# 5. The implementation of the new reference level for sand extraction on the Belgian Continental Shelf

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## 5.1. Historical overview

The impact of sand extraction on the Belgian part of the North Sea on the physical seabed was until the end of 2020 only limited by an arbitrary vertical boundary of 5m. When using a fixed maximum extraction depth, the nature and structure of the seabed and the sediments present, and the resulting differences in impact, are not taken into account. This method prohibits efficient and sustainable management that should consider (1) the quality and quantity of the marine sediments present, (2) the continuous demand for raw materials by the industry and government and (3) the most recent environmental legislation.

In 2014, the Continental Shelf Service started a study to define a new limit for sand extraction based on scientific and economic criteria. This new surface aims to reduce the impact of activities in the most sensitive areas in terms of sediment and habitat and to increase economic sustainability by taking into account the available volumes and quality of sand. In 2017, the results of this study were extensively presented at the triennial study day (Degrendele et al., 2017). At the request of the Consultative Commission[1], the possible impact of the new reference on coastal safety was investigated by the Royal Belgian Institute of Natural Sciences (RBINS), Flanders Hydraulics Research and Fides Engineering (Van den Eynde et al., 2019). After the presentation of the results and the report at the meeting of 18 June 2019, the committee agreed with the conclusions of this study.

Six years after the start of the research into a scientifically substantiated reference surface for sand extraction in the Belgian part of the North Sea, this project culminated in the Ministerial Decree of 28 September 2020 establishing maximum extraction depths for sand and gravel exploration on the Belgian Continental Shelf. As of 1 January 2021, the new defined references replaced the previously applicable limit for sand extraction of 5m.

## 5.2. Reference level

A number of criteria were taken into account when defining the new surface:

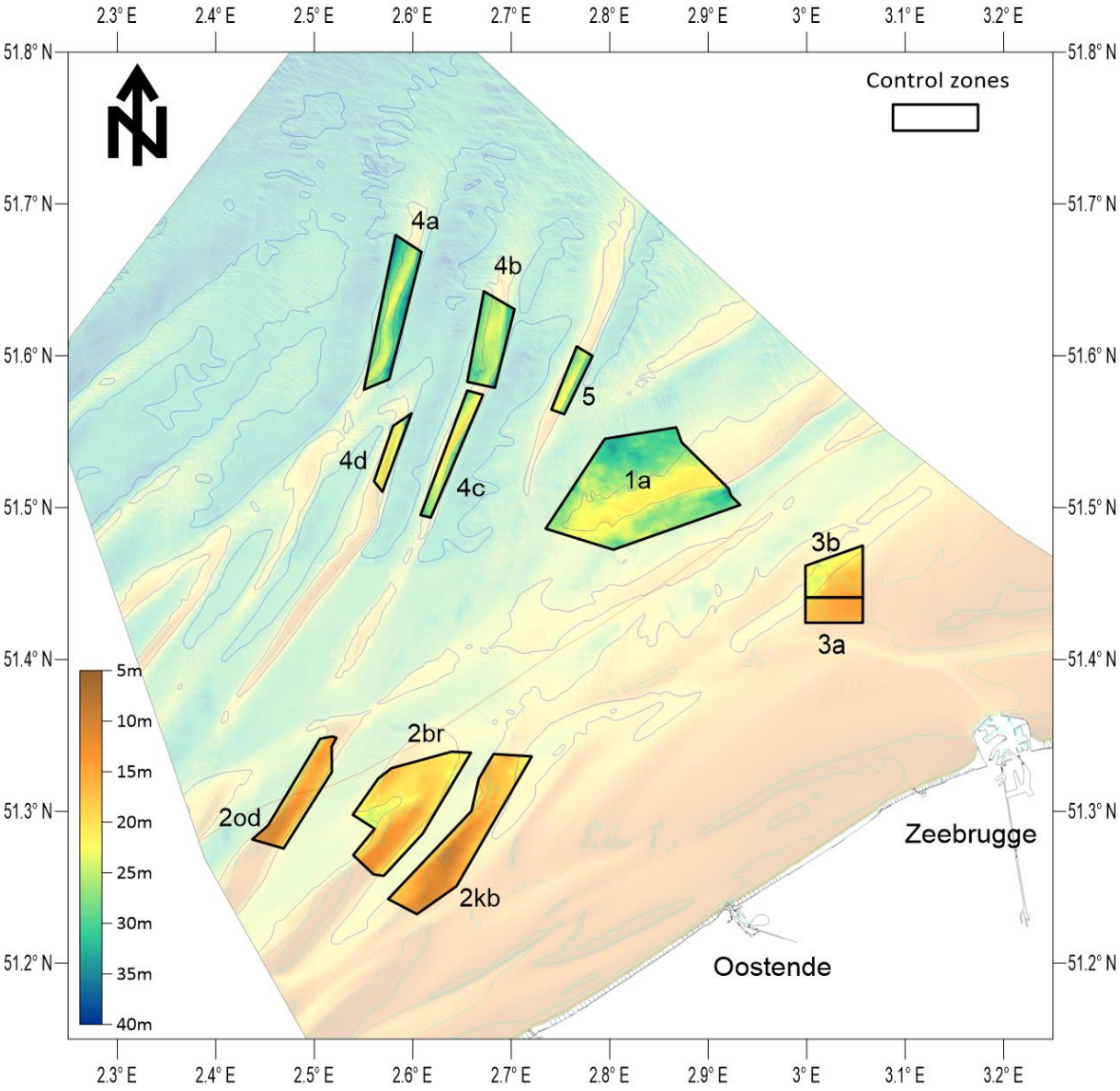
- No change in the sediments on the surface of the seabed in order to best preserve the integrity of the seabed. Taking into account the European Framework Directive MSFD (Marine Strategy Framework Directive) and its implementation in Belgian law (Royal Decree of 23 June 2010), the Member States are required to preserve as much as possible the integrity of their seabed and to limit the impact on the hydrodynamic conditions;
- The preservation of the structure of the sandbanks, based on their role in the protection of the Belgian coast;
- Maximum use of the available sand in mobile structures such as sand waves;
- Limiting the impact on hydrodynamic conditions.

[1] Consultative Commission to ensure the coordination between the administrations involved in the management of exploration and exploitation of the continental shelf and territorial sea (RD 12-08-2000).

Based on the available geological data, reference surfaces were drawn up for each individual control zone (figure 1). These surfaces consist of the maximum depths relative to LAT (Lowest Astronomical Tide) to which the seabed may be extracted. These surfaces are available digitally in the form of grids or map layers on request from the Continental Shelf Service.

Figure 1: Reference surfaces (depth in meter LAT).

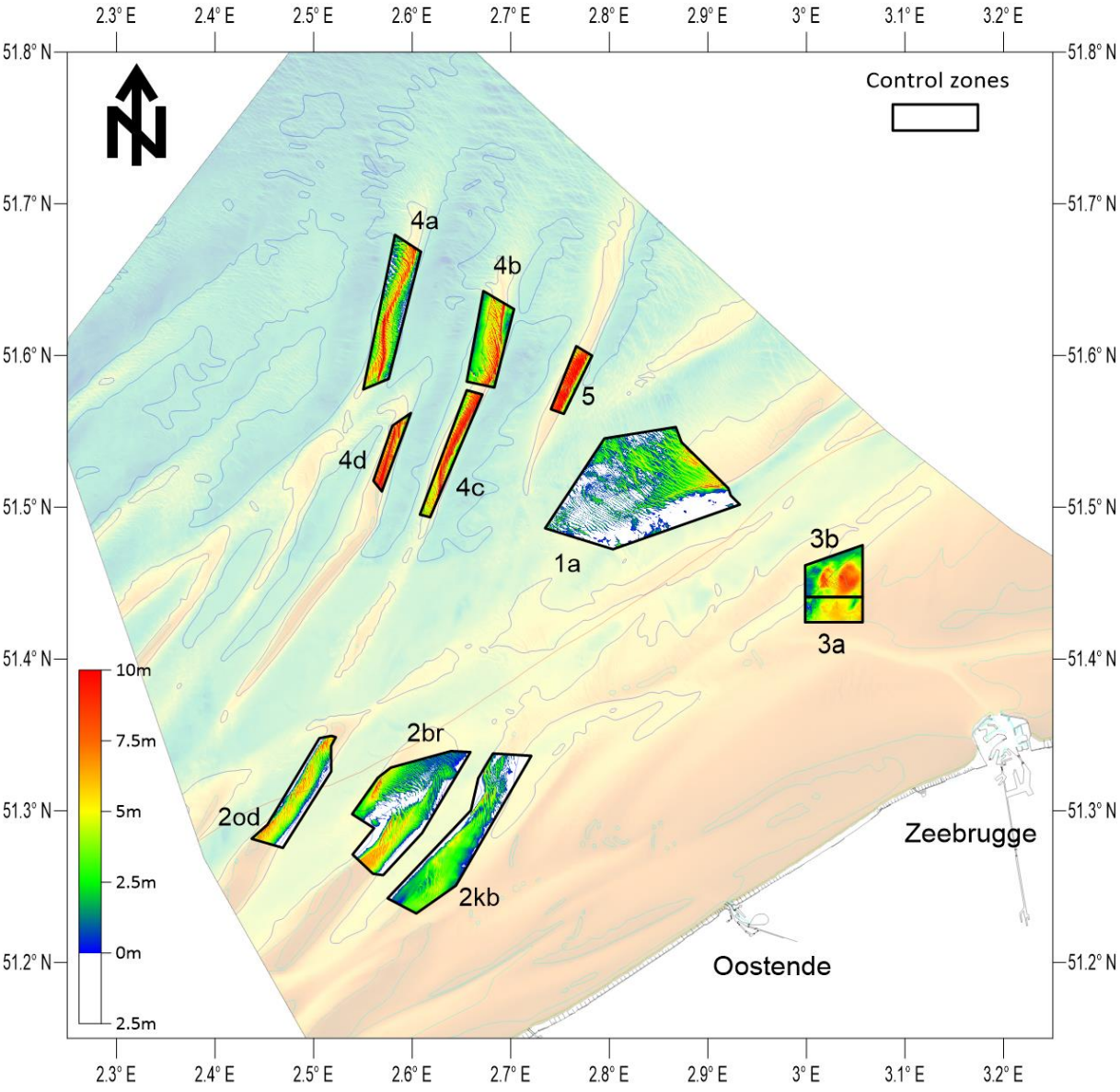
*Background: Bathymetric map of the Belgian part of the North sea (Continental Shelf Service and Flemish Hydrography)*




The available volume of sand for extraction is established by calculating the difference between the reference surface and the actual seabed surface (the bathymetry). Figure 2 shows the thickness of the exploitable sand layer within the various zones in 2021. The values vary from negative values, where the limit has been reached, to more than 10m in sectors 4c, 4d and control zone 5.

Figure 2: Thickness of the sand layer available for extraction (in meter).

*Background: Bathymetric map of the Belgian part of the North sea (Continental Shelf Service and Flemish Hydrography)*




## 5.3. Demarcation of closed areas

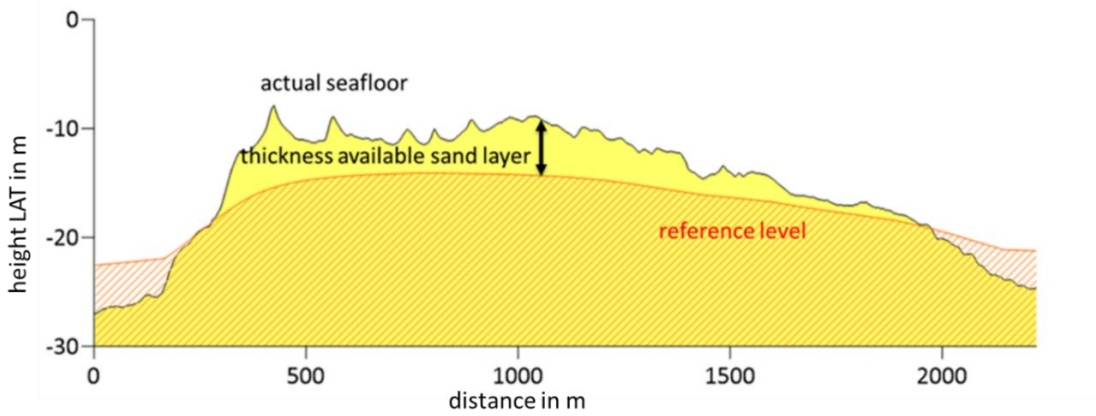
Based on the reference level in force as of 2021, subzones within the control areas are defined, where this level is globally reached or exceeded. Annually in September, the delineated zones are re-evaluated and after approval by the Consultative Commission closed for extraction as of 1 January of the following year.

Following the advice from the Continental Shelf Service (Degrendele et al., 2020), the areas KBMA, KBMB and BRMC, that were closed for extraction based on the 5m rule, are reopened as from 1 January 2021 and are taken into account in the definition of the subzones. As a result, only the Thorntonbank monitoring zone (THREF), defined in the Marine Spatial Plan 2020-2026[2], remains closed to extraction prior to the evaluation.

[2] http://www.health.belgium.be/en/marinespatialplan.be

Based on the difference between the most recent seabed terrain model and the depth of the reference level, the thickness of the sand layer that can be exploited, is determined. We can also describe this difference in height as the "maximum permissible extraction depth". Figure 3 illustrates that it can be both positive or negative, i.e. the actual seabed has not or has reached the reference level.

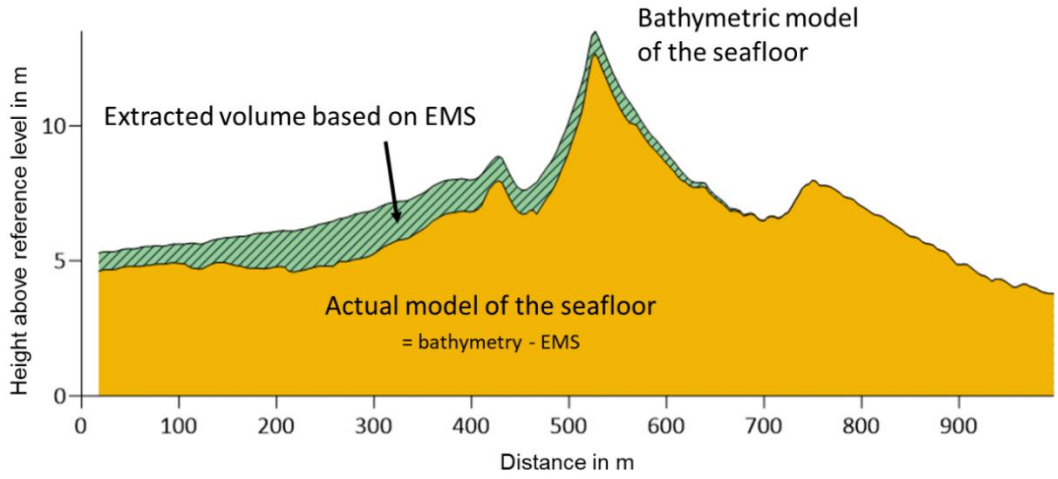
Figure 3: Example of the difference in height between the actual seabed and the reference level (profile through Sector 2od - Oostdyck), resulting in the thickness of the sand layer available for sand extraction (= maximum permissible extraction depth). This difference can be either positive (current seabed is above the reference level) or negative (current seabed is below the reference level).




The reference level is defined in the Ministerial Decree of 28 September 2020 on the maximum extraction depths for sand and gravel exploration in the Belgian marine areas, and will only be adjusted in case of important new scientific insights and/or improved quality and quantity of the geological data that are the starting point for the definition.

Due to the lack of a complete, detailed and up-to-date bathymetric model of the seabed for all zones, the bathymetric reference models build for the evaluation of the maximum extraction depth of 5m, were used in control zones 1 to 4. For each zone, these older models were corrected using the charted extracted volumes recorded with EMS (Van den Branden et al., 2017) to represent as best as possible the actual seabed (figure 4). Given the strong correlation found between the bathymetric evolution measured with an echosounder and the calculated evolution of the bathymetry based on EMS data, the latter can be used as a good approximation (Roche et al., 2017). The new control zone 5 on the Bligh Bank was fully mapped in 2018, which made the resulting model immediately usable in the calculations.

Figure 4: Example of the correction of the bathymetric model of the seabed with the extracted volumes based on EMS data. The end result is an updated seabed model that is further used in the calculations.



For each control zone, subzones are defined within which mining is prohibited, with the following criteria being pursued:

a. The average permissible extraction depth for the entire subzone is negative.

b. At least 50% of the area of the subzone is below the reference level (in other words the median is negative).

The remaining part of the control zone naturally remains open for exploitation. A number of criteria are also pursued for this part of the area:

a. The average permissible extraction depth for the entire subzone is > 1m.

b. 90% of the area of the subzone lies above the reference level.

Overall, we strive to demarcate contiguous areas, in order to guarantee exploitability. In addition, in the application of the criteria and delineation, a balance will be sought between exploitable volume in closed zones and volumes below the reference level in open zones.

## 5.4. First implementation in 2021

For the first evaluation and implementation, the available EMS data up to the end of 2019 were used. For the year 2020, the EMS data were only available to a limited extent, which means that the extraction in the current year could not be taken into account.

The adopted proposal from the Continental Shelf Service comprises the closure of a total of 11 subzones, spread over control zones 1, 2 and 4. Following the working method described above, several possible options were reviewed and the most appropriate ones were retained in the proposal. Inside control zones 3 and 5 the limit was nowhere exceeded, so no subzones were defined there.

We go through the defined subzones and their impact per control zone.

### 5.4.1. Control zone 1

The specific geological context - a limited quaternary sand layer - of control zone 1 leads to the most complex situation of the different reclamation zones (figure 5).

A large part of the zone is below the reference level. The eastern part of the zone is a continuous area with a large volume of available sand, while in the western part of the zone there is an alternation of sand waves above the reference level and troughs below the reference level (recognisable on figure 5 by the alternation of green/blue coloured crests of the waves and the white coloured troughs in between).

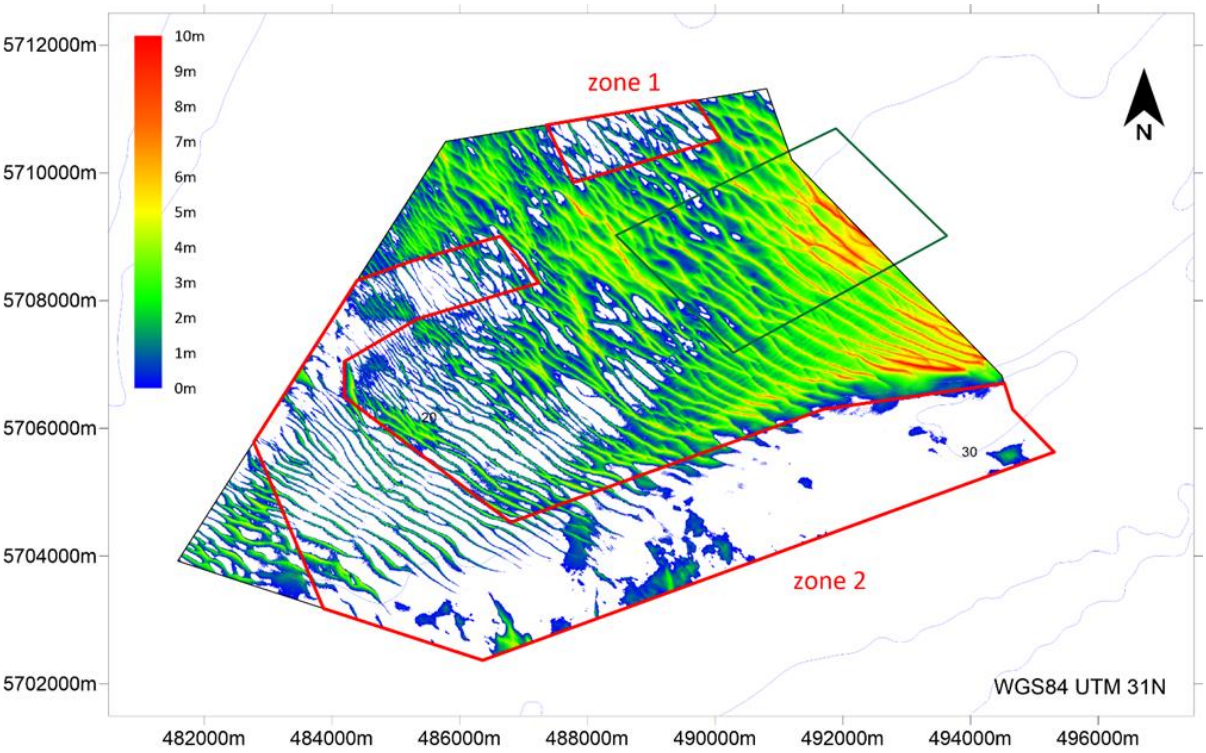
This complex situation makes the delimitation extremely difficult, taking into account the criteria established. As a solution, 2 subzones are delineated (figure 5).

Table 1: Characteristics of the delineated subzones in control zone 1: mean difference in height between the reference level and the actual seabed model (= average permissible extraction depth), and percentage of the area below and above the reference level (= limit).

| Control zone 1 | Average permissible extraction depth | Area of subzone below limit | area of subzone above limit |
|---|---|---|---|
| Subzone 1 | -0.03m | 54% | 46% |
| Subzone 2 | -0.54m | 76% | 24% |
| Open zone | +1.87m | 16% | 84% |

Figure 5: Thickness of the available sand layer (in meter) compared to the reference level in zone 1. Negative values (reference level reached or exceeded) in white. Delimited subzones in red. Closed THREF zone in green. Boundary of the sand extraction areas as laid down in the Marine Spatial Plan 2020-2026.

*Background: Hydrographic chart D11 (source: Flemish Hydrography).*




Subzone 1 in the north is an obvious choice. Most of the zone is below the limit (table 1) and the zone is surrounded by a continuous area with sufficient available sand for exploitation.

Subzone 2 consists of a southern area with only sporadically available sand. The local sand deposits are too small to be exploited separately, and were therefore included in this subzone. In addition, subzone 2 also includes the western part of the large sand wave area. This is the most heavily exploited part of the bank, and the limit is already exceeded in many places. Despite the significant volume still available in this area, this subzone also broadly satisfies the criteria set (table 1).

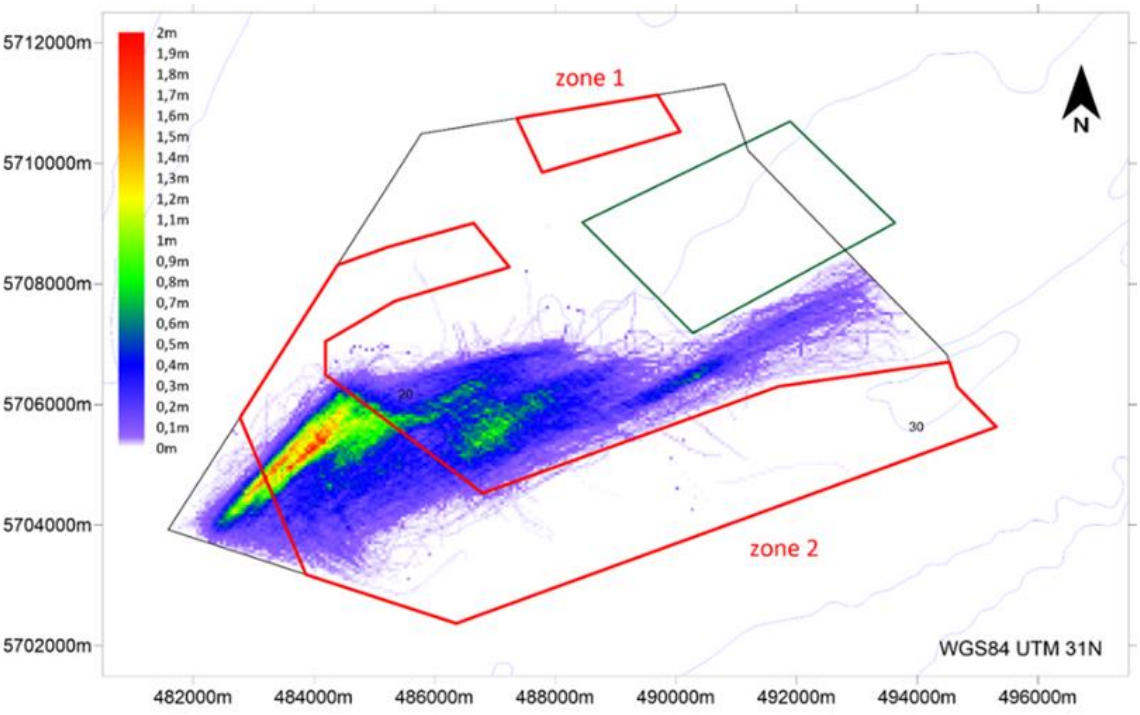
The restriction to these two subzones means that the remaining open part of the bank remains a contiguous area. Only in the extreme west a smaller area stays open. The eastern part of the sand bank area remains open for extraction and thus ensures a balance with the available volumes that are lost in both subzones. Before the delimitation, only 51% of control zone 1 was above the reference level. After the closure of the delimited zones this becomes 84%. So the 90% criterion has not yet been reached, but this gradual closure gives the sand extraction sector some time to adapt to this drastic change. This transitional situation is re-evaluated and adjusted in September 2021.

With this proposal, the mineable area of control zone 1 is limited to 40.54 km$^2$ or 57% of the total area of control zone 1. This loss of area is mainly at the expense of the part of the zone where the extraction limit is reached (from 29.95 km$^2$ to 6.35 km$^2$). The impact in terms of available volume for extraction is limited: it decreases from 90 to 82.5 million cubic meters.

However, the magnitude of the impact becomes particularly apparent when we map the extracted volumes based on EMS data and compare them to the delineated zones (figure 6). Subzone 1 has no impact, but 45% of the extraction that took place in control zone 1 in the period 2017-2019, lies within subzone 2. Therefore, closing this subzone will result in a very significant relocation of the extraction on the Thorntonbank.

Figure 6: Thickness of the sand layer in meters extracted in the period 2017 - 2019 in control zone 1, based on EMS data. This corresponds to the depth due to extraction for this period. Demarcated subzones in red. Closed THREF zone in green. Boundary of the sand extraction areas as defined in the Marine Spatial Plan 2020-2026.

*Background: Hydrographic chart D11 (source: Flemish Hydrography).*



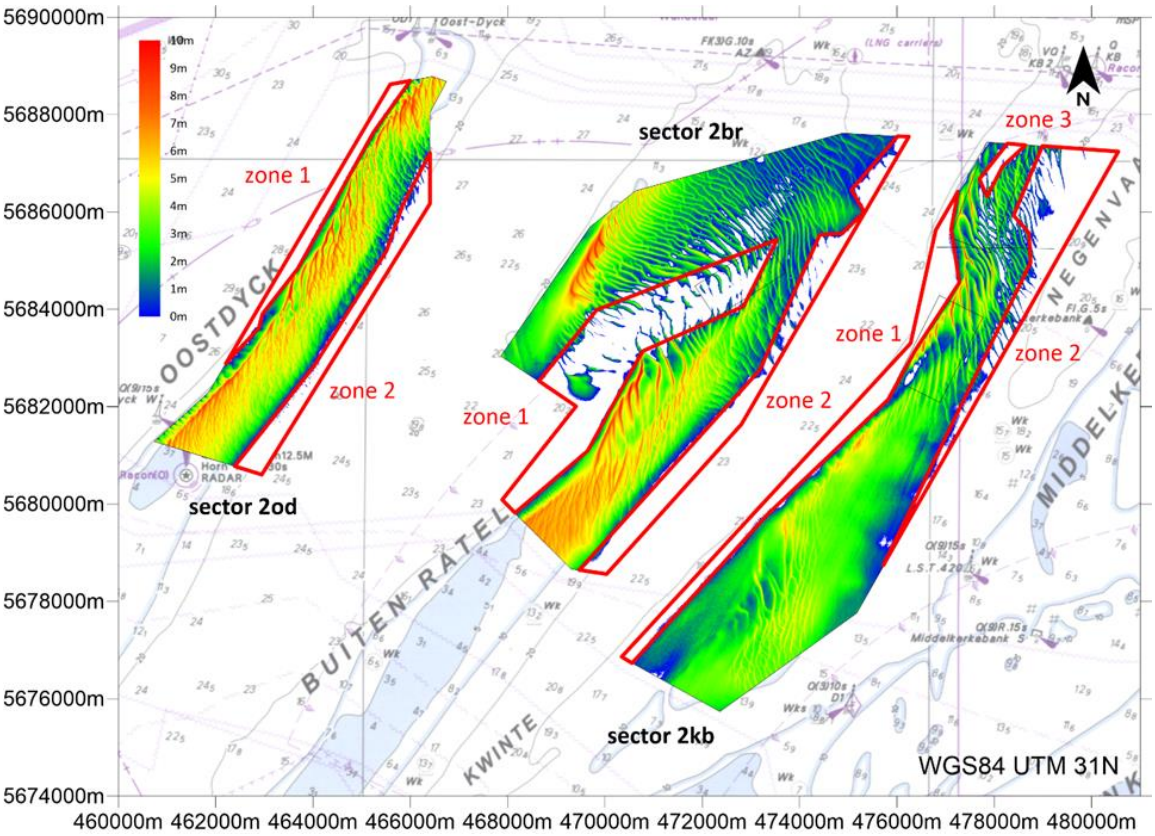

## 5.4.2. Control zone 2

Within the different sectors of control zone 2 (2od, 2br and 2kb), a total of 7 subzones are defined (figure 7). All subzones meet the predefined criteria, and the available volumes within them are limited. Again, there is a balance between the available volumes in the closed zones and the limited presence of areas where the limit is reached in the open zones. The share of these areas below the reference surface in the three sectors is reduced from 24% in sectors 2kb and 2od, and from 28% in sector 2br to 1-3% (table 2). Thus, the target criteria for the open areas are also met.

Table 2: Characteristics of the delineated subzones in control zone 2: mean difference in height between the reference level and the actual seabed model (= average permissible extraction depth), and percentage of the area below and above the reference level (= limit).

| Control zone 2 | | Average permissible extraction depth | Area of subzone below limit | Area of subzone above limit |
|---|---|---|---|---|
| Sector 2od | Subzone 1 | -1.77m | 94% | 6% |
| Sector 2od | Subzone 2 | -1.24m | 93% | 7% |
| Sector 2od | Open zone | +4.09m | 1% | 99% |
| Sector 2br | Subzone 1 | -0.89m | 78% | 22% |
| Sector 2br | Subzone 2 | -0.77m | 88% | 12% |
| Sector 2br | Open zone | +2.85m | 3% | 97% |
| Sector 2kb | Subzone 1 | -1.24m | 96% | 4% |
| Sector 2kb | Subzone 2 | -0.56m | 79% | 21% |
| Sector 2kb | Subzone 3 | -0.82m | 86% | 14% |
| Sector 2kb | Open zone | +2.45m | 3% | 97% |

Figure 7: Thickness of the available sand layer (in m) compared to the reference level in control zone 2. Negative values (reference level reached or exceeded) in white. Delimited subzones in red. Boundary of the sand extraction areas as laid down in the Marine Spatial Plan 2020-2026.
*Background: Hydrographic chart D11 (source: Flemish Hydrography).*




The impact on the available volume for extraction is limited: 2.89 million cubic meters in all subzones combined. In contrast: 29% of the extraction in the 2br sector in the period 2017-2019 took place in subzone 2. In subzone 2 of sector 2od this is even 31%. Within the other subzones, little or nothing was extracted during this period. The closure of these subzones could therefore, as on the Thorntonbank, result in a significant shift of activity in the sectors on the Buiten Ratel and Oostdyck.

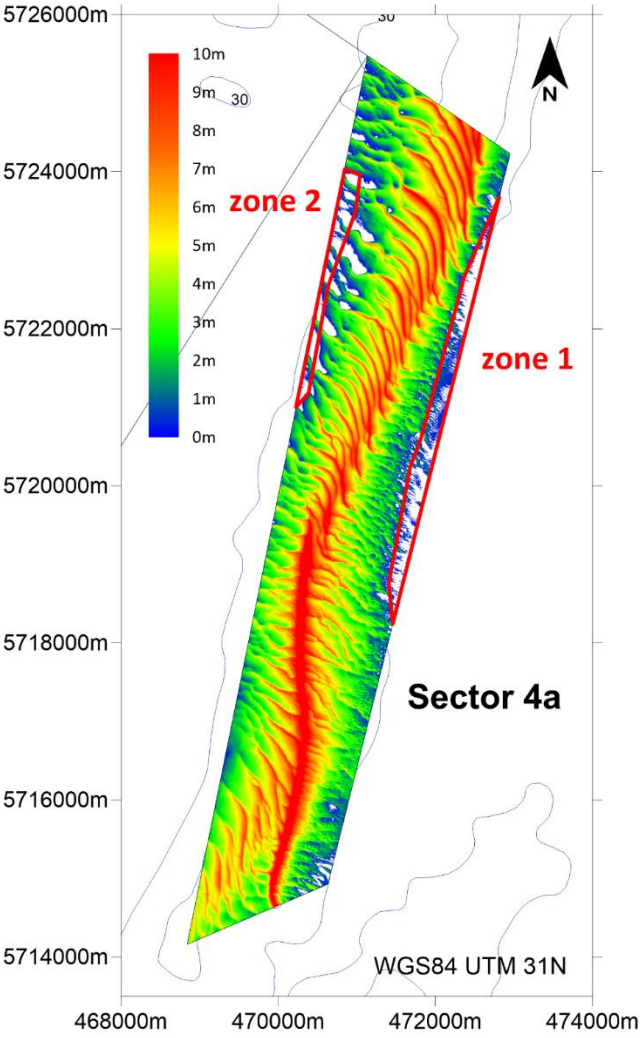
## 5.4.3. Control zone 4

In control zone 4, the reference level is only significantly reached in sector 4a. In sector 4b, the area below the limit is negligible and located at the edge of the sector - no subzone is defined. The other sectors 4c and 4d are entirely above the reference surface. In sector 4a, the new limit is locally reached on the two flanks of the Noordhinder (figure 8).

Table 3: Characteristics of the delineated subzones in control zone 4, sector a: mean difference in height between the reference level and the actual seabed model (= average permissible extraction depth), and percentage of the area below and above the reference level (= limit).

| Sector 4a | Average permissible extraction depth | Area of subzone below limit | Area of subzone above limit |
|---|---|---|---|
| Subzone 1 | -0.07m | 56% | 44% |
| Subzone 2 | -0.01m | 57% | 43% |
| Open zone | +4.45m | 2% | 98% |

Figure 8: Thickness of the available sand layer (in m) compared to the reference level in sector 4a. Negative values (reference level reached or exceeded) in white. Delimited subzones in red. Boundary of the sand extraction areas as laid down in the Marine Spatial Plan 2020-2026.
*Background: Hydrographic chart D11 (source: Flemish Hydrography).*




The two delineated zones shown in figure 8 both meet the predefined criteria (table 3). The impact of closing these zones is very limited, both on the available volume and on the location of extraction.

## 5.5. First evaluation and follow-up

A first analysis of the follow-up of the new regulations was made with the available AIS data from the start of 2021. The mapping of AIS data demonstrates that the delimitation of the zones is well known and respected (Barette et al., this contribution).

In September 2021 the defined zones were re-evaluated for the first time. The bathymetry of zone 3 (Sierra Ventana) was replaced with a new model, surveyed in 2019 and 2020 (Degrendele et al., this contribution). For the other areas the bathymetric models were updated with the EMS derived extracted depths up to the end of 2020. The characteristics for all subzones are recalculated and re-evaluated according the same criteria.

The impact of the recalculation was minimal for all areas and induced no significant changes in the values for the different criteria. Based on this exercise, the subzones of 2021 could remain unchanged for 2022.

But, as mentioned above, not all criteria were met for control zone 1. In the remaining open area only 84% lies above the reference surface. This is confirmed in the new calculation: due to the intensive extraction the percentage drops further to 83%. As stated before, this was considered a transitional measure, and the criteria would be met in future evaluations. To comply with this criterium, the subzone 2 was enlarged with the most extracted central area (figure 9). The new delineation of subzone 2 augments the surface percentage of the remaining open area above the limit to 90% (table 4).

Figure 9: Thickness of the available sand layer (in meter) compared to the reference level in control zone 1. Negative values (reference level reached or exceeded) in white. Delimited subzones in red. Closed THREF zone in green. Boundary of the sand extraction areas as laid down in the Marine Spatial Plan 2020-2026.

*Background: Hydrographic chart D11 (source: Flemish Hydrography).*

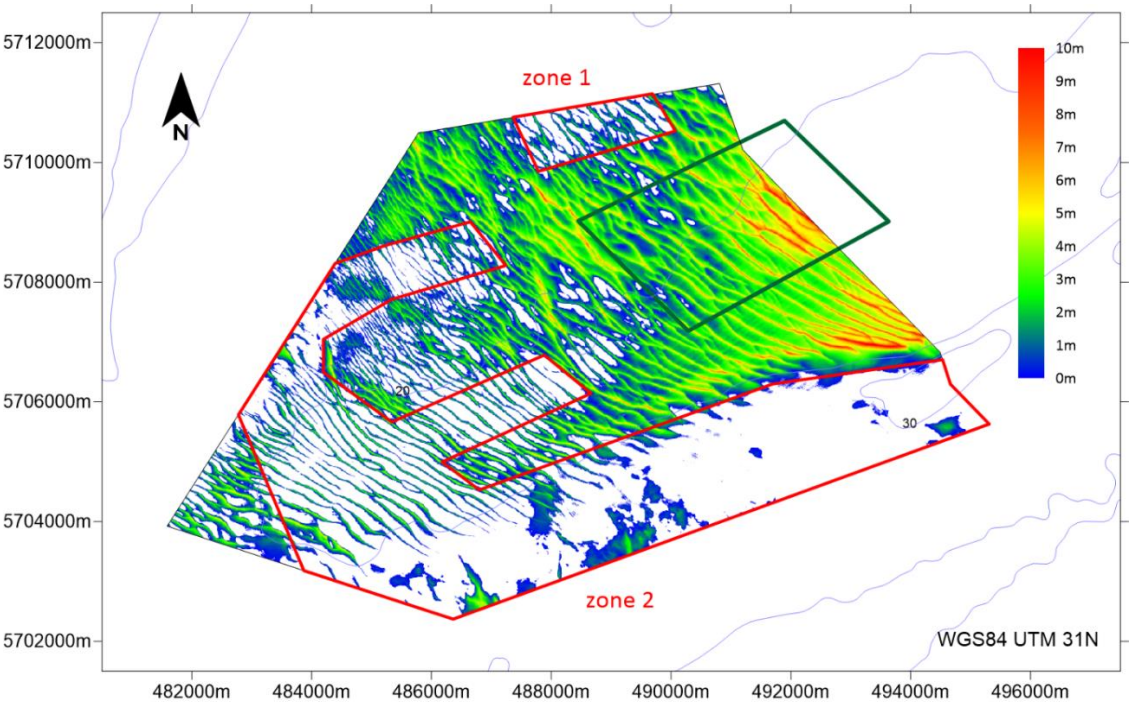



Table 4: Characteristics of the delineated subzones in control zone 1: mean difference in height between the reference level and the actual seabed model (= average permissible extraction depth), and percentage of the area below and above the reference level (= limit).

| Control zone 1 | Average permissible extraction depth | Area of subzone below limit | Area of subzone above limit |
|---|---|---|---|
| Subzone 1 | -0.03m | 54% | 46% |
| Subzone 2 | -0.55m | 77% | 23% |
| Open zone | +2.01m | 10% | 90% |

With this expansion, the closed subzone now covers 64% of the extracted volume in control zone 1 in the period 2017 - 2020, amounting to 5 $10^6$ $m^3$ sand (figure 10). Based on the AIS cartography the enlarged subzone 2 now covers more than one quarter of the extracted volume during the first half of 2021: 0,51 $10^6$ $m^3$ of sand was extracted up to 23 August 2021 or 27% of the total volume extracted in control zone 1 (figure 11).

Figure 10: Thickness of the sand layer in meter, extracted in the period 2017 - 2020 in control zone 1, based on EMS data. This corresponds to the depth due to extraction for this period. Demarcated subzones in red. Closed THREF zone in green. Boundary of the sand extraction areas as defined in the Marine Spatial Plan 2020-2026.

*Background: Hydrographic chart D11 (source: Flemish Hydrography).*

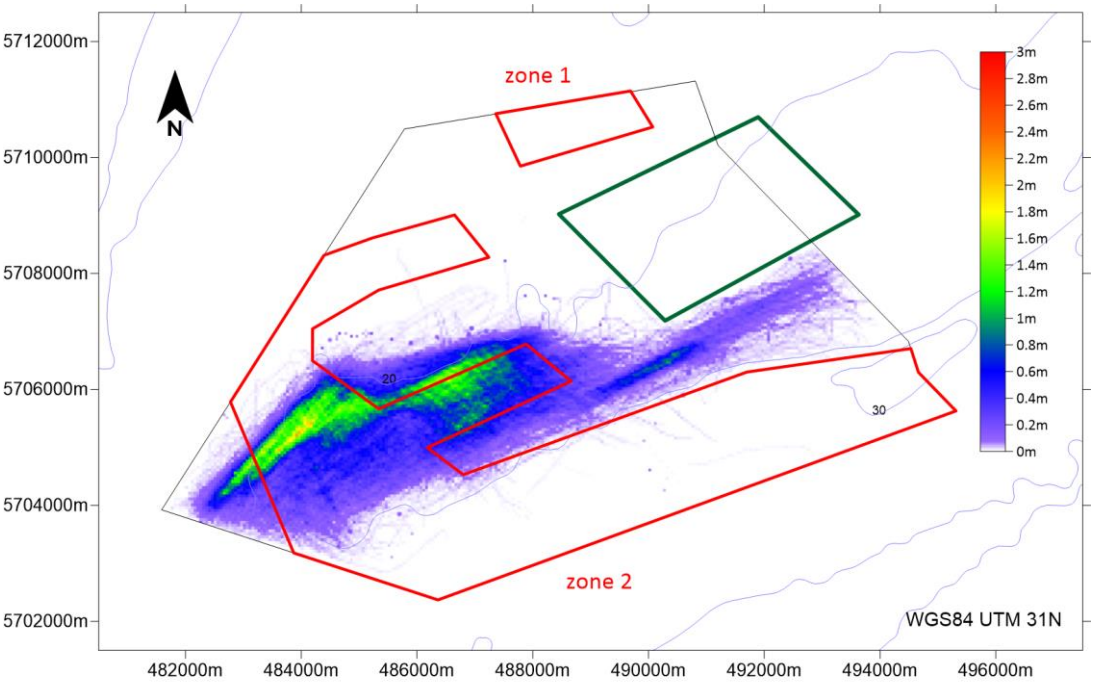
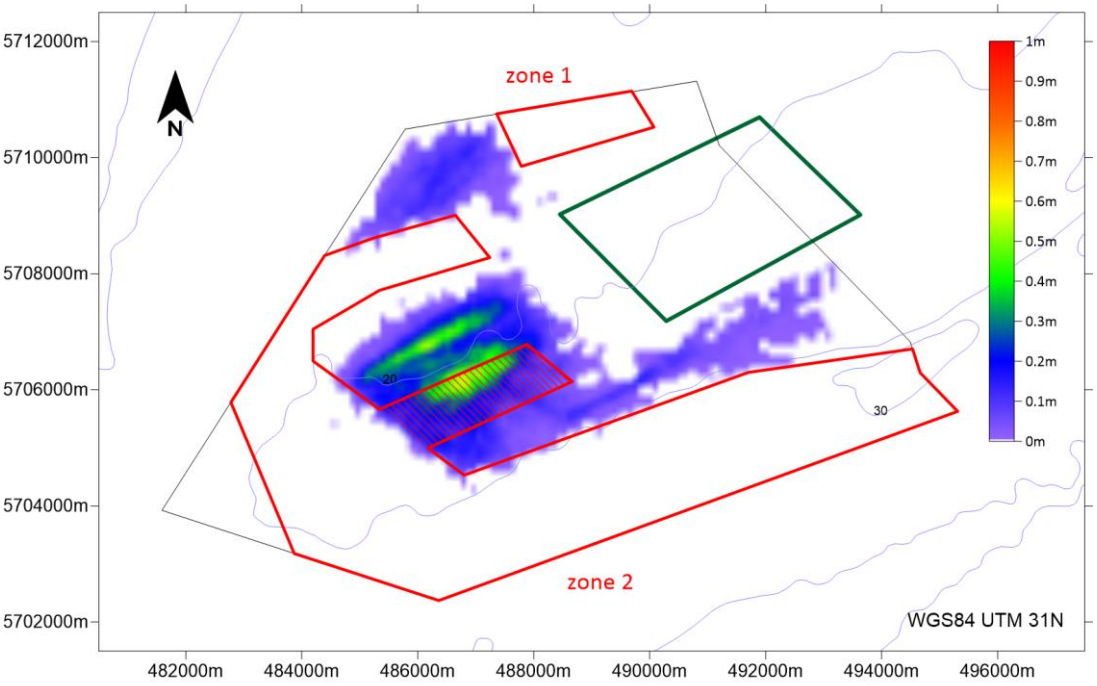



Figure 11: Thickness in meter of the sand layer extracted in the first half of 2021 in control zone 1, based on AIS data. This corresponds to the depth due to extraction for this period. Demarcated subzones in red – enlarged area of subzone 2 shaded in red. Closed THREF zone in green. Boundary of the sand extraction areas as defined in the Marine Spatial Plan 2020-2026.

*Background: Hydrographic chart D11 (source: Flemish Hydrography).*



Overall the impact of the implementation of the reference surface can be summarized in one figure: 25% of the total surface in all control zones is now closed based on the criteria. Compared to the 2% of the surface that was closed before the introduction, this can be considered a complete turnaround. Not only is the area directly impacted by extraction strongly reduced, the closed areas are predominantly located on the deeper parts of the extraction areas, which constitute the ecologically most valuable areas. Therefore we can already conclude that the ecological impact is clearly positive.

Although the impact on the available sand quantity is limited (amounts to 1.7% loss of the total available volume), the impact on the quantities of sand with guaranteed quality is important. The gradual but ongoing closing of the main part of control zone 1 increases the demand for alternative sources of qualitatively similar sand. The possible delineation of new zones in the exploration area and the reopening of the reference area on the Thorntonbank (for the biological monitoring of the impact of sand extraction and wind energy) thus become important future perspectives.

The use of AIS for extraction mapping will allow for more responsive and faster future annual evaluations. In addition, the possible application of a more generalized reference level for all seabed disturbing activities could be investigated, so that a positive contribution can be made to limiting the direct environmental impact on the entire Belgian part of the North Sea.

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