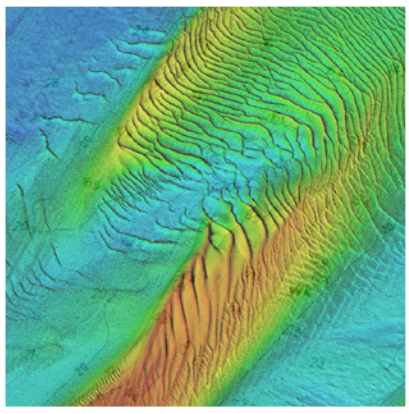
Sand and **gravel extraction** in the **Belgian** part of the **North Sea**



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Rue du Progrès 50 — 1210 Brussels

Enterprise no: 0314.595.348

○ 0800 120 33 (free number)
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Table of contents

List of figures

List of graphics

List of tables

1. The history of the extraction of sea granules

Locations for sand extraction on land are increasingly difficult to find. Marine sand is therefore an interesting alternative, both in Belgium and its neighbouring countries. Since the 1970s, the share of extracted marine sand in Belgium's total sand production has constantly increased.

There are four sources of supply in Belgium to meet the need for sand:

- land and rivers,
- imports from abroad,
- secondary raw materials (recycling or as a by-product), and
- the North Sea.

Sand and gravel extraction on land has a major impact on nature, where animals and plants suffer from mining activities, as well as on human society. This includes nuisances from noise, dust and truck traffic. As a result, spatial planning and environmental policy have restricted the sand and gravel extraction on land.

Since the 1960s and 1970s, the demand for marine sand and gravel as an alternative has steadily increased. Preconceived ideas with regard to these raw materials slowly disappeared and the arrival of concrete plants with unloading quays along canals made inland shipping possible. The lower cost price of marine sand in comparison to river sand made it even more attractive.

As a result of the ever increasing interest in the use of marine sand, the professional association "Federation of importers and producers of dredged sea granulates", in short "Zeegra", was founded in 1981. The aim of this association is to defend the common interests of importers and producers of marine sand and gravel.

2. Use of marine sand

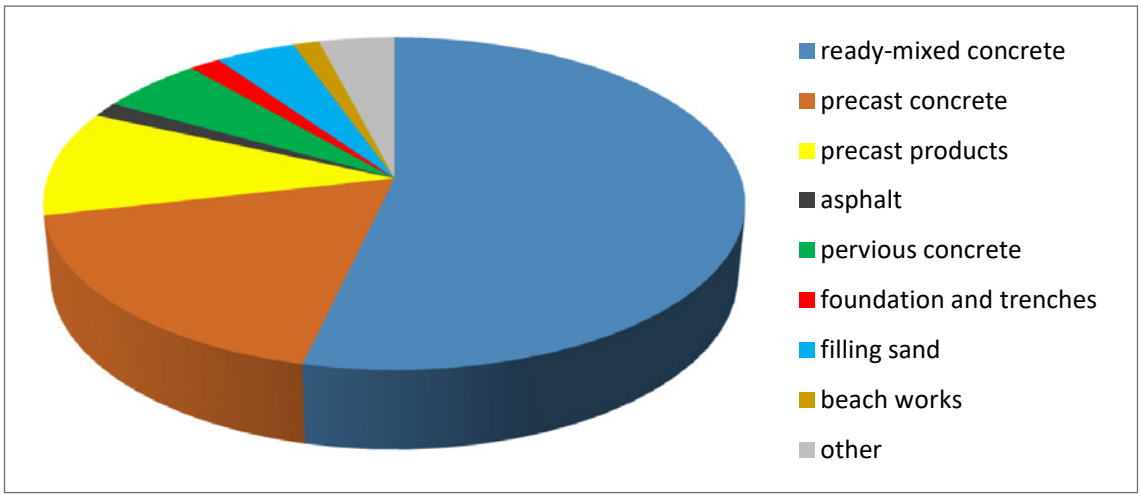
Marine sand is used on the one hand in the construction industry and on the other hand for the protection of the Belgian coast.

2.1. Construction sector

Considering that sea sand has become one of the basic raw materials for the construction sector over the past 40 years, it has undoubtedly acquired a great social and economic importance in Belgium. In recent years, 3 to 4 million m^3 of Belgian marine sand has been extracted per year, of which almost 75 % was used in the construction sector.

In the past decades, the concrete sector has increasingly switched to Belgian marine sand as a replacement for river sand from the Netherlands and/or Germany. The sand that is most often extracted is medium coarse sand (diameter between 0.25 and 0.5 mm) that is processed in ready-mixed concrete and precast concrete. In addition to concrete, marine sand is used for the production of asphalt, masonry mortar and as drainage sand, foundation sand and replenishment sand (graphic 1).

Graphic 1 – Use of marine sand in the private sector (in 2016)



Source: Continental Shelf Service, FPS Economy.

The sea sand of the Belgian part of the North Sea is essentially a mixture of mineral particles from the erosion of rocks and particles of organic origin such as fragments of shells. During the Quaternary, the most recent geological era, particles of erosive origin transported by rivers and wind settled in the southern part of the North Sea. Slowly, sea currents and waves transported and abraded these particles, mixing them with shell fragments. It is with this sedimentary material stirred and constantly reshaped by the ocean currents that the current sandbanks were slowly built. The marine sands constituting the sandbanks have the same geological origin and the same mineralogical composition as their terrestrial equivalents. However, there are differences due to the sorting of sediments by sea currents: a very low content of fine particles (silt and clay) and a relatively higher concentration of the most resistant particles.

Initially, the construction industry was very hesitant to use marine sand because of the presence of sea shells and sea salt. Since then, numerous technical evaluations have shown that this reluctance was unfounded. As long as marine sand meets the imposed standards, it is as effective for use in construction and civil engineering as land-won sand.

Sea sand that is extracted in the Belgian part of the North Sea is very pure, so that the sand can be used almost unprocessed. Sea sand is also very constant in composition, so that the producer of concrete or asphalt can guarantee a constant quality.

The gravel in the Belgian part of the North Sea is chemically and physically heterogeneous. Due to its low quality, only small quantities of gravel are extracted. Gravel of marine origin is only used for ballast, such as for the construction of submarine gas pipes or for the construction of quay walls.

2.2. Coastal protection

Beach nourishment (spraying) is an important measure for creating sea defences along the coast. Beach nourishment produces wider and higher beaches to protect the coast against flooding during very heavy storm tides (figure 1). The CREST research project confirmed that beach nourishments are a sustainable solution for coastal protection: they strengthen the beaches, the sea banks that extend behind them as well as the dunes.

Figure 1 – Beach nourishment

A mixture of sand and water is sprayed onto the beach through a pipe system and then redistributed with bulldozers.

Source: MDK – Afdeling Kust.

The Belgian coast is only 67 kilometres long, but every meter of it is used intensively. Multiple residential and natural areas, tourist recreational areas and industrial zones are located along the coastline. Since 2011, the Coastal Department of the Flemish Government ("Vlaamse Overheid – Afdeling Kust") is taking measures along the entire coastline to protect it from a 1,000-year storm surge. Those measures are implemented within the framework of the Coastal Safety Master Plan that is based on the principle "soft where possible, hard where necessary". With the aim of ensuring a safe and attractive coast, beach replenishments are carried out where appropriate.

In some places, protection by a wider and higher beach is insufficient. In those places, extra measures are therefore taken by building storm walls, a wave-damping extension, a wider bank or a storm surge barrier. These are the hard measures.

The implementation of the Master Plan is also necessary from a social and economic point of view. In 2010, a third of the Belgian coast was insufficiently protected against the so-called "super storms" or "1,000-year storms", which could lead to an economic damage of several billion euros as well as to thousands of casualties.

In the Master Plan, all flood risks are considered and the risk zones are mapped. Measures and possible alternatives have been studied for each risk zone.

A total supply of 20 million m^3 of sand is required for the works under the Coastal Safety Master Plan over a period of 10 years.

In order to maintain the entire seawall so that it continues to meet the proposed safety level, the Coastal Department also carries out maintenance replenishments. Repairs of major storm damage such as after the storm "Saint Nicholas" in 2013, storm "Dieter" in 2017 (figure 2) or storm "Ciara" in 2020 (figures 3 and 4) are also necessary.

Figure 2 – Calving of the dune at the Zwin estuary after storm Dieter

Source: MDK – Afdeling Kust.

Figure 3 – Damage to the beach after the passage of storm Ciara

Source: MDK – Afdeling Kust.

Figure 4 – Damage to the beach after the passage of storm Ciara

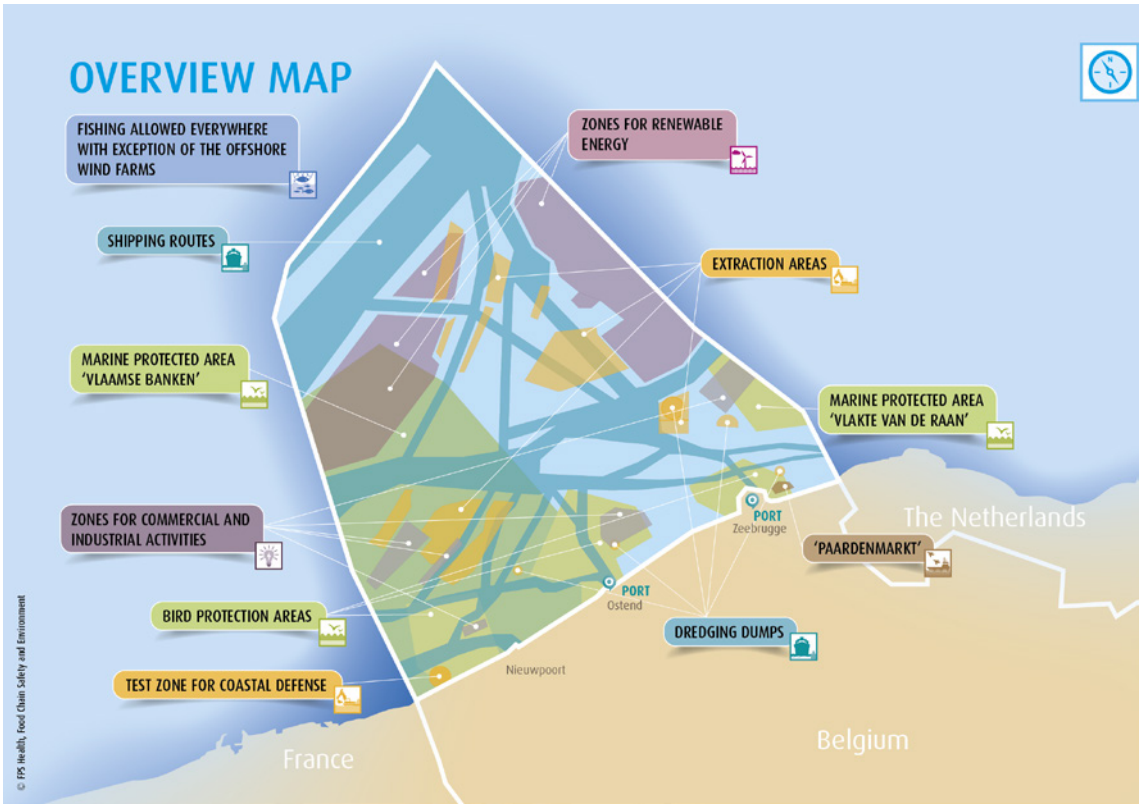
Source: MDK – Afdeling Kust.

3. The sand extraction areas in the Belgian part of the North Sea

Sand and gravel extraction in Belgium takes place in the Belgian part of the North Sea. This part of the North Sea is also home to numerous other activities, such as:

- shipping,
- fishing,
- installation of communication cables and pipelines,
- sludge dumping,
- military activities, and
- installation and operation of wind farms.

Figure 5 – Overview map of the Marine Spatial Plan 2020-2026



Source: Annex 4 - Royal decree of May 22, 2019 establishing the marine spatial plan for the period 2020 to 2026 (Federal Public Service Public Health, Food Chain Safety and Environment).

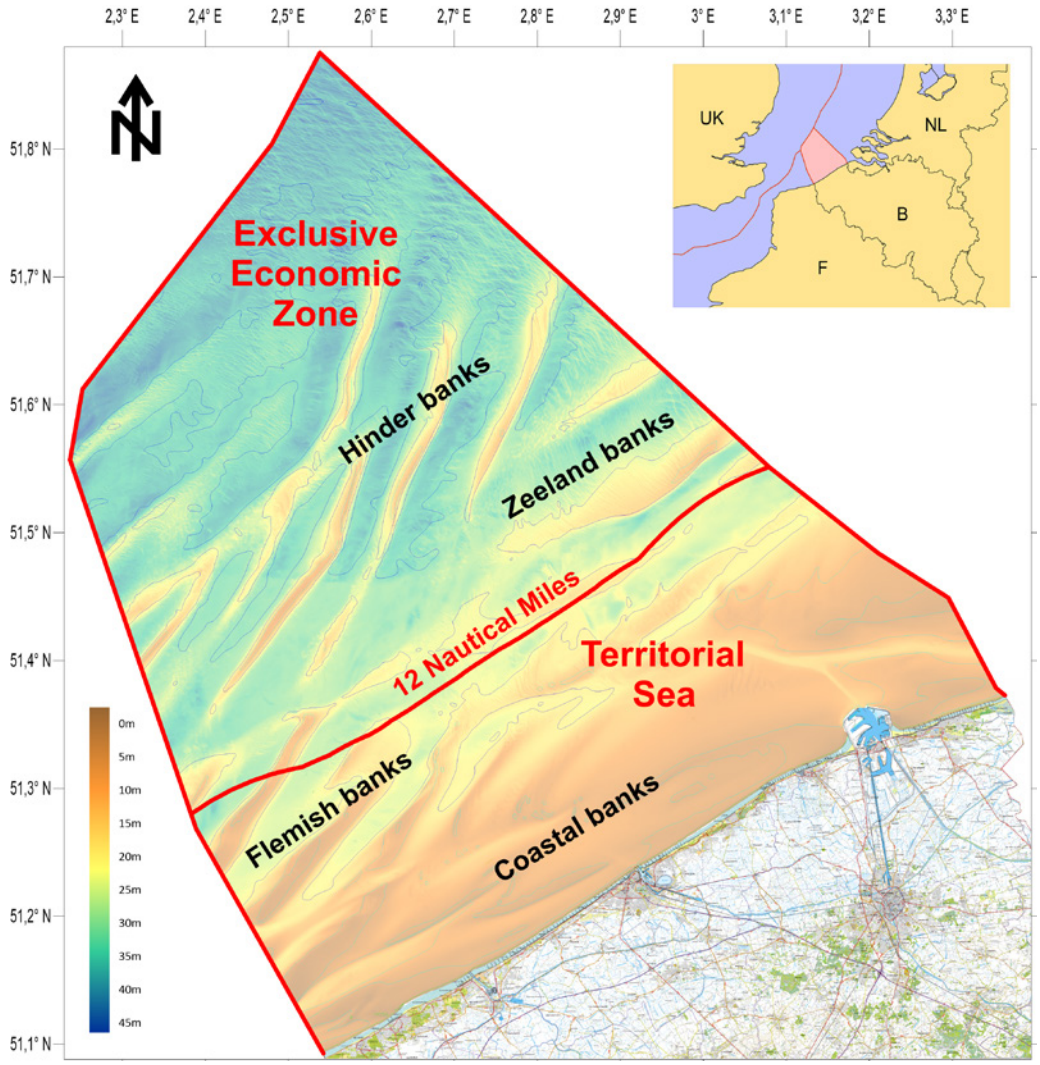
The Belgian part of the North Sea

The Belgian part of the North Sea has an area of 3,447 km² and is part of the southern North Sea (figure 6). The area stretches the entire length of the coast, about 67 km, to about 65 km seawards. It is characterized by a shallow depth that varies between 0 and 55 m.

This transition area to the Channel consists of numerous sandbanks that can be tens of kilometres long, a few kilometres wide and up to 20 m high. The banks are subdivided on the basis of their location and orientation into: the Coastal Banks, the Flemish Banks, the Zeeland Banks and the Hinder Banks (figure 6).

From a legal point of view, the Belgian part of the North Sea is divided into two areas (figure 6). The territorial sea covers an area from the coast up to 12 nautical miles (or about 22 km) at sea. Adjacent to this area is the Exclusive Economic Zone (EEZ). This Exclusive Economic Zone consists of the Belgian Continental Shelf and the waters above the seabed.

Figure 6 – Location of the Belgian part of the North Sea



Source: Continental Shelf Service, FPS Economy.

Sand extraction is permitted in areas defined by law, called control zones. The quality and diversity of the sand depends on the extraction site, since each sandbank has a specific grain size distribution and a different shell content.

In total, there are five control zones (figure 7):

- zone 1: Thornton Bank;
- zone 2: Flemish Banks (Kwintebank, Buiten Ratel and Oostdyck);
- zone 3: Sierra Ventana;
- zone 4: Hinder Banks (Noordhinder, Westhinder and Oosthinder);
- zone 5: Bligh Bank.

Each control zone consists of one or more sectors.

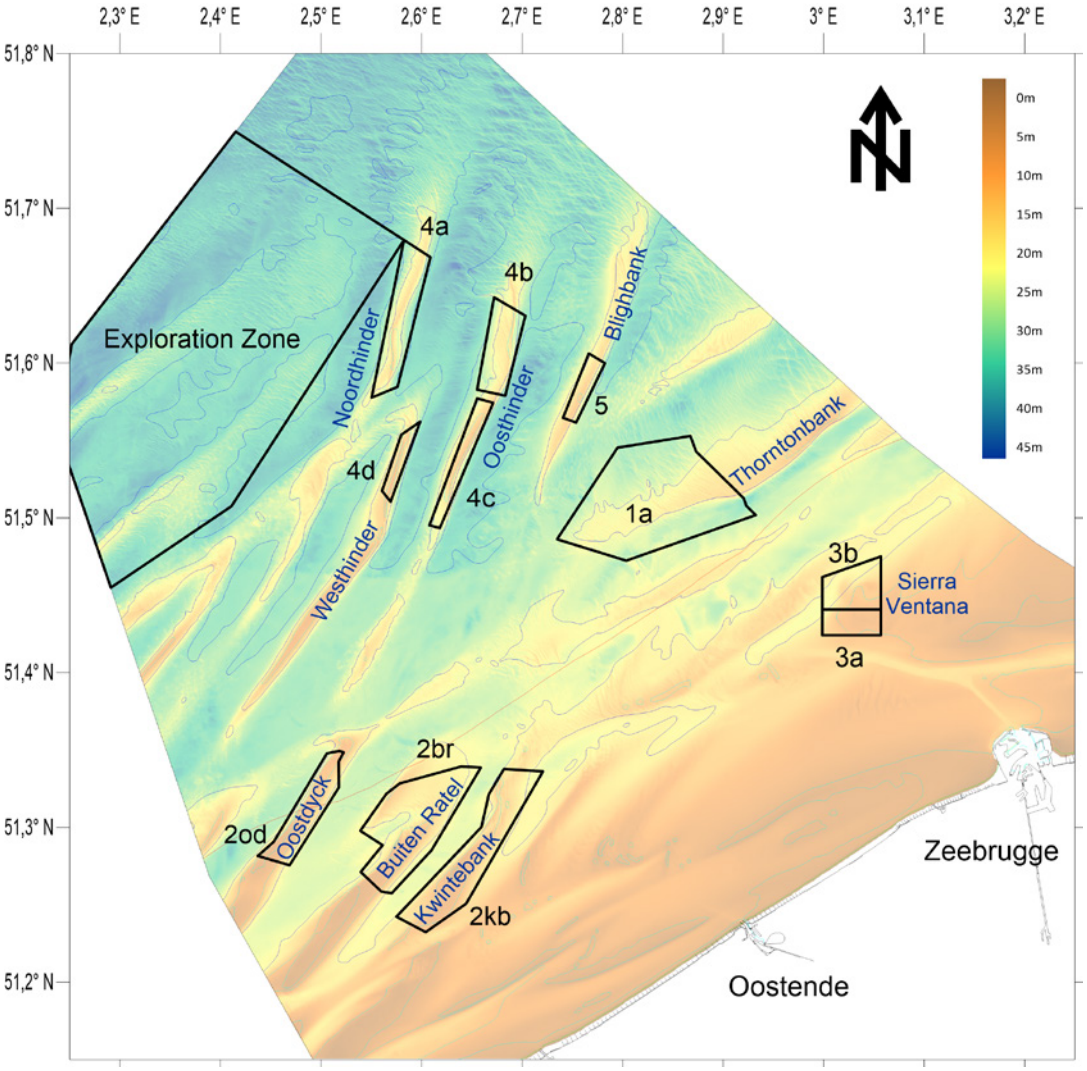
Three types of sand are distinguished in these control zones:

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

For the sand extraction industry, knowledge of the quality of the sand in the various extraction sites is very important so that it can deliver the desired quality of sand.

There is an exploration zone for sand extraction in the northwest of the Belgian part of the North Sea.

Figure 7 – Location of the control zones (and sectors) and exploration zone in the Belgian part of the North Sea



Source: Continental Shelf Service, FPS Economy.

4. Regulations

The extraction of sea sand in the Belgian part of the North Sea is strictly monitored by the government and is regulated by the Act of 13 June 1969.

The aim of this Act and the subsequent royal decrees is to regulate the exploration for and exploitation of sea sand and gravel in a sustainable manner. The concession permits are subject to strict regulations and an Advisory Committee on Sand meets at least once a year. This committee coordinates the administrations involved in the management of sand and gravel extraction.

The main tasks of the Advisory Committee on Sand are:

- *Give advice to the minister:*
  - *about applications for concessions;*
  - *about the allocation of the annual extraction volumes;*
  - *on the closure of extraction areas.*
- *Follow up various studies with respect to the impact of sand extraction.*
- *Organize in-depth consultations between the relevant government departments.*

Sand extraction is subject to additional Belgian legislation such as the Marine Environment Act. International legislation such as the European Habitats and Birds Directives and the European Marine Strategy Framework Directive also influence sand extraction in the Belgian part of the North Sea.

The extensive legislation as well as the procedure for applying for a new concession, continuation or extension can be found in the brochure “Sand and gravel extraction in the Belgian part of the North Sea: the regulations” (Publication FPS Economy - Continental Shelf Service).

4.1. Concession permit

A concession permit is mandatory. It determines the period of the concession (standard 10 years) and the control zones where sand and gravel can be extracted as well as the exploration zone in which one can search for sand and gravel. The concession holder can submit an application for the continuation and/or extension of his concession permit.

4.2. Extraction depth

For each control zone, a reference surface has been defined to determine up to which depth sand and gravel can be extracted from the seabed. These reference surfaces are based on scientific and economic criteria and are effective from 1 January 2021 onwards. The new reference surfaces aim to limit the impact of extraction in the most sensitive zones in terms of sediment and habitat and to increase economic sustainability by taking into account the available volumes and the quality of the sand present.

The surface area

Until the end of 2020, the total extraction depth was not allowed to go deeper than 5 meters below a certain reference level. When using a fixed maximum extraction depth of 5m, 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 guidelines.

In 2014, the Continental Shelf Service started a project to determine a new reference area. A number of criteria were taken into account when defining the new surface:

- *no change in the sediments on the surface of the sea bed in order to best preserve the integrity of the seabed[1];*
- *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.*

Based on the available data, reference areas were drawn up for each control zone[2]. 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.

In 2017, the results of this research were extensively presented at the three-yearly study day. The 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. Their study concluded that the impact on coastal safety of extraction to the maximum permissible depth according to the new reference level is negligible.

From the reference surfaces described above, maps are drawn up with the available volume of sand. The latter is defined as the difference between the reference surface and the actual sea bed surface (bathymetry). The volume maps form the basis for defining, within the various sectors, areas where either exploitation is possible or not permitted. The demarcation of these areas is adjusted annually to the current situation and communicated to the licensees, controlling institutions and other stakeholders.

1 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.

2 More information about the reference surfaces per control zone and the accompanying volume maps can be found in the brochure “Sand and gravel extraction in the Belgian part of the North Sea: the regulations”.

4.3. Extraction volumes

In the control zones, a maximum volume of 15 million m^3 can be mined by all concession holders taken together, spread over a period of 5 years. Each year, based on a proposal from the Advisory Committee, the minister sets the maximum permitted annual exploitation volume per concession holder. New concessions are awarded a minimum of 100,000 m^3 / year per concession.

In order to protect the habitat area “Flemish Banks”, the extraction of gravel is prohibited in control zone 2.

4.4. Fees

Each concession holder pays an annual fee of at least 18,592.02 euros, in accordance with the volume extracted. The amounts of the fees are adjusted annually and vary according to the type of material:

- sand from control zones 1, 2, 4 and 5: 0.73 euro/m^3 in 2021;
- sand from control zone 3 (lower quality): 0.48 euro/m^3 in 2021;
- gravel: 1.55 euro/m^3 in 2021.

The fees paid by concession holders are used completely to carry out continuous research into the impact of sand and gravel extraction on the seabed and the marine environment and for the management and control of sand extraction.

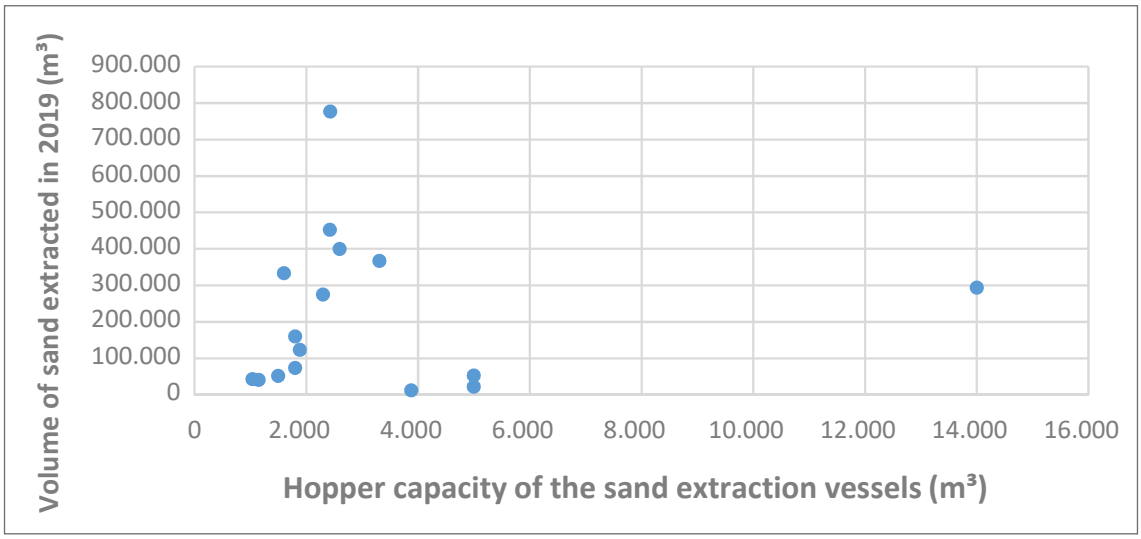
5. Sand extraction in practice

Only trailing suction hopper dredgers are allowed for the extraction of sand and gravel. In control zone 3, however, the use of non-trailing suction hopper dredgers (for sand extraction from an anchored position) is also permitted.

The sand must be extracted over a contiguous area in layers of maximum 0.5 m. During the extraction, the dredger must maintain an average speed with respect to the seabed that is greater than 0.5 knots (0.926 km / h or 0.257 m / s). If several dredgers are working close to each other, they must maintain a minimum distance of 500 meters between them.

Due to the growing demand for sea sand, the vessels responsible for the extraction and supply of marine sand have become larger and more modern. Through innovation and experience, these vessels are able to deliver sand and gravel of uniform quality.

Graphic 2 – Extracted volumes compared to the hopper capacity of sand extraction vessels in 2019



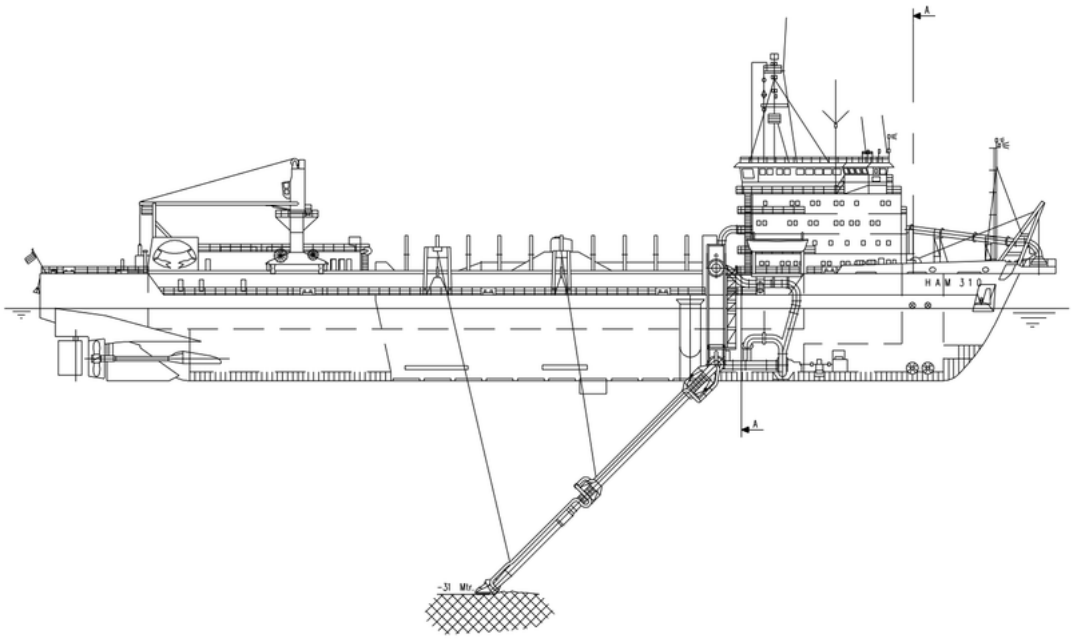
Source: Continental Shelf Service, FPS Economy.

In 2019, 16 vessels were used for the extraction of sand and gravel at sea (see graphic 2). The smallest ones, with a hopper capacity of 1,000 to 2,000 m³ (7 vessels), were responsible for 24 % of the extractions. The vessels with a hopper capacity between 2,000 and 3,000 m³ (four vessels) delivered 55 % of the sand. Two vessels with a hopper capacity between 3,000 and 4,000 m³ extracted 11 % of the total volume in 2019. Two mining vessels with a hopper capacity of 5,000 m³ were responsible for 2 % of the extractions. One of the vessels that were deployed for coastal defence (see page 7) had a hopper capacity of no less than 14,000 m³ (good for 8 %).

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 8). 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 the draghead is kept well above the seafloor, it only sucks up water. By lowering the head, the mixture of sand and water that it takes in can be regulated. A trailing suction hopper dredger stores the dredged material in its own hopper. The material settles and the remaining water is discharged overboard. When the dredger is fully loaded, the vessel navigates to the unloading quay.

Figure 8 – Drawing of a trailing suction hopper dredger



Source: https://www.researchgate. net/figure/Trailing-Suction-Hopper-Dredge-HAM-310_fig1_295080208.

A trailing suction hopper dredger can empty its hopper in different ways:

- *Dumping – by opening the doors or valves in the bottom of the vessel, the load drops out.*
- *Pressing - using jet pumps, water is pumped into the hopper under high pressure, so that the material in the hopper becomes liquid again. The dredge pumps then suck up the resulting mixture and the ship can then pump the load by coupling a pipe to the ship.*
- *Rainbowing - This method works in the same way as pressing, except that the load here is not pressed through a pipe, but is sprayed over the vessel's bow with an arc (the rainbow) at the desired location.*
- *Unloading by crane or conveyor belt - The extracted sand is removed from the hopper using unloading cranes or a conveyor belt (figure 9).*

Figure 9 – A trailing suction hopper dredger in the process of unloading marine sand

Source: Continental Shelf Service, FPS Economy.

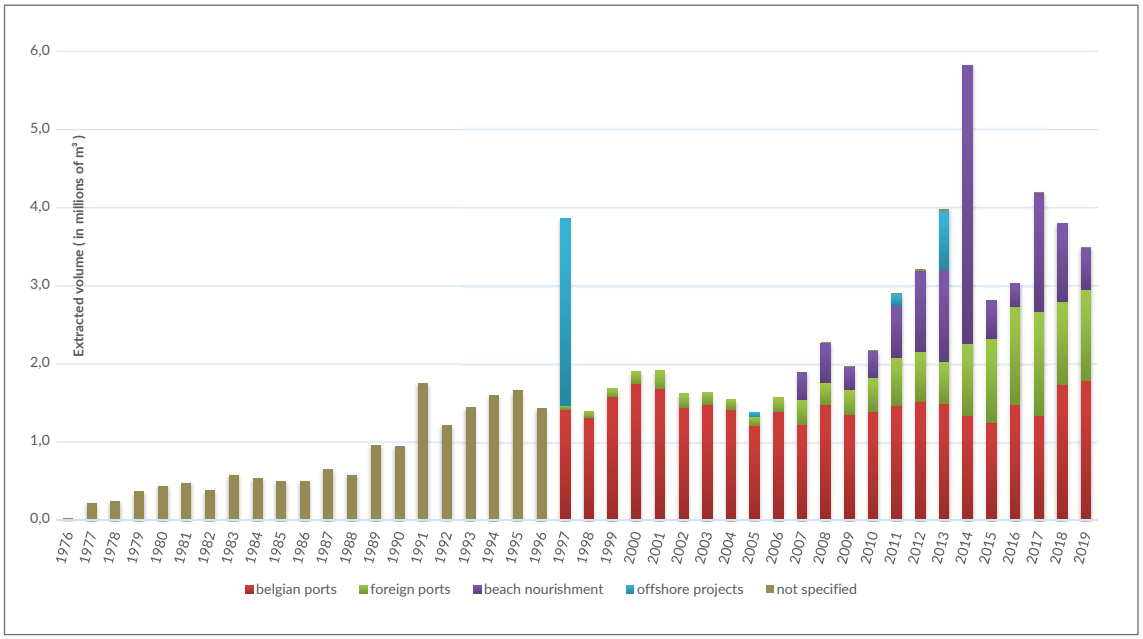
6. The annual extraction volumes and the sand reserves

6.1. The evolution of the extraction volumes

Marine sand and gravel have been extracted in the Belgian part of the North Sea since 1976. Since 1997, a distinction is made between sand and gravel that is 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 extraction of 29,000 m^3 (graphic 3). Annual extraction volumes show an upward trend with some peaks. In 1991 and 1997, extraction peaked due to the construction of submarine gas pipelines. In 2014, almost 6 million m^3 of sand was extracted. 60 percent of this was used for beach nourishment at that time.

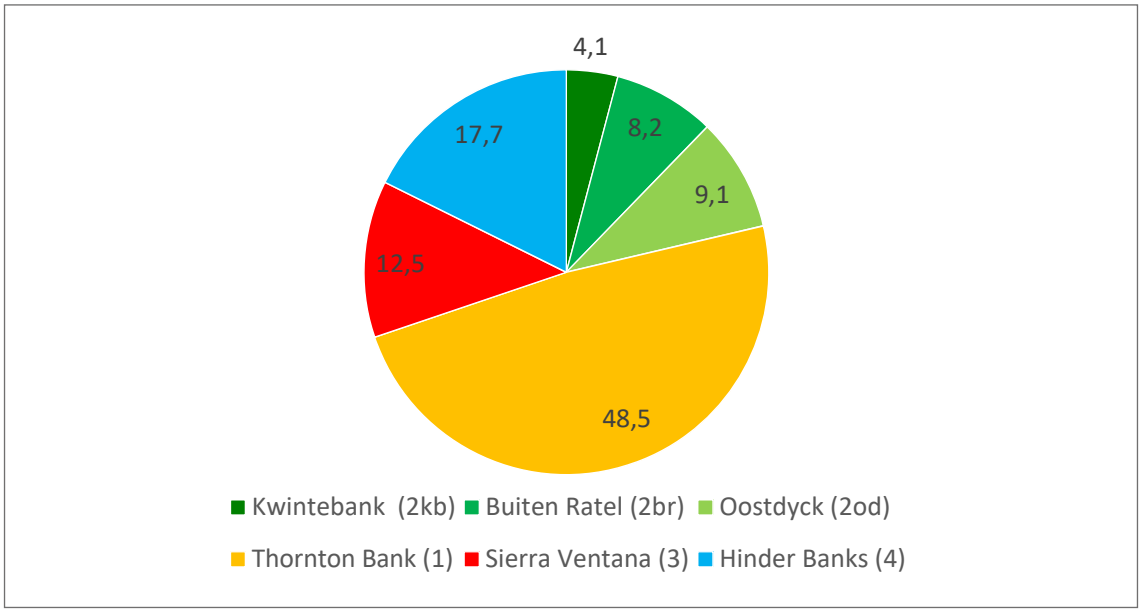
Graphic 3 – Evolution of the extraction of marine aggregates in the Belgian part of the North sea



Source: Continental Shelf Service, FPS Economy.

In 2019, 3.5 million m^3 of sand was extracted. 55 % of the sand was unloaded in Belgian ports, 15 % was used for beach nourishment and 30 % was unloaded abroad (the Netherlands, France and the United Kingdom). Thirteen percent of what was unloaded abroad ended up back in Belgium via inland shipping.

Graphic 4 – Distribution of the extraction activities in the period 2015-2019 over the different control zones



Source: Continental Shelf Service, FPS Economy.

In the period from 2015 to 2019, more than 48 % of the extraction took place in control zone 1, 21 % in control zone 2, 13 % in control zone 3 and 18 % in control zone 4. By adjusting the boundaries of the existing zones and the demarcation of a new control zone 5 on the Blighbank in the Marine Spatial Plan 2020-2026 (MSP 2020-2026), this ratio may change from 2020 onwards. The closure of some parts of the control zones due to the entry into force of the new reference surface in 2021 will probably also influence the distribution of the extraction.

6.2. The sand reserves

The economic sustainability of sand extraction can be increased by ensuring that sufficient sand reserves remain available on the long term. Based on the demarcation of the control zones in the Marine Spatial Plan 2020-2026 and the renewed reference level, we can calculate the total available stock of sediments for extraction. This calculation does not take into account technical limitations and the suitability of the sediments for extraction. The latter requires extensive knowledge of the sediment present, both on the surface of the seabed and in the subsoil. The results from the TILES project allow to visualize and quantify the sand reserves according to their different qualities.

By way of illustration, the total available volumes per sector were calculated and summarized in the table below. Only a rough estimation was made of the volume for zone 3, due to its specific nature (re-use of dumped material) and the unavailability of a detailed bathymetrical model within the adjusted demarcation of the Marine Spatial Plan 2020-2026.

Table 1 – Available volume of exploitable sand according to the demarcation in the MSP 2020-2026 and the new reference level, taking into account the extraction up to 2016

(= rough estimation of the volume)*

	Area	Available Volume
	in km^2	in million m^3
Sector 1a	71.46	93.20
Sector 2kb	32.64	60.95
Sector 2br	37.49	76.78
Sector 2od	15.79	49.50
Sector 3a/3b	19.94	90*
Sector 4a	19.14	80.18
Sector 4b	13.79	62.50
Sector 4c	9.13	59.79
Sector 4d	4.50	33.63
Sector 5	5.46	41.20

Source: Continental Shelf Service, FPS Economy.

7. The monitoring of sand extraction

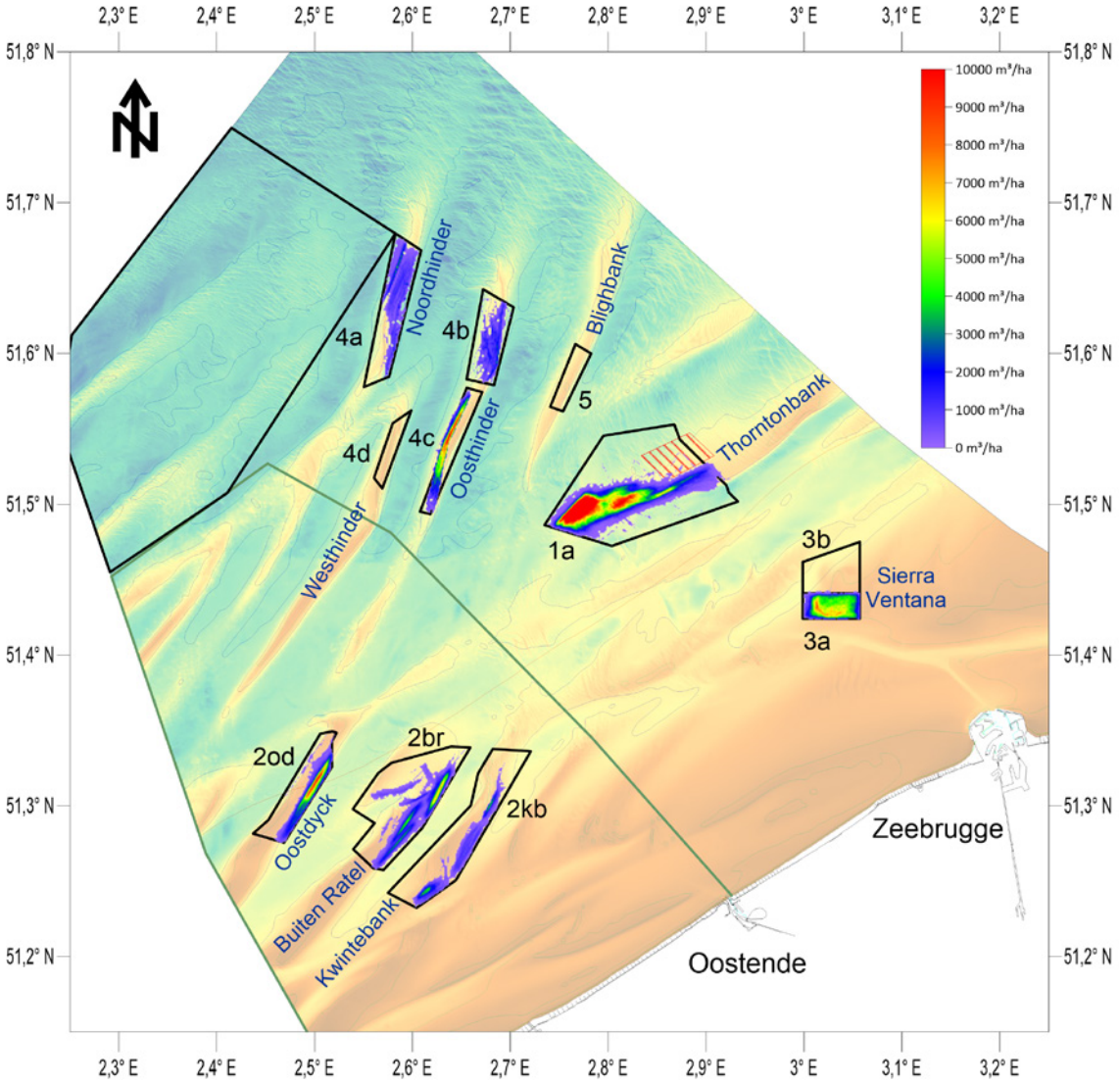
The monitoring of sand extraction takes place in two ways: monitoring of the activity and monitoring of the impact of the extraction on the marine environment.

7.1. Monitoring of the activity

Every mining vessel operating in the Belgian part of the North sea must have a log on board. In this log the captain of the mining vessel records all relevant information about each extraction operation. Since the late 1990s, the control of sand extraction has been facilitated by the presence on board of a sealed automatic recorder, also known as a “black box” (Electronic Monitoring System, EMS). Unannounced inspections can also be carried out at sea or in ports.

Figure 10 – Detailed mapping of the mining quantities (in m^3 per ha) based on EMS data in 2019

The control zones are pictured in black, the Thorntonbank monitoring area in red and the Habitats Directive area “Flemish Banks” in green.



Source: Continental Shelf Service, FPS Economy.

Automatic recorder

On board of every mining vessel, a Belgian "black box" has to be installed at the expense of the concession holder. After inspection and sealing of the system, the on board personnel sets the identification of the concession holder and the sequence number for each trip.

The black box automatically records the following parameters:

- *identification of the mining vessel;*
- *date and time of the registrations;*
- *position (geographical coordinates) and speed of the mining vessel;*
- *status of the pumps (on/off);*
- *status of extraction (on/off).*

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

Once the cargo has been measured, the captain enters the actual loaded volume (m^3) in the recorder.

Commissioned by the Continental Shelf service, the Measurement Service Ostend of the RBINS takes care of the management and inspection of these automatic recording devices, as well as the processing of the registered data. In this way, it can be checked whether the conditions imposed in the concession permit decision are respected.

7.2. Monitoring of the impact of extraction on the marine environment

Every year, various measurement campaigns are organized aboard the research vessels Belgica and Simon Stevin to investigate the consequences of the extraction on the seabed and on the marine environment. This research is carried out jointly by three bodies:

- the Continental Shelf Service (see section 8);
- the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO);
- the Management Unit of the North Sea Mathematical Models (MUMM – a scientific service of the Operational Directorate (OD) Natural Environment of the Royal Belgian Institute of Natural Sciences (RBINS)).

7.2.1. Measurements at sea with a multibeam sonar

Since 1999, the Continental Shelf Service carries out 4 to 6 surveys per year with the federal research vessel Belgica, and since 2012, it has also carried out research on board of the Flemish research vessel Simon Stevin.

Research vessels

Figure 11 – Images of the research vessels

Research vessel RV Belgica

© KBIN/OD Natuur

RV Simon Stevin

© VLIZ - Decleer

New research vessel RV Belgica

© Freire Shipyard/Rolls-Royce Marine AS

The “old” RV Belgica

In 1984, the oceanographic research vessel Belgica, which has its home port in Zeebrugge, entered into service. The ship was made available to Belgian scientists to carry out marine scientific research.

RV Belgica was at sea up to two hundred days a year and thanks to the special equipment on deck and a range of oceanological instruments, all types of samples could be taken from the water, the air and the seabed. On this floating laboratory, the Continental Shelf Service conducted research into the influence of sand extraction on the seabed.

In 1999 and ten years later in 2009, the Continental Shelf Service, in close collaboration with the Measurement Service Ostend of the RBINS, invested in two multibeam echo sounders that were installed on the RV Belgica. It is mainly thanks to these two measuring instruments that research has been conducted for 20 years on the influence of sand extraction on the seabed.

RV Simon Stevin

Every year, during a number of campaigns, the Continental Shelf Service also makes use of the Flemish research vessel Simon Stevin. This multidisciplinary research vessel is based in Ostend.

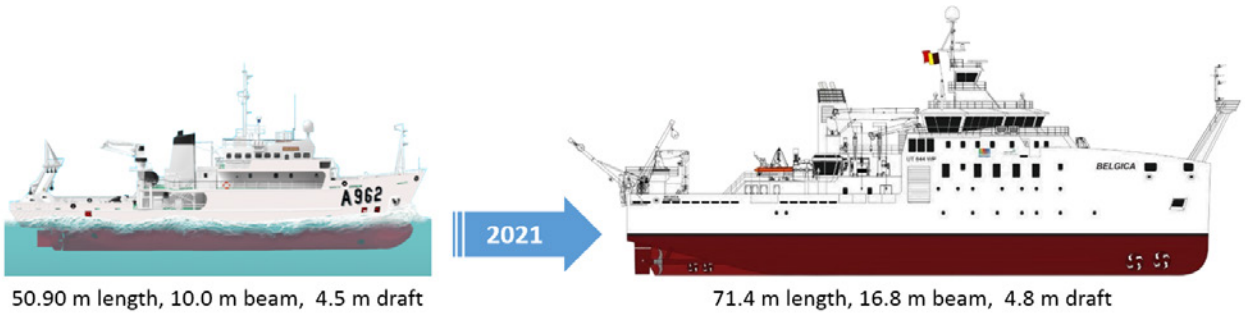
The RV Simon Stevin is equipped with all standard sampling equipment and high-tech sonar techniques to meet the needs of various marine research disciplines.

A dynamic positioning system ensures accurate positioning. A diesel-electric propulsion offers the possibility to navigate as a “silent ship”, allowing optimal use of all acoustic instruments, including the multibeam sonar.

The new federal research vessel: Belgica (II)

Since RV Belgica is due for replacement after 36 years of service, the Federal Government commissioned the building of a new modern research vessel.

Figure 12 – The distinction between the "old" and the "new" Belgica



This research vessel is also multidisciplinary and can support various research disciplines. In contrast to the old Belgica, there is more room for scientists and for research and it is equipped with the most modern scientific equipment. The ship can spend about 300 days at sea annually and is able to cover a larger research area. It is also built according to the strictest standards regarding energy consumption, emissions (green ship) and noise production (acoustically silent ship).

More information about the research vessels can be found on the websites of the Flanders Marine Institute (VLIZ) and BELSPO.

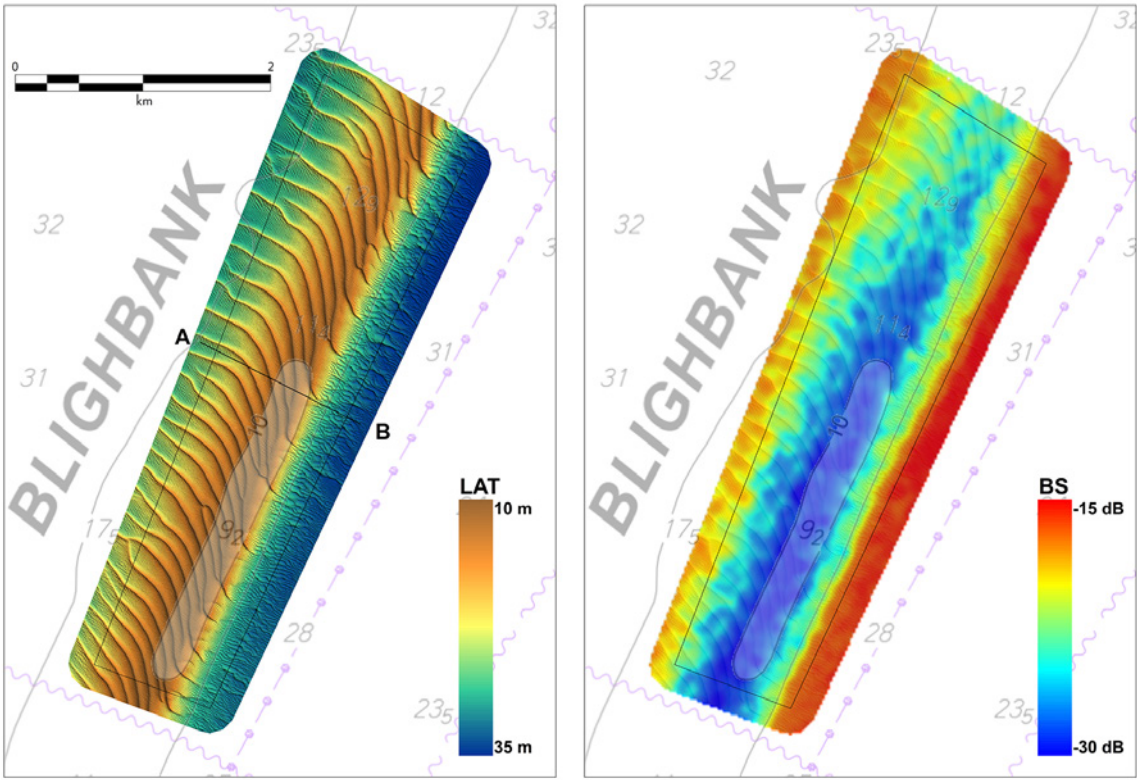
A multibeam sonar is used to generate a detailed mapping of the seabed from which the impact of sand extraction on the seabed's morphology can be evaluated. The multibeam echo sounder also allows to determine the nature of the seabed sediments. After measurements at sea, the data is subject to detailed study (corrections, controls and filtering) and processing. After the processing of the bathymetric data, which provides information about depth, the evolution of the seabed can be followed up precisely in the sand extraction zones. In this way, it is possible to evaluate the effects of mining.

Figure 13 shows the digital terrain model of control zone 5 as the end result of the thorough processing of the bathymetric and backscatter data.

Figure 13 – Control zone 5 based on multibeam measurements of 2018

Left: Terrain model (bathymetry in morphology, depth in meters relative to LAT)

Right: Backscatter strength (in decibels)



Source: Continental Shelf Service, FPS Economy (Background: hydrographic map BNZ 2014 - source: Flemish Hydrography).

Extensive cooperation with scientific institutions is required to conduct thorough impact monitoring and research. In 1999, the Federal Public Service Economy bought a multibeam sonar and installed it on board of the RV Belgica in collaboration with the MUMM. In 2009, in order to measure faster and more efficiently and to create more detailed maps, the Continental Shelf Service replaced the device on board with a newer model. This multibeam sonar is not only used by the service itself, but is also available for all scientific institutions for, among others, determining the physical impact of beam trawling and registering wreck sites. In this way the Federal Public Service Economy has an important contribution to marine research in Belgium. This is also reflected in the cooperation between the Continental Shelf Service and the Flanders Marine Institute (VLIZ) for the multibeam sonar on board of the research vessel Simon Stevin. Here too, continuous cooperation is necessary to work in a high-quality manner.

This cooperation continues with the new research vessel Belgica: the Federal Public Service Economy is again investing in the installation of the specific multibeam sonar for mapping the seafloor of the Belgian part of the North Sea.

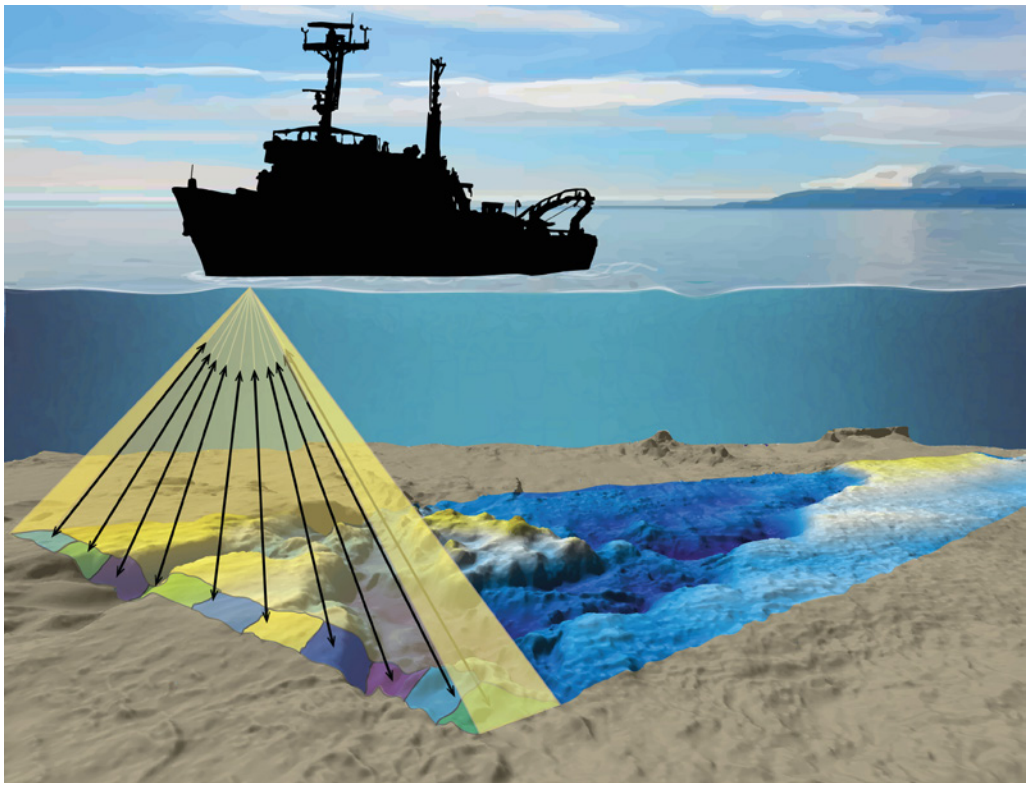
How does a multibeam echosounder work?

A multibeam echosounder consists of one or two transmit and receive units, called transducers, which are mounted under the ship's hull. These transducers transmit several acoustic pulses simultaneously at different angles (figure 14): 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 (echo detection). As the ship moves, the depths are measured several times per second for each pulse. 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 complete coverage of the area. In order to accurately position the depth measurements, the 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). These movements are compensated when calculating the correct positions and depths.

In addition to the bathymetry (figure 14), the multibeam echosounder records the reflection of the signal or backscatter (figure 15). Backscatter allows to characterize the nature of the seabed but is relatively complex since it also depends on the geometry of the measurements and the settings applied to the multibeam echosounder at the time of data acquisition. Rigorous corrections are required to extract useful information from the backscatter data, such as the type of sediment, the characterization of marine habitats and the monitoring of the impact of extraction on the nature of the seabed.

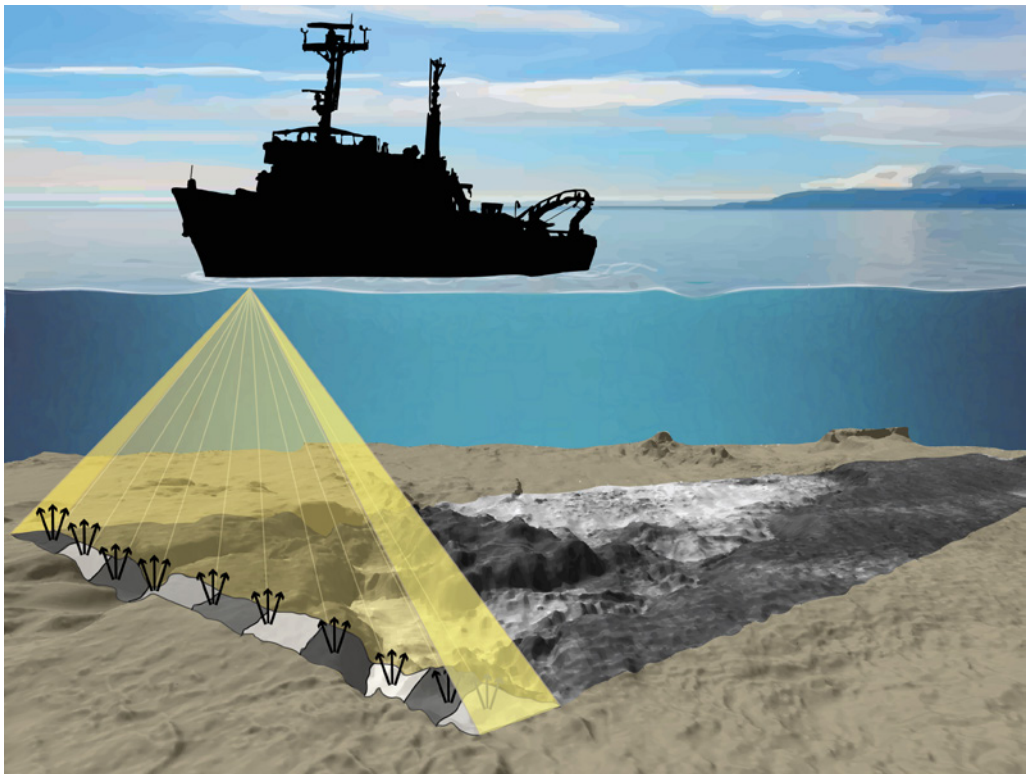
A modern multibeam echosounder is the ideal instrument for the creation of bathymetric maps, and the mapping of habitats and underwater heritage.

Figure 14 – Depth measurement with the multibeam



Source: Applied Oceans Research Group, Nova Scotia Community College.

Figure 15 – Measurement of the difference in energy (backscatter) with the multibeam



Source: Applied Oceans Research Group, Nova Scotia Community College.

7.2.2. Monitoring

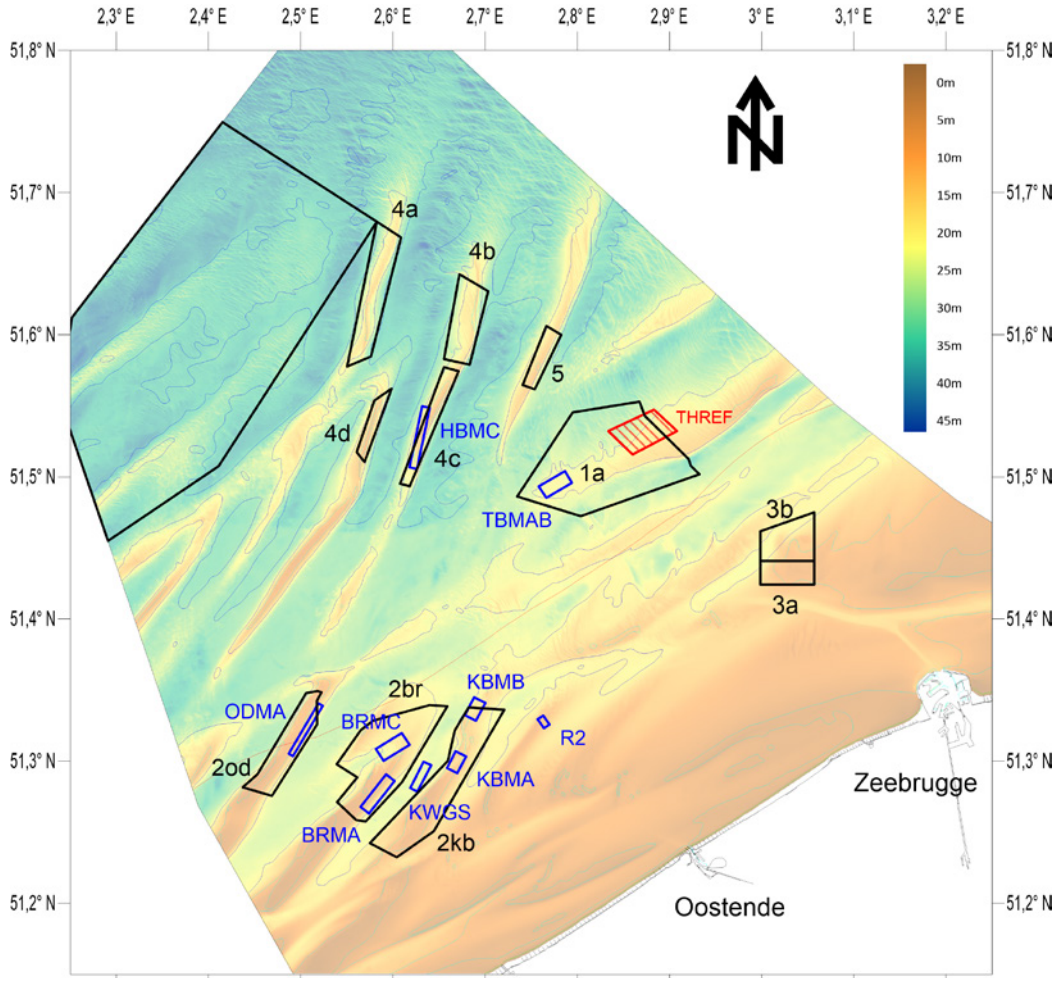
In order to evaluate the consequences of the extraction more accurately, several monitoring zones were defined. A monitoring zone is an area that is surveyed on a regular basis in order to accurately follow up the evolution of the extraction on the seabed and to evaluate the impact of the sand extraction. Such a monitoring zone can be located both inside and outside a control zone. In this way, the evolution of the seabed in a mining area can be compared to the natural evolution of the seabed. These areas are mapped at least twice a year.

Figure 16 shows the monitoring zones:

- on the Middelkerkebank: R2;
- on the Kwintebank: KBMA and KBMB;
- on the Buiten Ratel: BRMA and BRMC;
- between the Kwintebank and the Buiten Ratel (Kwintegeul): KWGS;
- on the Oostdyck: ODMA;
- on the Thornton Bank: TBMAB;
- on the Hinder Banks: HBMC.

Figure 16 – The control zones and the exploration zone are in black with the monitoring zones in blue

The monitoring zone on the Thorntonbank (THREF) is shown in red.



Source: Continental Shelf Service, FPS Economy.

In 2020, following the initiative of the Continental Shelf Service and the Flemish Hydrography, a zone was delineated for the calibration and quality evaluation of measuring devices. The KWINTE reference zone (KWGS) is defined in the Marine Spatial Plan 2020-2026 for the Belgian part of the North Sea as a reference zone for underwater acoustic measurements. Since the installation and configuration of the measuring devices is different on every vessel that performs acoustic measurements with a multibeam sonar, a thorough calibration of the systems on a well-known area is required to ensure the quality of the measurements. More information about this zone is available on the website of the Flemish Hydrography.

7.2.3. The impact of sand extraction

Research of the Continental Shelf Service shows a linear correlation between the extracted volumes and the evolution of the depth of the seabed. On a larger scale, almost all of the variation in depth can be explained by mining activities. The Continental Shelf Service states that sand and gravel are a non-renewable resource and that the impact of extraction is only local and does not lead to further natural erosion.

In addition to the impact on the seabed, the biological impact of sand extraction on the marine environment is also examined. This is done in collaboration with ILVO. Their research shows that the biological impact of sand extraction depends on the local geological context and on the intensity and frequency of the extraction. The resilience of the benthic species also plays a role.

The OD Natural Environment is responsible for monitoring hydrodynamics and sediment transport. They monitor this on the basis of numerical models and terrain measurements and establish the relationship with possible habitat changes. Numerical impact models are linked to geological models in 3D and thus map the quality and quantity of the extractable geological layers.

The most recent research results are always presented at the sand extraction study day that takes place every three years. A written record of this can be found in the article bundles (in English).

8. The tasks of the Continental Shelf Service

The Continental Shelf Service of the FPS Economy, SMEs, Self-employed and Energy is responsible for sand and gravel extraction in the Belgian part of the North Sea.

The main tasks of the service are:

- granting of concession permits;
- management of operating concessions;
- control of sand extraction;
- updating the related legislation;
- management of the “Budget for Sand Extraction” (formerly the Fund for Sand Extraction).

The Continental Shelf Service is the reference for sand extraction on the Belgian Continental Shelf and has extensive cartographic data and other documentation. Every three years, the service organizes a study day in which, among other things, the monitoring results of the past three years are discussed.

Information

Federal Public Service Economy, SMEs, Self-employed and Energy
Directorate-General Quality and Safety
Quality and Innovation Division
Continental Shelf Service
Koning Albert II-laan 16
1000 Brussels
copco@economie.fgov.be
https://economie.fgov.be/en/themes/enterprises/offshore-sand-and-gravel
https://www.facebook.com/continentaalplat/

Contacts

- Marc Roche – head of service
  Surveys, data processing and analysis
  Marc.Roche@economie.fgov.be – 02 277 77 47

- Florian Barette – analyst
  Control, GIS and data analysis
  Florian.Barette@economie.fgov.be – 02 277 85 18

- Koen Degrendele – analyst
  Surveys, data processing and analysis
  Koen.Degrendele@economie.fgov.be – 02 277 84 11

- Ilse Herpoelaert – administrative expert
  Secretariat, surveys and data processing
  Ilse.Herpoelaert@economie.fgov.be – 02 277 67 79

- Patrik Schotte – expert for regulations
  Regulations and quality system
  Patrik.Schotte@economie.fgov.be – 02 277 85 51

- Helga Vandenreyken – case manager
  Management of concession files, Advisory Committee, accounting and communication
  Helga.Vandenreyken@economie.fgov.be – 02 277 87 78

FPS Economy, S.M.E.s, Self-employed and Energy

Rue du Progrès 50
1210 Brussels
Enterprise no: 0314.595.348
economie.fgov.be