Monitoring The Sand Extraction On The Belgian Continental Shelf

Methodology, Results And Expectations

K. Degrendele and M. Roche

Within the framework of a sustainable exploitation of the mineral resources on the Belgian Continental Shelf, the Belgian government has established a surveillance and monitoring program of the extraction activities and the impact on the environment. The up to date results show a concentration of the activities on the Kwintebank, resulting in a strong but merely local impact of the extractions on the bathymetry and sediments of the seafloor. In the near future the governmental control will evolve to a real-time surveillance and a dynamic and three-dimensional monitoring program to assure the future sustainability of the economically important exploitation of mineral resources.

Legislative and economic framework

Numerous tidal sandbanks characterize the Belgian continental shelf. These sedimentary bodies stretch out over several tens of km. They reach a height ranging between 10 and 20m and are separated by parallel swales with a maximum depth of 40m. The extraction of sand on tidal sandbanks of the Belgian Continental Shelf started very cautiously in 1976 and is inventoried since 1979. The annual extraction has increased regularly from 370,000m^3 in 1979 to 1,700,000m^3 in the mid of the 90's. In 2001 the production exceeded the limit of 1,900,000m^3 (or nearly 3,000,000m^3 tons at a mean density for sand of 1.5t/m^3). The last 3 years, however, the production has been around 1,600,000m^3.

To assure a sustainable exploitation of the mineral resources on the Belgian Continental Shelf a legislative framework for the regulation of the exploration and exploitation of the aggregates was established in 2004 by the General Direction Quality and Safety of the FPS Economy. Within this framework, three control zones and one exploration zone are defined (Figure 1).

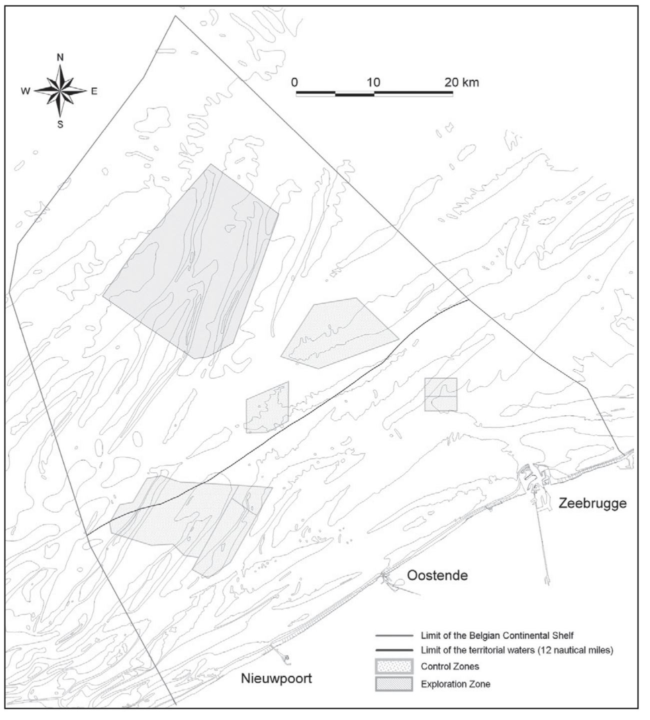


Figure 1: Dredging zones on the Belgian Continental Shelf.

Methodology and results

The governmental control is two-fold:

Monitoring of the extraction activities

- Each extraction vessel operating in Belgium has to be in possession of a register providing all relevant information on each extraction (vessel identification, date and location and discharging volume);
- A black box has to be installed aboard each exploitation vessel, This black box registers parameters entered by the crew before each journey (identification of the concession holder and reference number of the journey) and the automatically collected data (identification of the vessel; date and hour of the registration; position and speed of the vessel; status of the pumps and status of the extraction activity). All data are collected and analysed.

The analysis of the registers and the black-box records of the trailer suction hopper dredgers operating on the Belgian Continental Shelf reveals that, since the beginning of the extraction in 1976, at least 75% of the total extracted volume originates from only one sandbank, the Kwintebank.

On this sandbank the two most dredged areas are morphologically distinguished by two depressions: one in the central and one in the northern part of the bank (Figure 2). In order to limit the impact of the sand extraction on the bathymetry, the Fund for Sand Extraction has closed the central depression of the Kwintebank for exploitation in February 2003.

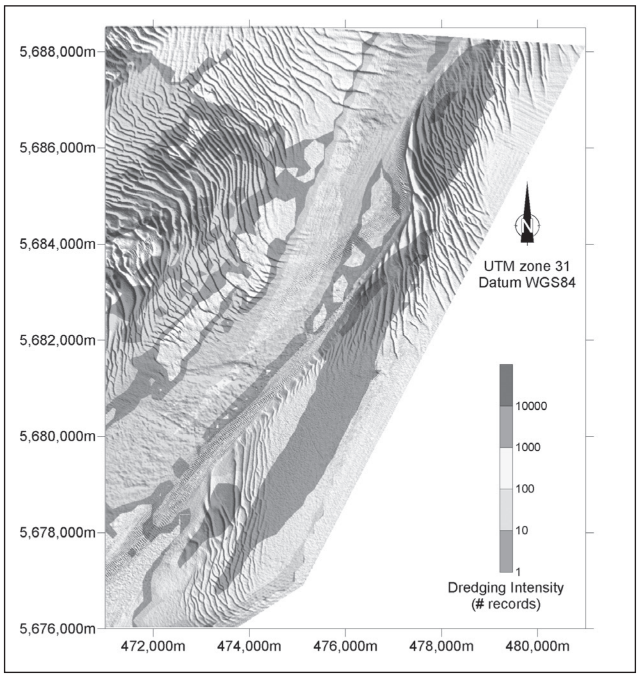


Figure 2: Superposition of the extraction intensity on the geomorphological model of the Kwintebank (number of dredging records from 05/11/1996 to 30/03/2005; each record represents 30 seconds of operation by a trailer suction hopper dredger).

Monitoring of the impact of the extraction on the seabed

In the framework of the follow-up of the marine extractions by the Fund for Sand Extraction, the Federal Public Service Economy acquired a Kongsberg Maritime 1002S multibeam echosounder. This system has been installed aboard the RV Belgica in summer 1999.

The EM1002 provides 111 beams of 2° (athwart) x 3.3° (fore-aft) width. It works at a nominal frequency of 95kHz with a ping-rate of around 4 to 6Hz. The data are real-time corrected for the roll and heave with a Seatex MRU 5 motion sensor and for the heading with an Anschütz Standard 20 gyrocompas. The geographic co-ordinates are provided by a Sercel NR103 (1999 until January 2003) and a Thales Aquarius 02 (since January 2003) GPS positioning system with a theoretical precision of respectively <5m and 10mm.

The soundings are tide-corrected using the specific M2 tidal reduction method for the Belgian coastal zone and referenced to the level of mean lowest low water at springtide (MLLWS).

The large amount of gathered data and the full-coverage capabilities of such remote system allow the construction of accurate terrain models of the seafloor. A global bathymetric error (2σ) of 0.35% of depth has been estimated on the basis of the variance between the resulting bathymetrical digital terrain models of four successive surveys of the same area within one tide cycle and on successive measurements on a stable wreck. This global error on the final product, the terrain model, is the combination of the independent errors of the EM1002 multibeam echosounder, the auxiliary sensors and the draught and tide corrections.

The processing of the backscattered acoustic signal through specific software packages results in the acoustic cartography of the seabed (seabed imagery). Despite the large amount of along-track artefacts, acoustic zones can be delimited (acoustic classification). The resulting maps partially reflect the real sedimentary nature of the seabed.

To evaluate the impact of the extraction in detail, several monitoring zones were defined: two in the active control zones (central and northern part of the Kwintebank) and one on the neighbouring bank to the east, the Middelkerkebank, situated outside the control zones (Figure 3). From November 1999 until the closure for extraction in February 2003 and the subsequent post-dredging evolution until June 2005, a total of 17 surveys were carried out on the central part of the Kwintebank (KBMA, Figure 4) and on a reference zone situated on the Middelkerkebank (R2), outside the dredging area. The resulting time series of digital terrain models (DTMs) and backscatter strength maps allow a detailed comparison of the bathy-morphological and sedimentary evolution of both monitoring areas.

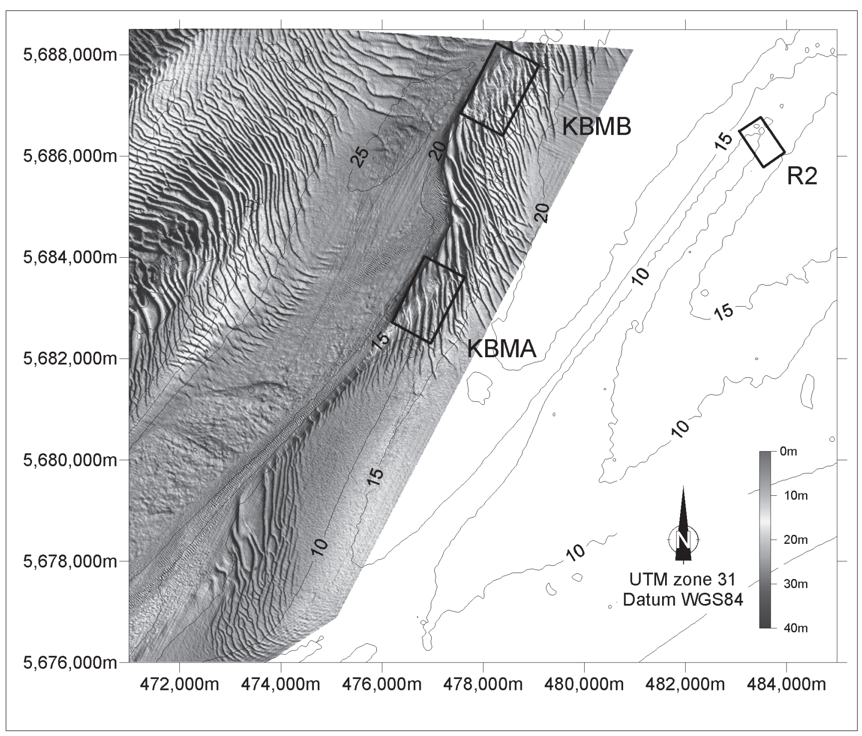
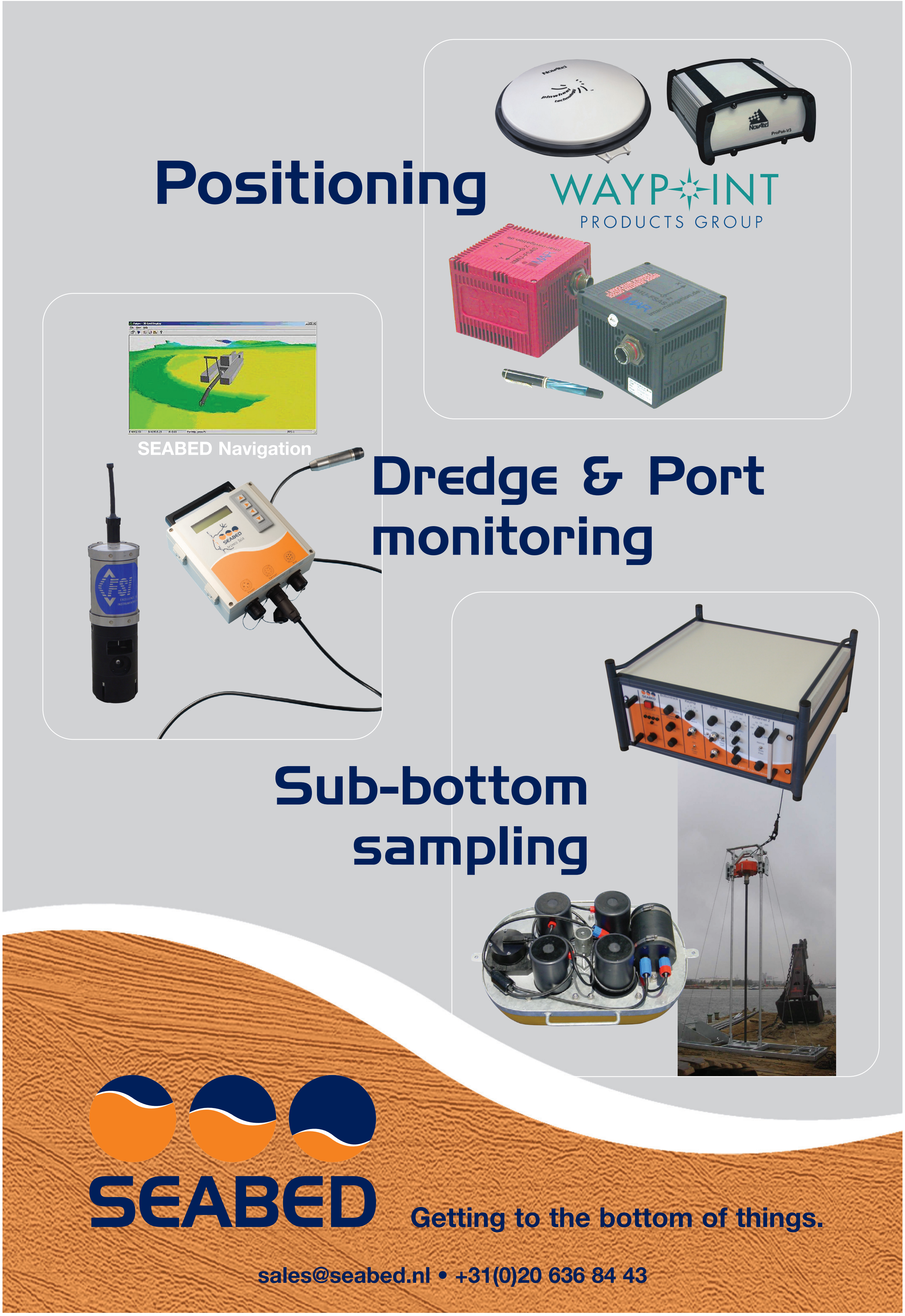


Figure 3: Location of the monitoring areas KBMA, KBMB and R2.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Since the start of multibeam monitoring in 1999, a global deepening of 0.5m of the whole KBMA monitoring zone is observed until February 2003. From that moment on, KBMA was closed for extraction and the bathymetrical trend on the central depression becomes less negative. The evolution of the KBMA can be considered as a combination of natural and anthropogenic factors. After the subtraction of the extracted volumetric component from the total volume evolution of the KBMA monitoring area, a close to natural evolution can be deduced and enables a comparison with the volume evolution of the R2 area outside the dredging area. This forms, together with the much smaller decrease since the closure of the zone for extraction and the lack of indications for cumulative effects on the bathymetry, a clear evidence of the merely local impact of the extraction. At the scale of the KBMA monitoring area, there is no indication of a change in natural processes. The volume evolution that was observed during extraction is reversed nor maintained.

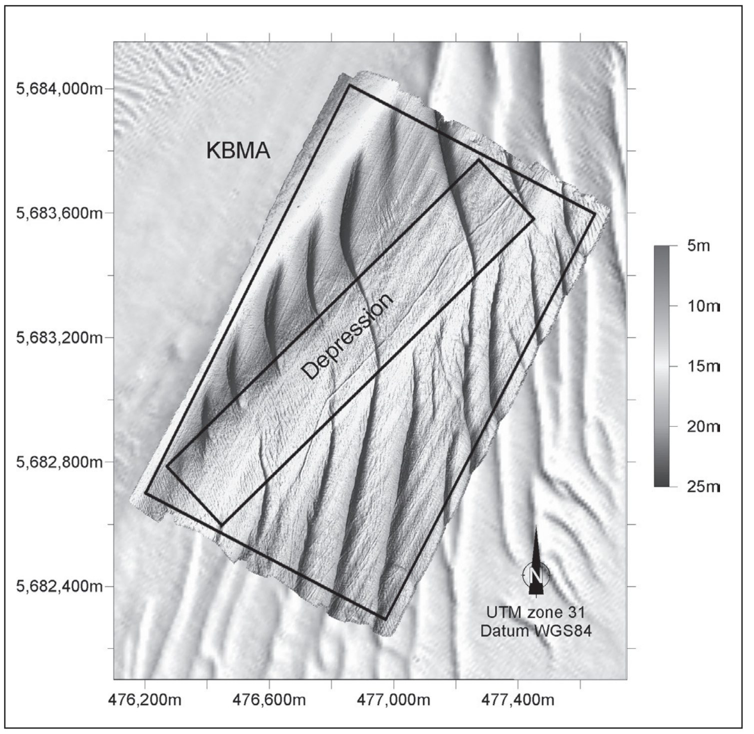

Figure 4: Detail of the monitoring area KBMA and the delimitation of the central depression.

The mapping of the backscatter values suggests a clear difference in sediments between the depression *sensu stricto* and the rest of the KBMA monitoring area. The central depression has a mean backscatter value of –24dB, which coincides with a backscatter strength mean value for medium to coarse sand. The mean of the backscattered strength values recorded on the east side of the KBMA area is up to –27dB, suggesting the dominance of very fine sand in this sub-area. The western side of the KBMA shows intermediate backscatter values, and is characterized as medium to coarse sands with grab samples. The focus of the extraction industry on this depressed part of the bank is explained by the presence of this medium to coarse sand. The backscatter strength values are fairly stable and do not show a clear evolution before or after the cessation of dredging. According to these data within the KBMA area, the sedimentary composition of the seabed at the water-sediment interface seems to be quite stable. However, the seabed classification indicates a minor tendency towards more fine and homogenous sand in the depression after February 2003. A similar stability of the backscatter strength is observed for the R2 monitoring area.

Expectations

The monitoring of the extraction activities is a control activity with a delay of a few months at best. The registers and black box readings are collected at regular intervals and processed. This constitutes an effective control of the extraction activities, but doesn't allow a real-time surveillance. Furthermore, the extracted volume for each dredging vessel and company is calculated based on the extracted volumes listed in the registers. These values are submitted on his word of honour by the exploitation vessel's captain. To establish a real-time monitoring independent of the controlled organisations the black boxes should be used to calculate the extracted quantities. The black box data should be collected as close as possible to real time to enable a direct response to infractions and a close follow up. For the latter, the use of AIS data can complement the information of the black boxes and provide a real time follow up of the extraction vessels and activities.

The monitoring of the seabed can still be improved on a few fundamental points. The important compensations for the draught of the vessel and the tidal height can be ameliorated and made available in real-time. Most important however, the use of a more adapted tool for the measurements, a very shallow water high frequency echosounder, instead of the by all means non ideal solution of a shallow to medium water echosounder, will greatly improve the accuracy, resolution and efficiency of the measurements. This will permit the researchers to refine and intensify the study of the impact of the extractions. Due to the limitations of the present system the monitoring is confined to small areas. The large-scale monitoring is currently executed by comparing the mapped sandbanks with recently sailed transects. With a more efficient system the re-mapping of large structures becomes a feasible option.

If the monitoring of the extractions activities can evolve to a near real-time surveillance, a dynamic monitoring of the impact becomes possible. The surveillance will enable the adjustment of the monitoring to the up to date information and provide a more adaptive, dynamic monitoring.

The monitoring of the seabed is at present a 2D evaluation of the surface of the seafloor. A real 3D evaluation of the mineral resources and present sedimentary bodies is necessary to establish the impact on the available volumes of sand and gravel and to develop a sustainable exploitation. From this point of view the Fund for Sand Extraction has launched a new project to develop and optimise techniques to transgress to a full 3D monitoring and cartography of the Belgian Continental Shelf.

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Koen Degrendele, Federal Public Service Economy - Fund for Sand Extraction, 1000 Brussels, Belgium
e-mail: Koen.Degrendele@mineco.fgov.be
Marc Roche, Federal Public Service Economy - Fund for Sand Extraction, 1000 Brussels, Belgium
e-mail: Marc.Roche@mineco.fgov.be