Sand and gravel extraction in the Belgian part of the North Sea

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Within the framework of the mission of the FPS Economy, SMEs, Self-employed and Energy, which consists of creating the conditions for a competitive, sustainable and balanced functioning of the Belgian market of goods and services, the Directorate-general Quality and Security has issued this publication in view of informing the general public.

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«Creating the conditions for a competitive, sustainable and balanced operation of the goods and services market in Belgium.»

Content

1. Why marine sand?

Locations for sand extraction on land are becoming scarce. Marine sand is an interesting alternative, both in Belgium and in neighbouring countries. Since the seventies the total sand production at sea has gradually increased.

There are four sources of sand in Belgium: land and rivers, import from foreign countries, secondary materials (recycling or as a by-product) and the North Sea (figure 1).

Spatial planning and environmental policies ban or limit the extractions of sand and gravel on land. The impact on land is considerable, not only for nature (animals are disturbed and fauna is impacted or disappears), but also for humans (noise, dust and heavy traffic).

Since the sixties and seventies the demand for marine sand and gravel as an alternative has increased. Prejudices regarding marine sand and gravel have been gradually omitted and the arrival of concrete plants with quays along canals made inland shipping possible. The lower cost price compared to river sand makes marine sand even more attractive.

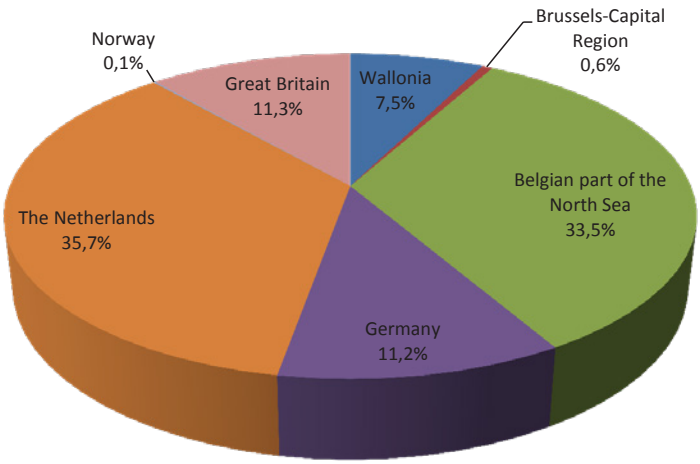

Figure 1: Import flows of sand in Flanders in 2011

(Source: 'Monitoringsysteem Duurzaam Oppervlaktedelfstoffenbeleid – Jaarverslag 2012')

With the rising interest in the use of marine sand the professional federation 'Federatie van invoerders en producenten van gebaggerde zeegranulaten' (Federation of importers and producers of dredged sea granules) or briefly 'Zeegra' was founded in 1981. The aim of this federation is to defend the joint interests of the importers and producers of marine sand and gravel in Belgium.

2. What do they use marine sand for?

Marine sand is used on the one hand in the construction industry and on the other hand for the protection of the Belgian coast.

Construction industry

Since marine sand became one of the basic raw materials for the construction industry during the past thirty years, it indisputably increased its social and economic importance for Belgium. At present about 3.000.000 tons or 2.000.000 m³ of Belgian marine sand is extracted each year, of which 80 % is used in the construction industry.

During the past years a shift has been observed within the concrete sector from the use of river sand from The Netherlands and/or Germany to Belgian marine sand. The most extracted type of marine sand is medium coarse sand, used for ready-mixed and precast concrete. Furthermore, marine sand is used for the production of asphalt and mortar, as drainage sand, foundation sand and replenishment sand.

Marine sand and gravel have the same geological origin and mineralogical composition as their equivalents on land. However, the marine environment has some positive consequences: (1) no contamination of clay and silt, and (2) concentration of the most resistant particles.

Also, the prejudices concerning the presence of shell fragments and salt in marine sand have been proven to be unfounded. Meanwhile numerous technical evaluations have shown that this reticence was unnecessary. Marine sand, that complies with the enforced industrial standards, is just as suitable for the construction industry, road industry and hydraulic engineering as land won aggregates.

The main characteristics of Belgian marine sand are:

- purity allowing an almost unprocessed use;
- consistency guaranteeing the producer of concrete or asphalt a constant quality.

Only small quantities of gravel are extracted due to the bad quality (chemical and physical heterogeneous). It is used as ballast for, among others, the construction of submarine gas pipes or embankments.

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Coastal defence

Today, beach nourishment is the most important action taken for the protection of the coast line. Beach nourishment produces wider and higher beaches, protecting the coast against flooding during very heavy storm tides.

The Belgian coast line is only 67 km long but every metre is heavily used: residential areas, nature reserves, tourist and recreational areas and industrial zones. In 2007 the 'Vlaamse Overheid - Afdeling Kust' (Coastal Department of the Flemish government) started to investigate how the Belgian coast could reach a minimum level of safety to protect it against a severe storm. This study resulted in the Master plan 'Kustveiligheid' (Coastal Safety).

The aim of the Master plan is to protect the coast as a natural and attractive area. Additionally it is important from a social and economic point of view. The study showed that one third of our coast is insufficiently protected against the so-called 'super

storms' or '1000-year storms', leading to possibly thousands of casualties and several billions of euros of economic loss.

Several measures were proposed for all vulnerable areas. Environmental impact, social costs and benefits and the reduction of the flood risk were studied in detail for each measure. In the bathing areas the beaches will be raised and the seawalls will be strengthened. In the harbours, storm walls around the channels will be built, and quays raised or flood barrier built.

In total more than 20 million m^3 of sand is necessary over a period of 10 years for the coastal works within the framework of the Master plan Coastal Safety!

Further information (only in Dutch) on coastal defence is available on http://www.kustveiligheid.be.

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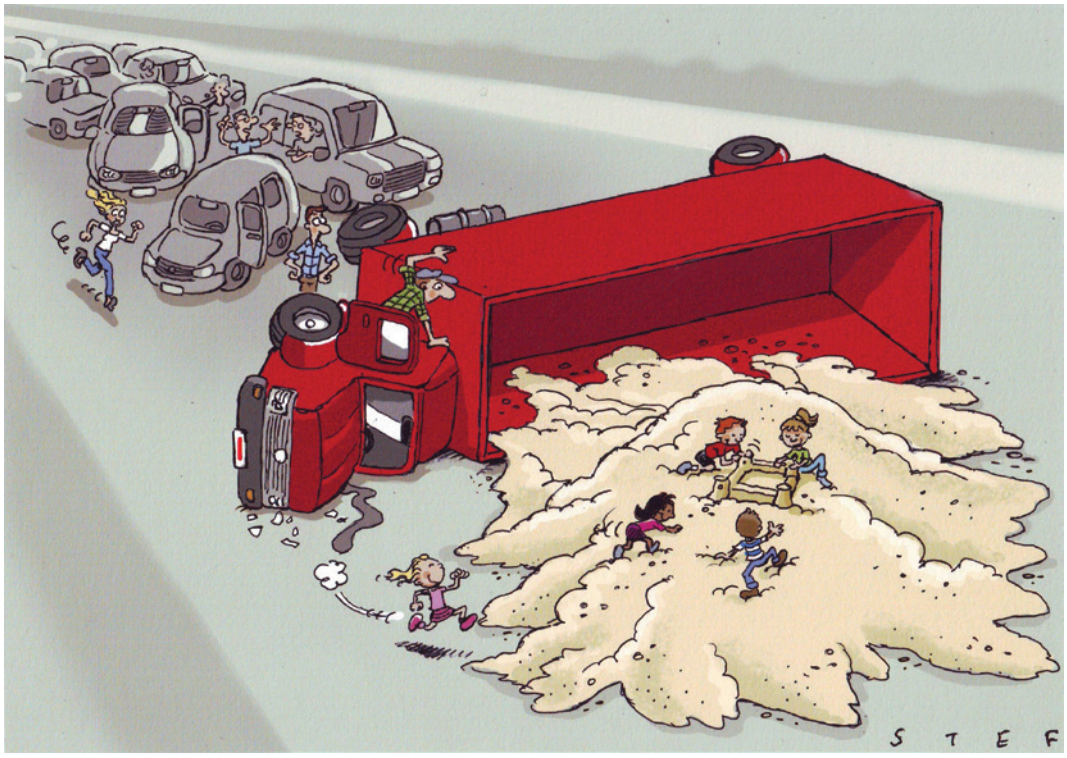
3. Where do they extract marine sand in Belgium?

The sand and gravel extraction in Belgium occurs in the Belgian part of the North Sea, which is home to numerous activities such as shipping traffic, fisheries, construction of communication cables and pipelines, dumping sites, military activities and wind farms (figure 2).



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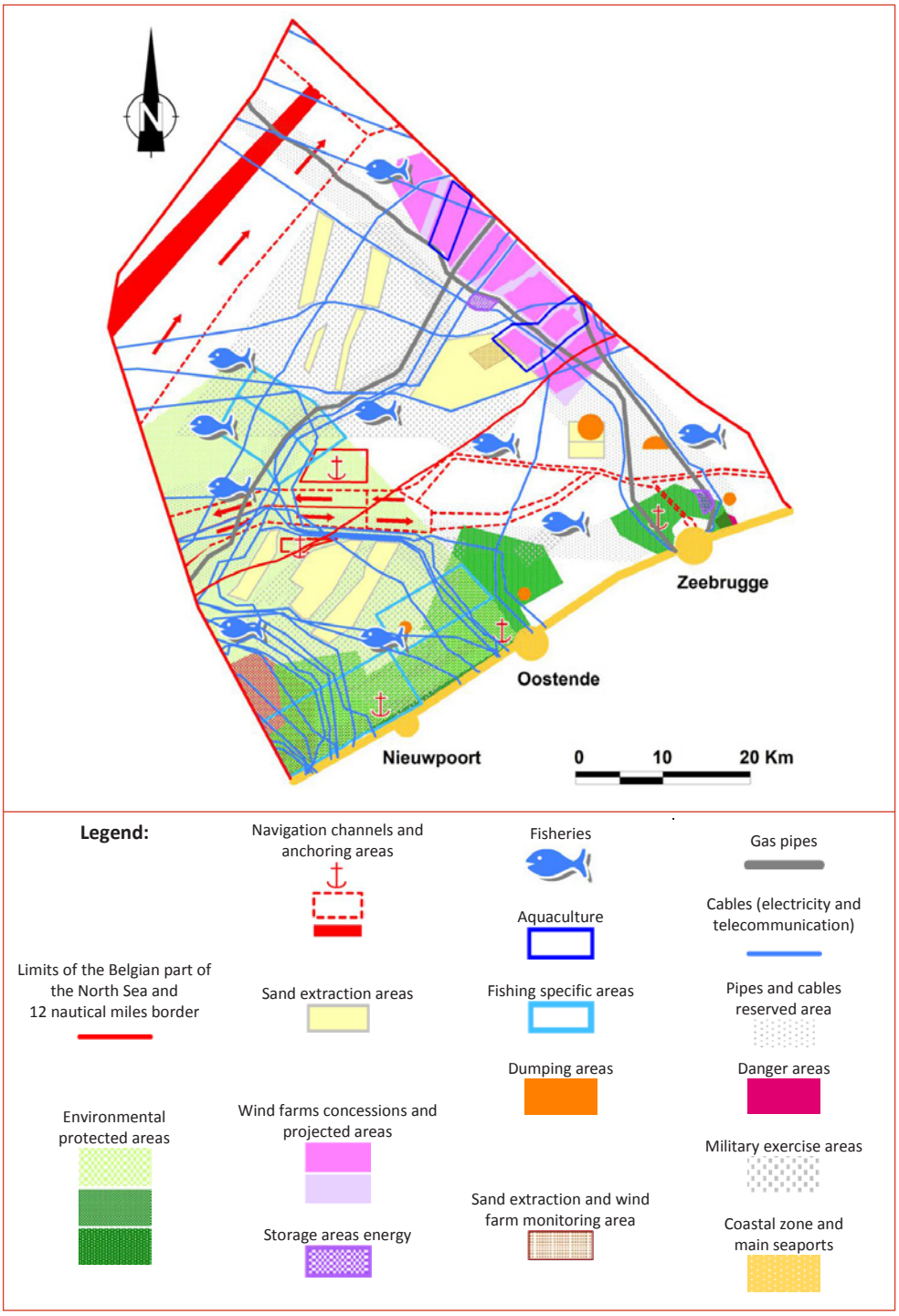

Figure 2: Activities in the Belgian part of the North Sea

What is the Belgian part of the North Sea?

The Belgian part of the North Sea covers an area of 3447 km² and is part of the southern North Sea (Figure 3). It is stretched out along 67 km of the coast and reaches 65 km seawards. Depths vary between 0 and 55 m.

This transition area towards the English Channel is characterised by numerous sand banks which are tens of kilometres long, several kilometres wide and up to 20 m high. The banks are subdivided based on their location and orientation: coastal banks, Flemish banks, Zealand banks and Hinder banks (figure 3).

The Belgian part of the North Sea is legally divided in two areas (figure 3). The territorial sea covers an area from the coastline up to 12 nautical miles (or about 22 km) seawards. The Exclusive Economic Zone (EEZ) extends further seawards and contains the Belgian continental shelf and the overlying waters.

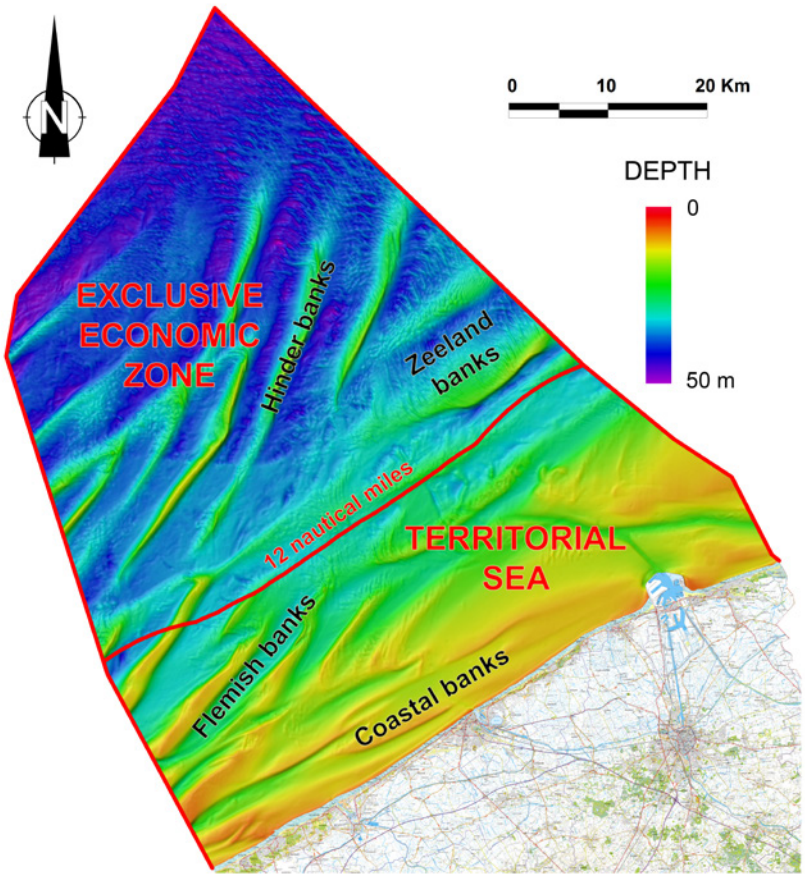

Figure 3: Location of the Belgian part of the North Sea

Control zones

Sand extraction is allowed in by law pre-defined areas, so-called control zones. The quality and diversity of the available sand varies between these areas. The present sand banks have specific grain size distributions and different amount of shell fragments.

There are four control zones (figure 4):

- zone 1: Thorntonbank;
- zone 2: Kwintebank, Buiten Ratel and Oostdyck;
- zone 3: Sierra Ventana;
- zone 4: Hinder banks.

Each control zone contains one or several sectors.

In these control zones three types of sand are distinguished by use:

- very fine sand which is used as replenishment sand and for the production of asphalt;
- fine sand for the production of mortar, concrete and asphalt, as drainage sand and for beach nourishment;
- medium coarse sand for the production of concrete.

For the sand extraction industry it is very important to know the quality of the sand in the different extraction areas in order to be able to deliver the desired quality.

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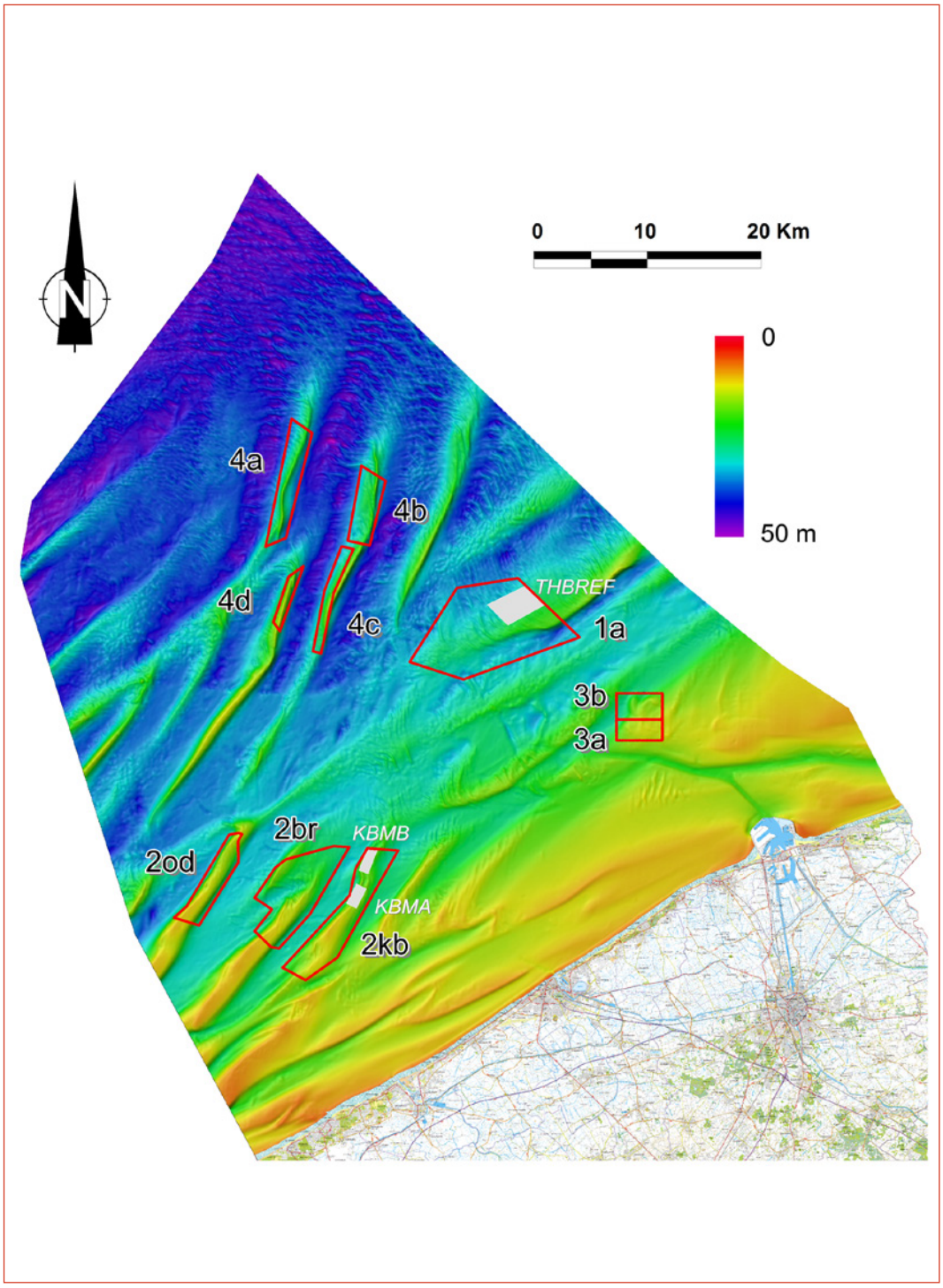

Figure 4: Location of the control zones and closed areas for sand and gravel extraction

4. How much marine sand do they extract?

Marine sand and gravel has been extracted in the Belgian part of the North Sea since 1976. Since 1997 a difference is made between sand and gravel extracted for commercial purposes and for offshore projects and beach nourishment.

The extraction of sand and gravel in Belgium started in 1976 with an annual production of 29.000 m³ (figure 5). The annual extraction gradually increased between 1981 and 1986 until an average of 500.000 m³ per year. After this period the production strongly increased until 1995 when a production of 1.660.000 m³ was reached. Since then the production fluctuates between 1.400.000 m³ and 2.100.000 m³ sand per year. Since 2007 sand is also extracted for beach nourishment explaining the small increase during the past years. In 2013 the limit of 3.500.000 m³ has been exceeded.

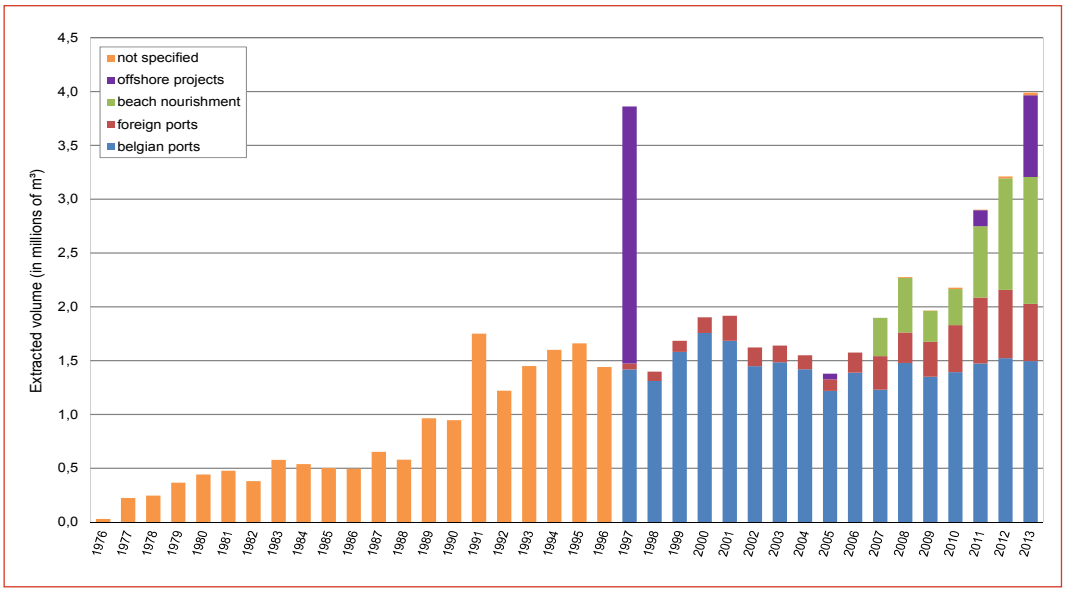

Figure 5: Evolution of the extraction of marine sand in the Belgian part of the North Sea between 1976 and 2013.
Remark: construction of submarine gas pipes in 1991 and 1997.

Control zone 2 remains the most extracted area with more than 75% of all extractions. Within zone 2 a shift has been observed since 2007 from sector 2kb on the Kwintebank to sector 2br on the Buiten Ratel. A new "hot spot", with an extraction of more than 10.000 m³/ha, is located on the central part of the Buiten Ratel. At present more than 50 % of the sand extraction takes place in sector 2br.

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The major part of the extracted sand is unloaded in Belgian ports such as Brugge, Oostende and Nieuwpoort. A smaller amount is exported to harbours in Nord-Pas-de-Calais (France) and Zeeuws-Vlaanderen (The Netherlands).

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5. How do they extract sand at sea?

Only trailing suction hopper dredgers are allowed for the extraction of sand and gravel. In addition, the use of (non-trailing) suction hopper dredgers is allowed in control zone 3.

The sand must be extracted over a contiguous area in layers of maximum 0,5 m. During extraction the dredger must keep an average speed over ground higher than 0,5 knot (0,926 km/h or 0,257 m/s). If several dredgers are working close to each other they must keep a minimum distance of 500 m between each other.

Due to the increasing demand of marine sand the vessels responsible for the extraction and supply of marine sand are becoming larger and more modern. Through innovation and experience these vessels are able to deliver sand and gravel of constant quality.

In 2012 15 vessels were used to extract sand and gravel at sea. The smallest, with a hopper capacity between 1.000 and 2.000 m^3 (8 vessels), were responsible for 24 % of the extractions. The vessels with a hopper capacity between 2.000 and 4.000 m^3 (3 vessels) delivered 47 % of the sand. Three vessels with a hopper capacity between 4.000 and 5.000 m^3 extracted 17 % of the total volume in 2012. One vessel was deployed for beach nourishment (see page 7) with a hopper capacity of 9.000 m^3 (12 %).

What is a trailing suction hopper dredger?

A trailing suction hopper dredger is a dredger that sucks up sand, clay, silt and even gravel by means of powerful dredging pumps (figure 6). This type of vessel trails one or two adjustable suction pipes or arms on the seafloor during dredging. A draghead is attached to the end of the suction pipe, comparable to the head of a vacuum cleaner. If they keep the draghead considerably high above the seafloor, they only suck up water. By lowering the head, they are able to regulate the mixture of sand and water that it takes in. A trailing suction hopper dredger stores the dredged material in its own hopper. The material sinks and the left-over water is discharged overboard. When the dredger is fully loaded the vessel sails to the unloading quay.

Figure 6: Drawing of a trailing suction hopper dredger (left) and a picture of the unloading of marine sand (right)

A trailing suction hopper dredger is able to empty their hopper in different ways:

- Depositing – by opening the doors or valves on the bottom of the vessel the load drops out.
- Pumping – using jet pumps water is pumped into the hopper under high pressure which makes the material in the hopper fluid again. The dredge pumps can then pump the resulting mixture through a pipeline which is connected to the vessel.
- Rainbowing – this method is the same as pumping, except that the load is not pumped through a pipeline but is sprayed over the vessel's bow directly at the desired location.
- By crane or conveyor belt – the extracted sand is removed out of the hopper using cranes or a conveyor belt.

6. Which regulation is applicable to the sand extraction at sea?

The extraction of marine sand in the Belgian part of the North Sea is strictly supervised by the government and is regulated by the law of June 13th 1969.

The aim of this law and the subsequent royal decrees is to regulate in a sustainable way the exploration and extraction of marine sand and gravel in the Belgian part of the North Sea. The licensees are subjected to a strict regulation and at least once a year the Advisory Committee meets. This committee coordinates the administrations involved in the management of the sand and gravel extraction.

Licence

A licence is obliged. This licence determines the period of extraction (standard 10 years) and the control zones where extraction of sand and gravel is allowed. The licensee can apply for an extension of the licence.

Extraction depth

The total extraction depth is limited to 5 m below a reference level defined by the authorities. If this depth is exceeded, the involved area can be closed for extraction.

Extraction volumes

In the control zones all licensees can extract a maximum volume of 15 million m^3 during a period of 5 years. At the suggestion of the Advisory Committee, the minister will fix the maximum annual allowed exploitation volume for each licence. New licensees are allowed to extract at maximum 100.000 m^3/year.

In order to protect the habitat area "Vlaamse Banken" there is in zone 2, besides the prohibition to extract gravel, a limitation on the extraction volume. The extracted volume in this zone decreases each year with 1 % (17.000 m^3).

Year	Maximum volume in control zone 2
2014	1.663.000 m^3
2015	1.646.000 m^3
2016	1.629.000 m^3
2017	1.612.000 m^3
2018	1.595.000 m^3
2019	1.578.000 m^3

Fees

Each licensee has to pay a fee corresponding to the extracted volume of sand and gravel with an annual minimum of 18.592,02 euro. These fees are annually adapted and differ depending on the type of extracted material:

- sand from control zones 1, 2 and 4: 0,65 euro/m³ in 2014;
- sand from control zone 3 (lower quality): 0,42 euro/m³ in 2014;
- gravel: 1,36 euro/m³ in 2014.

The fees paid by the licensees are used for the continuous research on the impact of sand and gravel extraction on the seafloor and the marine environment.

The most important tasks of the Advisory Committee are:

- Give advice to the minister:
  - about applications for a licence;
  - about the allowance of the annual extracted volumes;
  - about the closing of extraction areas.
- Follow up of different studies regarding the impact of sand extraction.

The sand extraction is subject to additional Belgian legislation such as the law 'Marine Environment' and international legislation like the 'European Habitats and Birds Directives' and the 'European Marine Strategy Framework Directive'. In this last legislation, the establishment of five marine protected areas aims to achieve a good environmental status in the near future. The consequences for sand extraction in the Belgian part of the North Sea are still unknown, although gravel extraction will certainly be almost impossible.

The entire legislative context and the procedure for the application or extension of a licence are both extensively described in the brochure 'Regulation concerning sand and gravel extraction in the Belgian part of the North Sea' (Publication FPS Economy – Continental Shelf Service) (only in Dutch and French).

7. How do they control sand extraction?

The monitoring of sand extraction is organised in two ways: supervision of the activity and monitoring of the impact of extraction on the marine environment.

The monitoring of the sand extraction is divided in two parts:

- **Supervision of the activity**

Each dredger active in Belgium has a logbook on board. In this logbook the captain has to fill in all relevant information for each extraction. Since the late nineties the verification is simplified by the presence of an electronic monitoring system. Additionally unannounced controls can take place at sea or in the harbour.

- **Monitoring of the impact of extraction on the marine environment**

Annually, several surveys are organised on board of the RV Belgica in order to verify the consequences of the extraction on the marine environment. Three institutes are involved in this research: (1) the Continental Shelf Service [1], (2) the ILVO [2] en (3) the MUMM [3].

1 See chapter 8.

2 Institute for Agriculture and Fisheries Research

3 Management Unit of the North Sea Mathematical Models (a scientific service of the Operational Directorate (OD) Natural Environment of the Royal Belgian Institute of Natural Sciences)

Electronic monitoring system

On board of each dredger the licensee has to install, at his own expense, an electronic monitoring system, the so-called black box. After the testing and sealing of the system, the on board personnel is obliged to fill in at the start of each trip the identification number of the licensee and the number of the voyage.

The black box automatically records the following parameters:

- identification of the dredger;
- date and time of the registration;
- position and speed of the dredger;
- status of the pumps (on/off);
- status of extraction (yes/no).

During dredging these parameters are recorded on average every 30 seconds.

As soon as the load is measured, the captain enters the real loaded volume (m^3) in the monitoring system.

The management and testing of these electronic monitoring systems as well as the processing of the data is executed by MUMM under the authority of the Continental Shelf Service.

Surveys on board of RV Belgica

Since 1999 the Continental Shelf Service annually performs 4 to 6 surveys on board of the RV Belgica. A multibeam echosounder is used for detailed mapping of the seafloor.

Detailed mapping of the seafloor allows the evaluation of the impact of the extraction on the morphology of the seafloor. Additionally the multibeam echosounder has the possibility to determine the type of sediments on the seafloor. The measurements are taken at sea and the data is processed (corrections, verification and filtering of the data). After the processing of the bathymetric data (the depth measurements), it is possible to accurately follow up the evolution of the seafloor within the sand extraction areas resulting in an evaluation of the consequences of the sand extraction.

Figure 7 shows the digital terrain model of control zone 2, which is the result of an extensive acquisition and elaborate processing of the bathymetric data.

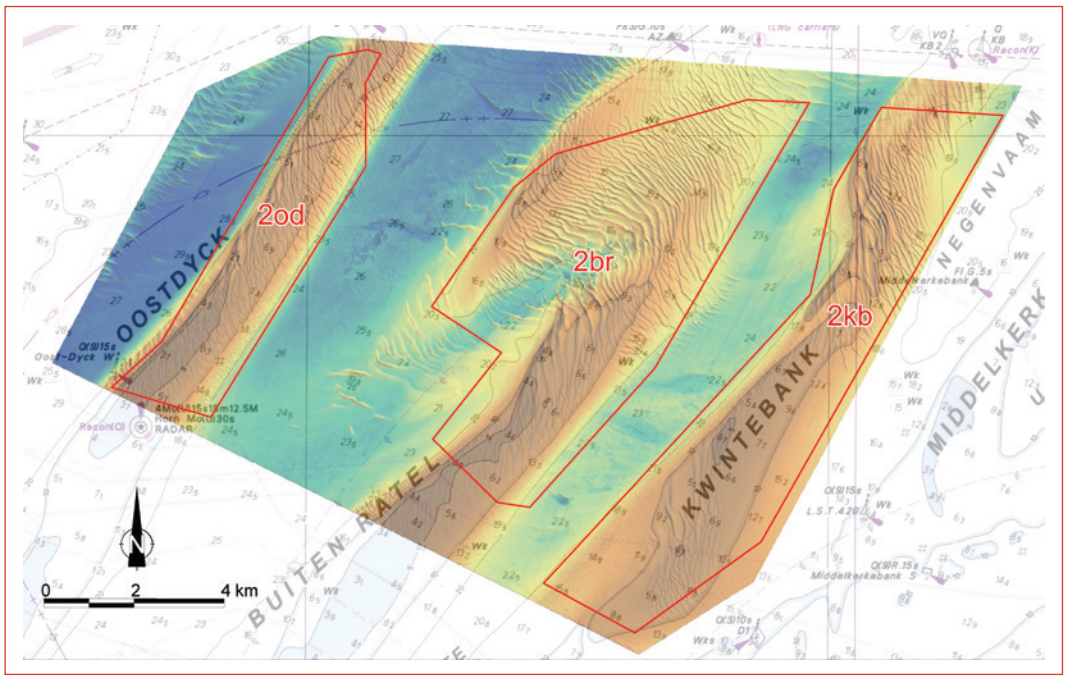

Figure 7: Digital terrain model of control zone 2 (Kwintebank, Buiten Ratel and Oostdyck) as result of the profound processing of the bathymetric data

How does a multibeam echosounder work?

A multibeam echosounder consists of one or two transmit and receive units, called transducers, which are mounted to the hull of the ship. These transducers transmit a broad acoustic pulse under different angles (figure 8): narrow (1 to 5 degrees) in the sailing direction and wide (150 degrees) perpendicular to the sailing direction. The depth of the seafloor is measured by the detection of the two-way travel time of the acoustic pulses. As the ship moves the depths are measured several times per second. The consecutive measurements make it possible to obtain a complete image of the seafloor. The distances between the navigation lines are defined in order to have overlapping data and consequently obtain a fully coverage of the area. A multibeam echosounder is combined with a positioning system (GPS) and a motion sensor which registers in real time all the movements of the ship (heading, pitch, roll and heave) in order to obtain the correct position for each depth measurement.

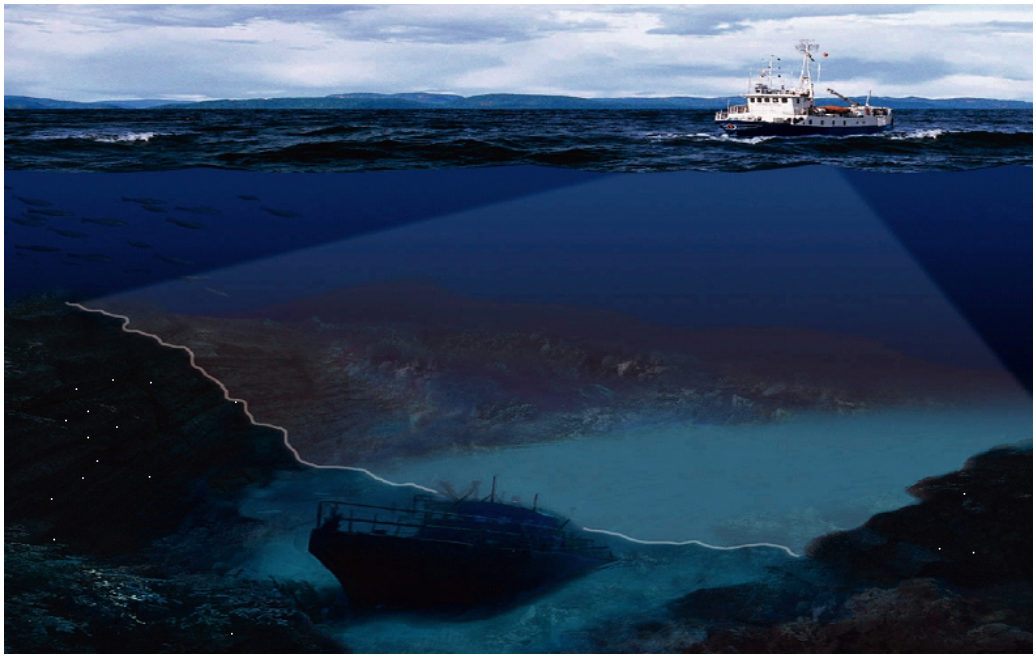

Figure 8: General principle of a multibeam echosounder (Source: Kongsberg Maritime)

In order to perform these measurements, the Federal Public Service Economy purchased a multibeam echosounder (Kongsberg EM1002S) in the summer of 1999 and installed it in cooperation with MUMM on board of RV Belgica. In 2009 a new multibeam echosounder (Kongsberg EM3002D) was installed in order to obtain a higher resolution and a higher acquisition speed resulting in a more efficient and accurate monitoring (figure 9). This multibeam echosounder is not only used by the Continental Shelf Service but is also available for other scientists, further contributing to marine research in Belgium.

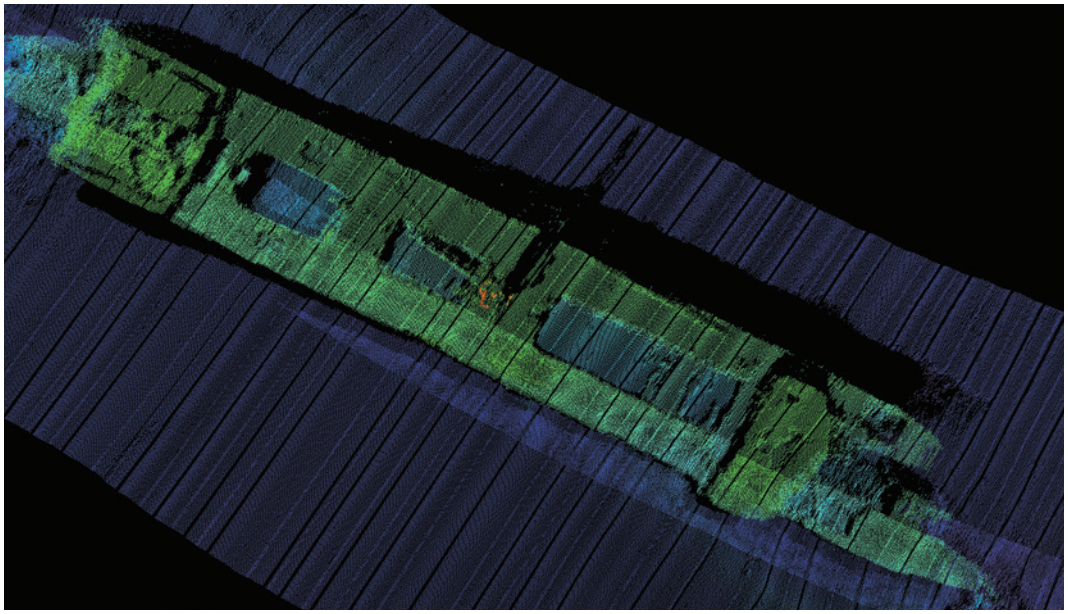

Figure 9: Recording of the wreck of the Birkenfels with the Kongsberg Maritime EM 3002D multibeam echosounder on board the RV Belgica by the Continental Shelf Service

Several monitoring zones were defined, allowing a more accurate evaluation of the consequences of the extraction. A monitoring zone is an area which is surveyed on a regular base in order to accurately follow up the evolution of the seafloor as well as to evaluate the impact of the sand extraction. Such a monitoring zone can be located within or outside a control zone. This allows a comparison between the evolution of the seafloor within an extracted area and the natural evolution of the seafloor.

Figure 10 shows the monitoring zones:

- on the Middelkerkebank: R2;
- on the Kwintebank: KBMA and KBMB;
- on the Buiten Ratel: BRMA, BRMB and BRMC;
- on the Oostdyck: ODMA;
- on the Hinder banks: HBMA, HBMB and HBMC.

These areas are mapped at least twice a year. This monitoring showed that the extraction limit of 5 m was reached at certain locations on the Kwintebank, resulting in the closing of the central part of the Kwintebank (KBMA) in 2003 and of the northern part of the Kwintebank (KBMB) in 2010 (figure 10). Since then further monitoring of these areas showed that the sand banks do not recover naturally which means that both areas remain closed for extraction.

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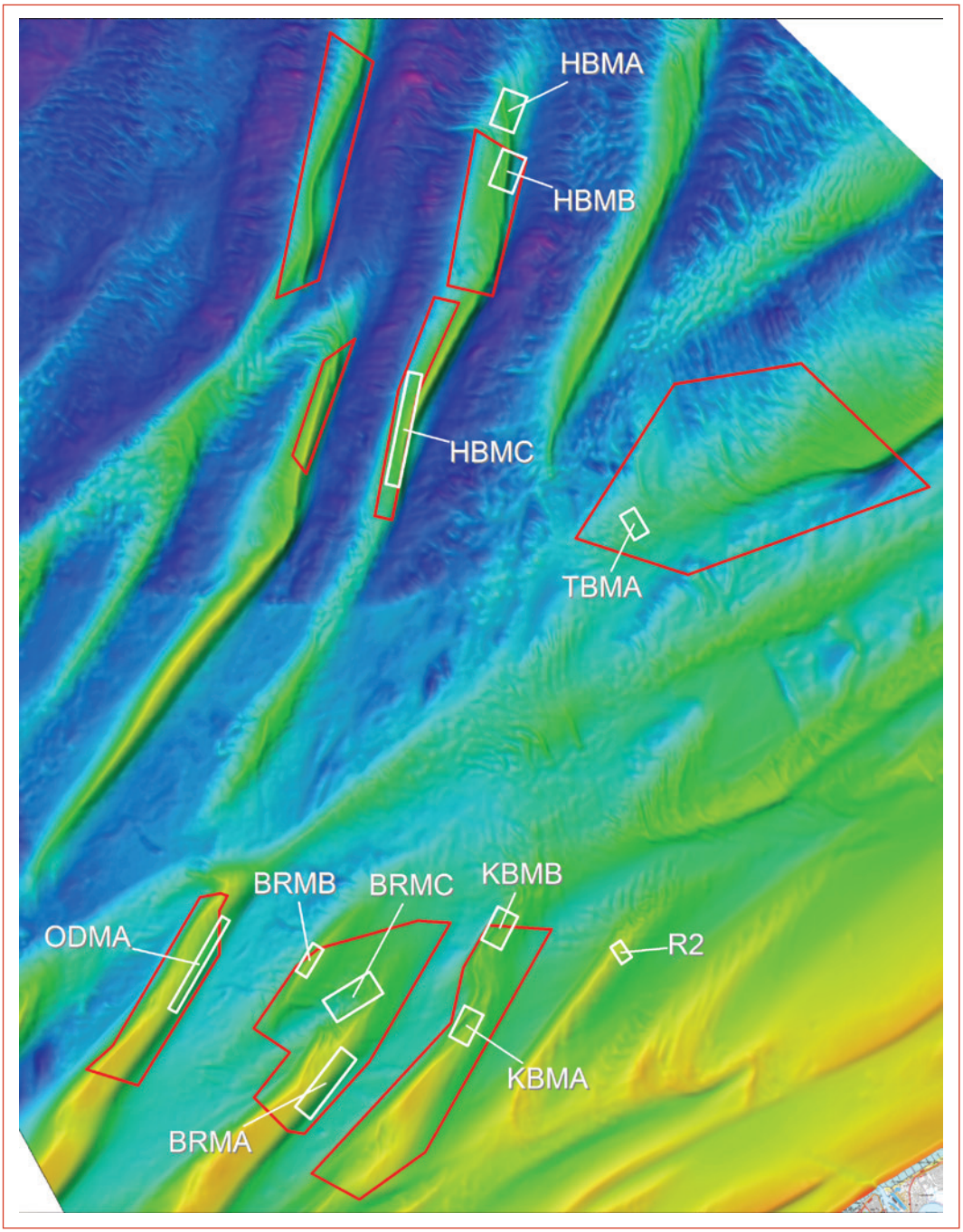

Figure 10: Location of the monitoring areas

Research of the Continental Shelf Service shows a linear correlation between the extracted volumes and the depth evolution of the seafloor. On a larger scale the total variation in depth can be explained by the extraction activities. In the areas without extraction the evolution of the depth is stable or slightly positive. The Continental Shelf Service states that sand and gravel is a non-renewable source and that the impact of extraction has only a local effect and is non-cumulative.

Besides the impact on the seafloor (figure 12) the biological impact of sand extraction on the marine environment is investigated in cooperation with ILVO. This research shows that the biological impact caused by intensive sand extraction is strongly dependent on the natural environment of the area where sand is extracted.

Finally the OD Natural Environment is studying the ecosystems of the North Sea using mathematical modeling techniques. If a model corresponds with the measurements, it can be used for management purposes and to a certain extent for forecasting. Depth changes due to sand extraction are a magnitude higher than the natural evolution of the seabed modeled by OD Natural Environment. According to their models seafloor erosion increases when extraction coincides with intense hydro meteorological circumstances.

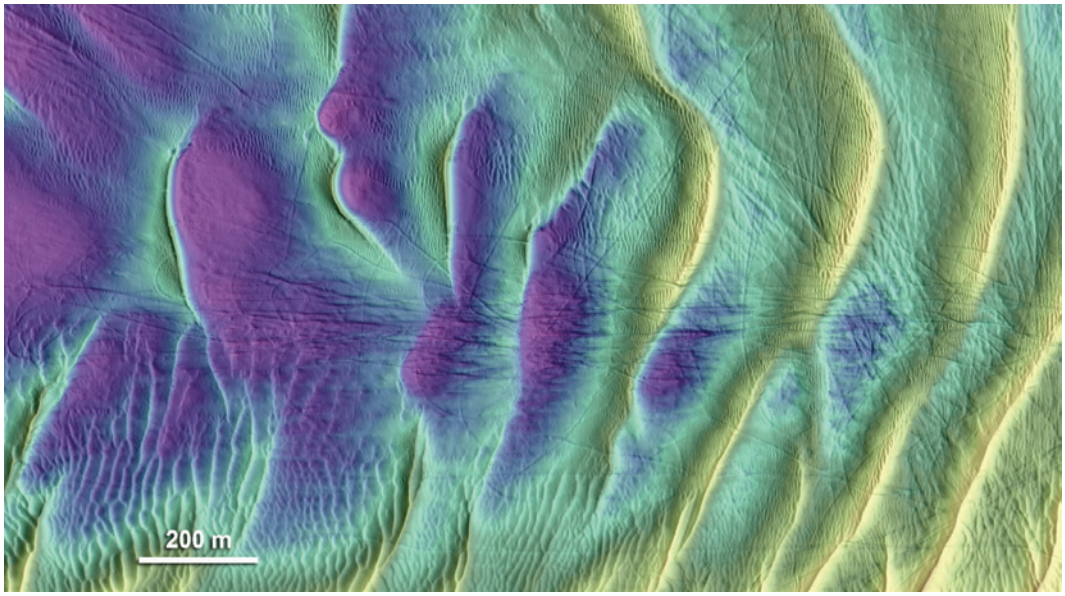

Figure 12: Traces of impact on the Buiten Ratel

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What is the RV Belgica?

The oceanographic research vessel Belgica belongs to the Belgian State and falls under the responsibility of the Belgian Science Policy (figure 11). The ship and its scientific equipment are managed by the OD Natural Environment, Meetdienst Oostende, which is also responsible for planning and organising scientific campaigns at sea. The Belgian navy provides the crew and takes care of the operational aspects as well as the moorage in Zeebrugge, the Belgica's homeport. Her Majesty Queen Fabiola is godmother of the ship and the city of Temse accepted the godparenthood.

The ship was constructed in 1984, it has an overall length of 50.9 m and is 10 m wide. It has a maximum draught of 4.6 m and can sail with a maximum speed of 12 knots (22 km/h). The Belgica, thanks to its specialised equipment and oceanographic instruments can take many different kinds of samples, from air, from water, and the sediment and then analyse these in the on-board laboratories. This all-purpose research vessel, which spends around 200 days a year at sea, both monitors the quality of the marine environment and undertakes numerous expeditions for scientific research. The RV Belgica has 15 crew members on board and has space for 16 scientists.

More information is available on http://www.mumm.ac.be/EN/Monitoring/Belgica/index.php.

Figure 11: Picture of the research vessel Belgica (Source: RV Belgica)

8. What does the Continental Shelf Service do?

The Continental Shelf Service is part of the Directorate-General Quality and Safety of the Federal Public Service (FPS) Economy, S.M.E.s, Self-employed and Energy.

The team of the Continental Shelf Service consists of 6 people who are responsible for:

- the management of the Fund for Sand Extraction;
- the grant of licences;
- the management of the licences;
- the update of the related legislation;
- the monitoring of the sand extraction.

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