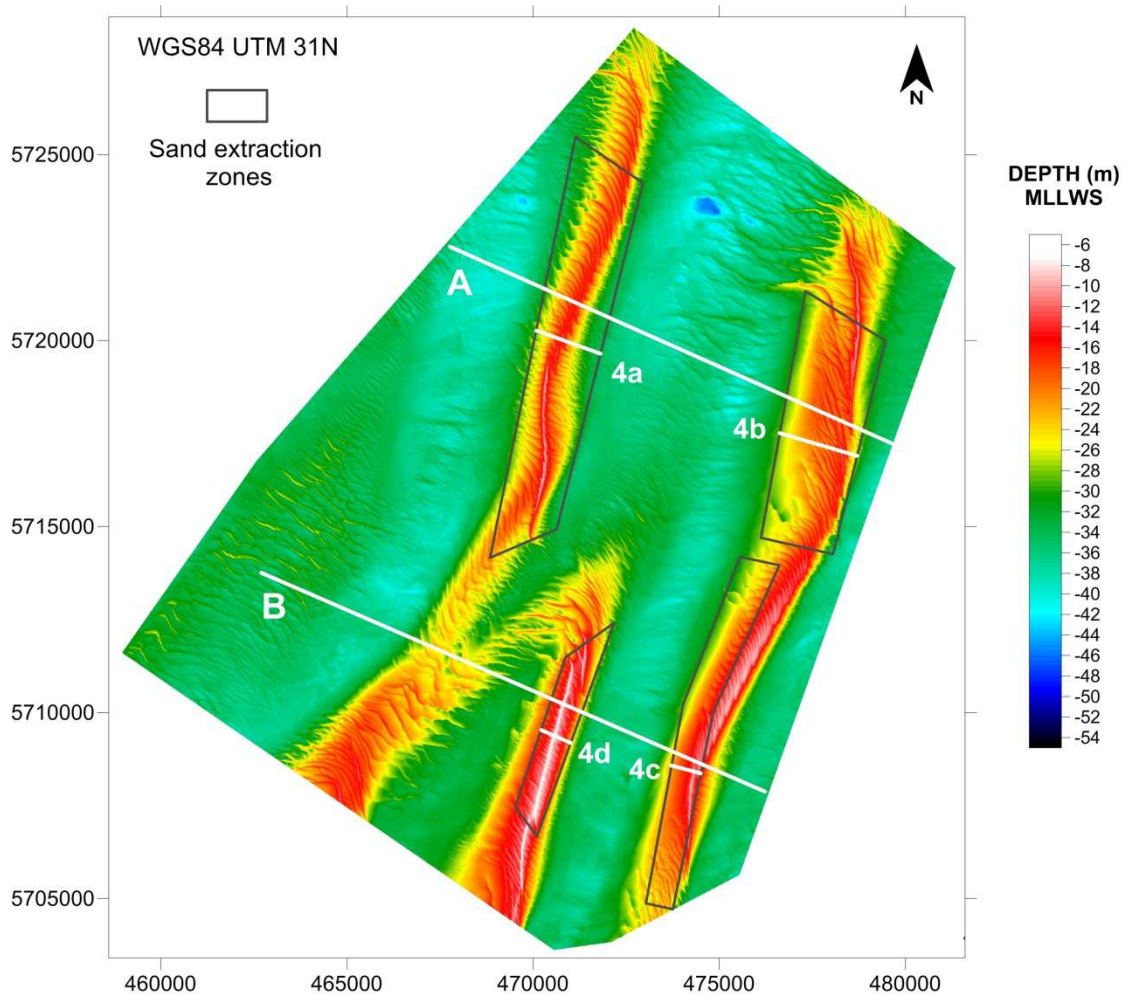


Figure 1: Bathymetric map of the case study area on the Hinder Banks including the location of the profiles.

The Paleogene deposits, mainly deposited during the Thanetian (59,2-56,0 million years ago) and Rupelian (33,9-28,1 million years ago), occur at a depth of -10 to -60 m (MLLWS), dipping in offshore direction (De Batist, 1989) and locally outcropping between the discontinuous cover of Quaternary sediments (Mathys, 2009). The top of the Paleogene is marked by a distinct angular unconformity, probably formed in marine as well as fluvial circumstances over a long period of time and under the influence of climatic changes (Mostaert et al., 1989). It is characterised by a number of planation surfaces, bounded by slope breaks and scarps, and several incised valley structures (e.g. Ostend Valley) (Mathys, 2009). Directly above the unconformity, at the base of the Quaternary deposits, a gravel lag deposit is commonly present. It consists of a heterogeneous mixture of silex and sandstone boulders and pebbles, and abundant shell fragments, mostly in a sandy matrix (Mathys, 2009). On the Hinder Banks the top of the Paleogene (Figure 2) varies between 32 m below seafloor (bsf)

underneath the sandbanks and 0 m in the gullies in between the sandbanks where the Paleogene is outcropping.

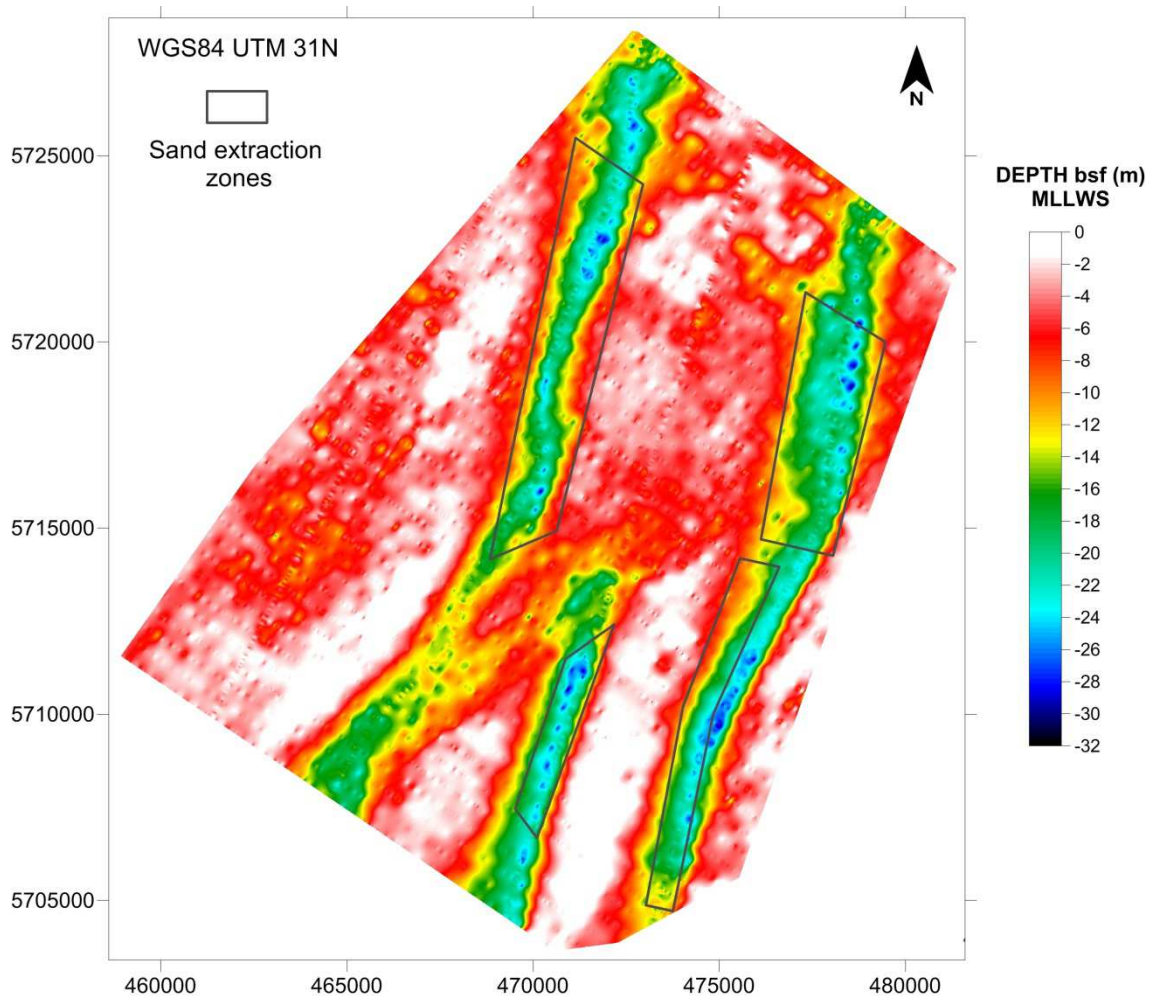


Figure 2: Depth chart of the top Paleogene on the Hinder Banks (in meters below seafloor).

The Eemian interglacial (128.000-116.000 years ago) caused a sea level rise where the coastline moved about 7 km inland compared to the present situation with even a marine influence up to 40 km inland the Flemish Valley (De Moor et al., 1996; Mathys, 2010). This sea level rise led to the deposition of a gravel layer in the BPNS from earlier infills of the Meuse and Ostend valleys (Mathys, 2010). However, this Eemian gravel layer is only fragmentary present in the BPNS where even questions rise about the correct age of these gravels (C. Baeteman, pers. comm.). On the Hinder Banks the top of the Eemian (Figure 3) varies between 26 m bsf underneath the sandbanks and 0 m in between the banks where it has been eroded.

During the Holocene (about 7000 years ago) the formation of the tidal sandbanks, such as the Hinder Banks, started on top of the Eemian marine transgressive surface (Mathys et al., 2009). These tidal sandbanks have a maximum thickness of 26 m on the Hinder Banks. An example of the internal structure of the Hinder Banks is shown in figure 4. On figure 5 two profiles through the Hinder Banks area are presented showing the most important geological boundaries as well as the current reference level of -5 m.

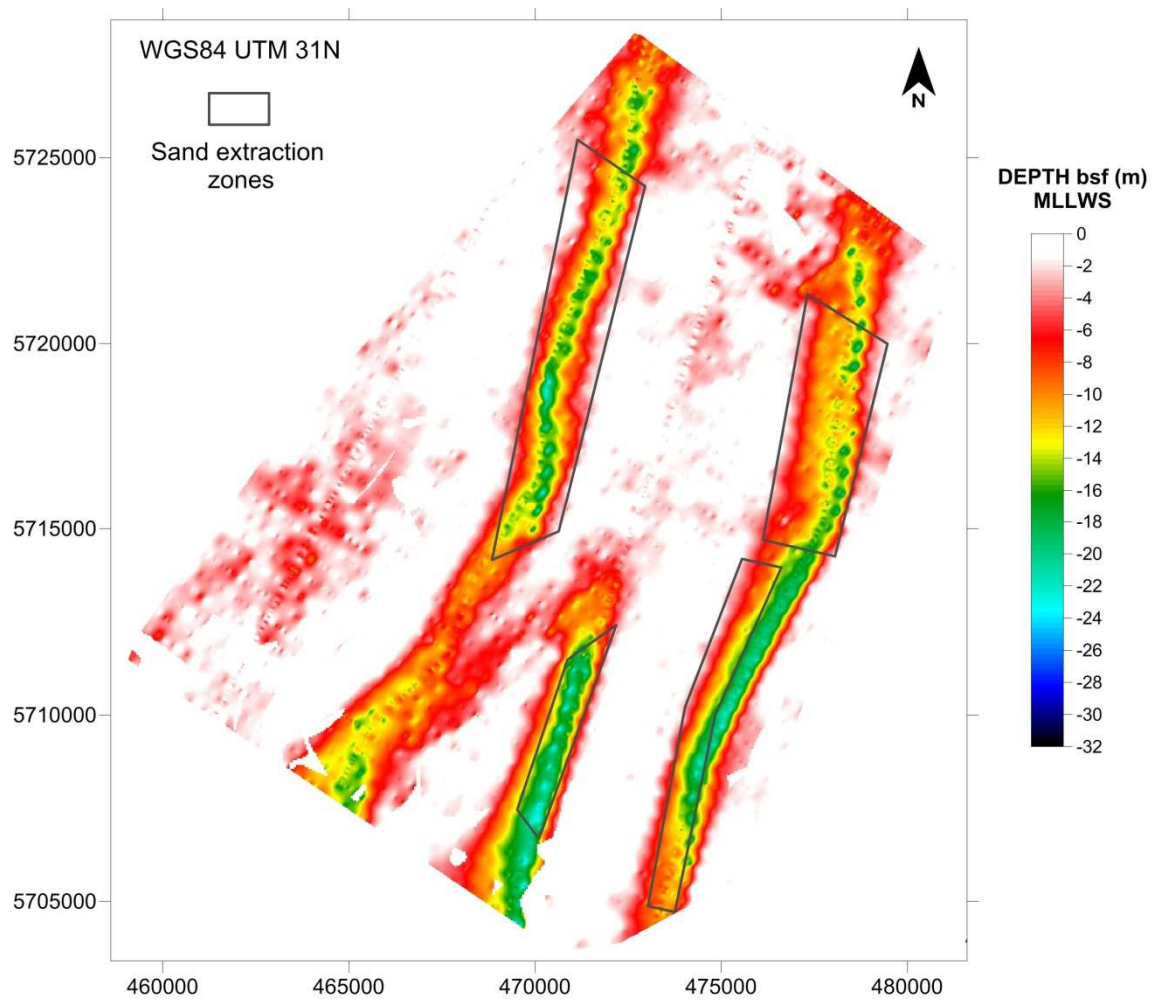


Figure 3: Depth chart of the top Eemian on the Hinder Banks (in meters below seafloor).

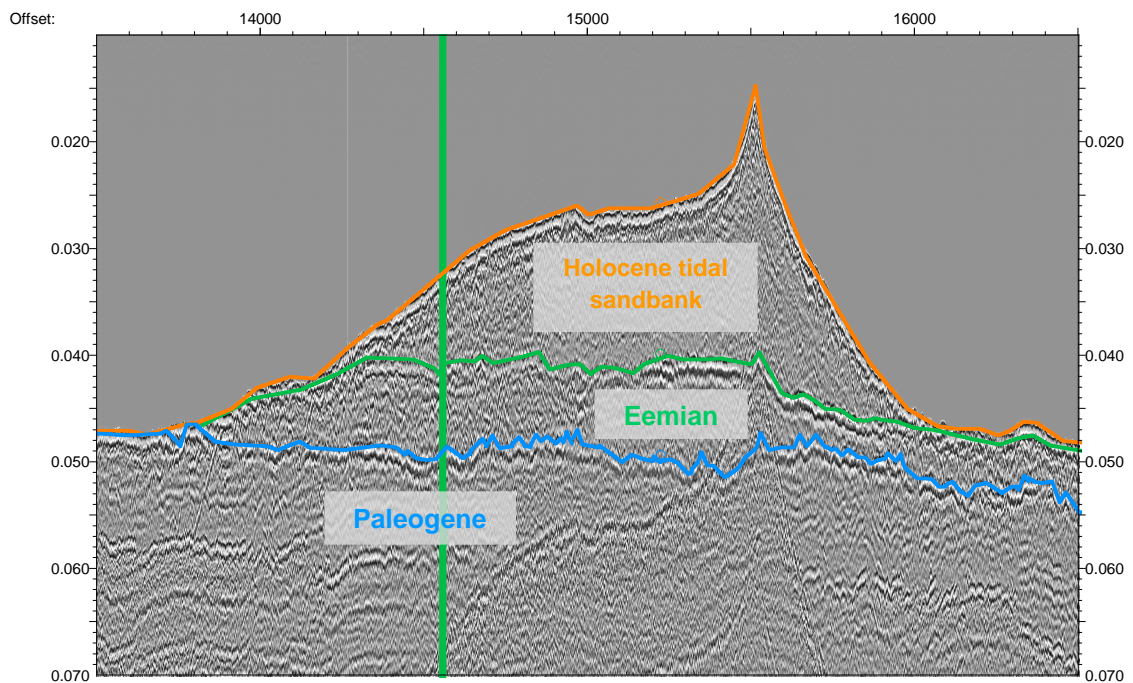


Figure 4: Example of a seismic profile showing the internal structure of the Hinder Banks (vertical scale in two-way travel time).

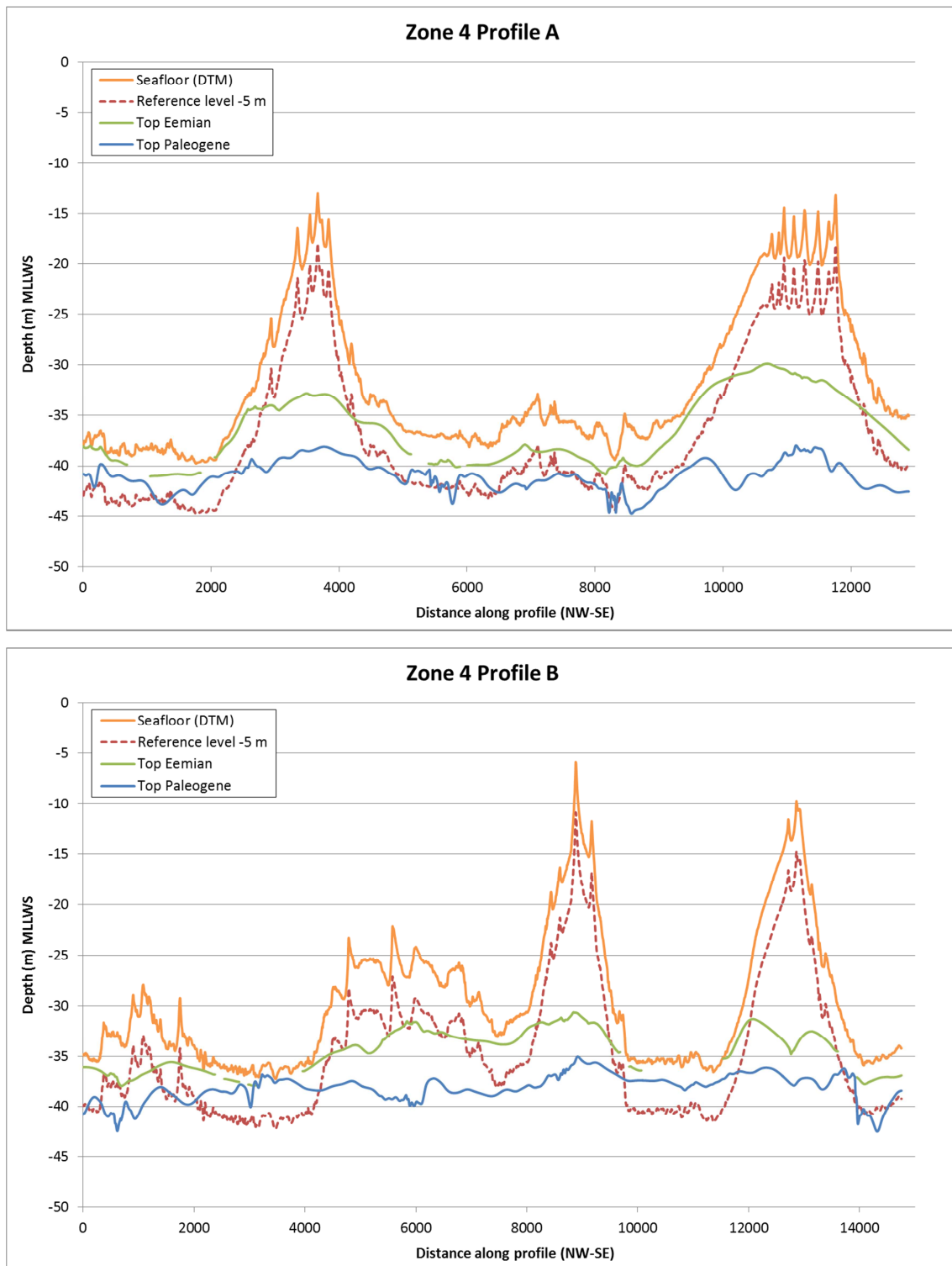


Figure 5: Profiles across the Hinder Banks (the location of these profiles is indicated on figure 1).

The following geological and geomorphological criteria will be used to define a new reference level for sand extraction in the BPNS:

- extraction is not allowed below the top of the Paleogene;
- extraction is not allowed below the top of the Eemian
- extraction on the flanks and extremities of the sandbanks as well as over 'kink' areas (if present) is limited;
- the volume of sand available for extraction should be at least the same as present.

These criteria are consistent with the recommendations for a sustainable exploitation of tidal sandbanks (Van Lancker et al., 2010). Indeed, increasing the potential volume for extraction in the upper part of the sandbanks while limiting the extraction in the less stable areas corresponds with the industrial and environmental needs.

A first proposal for a new reference surface in the four extraction sectors on the Hinder Banks is shown in figure 6. This reference level corresponds with a surface 12 m above the top of the Paleogene. In sector 4a this results in a reduction of the area, however, the total amount of available sand for extraction increases taking into account all sectors.

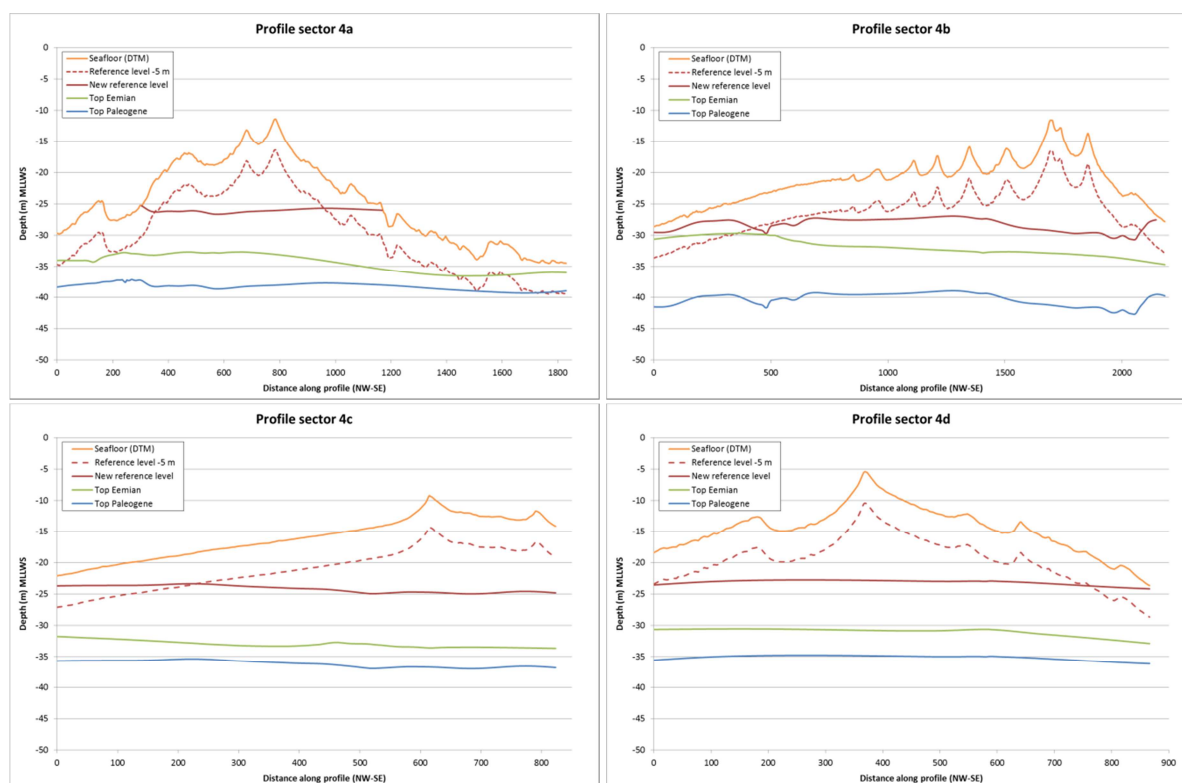


Figure 6: Proposal for a new reference level for sand extraction in sectors 4a, 4b, 4c and 4d on the Hinder Banks (the location of these profiles is indicated on figure 1).

In a next step, available sediment cores will be incorporated in order to refine the proposed reference level and the criteria. These cores will allow to include grain size distribution data which is valuable information for the sand extraction industry. Additionally, new vibrocores will be obtained, mainly on the Thornton Bank and the Flemish Banks.

Finally, an impact study will be performed in order to investigate the impact of this new reference level on the environmental and hydrodynamic conditions in the control zones as well as the impact on the coast. Taking into account the goal to reach a Good Environmental Status by 2020 (European Marine Strategy Framework Directive), no significant changes in seafloor integrity (Descriptor 6) and hydrographical conditions (Descriptor 7) are allowed.

This project, focusing on the sand extraction areas in the BPNS, shares many methodological aspects with the larger scale project TILES (Transnational and Integrated Long-term Marine Exploitation Strategies) funded by the Belgian Science Policy Office (2013-2017) (Van Lancker et al., this volume). In cooperation with the project partners this new reference surface, whose resolution will be adapted to the resolution necessary for a proper management of the sand resources and the new data on which it is based, will be integrated in the 3D geological voxel model developed in the near future.

Conclusions

Defining a new reference level for sand extraction in the BPNS is feasible, however, an extended scientific study is necessary. Based on seismic and bathymetric data a draft reference level is proposed using scientifically meaningful criteria. This reference level will be further refined using sediment cores followed by an impact assessment (e.g. changes in hydrographical conditions, impact on seafloor integrity, influence on the coast...).

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