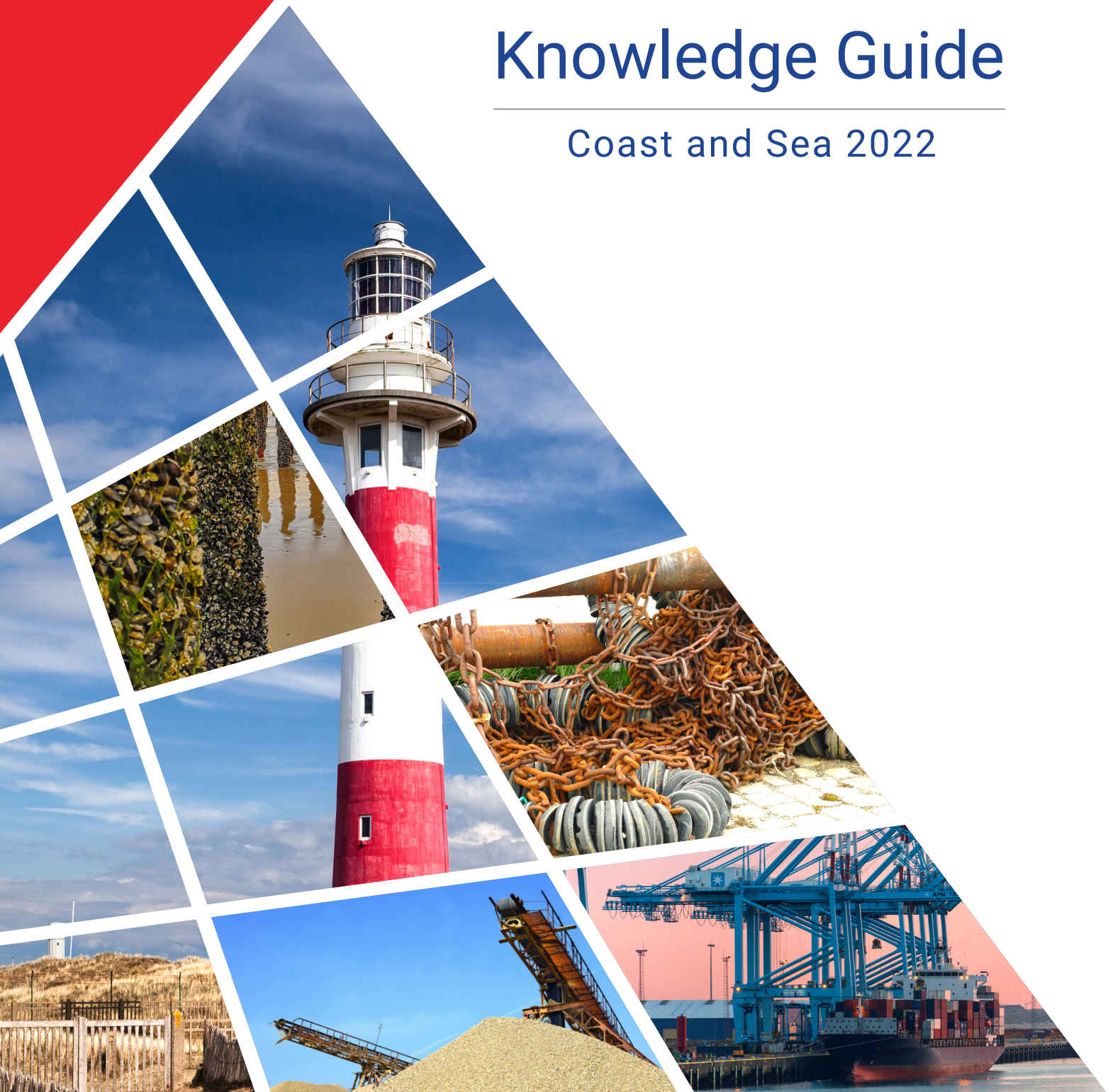
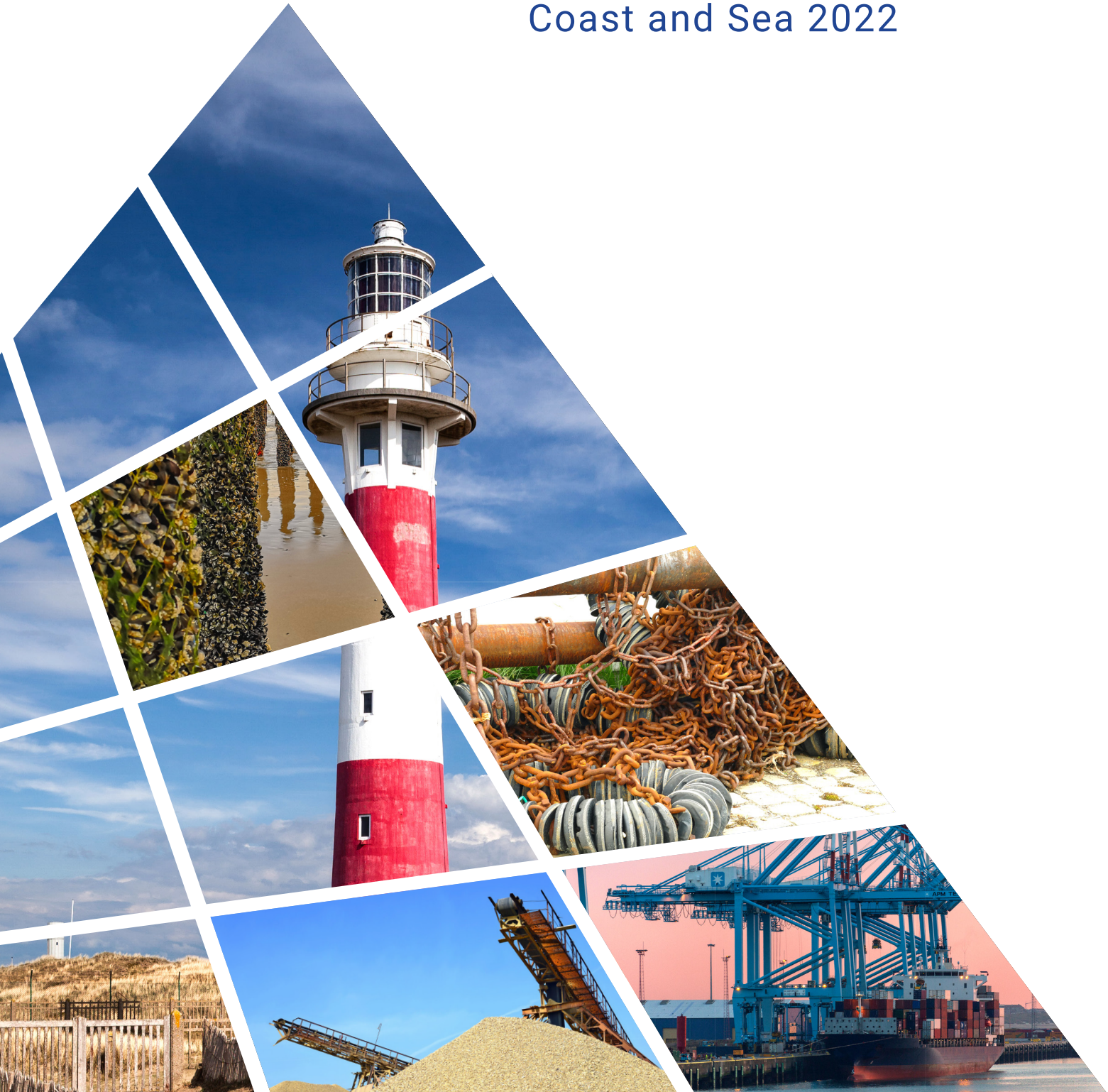
Knowledge Guide

Coast and Sea 2022



Knowledge Guide

Coast and Sea 2022



Colophon

The **Knowledge Guide Coast and Sea 2022** is a publication that is being prepared as part of the Compendium for Coast and Sea. The Compendium is coordinated by Flanders Marine Institute (VLIZ) and is the result of a cooperation between various academic groups, government bodies, civil society organisations and consultation platforms relating to the coast and sea. These bodies are represented in the 'Expert Group Compendium for Coast and Sea', which also provides for the process validation and quality assurance of the initiative.

The Compendium for Coast and Sea can be consulted online at www.compendiumcoastandsea.be. For the spatial data we refer you to the Coastal Portal (www.kustportaal.be). Both digital platforms are available in both Dutch and English and are updated regularly.

Secretariat Compendium for Coast and Sea (VLIZ):
dr. Hans Pirlet
dr. Thomas Verleye
Steven Dauwe
Lisa Devriese
Matthias Sandra
dr. Fien De Raedemaecker
Ine Moulaert
Chantal Martens
Maxime Depoorter
dr. Ann-Katrien Lescrauwaet

Contact:
compendium@vliz.be

Citation:
Dauwe, S.; Verleye, T.; Pirlet, H.; Martens, C.; Sandra, M.; De Raedemaecker, F.; Devriese, L.; Lescrauwaet, A.-K.; Depoorter, M.; Moulaert, I.; Mees, J. (Eds.) (2022). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. Flanders Marine Institute (VLIZ): Ostend. 267 p.
https://dx.doi.org/10.48470/25

Responsible publisher:
Jan Mees (Flanders Marine Institute, VLIZ)
Wandelaarkaai 7
8400 Ostend
Belgium

Graphic design:
Policy Information Division (VLIZ), Cayman bvba (Bruges) en Zoeck (Oostkamp)

Credits:
Pictures cover: Lighthouse © El Lobo / Aquaculture © Luoxi / Fisheries © Shutterstock / Sand extraction © Smereka / Port © Shutterstock

With valued contribution of:
Britt Lonneville, Jonas Lescroart, Chilekwa Chisala, Zohra Bouchti, Heike Lust, Fons Verheyde and the VLIZ-staff.

COMPENDIUM KUST & ZEE / COAST & SEA

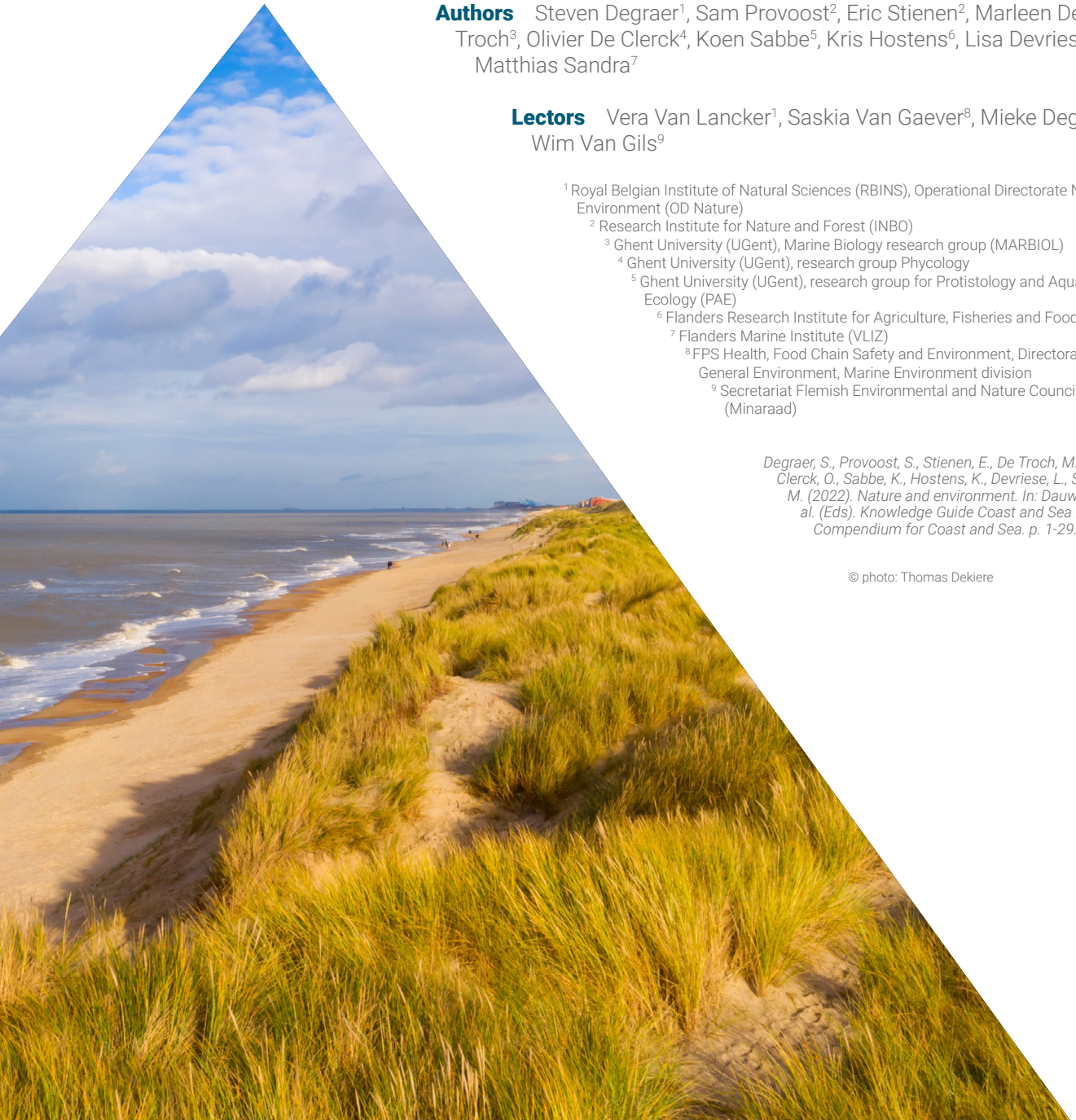
VLIZ

west-vlaanderen de gedreven provincie

Vlaanderen verbeelding werkt

Table of content

1 Nature and environment



Authors Steven Degraer[1], Sam Provoost[2], Eric Stienen[2], Marleen De Troch[3], Olivier De Clerck[4], Koen Sabbe[5], Kris Hostens[6], Lisa Devriese[7], Matthias Sandra[7]

Lectors Vera Van Lancker[1], Saskia Van Gaever[8], Mieke Degloire[8], Wim Van Gils[9]

[1] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature)
[2] Research Institute for Nature and Forest (INBO)
[3] Ghent University (UGent), Marine Biology research group (MARBIOL)
[4] Ghent University (UGent), research group Phycology
[5] Ghent University (UGent), research group for Protistology and Aquatic Ecology (PAE)
[6] Flanders Research Institute for Agriculture, Fisheries and Food (ILVO)
[7] Flanders Marine Institute (VLIZ)
[8] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[9] Secretariat Flemish Environmental and Nature Council (Minaraad)

Degraer, S., Provoost, S., Stienen, E., De Troch, M., De Clerck, O., Sabbe, K., Hostens, K., Devriese, L., Sandra, M. (2022). Nature and environment. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 1-29.

With an average water depth of 95 m, the North Sea is a rather shallow sea, which is mainly located on the European continental shelf. The seabed is predominantly characterised by sandy habitats. In the North Sea, water of the North Atlantic Ocean is mixed with fresh water from rivers of the surrounding countries (Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France and the United Kingdom) (OSPAR QSR 2010). The surface area of the North Sea amounts to approximately 670,000 km² (European Environment Agency 2015), of which the Belgian part of the North Sea (BNS) covers a modest 3,454 km², approximately 0.5% of the surface area of the North Sea (Dauwe et al. 2019, Verhalle and Van de Velde 2020). More geographical information about the BNS can be found on the Coastal Portal and the Marine Atlas. The current text elaborates on several natural and environmental characteristics of the BNS and its adjacent coastal area.

1.1 Characteristics of the marine and coastal environment

1.1.1 Sea

The marine ecosystem is a complex natural system of biotic (living organisms) and abiotic (physical and chemical) elements and consists of aquatic environments with high concentrations of dissolved salt. Marine organisms are highly dependent on each other and their abiotic environmental factors. The primary producers (phytoplankton and macroalgae) are the main food source of the zooplankton. Zooplankton and benthos are utilised as food by numerous organisms, including most fish species. Fish species, in turn, are an important food source for spcies of higher trophic levels such as seabirds, predatory fish and marine mammals. The marine food web is composed of a series of food chains that connect different trophic levels. This complex system is further enlarged by interactions with bacteria, microbiota and fungi, each of which plays an important role in the marine ecosystem, both in the soil and the water column (Herndl and Weinbauer 2003). These biotic interactions are additionally influenced by abiotic environmental factors. The highly dynamic nature of the marine environment causes organisms to be exposed to various natural stressors (salt stress, oxygen depletion, light penetration, currents, etc.). The biotic and abiotic elements of the marine ecosystem are further elaborated separately and at different levels below.

1.1.1.1 Abiotic elements of the marine ecosystem

Bathymetry and substrate

The BNS is a shallow part of the North Sea with a seabed that gradually deepens in a northwesterly direction up to a depth of 40 to 45 m. The relief of the seabed is characterised by the presence of a complex dynamic system of gullies and sandbanks. The sandbanks can be up to 30 m high in relation to the channels, 15 to 25 km long and 3 to 6 km wide. The orientation of the banks varies from parallel to the coast to southwest-northeast in the deeper parts of the BNS (figure 1). The substrate of the seafloor generally consists of non-consolidated Quaternary sediments with low thicknesses in the channels and up to 50 m at the level of the sandbanks (Le Bot et al. 2003 (BELSPO), Mathys 2009, Mathys 2010, Van Lancker et al. 2019 (TILES project BELSPO)). Underneath these Quaternary sediments is Paleogenic clay which is locally found at the seabed in the trenches. Often, this is accompanied by the occurrence of gravel (Lanckneus et al. 2001 (BUDGET project BELSPO), Le Bot et al. 2003 (BELSPO), Mathys 2009, Mathys 2010, De Clercq et al. 2016, Van Lancker et al. 2019 (TILES project BELSPO)). In general, the grain size distribution of the sediment on the seabed generally becomes coarser as the distance from the coast increases, and varies from silt-rich sediment close to the coast over fine to coarse sand in deeper waters, interspersed with gravel fields (Verfaillie et al. 2006, Van Lancker et al. 2007 (MAREBASSE project BELSPO), Van Lancker et al. 2015, Van Lancker et al. 2019 (TILES project BELSPO)).

Hydrodynamics and sediment transport

The currents in the BNS are dominated by semi-diurnal tides[1]. The tidal range can vary from 3 m at neap tide to over 4.5 m during spring tide, with a decreasing tidal range (between low and high tide) towards the northeast. Tidal currents can reach up to 1.2 m/s and are the main cause of sediment transport. In addition, currents caused by the wind can also play a role in this transport (Lanckneus et al. 2001 (BUDGET project BELSPO), Fettweis and Van den Eynde 2003, De Moor 2006, Van Lancker et al. 2012 (QUEST4D project BELSPO), Baeye 2012, Van Lancker et al. 2015). High concentrations of suspended sediment often occur along the Belgian coast, leading to zones of extremely turbid water (Fettweis and Van den Eynde 2003, Fettweis et al. 2007 (MOCHA project BELSPO), Baeye 2012, Fettweis and Baeye 2015, Fettweis et al. 2016, Fettweis and Lee 2017, Shen et al. 2018, Vanlede et al. 2019, Fettweis et al. 2019, Van Maren et al. 2020).

[1] Tidal type where there are two high tides and two low tides per day.

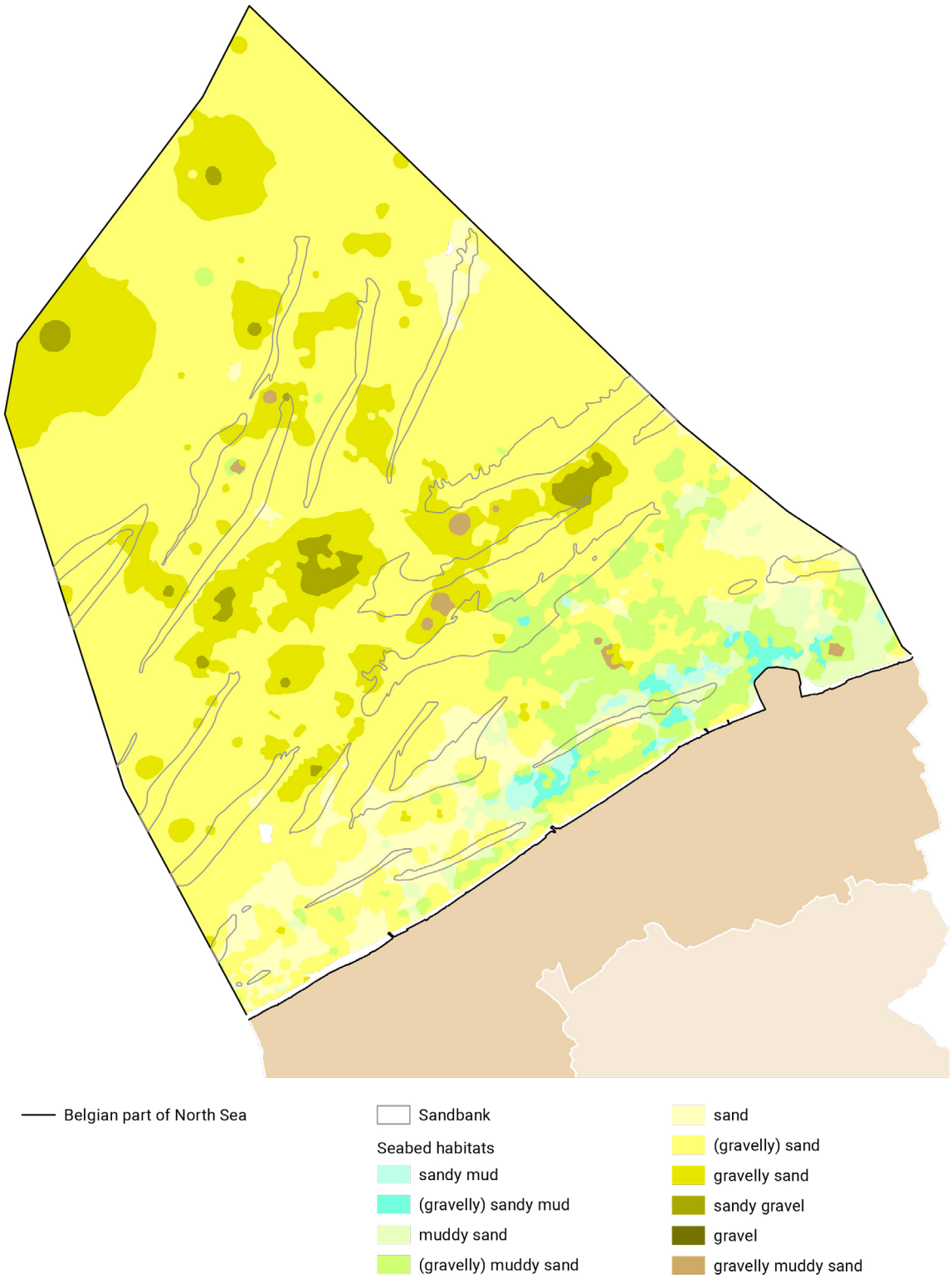


Figure 1. The sandbanks of the BNS, and the occurrence and distribution of seafloor habitat types mapped according to percentages of silt, sand, and coarse-grained sediments (Source: EMODnet Bathymetry, Van Lancker et al. 2013, Coastal Portal).

Measurement data and information on the hydrological and meteorological aspects (tides, currents, waves, wind, etc.) of the BNS can be consulted on the Flemish Banks Monitoring Network of the Flemish Hydrography. The administration also publishes the annual publication of the tide tables (Getijboekje 2021). Operational models using the hydro-meteorological data are available on the website of RBINS-Operational Directorate Natural Environment (OD Nature).

Seawater characteristics

The temperature of seawater in the BNS varies seasonally between 5°C and 20°C (Flemish Banks Monitoring Network). The seawater salinity in the BNS is strongly influenced by the river plumes[2] of the Scheldt, Rhine, Seine and Meuse rivers. This inflow of freshwater (salinity 0 PSU[3]) reduces the salinity of the water entering the BNS via the Channel (salinity 35 PSU) (Lacroix et al. 2004). The carbon chemistry of seawater has a seasonal variation and affects the acidity (pH) of the water, which fluctuates between 7.95 and 8.25 (Gypens et al. 2011, Le Quéré et al. 2015, Le Quéré et al. 2016, see also the Integrated Carbon Observation System (ICOS) and its entry in Schneiders et al. 2020 part E.7 Noordzee). Information about the nutrients and oxygen levels in the seawater was, *inter alia*, gathered in the context of the AMORE project (BELSPO), AMORE II project (BELSPO) and AMORE III project (phase 1 and phase 2 BELSPO) and the monitoring obligations for the OSPAR Commission (see also OSPAR IA 2017), the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (see below **2.4 Protection of the marine and coastal environment**). The impact of climate change on the physical seawater characteristics in the BNS is discussed in Van den Eynde et al. (2011) (CLIMAR project BELSPO), Huthnance et al. 2016, the Coastal Vision project (formerly Flemish Bays, e.g. De Maerschalck et al. 2017) and in the CREST project (see also thematic chapter **Safety against flooding**).

1.1.1.2 Biotic elements of the marine ecosystem

Benthic life

The sandbanks and channels in the BNS (EU Habitats Directive Habitat Type 1110) are characterised by a rich benthic life (benthos). Given the high turbidity[4] of the seawater, microphytobenthos[5] is almost absent from the (subtidal) BNS. Benthic life here is dominated by zoobenthos. The benthos has been subject of intensive research since 1970 and tracked through biomonitoring (e.g. Cattrijsse and Vincx 2001, Van Hoey et al. 2004, Degraer et al. 2006, Degraer et al. 2008, Merckx et al. 2010, Vanaverbeke et al. 2011, Van Hoey et al. 2013, De Backer et al. 2014, Van Hoey et al. 2014, Vieren 2014, TROPHOS project (BELSPO), WESTBANKS project (BELSPO), ICES 2017, Hummel et al. 2017 (COST Action EMBOS ES1003), Van Hoey et al. 2019, Belgian State 2020). The benthos constitutes an important food source for fish, shrimps, crabs and even some birds, and actively influences the degradation and transport of organic matter and nutrients (e.g. Braeckman et al. 2010, Braeckman 2011, Van Ginderdeuren 2013, Courtens et al. 2017). The following section provides more details on the classification and spatial distribution of benthic organisms in the BNS:

- Just above the seabed of the North Sea, in the lowest meter of the water column, the hyperbenthos can be found, which mainly consists of fish larvae, crustaceans and mysid shrimps (e.g. Mees 1994, Beyst 2001, Dewicke 2002, Fockedey 2005, De Neve et al. 2020);
- On the seabed, large numbers of starfish (Asteroidea), serpent stars (Ophiuroidea), shrimp (Caridea), crabs (Brachyura), lobsters (Astacidea) and squids (Cephalopoda), as well as sea anemones (Anthozoa) like dead man's finger (*Alcyonium digitatum*) can be observed on the rocky substrates. Together with a number of less common species, they form the epibenthos, referring to their way of life just on the seabed (e.g. Hostens 2003, Calewaert et al. 2005, Vieren 2014, Vandendriessche et al. 2015, De Backer et al. 2016, Breine et al. 2018a);
- The bottom of the BNS serves as an important breeding ground for benthic[6], demersal[7] and bentho-pelagic fish[8] (Vieren 2014, Vandendriessche et al. 2015, De Backer et al. 2016, Degraer et al. 2019, Pecceu and Van Hoey 2020). The most common demersal flatfish in the BNS are plaice (*Pleuronectes platessa*), sole (*Solea solea*), dab (*Limanda limanda*), lemon sole (*Microstomus kitt*) and brill (*Scophthalmus rhombus*). Other dominant demersal fish species are the lesser weever (*Echiichthys vipera*), dragonet (*Callionymus*

[2] Fresh water discharge from rivers.
[3] Practical salinity unit.
[4] The turbidity level is a measure of relative clarity of a liquid.
[5] Microscopic primary producers living on and in the upper centimeters of benthic substrates.
[6] Fish that live and feed on or in the seabed.
[7] Fish that live and feed on or near the seabed.
[8] Fish that live and feed just above or near the seabed.

spp.), whiting (*Merlangius merlangus*), pouting (*Trisopterus luscus*) and hooknose (*Agonus cataphractus*) (Reubens 2013, Vieren 2014, Degraer et al. 2020);
- Most species of soil-dwelling organisms can be found among the sand grains (infauna or endobenthos), mainly to a depth of approximately 10 cm below the seabed: these are mainly bivalves, polychaete worms, small crustaceans (macrobenthos[9], Speybroeck et al. 2004, Degraer et al. 2006), nematodes and copepods (meiobenthos[10], Speybroeck et al. 2004);
- The bacterial community in the seabed is clearly different from that in the water column (De Tender et al. 2015). The highest richness and diversity of bacteria in the soil is recorded in June, linked to the breakdown of phytoplankton blooms, while β-AOB and AOA[11] peaks occur in September (Yazdani Foshtomi et al. 2015). Seasonal variations in the composition of the bacterial community are also stronger in fine sediments (Franco et al. 2007). The biogeochemistry of the seabed, including the carbon cycle, is described specifically for the Belgian coastal zone in Van de Velde et al. (2018);
- The spatial and seasonal variation in composition of microbial eukaryotes (protists) in the subtidal North Sea are described in Pede (2012). The diversity of protists is also associated with the grain size of the sediment, geochemistry and metal contamination.

The distribution of bottom-dwellers is not uniform and is strongly linked to the physical characteristics of the seabed (e.g. grain size of the sediment) and to the lower part of the water column (for more information on distribution and numbers of species, see Degraer et al. 2008). Firstly, the seabed of the BNS is mainly characterised by soft substrates (from silt to fine to coarse sand). Five typical macrobenthic communities are found in the soft mobile substrates of the subtidal sandbanks (Van Hoey et al. 2004, Breine et al. 2018a). In the intertidal zone on the beach, a sixth community is found:

- The *Limecola balthica* community (subtidal);
- The *Abra alba* community (subtidal);
- The *Magelona-Ensis leei* community (subtidal);
- The *Nephtys cirrosa* community (subtidal);
- The *Hesionura elongata* community, before *Ophelia borealis-Hesionura elongata* community (subtidal);
- The *Eurydice pulchra-Scolelepis squamata* community (intertidal).

These communities, characterised by distinctive species with a certain diversity and density, are each observed in a specific and relatively well-defined environment (Degraer et al. 2003, Van Hoey et al. 2004, Degraer et al. 2008, Breine et al. 2018a).

In addition to the soft substrates, geogenic and biogenic reefs also occur in the BNS (EU Habitats Directive Habitat Type 1170). Geogenic[12] reefs host a typical fauna that lives on top of the gravel beds (so-called hard substrate epifauna) with e.g. sponges, soft corals, bryozoans and sea anemones (Van Lancker et al. 2007, Houziaux et al. 2008, Van Lancker 2017). Given the importance of these hard substrates for biodiversity, the evolution of natural gravel beds is being monitored (Van Lancker et al. 2016, De Mesel et al. 2017, Montereale-Gavazzi et al. 2018, Belgian State 2018a, Fettweis et al. 2020 (INDI67 project BELSPO), Van Lancker et al. 2020). Biogenic reefs are mainly shaped by the sand mason worm (*Lanice conchilega*) (Rabaut et al. 2009).

The increasing use of artificial hard substrates (e.g. wind turbines and artificial reefs) creates new opportunities for benthic organisms (Degraer et al. 2020). The dense coverage of the structures with a typical fauna of rocky substrates is striking: e.g. the mussel (*Mytilus edulis*) and the sea anemone (De Backer et al. 2020, Coolen et al. 2020). In addition, the scour protection of wind turbines provides opportunities for various species: e.g. the European lobster (*Homarus gammarus*) and the North Sea crab (*Cancer pagurus*) (Krone et al. 2017), macro algae, fish such as pouting (*Trisopterus luscus*) and cod (*Gadus morhua*) (Degraer et al. 2013, Reubens et al. 2013, Kerckhof et al. 2018, Vanaverbeke and Coolen 2019, Degraer et al. 2020), etc. Braeckman et al. (2020) showed that the species composition of the macrobenthic community varies according to the distance to the wind turbines. In general, a higher density and diversity was observed closer to the wind turbines. In addition, the structures provide space for an intertidal flora and fauna in the open sea in Belgian waters, which consists for a considerable part of non-indigenous species (Kerckhof et al. 2016, Kerckhof et al. 2018, Verleye et al. 2020). The effects of these hard substrates on the structure and activity of the biological communities in and on the surrounding soft substrates are monitored in the framework of several projects (e.g. Coates et al. 2013, Baeye and Fettweis 2015, FaCE-IT project (BELSPO), PERSUADE project (BELSPO), OUTFLOW project (BELSPO), Derweduwen et al. 2016, Mavraki 2020, Degraer et al. 2020).

[9] Organisms living on or in the seabed and larger than 1 mm.
[10] Organisms living in or on the seabed and between 0.063 and 1 mm in size.
[11] Ammonium oxidising bacteria (AOB) and ammonium oxidising archaea (AOA).
[12] Reefs whose topographic expression is the result of geological phenomena such as the gravel beds of the Hinderbanks.

Pelagic organisms

The pelagic zone or 'water column' (the ecological zone consisting of open water) mainly houses the floating phytoplankton, zooplankton, bacterioplankton and the actively swimming nekton (including specific fish species) and marine mammals (see below). The pelagic zone is the largest habitat in the world but, unlike the benthic ecosystem, has not been subject to a long research tradition in Belgian waters. The different components of the pelagic habitat are discussed below:

- Phytoplankton constitutes an important aspect of the marine food web (Castellani and Edwards 2017, Amadei Martinez et al. 2020). Changes in phytoplankton dynamics can strongly influence the zooplankton dynamics (Lancelot et al. 2007). The LifeWatch observatory is making efforts to map these phytoplankton communities. (Nohe 2019, Amadei Martinez et al. 2020, Lagaisse 2020, VLIZ 2021). The phytoplankton concentration, which typically achieves high concentrations in the coastal waters, is analysed on the basis of satellite images and chlorophyll a concentrations (Rousseau et al. 2006). In the last few decades, there have been strong changes in the phytoplankton of the BNS. In the period 1970-2000 the concentration of diatoms and dinoflagellates increased. After the turn of the century, however, the total phytoplankton biomass decreased and the annual phytoplankton bloom occurred earlier in spring. These changes are linked to a combination of de-eutrophication and climate warming. Furthermore, the number of potentially toxic phytoplankton species increased (Nohe et al. 2020, Desmit et al. 2020). During the summer months, a strong bloom of the dinoflagellate sea sparkle (*Noctiluca scintillans*) is often observed in Belgian waters. This bloom causes beautiful luminescent effects in warm and calm weather, but can lead to local oxygen deficiency due to the high oxygen consumption (Van Mol et al. 2007, Ollevier et al. 2020, AMORE II project (BELSPO)). In addition, it is important that the problems (structural and functional changes in ecosystems, habitat and biodiversity loss) related to the annual seasonal change in phytoplankton composition (e.g. Phaeocystis blooms) as a result of eutrophication are monitored properly (see thematic chapter **Agriculture**) (Vasas et al. 2007);
- The zooplankton community[13] of the BNS has a typical coastal nature, but is occasionally influenced by introduced species originating from the inflow of Atlantic water (Van Ginderdeuren 2013). The crustaceans (Crustacea), and more specifically the calanoid copepods (holoplankton[14], 66%), dominate the zooplankton with *Temora longicornis, Euterpina acutifrons, Acartia clausi, Paracalanus parvus* and *Centropages typicus* being the most common species (Van Ginderdeuren et al. 2012a, Deschutter et al. 2017, Semmouri et al. 2020). In addition, meroplanktonic[15] larvae of polychaetes, echinoderms, fish and barnacles are abundant in the BNS. May and June are the months with the highest mean zooplankton densities, followed by a smaller autumn peak in September. Zooplankton densities vary from 150 to 15,000 ind.m^{-3} and reach their peak a few kilometres off the coast, in the transition zone from coastal to offshore waters (Van Ginderdeuren et al. 2014a). Since 2012, the LifeWatch observatory has been monitoring zooplankton communities both nearshore (monthly) and offshore (seasonally) (Mortelmans et al. 2019, VLIZ 2020);
- Within the zooplankton community, specific attention has been paid to jellyfish (e.g. the non-indigenous warty comb jelly (*Mnemiopsis leidyi*) (Van Ginderdeuren et al. 2012b, Vansteenbrugge et al. 2015a, 2015b) and the common jellyfish (*Aurelia aurita*) (Dulière et al. 2014)), and copepodes (e.g.. the invasive *Caligus brevicaudatus* (Mortelmans et al. 2017) and *Pseudodiaptomus marinus* (Deschutter et al. 2018)). Zooplankton is generally considered to be one of the better bio-indicators to demonstrate environmental changes (e.g. ICES WGZE Report 2017, ICES WGZE Report 2021);
- The bacterioplankton, which is dominated by Proteobacteria and Bacteroidetes, is also a sensitive ecological indicator. Since 2012, the bacterial communities in the seawater of the BNS have been studied using DNA-based techniques (De Tender et al. 2015, Kopf et al. 2015, ten Hoopen et al. 2015, De Tender 2017, Micro B3 project, LifeWatch observatory);
- In the pelagic zone, floating macroalgae (besides drifting debris) provide a special habitat for numerous organisms. These organisms can originate from rocky shores where the macroalgae were detached (e.g. various species of marine isopods) and from colonising species at sea (e.g. by larval stages of many crustaceans). In North Atlantic waters, mainly *Himanthalia elongata*, *Ascophyllum nodosum*, *Fucus vesiculosus*, *Chorda filum* and *Laminaria* spp. were studied (Vandendriessche 2007);
- The research on pelagic fish in the BNS is limited, mainly due to the fact that the BNS is relatively shallow, so that both the typical pelagic fishing nets and sonar images can only be used to a limited extent. Van Ginderdeuren et al. (2014b) revealed that herring and sprat are common in the BNS. It mainly concerns immature individuals (0- and 1-year class) in coastal waters. Adult herring (*Clupea harengus*) is only observed in autumn when the fish are migrating to the spawning areas in the Channel. In summer, two

[13] A collective term for heterotrophic organisms which float, drift or swim in water.
[14] Organisms that are planktonic throughout their entire life cycle.
[15] Organisms that are planktonic only at a certain stage of life.

other pelagic species appear, namely mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). Young horse mackerels are present in the offshore pelagic fish community (Van Ginderdeuren et al. 2012a). The initial assessment of Belgian marine waters (Belgian State 2012a) indicates that several anadromous fish[16] (such as twait shad (*Alosa fallax*)), that were included in the Habitats Directive Annex II, are recovering (Breine et al. 2017).

Birds and marine mammals

Marine mammals constitute a separate group, which is elaborated below together with the occurrence of seabirds in Belgian marine waters:

- The BNS is an important wintering and foraging area for seabirds (Seys 2001, Stienen and Kuijken 2003, Haelters et al. 2004, Stienen et al. 2007, Degraer et al. 2010, Belgian State 2018a). During the winter months, internationally important numbers (i.e. more than 1% of the biogeographic population) of the grebe (*Podiceps cristatus*) and the great black-backed gull (*Larus marinus*) reside here. Furthermore, important numbers of the red-throated loon (*Gavia stellata*) and the common scoter (*Melanitta nigra*) are often recorded in the BNS during winter. The red-throated loon is included in Appendix I of the Birds Directive, while the common scoter is protected by the RAMSAR Convention (see **1.4.2 Policy instruments**). The BNS is also important for the common guillemot (*Uria aalge*) and the black-legged kittiwake (*Rissa tridactyla*) (Waggitt et al. 2019), but these species do not have a special protection status. The beaches, the groynes and piers along the coast constitute resting places for internationally significant numbers of herring gull (*Larus argentatus*) and the ruddy turnstone (*Arenaria interpres*) (Adriaens and Ameeuw 2008). In spring and summer, the coastal zone is an important foraging area for terns that mainly breed in the port of Zeebrugge, the Sluice Dock of Ostend and in the Zwin. Although three tern species used to regularly exceed the 1% standard (sandwich tern (*Thalasseus sandvicensis*), common tern (*Sterna hirundo*) and little tern (*Sternula albifrons*)) (Degraer et al. 2010), the populations of terns and black-headed gulls in Zeebrugge-Heist and the western outer port of Zeebrugge declined sharply after 2008 (Stienen et al. 2019). In 2016, terns did not even breed in Zeebrugge. With the help of sound and dummies, several coastal breeding birds were lured back to the tern peninsula in Zeebrugge in 2017 and 2018. Some of the common terns moved to the newly constructed islands in the Sluice Dock at Ostend and in the Zwin, but the great tern and little tern (almost) disappeared in Flanders (Stienen et al. 2018, Stienen et al. 2019, Vermeersch et al. 2020, Faveyts and Stienen 2020). An important trend in recent years is the sharp and steady decline of the common scoter, which is probably related to a decreasing availability of suitable shellfish. Most other seabirds show fluctuating trends. What is remarkable, however, is the very similar trend of the razorbill (*Alca torda*), the little gull (*Hydrocoloeus minutus*) and the black-legged kittiwake, with increased numbers around 2010. These species are all highly dependent on the presence of sand eels and often occur together (Stienen and Vanermen 2018);
- The BNS functions as an important migration corridor used by more than one million seabirds each year. During the migration period, internationally significant numbers of lesser black-backed gull (*Larus fuscus*), sandwich tern and common tern are regularly observed (Stienen et al. 2007) and the BNS is also a fairly important migration route for gannets (*Morus bassanus*) (Waggitt et al. 2019). Incidentally, songbirds also migrate in large numbers across the North Sea;
- Research shows that seabirds are also affected by the wind farms in the BNS (Vanermen et al. 2020). For example, between 2013 and 2019, the gannet, common guillemot and razorbill were observed less often on the Thornton Bank, while the great black-backed gull and cormorant (*Phalacrocorax carbo*) were recorded more frequently (Vanermen et al. 2019). Furthermore, the collision risk of six seabird species in the Belgian wind farms was examined (Brabant and Vanermen 2020) and a first assessment was made of the possible loss of seabirds by the installation of wind turbines, as a result of habitat loss (Stienen and Vanermen 2020). In the latter publication, a decrease of several tens of percent is expected for the red-throated diver, common guillemot, razorbill and gannet after the completion of the second zone for renewable energy on the Hinderbanks;
- Furthermore, Belgian marine waters are considered to be important for four species of marine mammals listed in Annex II of the Habitats Directive (see **1.4.2 Policy instruments**), namely the harbour porpoise (*Phocoena phocoena*), the bottlenose porpoise (*Tursiops truncatus*), the harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) (Degraer et al. 2010, Haelters et al. 2016, Buyse 2018, Haelters et al. 2020). In the period February-April, the number of harbour porpoise in the BNS can increase to more than 1% of the estimated North Sea population (Haelters et al. 2011, Waggitt et al. 2019). The number of strandings of harbour porpoises along the Belgian coast also differs seasonally. A first peak is observed

[16] Fish that live in the sea and migrate into fresh water to spawn.

in spring (March-May) followed by a second, less pronounced, peak in September. Furthermore, there are indications that the number of strandings could be higher in months with prolonged periods of intermittent high-intensity impulse noise from the construction of wind farms (Rumes et al. 2019). Finally, within the framework of the LifeWatch project, a passive acoustic network was set up to monitor the presence of harbour porpoises and dolphins in the BNS;

- In addition to marine mammals, several species of bats have been observed along the coast and above the BNS. The species most frequently observed at sea is Nathusius' pipistrelle (*Pipistrellus nathussii*). However, other species also occur above the sea, such as the common pipistrelle (*Pipistrellus pipistrellus*), Daubenton's bat (*Myotis daubentonii*), the parti-coloured bat (*Vespertilio murinus*) and the common noctule (*Nyctalus noctula*). These species undertake seasonal migrations between northern and southern Europe and also pass through the southern North Sea coasts (Brabant et al. 2016a, Brabant et al. 2016b, Lagerveld et al. 2017, Gillebert 2018). In the BNS, bats are mainly observed close to shore, but some bats also migrate across the channel. Therefore, the potential risks of offshore wind turbines for migrating bats are also investigated (Brabant et al. 2016a, Brabant et al. 2018). In order to study the distribution of bats along the coast and at sea, the LifeWatch observatory has set up an acoustic network.

The impact of human activities (e.g. fishing and offshore wind energy) on the distribution of seabirds and marine mammals is further discussed in table 1, chapter **1.3 Impacts on the Marine and Coastal Environment** and the thematic chapters **Fisheries** and **Energy (including cables and pipes)**.

Biological valuation of the sea

Within the framework of the BWZee project (BELSPO), the spatial distribution data of all components of the marine ecosystem were integrated and biological valuation maps were drawn up for the BNS (figure 2) (Derous et al. 2007). This includes benthos, demersal fish and seabirds. A complete overview of the species lists in the BNS is available within the Belgian Register of Marine Species (BeRMS, Vandepitte et al. 2010). In addition, many non-indigenous organisms are found in Belgian waters. The website 'Non-indigenous species' provides an overview of the 'established' non-indigenous marine and coastal species in the BNS and adjacent estuaries (Verleye et al. 2020).

1.1.2 Beach

1.1.2.1 Abiotic elements of the beach ecosystem

Beaches are relatively narrow, elongated strips that follow the boundary between land and sea, part of which is alternately situated above and below water due to tidal changes in the water level. They occur in coastal areas exposed to waves, resulting in deposits of mainly sandy sediments. On the beaches along the Belgian coast, this concerns medium fine quartz sand with a lot of shell grit. The beaches are generally characterised by a micro-relief of smaller shapes: low, elongated, longitudinal sand ridges separated by shallow, trench-shaped depressions (*zwinnen*), as well as other smaller features such as *wallen* and *hoornen* (rhythmic shapes). Waves and currents shape all sorts of ripple marks on the beach. The coast is subject to a semi-diurnal tide with tidal currents almost parallel to the coast. An elaborated overview of the geomorphology, processes and dynamics along the Flemish beaches is given in De Moor (2006) (see also Deronde 2007, Van Lancker et al. 2015).

1.1.2.2 Biotic elements of the beach ecosystem

The beach is a unique habitat where large numbers of organisms are present. In Speybroeck et al. (2005), Speybroeck et al. (2008) and Van der Biest et al. (2017a), an overview is given of the principal habitats, species and their interactions:

- Near the high water mark, on the dry beach, vascular plants can be found that are generally short living and dispersed by the sea (the most common species are the European searocket (*Cakile maritima*) and prickly glasswort (*Salsola kali* subsp. *kali*)). The establishment of the perennial species sand couch (*Elymus farctus* subsp. *boreoatlanticus*) or sea sandwort (*Honckenya peploides*) marks the starting point for the development of embryonic dunes because the sand deposited around these plants can accumulate permanently. The flood marks[17] are also the habitat for several terrestrial arthropods (the most common

[17] A landscape marking left by the high water mark.

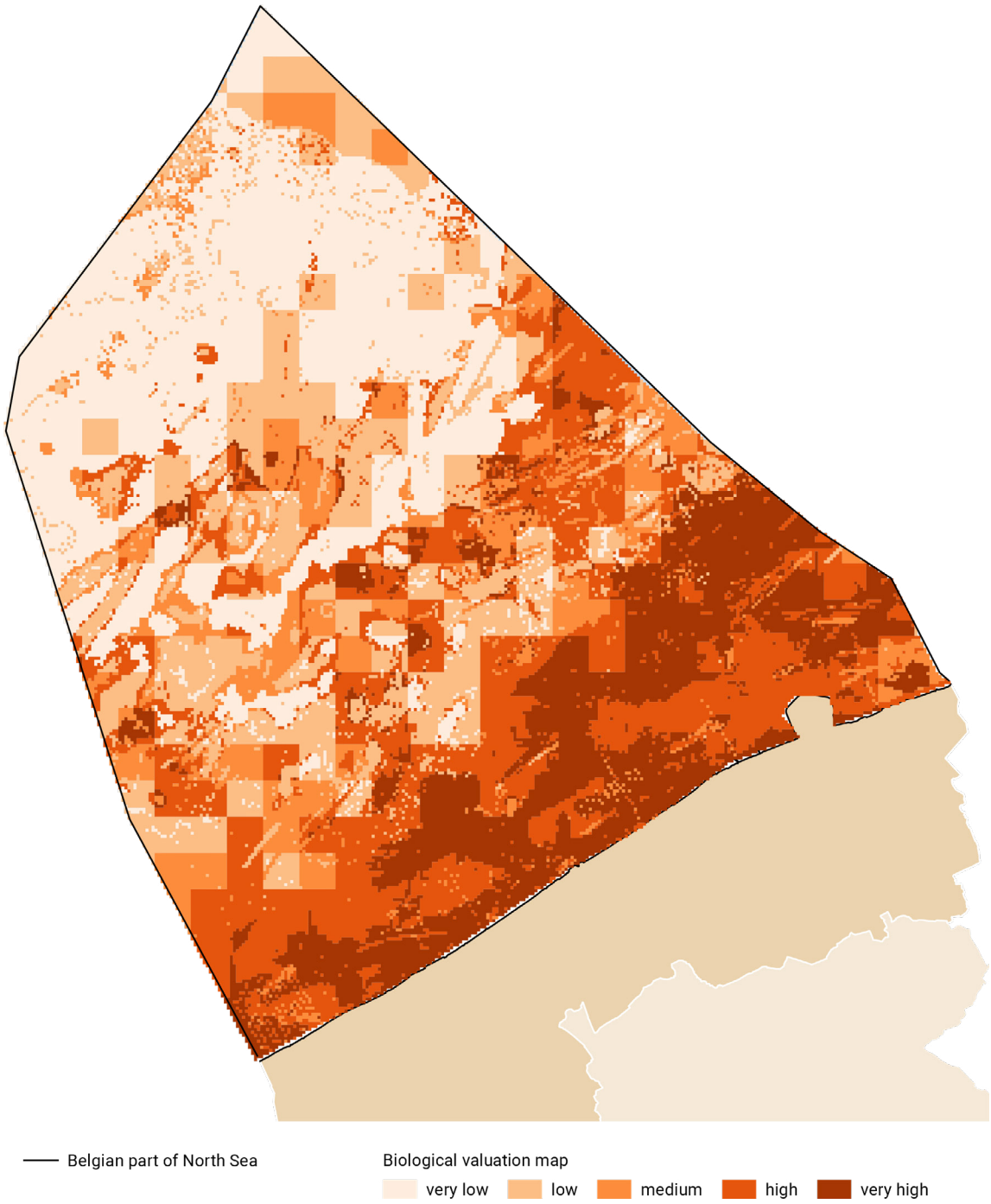


Figure 2. The biological valuation map of the BNS in which the valuation maps for macrobenthos, epibenthos, demersal fish and seabirds were combined (Source: BWzee project (BELSPO), Coastal Portal).

species being the sand hopper (*Talitrus saltator*) and a number of specialised fly species (Grootaert and Pollet 2004));

- Microphytobenthos, especially diatoms, constitutes an important primary producer at the Belgian coast (Speybroeck et al. 2005). The biomass of the microphytobenthos on sandy beaches is, however, much lower than in silty sediments (such as mudflats). The highest biomass is observed in summer and consists mainly of diatoms, to a lesser extent dinoflagellate and occasionally Euglenophyta. About 120 species have been observed so far, but this is probably a strong underestimation (van der Ben 1973, Blondeel 1996, Speybroeck et al. 2004, Speybroeck et al. 2005, Speybroeck et al. 2007);

- The meio- and macrobenthos on the beach include specific communities such as the macrobenthic (*Scolelepis squamata-Eurydice pulchra*) community. The geomorphology of the beaches, including their grain size and slope, determines to a significant extent the distribution of the (marine) benthic life on beaches. Beaches with gentle slopes and fine grain are generally richer than steep-sloped beaches with coarse sand particles (Degraer et al. 2003, Speybroeck et al. 2004, Vanden Eede et al. 2014a);
- The aforementioned beach fauna is an important food source for higher trophic levels of the marine environment, such as juvenile fish (e.g. plaice) and brown shrimp (*Crangon crangon*) (Beyst et al. 1999, Heindler et al. 2019). It is possible that the beach morphology has an impact on the breeding ground function of the intertidal beach sections for juvenile flatfish (Breine et al. 2018b);
- Birds only breed in the quiet beach reserve of Heist, where they are hardly disturbed by recreation, the tern peninsula in Zeebrugge and the edges of the new breeding islands in the Zwin and the Sluice Dock in Ostend (e.g. little tern, common tern, common ringed plover (*Charadrius hiaticula*) and Kentish plover (*Charadrius alexandrinus*)). However, the beaches remain an important resting and foraging area for all kinds of gulls and waders (Speybroeck et al. 2005, see also **Birds and marine mammals**).

Biological valuation of the beach

Based on the available biological information of macro-, epi- and hyperbenthos and birds, biological valuation maps have been created in Vanden Eede et al. (2014b) for a number of beaches along the Belgian coast. Scientific knowledge on coastal processes and dynamics, including the occurring species and their interactions, is crucial to assess the impact of human activities on the coastal environment and the maintaining of a healthy coastal ecosystem (Van der Biest et al. 2017a, Van der Biest et al. 2017b).

1.1.2.3 Artificial hard substrates

Along the Belgian coast, various artificial substrates have been constructed to protect the beaches, buildings and harbours from storms. From the French border to the Dutch border, more than 100 groynes and several dikes have been constructed (Engledow et al. 2001, Mertens 2009). In addition, the pier of Blankenberge and the Belgian ports also provide a lot of artificial hard substrates such as harbour walls, jetties (Nieuwpoort, Blankenberge and Ostend) and breakwaters (Ostend and Zeebrugge). Besides coastal safety, these hard substrates also form a unique habitat for many indigenous and non-indigenous species (Volckaert et al. 2002, Bouwens 2019). There are three communities on the groynes and in the harbours depending on their position in relation to the lowest astronomical tide (LAT) (Engledow et al. 2001, Volckaert et al. 2003, Volckaert et al. 2004). These communities consist of various fauna and flora:

- The most common epilithic fauna[18] are the polychaeta worms (Polychaeta), molluscs (Mollusca) and crustaceans (Crustacea). The latter group, including barnacles, is particularly well represented (Engledow et al. 2001, Volckaert et al. 2002);
- Various species of green algae (Chlorophyta), red algae (Rhodophyta) and brown algae (Phaeophyceae) can be found in the BNS on the artificial hard substrates in the intertidal zone (at the coastline and on the windmills). *Fucus* spp. and *Ulva* spp. are dominant genera along the Belgian coast and form a substrate on which other epiphytic seaweeds[19] can grow. These seaweeds can be obligate epiphytic (e.g. *Elachista* spp.) or can equally grow on the hard substrate itself (e.g. *Ulva* spp. or *Porphyra* spp.) (Engledow et al. 2001, Volckaert et al. 2004).

1.1.3 Dunes

The dune area of the Belgian coast, together with the mudflats and marshes and the upper beach are considered to be part of the 'Ecoregion of the Coast Dunes' (Sevenant et al. 2002). This area covers an area of 76.7 km². Based on pedology, this zone is characterised by the presence of sand that has been deposited by the wind (Kust en Klimaat 2020). These deposits date from after the last ice age, but are generally not older than a few hundred years. The oldest dunes at the Belgian coast are situated between Adinkerke and Ghyvelde in the North of France. They supposedly originated 5,000 years ago (De Ceunynck 1992, De Clercq and De Moor 1996). The largest part of the dunes, however, originated in the early Middle Ages and is referred to as 'young dunes'.

[18] Fauna living on hard substrates.
[19] Seaweeds growing on other seaweeds without extracting nutrients from them.

At present, dune formation and geomorphodynamics are generally limited to the dunes bordering the beach (*zeereep*[20]). A good dynamic in this zone is important for the formation of new dunes and the resilience of the coastal protection. Shifting sand is trapped on the high beach by specialised sand-binding grass species, such as sand couch (*Elytrigia juncea*) and especially European marram grass (*Ammophila arenaria*). Marram grass dunes can grow several metres along with shifting sand and form a robust protection against marine flooding (Provoost and Bonte 2004). Only in *De Westhoek* (De Panne) and *Ter Yde* (Oostduinkerke) inland dunes still show a certain dynamic. These are remnants of former migrating dunes, unvegetated dune ridges that move in the direction of the dominant winds. As in all of NW-Europe, migrating dunes in Belgium tend to stabilise (Provoost al. 2011).

The age of the dunes determines the degree of decalcification of the sand and is an important ecological determinant (Ampe 1999, Ampe et al. 2015). Deeply decalcified soils can be found in the old dunes of Adinkerke, the inner dunes of Westende and Bredene-De Haan and locally in the inner dunes of Knokke. Quantitatively, the ecological diversity is mainly determined by the soil moisture, which is in turn related to the dune relief in combination with the hydrology. A freshwater supply has built up below the dunes as a result of the percolation[21] of excess precipitation. The volume of this supply mainly depends on the width of the dunes. In the subsoil, this water body rests on an impermeable Paleogene clay layer of tens of metres thick. At the level of deep dune valleys (dune pans) or low-lying former beach plains, this groundwater can periodically rise above ground level[22] and be subject to ecological conditions that can lead to the development of swamp vegetation (Provoost et al. 2004, Provoost et al. 2020).

The complex of soil and vegetation development and numerous biotic interactions cause further differentiation in ecotypes (Rappé 1996, Provoost en Bonte 2004). According to the European Habitats Directive (see **1.4.2 Policy instruments**), 14 more or less natural coastal ecotypes that are limited to the coastal area within Flanders can be distinguished (Decleer 2007, Provoost 2019) (see also Natura 2000 in Flanders website for more information). Six of the ecotypes are intertidal, the remaining eight belong to the dunes:

2110 - Embryonic shifting dunes;
2120 - Shifting dunes along the shoreline with European marram grass (*Ammophila arenaria*) ('white dunes');
2130 - Fixed coastal dunes with herbaceous vegetation ('grey dunes');
2150 - Atlantic decalcified fixed dunes (*Calluno-Ulicetea*);
2160 - Dunes with sea-buckthorn (*Hippophae rhamnoides*);
2170 - Dunes with creeping willow (*Salix repens* ssp. *argentea* (*Salicion arenariae*));
2180 - Wooded dunes of the Atlantic, continental and boreal coasts;
2190 - Humid dune slacks.

The ecological specificity of the dune ecosystem is mainly related to the geomorphological dynamics of the contact zone between land and sea, the typical microclimate and the environmental gradients of fresh-saline, dry-wet and calcareous-decalcified environments. In the dunes, the typical coastal species can almost all be found in the embryonic shifting dunes, the white dunes and the early stages of the grey dunes and dune valleys (Provoost and Bonte 2004). From the perspective of the European Habitats and Birds Directives (see **1.4.2 Policy instruments**), the following species deserve special attention (see also the website Natura 2000 in Flanders):

- Plant species in appendix II: creeping marshwort (*Apium repens*) and fen orchid (*Liparis loeselii*) (extinct at the Belgian coast);
- Bats in appendix IV: whiskered bat (*Myotis mystacinus*), brown long-eared bat (*Plecotus auritus*), Brandts' bat (*Myotis brandtii*) (hibernator), Daubenton's bat (hibernator), grey long-eared bat (*Plecotus austriacus*) (hibernator), common pipistrelle (during summer), Nathusius's pipistrelle (during summer), serotine bat (*Eptesicus serotinus*) (during summer) and common noctule (during summer) (De Maeyer and Velter 2004);
- Breeding birds in appendix I: black-crowned night heron (*Nycticorax nycticorax*), little egret (*Egretta garzetta*), European honey buzzard (*Pernis apivorus*), common tern, little tern, European nightjar (*Caprimulgus europaeus*), middle spotted woodpecker (*Dendrocoptes medius*), Sandwich tern, woodlark (*Lullula arborea*) and bluethroat (*Luscinia svecica*);
- Amphibians in appendix IV: northern crested newt (*Triturus cristatus*) (appendix II), natterjack toad (*Epidalea calamita*) and European tree frog (*Hyla arborea*);
- Snails in appendix II: narrow-mouthed whorl snail (*Vertigo angustior*) and Desmoulin's whorl snail (*Vertigo moulinsiana*).

[20] The part of the dune belt that borders the beach and functions as a seawall.
[21] The downward movement of water into the unsaturated zone of the soil.
[22] The interface between the ground and the air. The ground level is often specified in relation to a national zero-level (*Oostende Peil* or O.P.).

The human influence on the coastal ecosystem is substantial. Approximately half of the dune area has been urbanised in the last 150 years and the remaining areas have undergone drastic changes in the landscape. The sand dynamics of dunes (see also Provoost et al. 2016) have largely stopped, and thicket and forest development have profoundly altered the vegetation structure. Within the coastal dunes, other important triggers for biodiversity changes are atmospheric deposition of nitrogen, climate change, recreation, water extraction and expansion of exotic species (Provoost en Bonte 2004), putting the typical dune biodiversity under pressure (Provoost 2014). The reporting in the framework of the Habitats Directive reveals that only one of the eight different dune habitat types (sea-buckthorn thicket 2160) has a good conservation status (Paelinckx et al. 2019).

Despite the growing awareness of the role of dune dynamics in supporting human well-being and biodiversity, redynamisation of dunes is rarely implemented in coastal management due to the rather limited possibilities within the highly urbanised and fragmented landscape. A dynamic dune complex is not only of great ecological importance, but would also provide substantial economic added value in terms of coastal safety and recreation (Van der Biest et al. 2017c, De Bruyn et al. 2020, Provoost et al. 2020) (see also thematic chapter **Safety against flooding**). In *Ter Yde* and recently in *De Westhoek*, projects are ongoing to increase the sand dynamics (Provoost et al. 2019). Nature restoration is mainly done by cutting down thickets[23] and forest in favour of open dune biotopes such as grasslands, moss-dunes and low dune slack vegetation. Large parts of the dunes are grazed and locally mowed as part of conservation management. This management is generally successful, but afforestation and thicket formation remain major challenges (Provoost et al. 2010, Provoost et al. 2015, Provoost et al. 2020).

1.1.4 Estuaries, mudflats and marshes

Intertidal mudflats and marshes occur in the lee parts of the coast where reduced marine dynamics allow sedimentation of fine-grained silt. Along the Belgian coast, they can be found in the Yser Estuary, the Bay of Heist, the Zwin and the tern peninsula in Zeebrugge (see also Van der Biest et al. 2017a, De Bruyn et al. 2020), covering a total area of approximately 200 ha. Real estuarine nature is only present in the river mouth of the Yser. Outside the Belgian coast, mudflats and salt marshes also occur in the Scheldt estuary, but will not be covered here (see thematic chapter **Scheldt estuary**).

Mudflats and marshes are by nature dynamic systems. A healthy and dynamic system is characterised by the interaction between sedimentation and erosion processes. The trend and speed of habitat changes determines whether the dynamics in the system are too large, too small or in balance (Maris et al. 2014, Van der Biest et al. 2017a).

The Atlantic salt marshes and salt meadows are included in three European habitat types (Decleer 2007, Vandevoorde et al. 2019):

1310 – Salicornia and other annuals colonizing mud and sand;
1320 – Spartina swards (*Spartinion maritimae*);
1330 – Atlantic salt meadows.

Estuaries are considered as a separate habitat type (1130) and may include, in addition to the water biotopes, different habitat types of the mudflats and marshes.

The Zwin used to belong to an estuary reaching Bruges (see, *inter alia*, Claeys 1981, Termote 2012, De Bruyn et al. 2020). At present, the Zwin is a cross-border nature reserve (Belgium – The Netherlands) consisting of an interrupted dune belt with tidal mudflats and marshes behind it. The North Sea enters the area through a gully, creating a system of creeks. The protection of the habitat types and species occurring in the Zwin, by means of the European Habitats Directive, is described in Bot (2007a). The tidal area is an important place to rest, forage, moult, breed and migrate for several birds, including different species which are protected by the European Birds Directive (Bot 2007b). Several of these species make use of the food availability that is present in large numbers in the benthos (Van Colen et al. 2009, Verstraete en Verbelen 2014). Due to the siltation of the Zwin, measures have been taken in the context of the Development Sketch 2010 for the Scheldt estuary (see thematic chapter **Scheldt estuary**; ScheldeMonitor), to restore the mudflats and marshes and expand the nature reserve (Verhaegen et al. 2010, Van Nieuwenhuyse et al. 2016, see also Het Zwin in verandering). The expansion of the Zwin was extensively monitored in several projects (Cosyns et al. 2015, Slabbinck et al. 2017).

[23] Thicket is a form of vegetation dominated by shrubs that are not higher than five metres.

Within the Yser estuary, only the area between the river mouth in the North Sea and the *Ganzenpoot* lock complex is still under tidal influence. On the right bank, an intertidal zone that is part of the Flemish nature reserve of the Yser estuary is present (Hoffman 2006). Thanks to a nature restoration project, the natural transitions of the various components of the coastal ecosystem (including mudflats and salt marshes) have been restored (Hoffman et al. 2006). The nature protection in the Yser estuary by the European Habitats and Birds Directives is described in more detail in Spanoghe et al. (2003). In recent decades, a strong expansion of saline vegetation has been observed, including sea couch (*Elytrigia atherica*) establishing itself among the pioneer vegetation. Grassification is kept under control by extensive grazing management (Provoost et al. 2020). The composition of the fish stock of the Yser estuary was investigated in 2015 by Breine et al. (2016). Within the framework of the construction of the storm surge barrier, the benthic community of the harbour channel of Nieuwpoort was mapped during an ecological monitoring programme (Van Hoey and Van Colen 2018).

The Bay of Heist forms a wide 'green beach' with an increasing complexity of geomorphology and associated biotope types. The area of pioneer vegetation seems to have stagnated recently. This stabilisation and succession translates into a strong increase in saltwater plant species and lower lying macroalgae. With 43 species of interest, the Bay of Heist is considered a botanical hotspot. As in the Yser estuary, grassification is the main point of attention for management (Provoost et al. 2020).

1.1.5 Polders and Polder complex

The 'Polders' is the name of the former intertidal areas, which have been almost completely withdrawn from the marine influence by land reclamation since the early Middle Ages. It is a flat and low-lying landscape with inversion relief[24] caused by the consolidation of clay layers and the subsidence of peat (Baeteman 2007, Baeteman 2013, De Bruyn et al. 2020). It is also the name of the Habitats Directive area in the coastal zone (Decision of the Flemish Government of 24 May 2002) which overlaps with the birds directive area 'Polder complex' (Decision of the Flemish Government of 17 July 2000) (see **1.4.2 Policy instruments**) (more information on the Polders in the context of Natura 2000 can be found on the website of Natura 2000 in Flanders).

- These special protection areas (SPAs) have been designated for six European protected habitat types and 2 European protected animal species within the habitats directive area 'Polders' (Paelinckx et al. 2009, Decision of the Flemish Government of 24 May 2002). The habitat types include Salicornia and other annuals colonizing mud and sand (1310), Atlantic salt meadows (1330), Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430), *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (6410) and alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (91E0). The species for which the habitats directive area has been established are the pond bat (*Myotis dasycneme*) and the northern crested newt. Recently, very few observations of the latter species have been made in the Polders;
- The birds directive area 'Polder complex' was established because the following European protected species breed or used to breed in this area: Eurasian bittern (*Botaurus stellaris*), little bittern (*Ixobrychus minutus*), ruff (*Philomachus pugnax*), short-eared owl (*Asio flammea*) and bluethroat. A number of non-breeding bird species are also relevant for the area: red-throated diver, Bewick's swan (*Cygnus bewickii*), whooper swan (*Cygnus cygnus*), the lesser white-fronted goose (*Anser erythropus*), barnacle goose (*Branta leucopsis*), red-breasted goose (*Branta ruficollis*), western marsh harrier (*Circus aeruginosus*), hen harrier (*Circus cyaneus*), merlin (*Falco columbarius*), golden plover (*Pluvialis apricaria*), wood sandpiper (*Tringa glareola*) and common kingfisher (*Alcedo atthis*) (Courtens and Kuijken 2004). The 'Polder Complex' has also been established because internationally significant numbers of geese stay in this area in the winter months. The pink-footed goose (*Anser brachyrhynchus*) and the greater white-fronted goose (*Anser albifrons*) annually exceed the 1% standard (Kuijken et al. 2005, Wetlands International 2006 – Waterbird Population Estimates, Devos and T'Jollyn 2016). The most recent status of breeding birds in Flanders is described in Vermeersch et al. (2020).

The Polders are also characterised by the occurrence of valuable historical permanent grasslands (HPGs). These were mapped by De Saeger et al. (2013). On 27 November 2015, the Government of Flanders definitely approved the map of the historically permanent grasslands (HPGs) in the agricultural region of the Polders (see thematic chapter **Agriculture**).

[24] Inversion of the relief whereby the soil that was initially lower than the surrounding land rises higher than its surroundings.

1.2 Ecosystem goods and services

The Millennium Ecosystem Assessment (MEA 2005) describes ecosystem services as the benefits that humans obtain from the ecosystem. They can be divided into goods, regulatory services, cultural services and support services. The concept of ecosystem services has been elaborated to also include the economic aspects of the ecosystem (The Economics of Ecosystems and Biodiversity, TEEB). The economic value of the services, which the marine and coastal ecosystems deliver, has been estimated by Costanza et al. (2014) at 660 and 8,944 US dollar per ha per year respectively. According to a study of the World Wide Fund (WWF) (Hoegh-Guldberg et al. 2015), the overall value of the ocean 'gross marine product' amounts to 24 billion US dollars. At European level, ecosystem services underpinning the EU blue economy are listed and documented with figures in The EU Blue Economy Report 2020.

For Belgium, the Belgian Ecosystems and Society community (BEES) network aims to map ecosystem services. The ECOPLAN toolbox has been developed to asses ecosystem services on land. For Flanders, Jacobs et al. (2010) published an exploratory inventory of ecosystem services (and potential ecosystem benefits). In addition, the nature report (NARA) is biannually drafted as an ecosystem assessment for Flanders, whereby the North Sea and the coastal dunes are analysed separately (Schneiders et al. 2020). In previous editions, 16 ecosystem services were developed (Stevens 2014). A separate chapter was dedicated to coastal protection (Provoost et al. 2014). Furthermore, nature valuation studies are also available (e.g. Hutsebaut et al. 2007). The calculation tool Natuurwaardeverkenner has been developed to support the quantification and economic estimation of the ecosystem services in a Social Cost-Benefit Analysis (SCBA) or other evaluations of (infrastructure) projects with an impact on nature (more information: Liekens et al. 2018).

Scientific knowledge about the ecosystem goods and services of the BNS (and the wider North Sea) and the adjacent coastal zone has been built up in various studies:

- A preliminary overview of the types of goods and services in the BNS delivered by marine biodiversity can be found in Beaumont et al. (2007);
- Within the renewed Ecosystem Vision Flemish Coast (Van der Biest et al. 2017a), an ecosystem service analysis was made, based on the CICES v4.3 classification[25] of ecosystem services for the purpose of developing a long-term vision 2100. Van der Biest (2018) presents the scientifically based methods for assessing and managing ecosystem services. For the coastal ecosystem, it was mentioned that the most important economic value in the dunes is created by recreation, and secondly by flood protection (Van der Biest et al. 2017c). The extraction of drinking water, for example, is also an important ecosystem service, although the net extraction of natural groundwater has a significant negative impact on biodiversity. The Ecosystem Vision emphasises that, despite the current scientific knowledge on the impact of human activities on the marine environment, it is a challenge to deal with uncertainties (e.g. carbon sequestration in the marine environment) and thus to preserve coherence between human activities and a healthy ecosystem. The determination of the cumulative effects of human activities remains a major challenge (Stelzenmüller et al. 2018).
- In the framework of the Marine Strategy Framework Directive (MSFD), a first socio-economic analysis of the use of Belgian marine waters and the costs associated with the degradation of the marine environment was prepared in 2012 (Belgian State 2012b, Börger et al. 2016). An update of this socio-economic analysis in the context of the MSFD was published in 2018 (Belgian State 2018b, Volckaert and Rommens 2018). In the context of this socio-economic analysis, the potential of an ecosystem service approach was also put forward (Belgian State 2018b, Volckaert and Rommens 2018). This approach provides information on the difference in value of the ecosystem that would be provided in the situation of a Good Environmental Status (GES as defined in the MSFD) compared to normal use. The focus was put on the Flemish banks for the aggregate extraction sector (see also thematic chapter **Sand and gravel extraction**). At present, the methodology and empirical application are not yet sufficiently developed to fully apply the ecosystem approach within the current reporting cycle of the MSFD;
- Although the socio-economic value of ecosystems is becoming increasingly important, it is not considered in spatial planning. Van der Biest et al. (2020) therefore wrote a method, based on two principles, that promotes the integration of ecosystem services and biodiversity in the spatial planning process. Firstly, the diversity of biotic and abiotic ecosystem processes must be considered. Secondly, these processes should be linked to biodiversity and socio-economic benefits to identify the interface between conflicting objectives;
- OSPAR is also taking action to establish an assessment framework for evaluating the economic and social value of the OSPAR maritime area (OSPAR IA 2017);

[25] A new version is now available: CICES v5.1.

- The MAES report (2018) (Mapping and Assessment of Ecosystems and their Services) proposed a list of policy-relevant key indicators to assess the pressure on marine ecosystem services and the state of the marine ecosystem;
- Within the SUMES project (2020-2023), in the framework of the Blue Cluster, a comprehensive model is being developed that assesses the capacity of the marine ecosystem to deliver certain goods and services. The project aims to use this model to identify the local, regional and global effects of (socio)-economic activities at sea and to gain more insight into cause-effect chains.

In addition, in recent decades, there has been a strong commitment to the sustainable use of the marine ecosystem within the framework of the blue economy and marine biotechnology. A broader perspective on the developments in the BNS is given in the thematic chapter **Blue Economy and Innovation**.

1.3 Impact on the marine and coastal environment

The marine and coastal environment described above host a region where various human activities take place, each of which has a specific impact on this environment (see thematic chapter **Integrated maritime policy**: figure 6). Several reports provide an overview of the human activities and the associated impact is provided: Maes et al. (2004) (MARE-DASM project BELSPO), Maes et al. (2005) (GAUFRE project BELSPO), Goffin et al. (2007), André et al. (2010), Belgian State (2012a), Belgian State (2018a), Kint et al. (2018), the third federal environmental report (2019a and 2019b), as well as European Environment Agency (2015) and OSPAR IA 2017 on a higher geographical scale. In addition, numerous studies exist on the (direct and indirect) impact of a specific user function. These publications are discussed in the thematic chapters of the different user functions under the section 'Impact'. In table 1, a list of the various thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022) is given, in more information on a specific type of impact can be found. This table does not provide an exhaustive overview of the impacts on the marine and coastal environment, but serves as a readers' guide.

Table 1. Referral table with an overview of the type of impacts dealt with in the specific thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

Impact	Thematic chapters
Impact on air quality	Maritime transport, shipping and ports; Tourism and recreation; Fisheries; Agriculture; Sand and gravel extraction; Safety against flooding; Energy (including cables and pipes).
Impact on the pelagic ecosystem (eutrophication, pollution, etc.)	Energy (including cables and pipes); Agriculture; Tourism and recreation; Aquaculture; Maritime transport, shipping and ports; Military use; Dredging and dumping; Fisheries; Sand and gravel extraction; Blue Economy and Innovation.
Impact on fish stocks	Fisheries; Marine aquaculture; Tourism and recreation; Energy (including cables and pipes).
Impact on seabirds and marine mammals	Energy (including cables and pipes); Maritime transport, shipping and ports; Fisheries; Aquaculture; Military use.
Impact on the seabed/ habitats	Sand and gravel extraction; Dredging and dumping; Energy (including cables and pipes); Military use; Safety against flooding; Fisheries; Marine aquaculture; Agriculture; Blue economy and innovation.
Impact on hydrographic properties	Energy (including cables and pipes); Maritime transport, shipping and ports; Military use; Safety against flooding; Marine aquaculture; Dredging and dumping; Sand and gravel extraction.
Impact on land use (including impact on nature area)	Social and economic environment; Tourism and recreation; Energy (including cables and pipes); Fisheries; Marine aquaculture; Agriculture; Safety against flooding; Sand and gravel extraction; Maritime transport, shipping and ports; Maritime and coastal heritage; Blue Economy and Innovation.
Impact on beach and dunes	Tourism and recreation; Safety against flooding; Marine aquaculture.
Impact on groundwater	Agriculture; Safety against flooding.

1.3.1 Litter

Given that the problem of marine litter is not specifically linked to one particular user function, its impact is described separately. Litter is caused by multiple activities and/or sectors, and also has a potential negative impact on multiple user functions. In Flanders, research on the presence and effects of litter and microplastics on the beach and in the sea has been carried out for twenty years (Devriese and Janssen 2021). In order to protect the marine environment, marine litter has been included in the OSPAR objectives and in the MSFD environmental

targets (descriptor 10) (see further **1.4 Protection of the marine and coastal environment**). In this context, experts from the EU member states have collaborated to determine a threshold of 20 pieces of waste per 100 m of tide line (van Loon et al. 2020). The revision of the initial assessment for the Belgian marine waters (Belgian State 2018a) showed that on average, 136 objects of litter per 100 m of coastline was found at the Flemish beaches (of which about 80% are plastic), and an average of 126 objects per km² are observed on the seabed (of which about 90% are plastic). Furthermore, the OSPAR intermediate assessment confirmed that plastic is the most common material on the seabed and the beach (OSPAR IA 2017, ICES 2020). These pieces of plastic can further fragment into very small pieces of plastic, called micro- or nanoplastics. Not only large plastic objects, but also the microscopic plastic particles cause various forms of negative impact: socially, economically and ecologically (see overview Devriese and Janssen 2021). Both fundamental and applied scientific research, as well as in the context of (government) policy, there are clear needs to further study and tackle the problem of litter and microplastics in Flemish aquatic environments (Devriese and Janssen 2021). Action against (marine) litter is currently being taken at several (policy) levels (Devriese and Janssen 2020 (Annex 1)), including Belgium and Flanders (Devriese and Janssen 2021). The policy statement of the minister for the North Sea mentions the need for coordinated actions at different areas and levels to tackle the flow of waste into the sea (Van Quickenborne 2020). Both the Flemish (OVAM 2017) and federal (De Backer 2017) action plan focus on measures to reduce marine litter (incl. prevention). Part of the measures from the Flemish action plan will be further implemented within the Flemish Implementation plans for Plastics. In addition, the Coalition Agreement of the Flemish Government (2019-2024) also tackles the litter problem. Given the social importance of this problem, not only the Flemish researchers are committed, but there is also a growing awareness among players in the Blue Economy of the need to invest in innovative solutions for marine litter and microplastics (e.g. through the Blue Cluster) (Devriese and Janssen 2021). The PLUXIN project, for example, cooperates with actors from research institutes, industry, citizens and policy to compile innovative solutions to reduce plastic litter in Flanders.

1.4 Protection of the marine and coastal environment

1.4.1 Policy context: administrations and organisations

The environmental policy concerning the coast and sea is to a large extent steered by several international, European and regional organisations (see also thematic chapter **Integrated maritime policy**). In 2015, the Sustainable Development Agenda 2030 (United Nations - UN) was adopted, including 17 Sustainable Development Goals (SDG). SDG 14 addresses the conservation and sustainable use of the seas, oceans and marine resources and focuses on the threats such as climate change, overfishing and pollution. In order to support countries in achieving SDG 14, the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) was announced. Under the umbrella of the UN, several (sectoral) organisations are involved in marine environmental and nature policy. The International Maritime Organisation (IMO) of the UN, is a specialised agency responsible for the safety and security of shipping and the prevention of marine pollution caused by ships (see also thematic chapter **Maritime transport, shipping and ports**). The United Nations Environment Programme (UNEP) aims to coordinate the development of environmental policy at global and regional level by bringing the environment to the attention of governments and the international community, while identifying new points of interest. Furthermore, through the Convention on Biological Diversity (CBD), the UN ensures the conservation of coastal and marine areas with considerable importance for biodiversity and ecosystem services, so called ecologically or biologically significant marine areas (EBSA).

At European level, the Directorate-General for the Environment (DG ENV) of the European Commission (EC) aims to protect, maintain and reinforce the European environment. Important European directives for this purpose are the Habitats and Birds Directives, which are relevant for both the marine and terrestrial environment. The European MSFD is an important umbrella instrument for the protection of the marine environment. The Directorate-General for Maritime Affairs and Fisheries (DG MARE) of the EC operates on multiple policy areas: the Common Fisheries Policy (CFP, see thematic chapter **Fisheries**), the Integrated Maritime Policy (IMP) and a sustainable blue economy (COM (2021) 240). The IMP aims to provide an integrated answer to the current challenges related to European seas: marine pollution, environmental protection, coastal development, job creation, etc. The European Environment Agency (EMA-EEA) of the European Union provides reliable and objective information on the environment to anyone involved or interested in environmental policy. In the OSPAR Commission, national governments from Western Europe (including Belgium) and the EU collaborate to protect the marine environment of the North-East Atlantic Ocean.

In Belgium, the Marine Environment division of the FPS Health, Food Chain Safety and Environment is competent for the environmental policy in the BNS. The division also chairs the advisory commission for marine spatial planning (MSP) in the Belgian maritime regions (RD of 13 November 2012). The scientific and technical support

for the marine environmental policy is provided by the Management Unit of the North Sea Mathematical Model of the Royal Belgian Institute of Natural Sciences (RBINS-MUMM). The objectives of the the policy statement of the Deputy Prime Minister and minister for Justice and the North Sea include more focus on Blue Energy, Blue Economy, Blue Shipping, more Blue at Sea and the protection of Blue Nature (Van Quickenborne 2020).

The North Sea is also discussed as an element in the solution to climate change and the North Sea vision 2050. The North Sea Vision 2050 which was later renamed the Think Tank North Sea, set up two thematic focus groups in 2019-2020: Working with nature and Living with climate change. Together with stakeholders, a working group report was developed for each theme. In a new working group (2021-2022), the think tank will establish a vision on Environmentally sustainable blue growth.

The policy on nature and the environment with regard to the coast (landward of the baseline) is a competence of the Government of Flanders (Policy Memorandum on the environment 2019-2024). The Department of Environment and Spatial Development (OMG) is the environmental administration of the Government of Flanders and is responsible for the preparation, follow-up and evaluation of the Flemish environmental policy. OMG is also responsible for operational matters such as environmental enforcement, environmental permits and approvals, environmental impact and safety reports, nature and environmental education, and nature conservation and development. In addition to OMG, the following relevant entities are included in the policy area Environment: the Agency for Nature and Forests (ANB), the Research Institute for Nature and Forest (INBO), the Flemish Energy and Climate Agency (VEKA), the Public Waste Agency of Flanders (OVAM), the Flemish Environment Agency (VMM), the Flemish Land Agency (VLM) and the territorial development programme Kustzone (T.OP Kustzone) of OMG and the Province of West Flanders.

The Province of West Flanders acts an intermediary between the federal Government, the regions and the municipalities, and has competences with regard to the environment, as it is responsible for granting permits, spatial policy, parts of water management, the management of provincial domains and green corridors, and nature and environmental education.

The municipal environmental services are competent for the treatment of complaints concerning the environment and nature, local nature preservation, monitoring and advice on environmental permits, waste management, environmental policy planning, development of a sustainable policy and raising awareness on the themes of nature, environment and sustainability towards the citizens and other target groups.

1.4.2 Policy instruments

The intense activities at sea and in the coastal zone have led to an elaborate package of legislation and regulation with the aim of mitigating, reducing or avoiding the impact of certain user functions on the environment (see Verleye et al. 2018, Legislative module Compendium website). This legislation and regulation is mostly sector-specific (e.g. MARPOL Convention) and is further discussed in the thematic chapters of the relevant user functions in the sections 'Policy Context' and 'Sustainable Use'. Hence, the most relevant nature and environment-related policy instruments for the BNS and the coastal zone are elaborated below (see also thematic chapter **Integrated maritime policy** for more information).

1.4.2.1 United Nations Convention on the law of the sea (1982)

The United Nations Convention on the law of the sea (UNCLOS 1982) can be considered as the first intergovernmental convention that creates an integrated legal framework for the use of the ocean. Notwithstanding the broad scope of this convention, part XII of UNCLOS (Protection and Preservation of the Marine Environment) specifically addresses the protection and preservation of the marine environment. The Intergovernmental Conference developed an international legally binding instrument (ILBI) under the UNCLOS on the conservation and sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ). This was established under the UN General Assembly (UNGA) in 2017 (UN Resolution A/RES/72/249).

1.4.2.2 Convention on biological diversity (1992)

The Convention on biological diversity (CBD) was established at the UN Convention on Environment and Development (UNCED, 3-14 June 1992, Rio de Janeiro) and covers ecosystems, species and genetic resources. The convention has three main objectives: (1) the conservation of biological diversity, (2) its sustainable use and

(3) the fair and equitable sharing of benefits arising from of the utilisation of genetic resources. The national biodiversity strategies and action plans (Biodiversity 2020, Update of the Belgian national strategy 2013) provide a principal instrument for the conservation and sustainable use of biological diversity with contracting parties cooperating where there are bilateral interests or where there is no national jurisdiction over the matter.

1.4.2.3 RAMSAR Convention (1971)

The Ramsar Convention (Ramsar, Iran, 1971) is an intergovernmental treaty aimed at the global protection and sustainable management of wetlands with special attention to the conservation of habitats of water birds (Goffin et al. 2007). The convention attempts to achieve the protection and rational and sustainable use of wetlands of international importance (including marine waters where the depth of water at low tide is less than 6 metres) by means of local and national measures and international cooperation.

1.4.2.4 OSPAR Convention (1992)

The OSPAR Convention (1992) constitutes an overarching framework for the protection of the marine environment of the North-East Atlantic Ocean (including the North Sea) with a cooperation of 15 national governments and the EU (= the 16 contracting parties). The OSPAR Convention replaces the Convention of Oslo (1972) and the Convention of Paris (1974). The convention contains general regulations on the protection of the marine environment from specific sources of pollution, such as pollution from land, by disposal or combustion and by offshore activities. Furthermore, agreements on the evaluation of the quality of the marine environment (OSPAR QSR 2010, OSPAR IA 2017) and the protection and preservation of the ecosystems and biological diversity are part of the OSPAR Convention (Goffin et al. 2007).

Overall, the work of the OSPAR Commission is guided by the ecosystem approach towards an integrated management of human activities in the marine environment. This is supported by an obligation of contracting parties to apply the precautionary and polluter pays principle (see thematic chapter **Integrated maritime policy**), and the use of best available techniques (BAT) and best environmental practice (BEP), including clean technology. The implementation of the ecosystem approach is established in the OSPAR's North-East Atlantic Environment Strategy (NEAE Strategy). This NEAE Strategy was drawn up in 2010 based on the holistic approach in the OSPAR QSR 2010 and was revised (NEAES 2030) in 2021 with focus on the offshore industry (OSPAR 2021). The strategy focuses on three challenges that address the main threats for the ocean (biodiversity loss, pollution, including marine litter, and climate change). The OSPAR intermediate assessment (OSPAR IA 2017) updates the OSPAR QSR 2010 and can be integrated into national obligations for the assessment of marine waters in the context of the European MSFD (see below). The OSPAR Secretariat also acts as a secretariat for the Bonn Agreement (1969). This is the mechanism by which the North Sea States and the European Union (the contracting parties) collaborate in combating pollution in the North Sea Area from maritime disasters and chronic pollution from ships and offshore installations, as well as to carry out surveillance as an aid to detect and combat pollution at sea (Lagring et al. 2012, Schallier and Van Roy 2016).

1.4.2.5 Habitats Directive (1992) and Birds Directive (2009)

The European **Habitats Directive** (Directive 92/43/EEC) aims to maintain and restore the European natural habitats and wild fauna and flora. The member states need to designate special protection areas (SPA-H or habitats directive areas) for certain habitats and species of European importance which are listed in the Annexes I and II of the directive. Of the entire 3,190 ha of undeveloped dunes along the Belgian coast, 94% has been included within SPA-H. All intertidal mudflats and marshes (in total approx. 200 ha) are also designated as SPA-H. The Habitats Directive also applies to the BNS where two areas have been designated as SPA-H. The Flemish Banks (111,198 ha), bordering France, consists mainly of permanently flooded shallow sandbanks in which biogenic and geogenic reefs also occur. Near the border with the Netherlands, the *Vlakte Van De Raan* (6,492 ha) is designated as a SPA-H, which also consists of permanently flooded shallow sandbanks containing biogenic reefs.

The aim is to achieve a favourable conservation status (FCS) for the habitats listed in annex I and for the species listed in Annex II and IV to this directive. Conservation objectives (COs) determine the scientific standards against which the FCS must be assessed (see also Bot 2007 and Oosterlynck et al. 2020 (local conservation status)). For the marine protected areas, too, COs were determined in the context of the Birds and Habitats Directives (see also: Degraer et al. 2010). This study, together with the objectives of the MSFD, formed the basis of the MD of 2 February 2017 on the adoption of conservation objectives for marine protected areas. These conservation objectives are currently (2021) being re-evaluated.

According to the Habitats Directive (art. 17), the member states are obliged to report every six years to the EC about the conservation status of the habitat types and species as well as about the results of the policy pursued. For the landward side, the conservation status of the species and habitats of European importance was reported by Paelinckx et al. (2019). On the sea side, reporting to the EC was based on the evaluation of the FCS in Degraer et al. (2009) and the update of the initial assessment in the context of the MSFD (Belgian State 2018a).

The European **Birds Directive** (Directive 2009/147/EC) aims to protect all species of wild birds. Special protection measures have been taken for the habitats of the bird species listed in Annex I and all species occurring in internationally significant numbers as breeding, migratory or winter birds. Each member state is required to designate special protection areas (SPAs or birds directive areas). These birds directive areas, together with the habitats directive areas, are part of the European ecological Natura 2000 network. According to the Birds Directive (art. 12), the member states are obliged to report every six years about the conservation status of the species and on the outcome of the policy pursued to the EC. The MD of 2 February 2017 contains the conservation objectives (COs) that were adopted for the BNS in the context of the Birds and Habitats Directives. The most recent report under the Birds Directive covers the period 2013-2018 (see Vermeersch et al. 2019). In Paelinckx et al. (2009) and Degraer et al. (2010) the current conservation of the bird species of the Birds Directive at the level of Flanders and the North Sea (see also DG Leefmilieu 2010) has already been determined, in order to underpin the COs (Belgian State 2018d).

The implementation of the Habitats and Birds Directives in the federal legislation has been provided by several decrees under the Law of 20 January 1999: e.g. the RD of 21 December 2001, the RD of 27 October 2016 and the RD of 22 May 2019. The Decision of the Flemish Government of 23 March 2014 resulted in the definitive designation of the SPA on the (landward side of the) coast (Achterhaven Zeebrugge-Heist, Dune areas and Polders) and the associated COs (see additional information and approved COs at www.natura2000.vlaanderen.be). An overview of the European nature state, based on the reports of the member states in function of the nature directives (Habitats and Birds Directive) is given in European Environment Agency (2020).

1.4.2.6 Programmatic Approach to Nitrogen (PAN) (2014)

The atmospheric deposition of nitrogen from agriculture, traffic, industry and households is in certain cases a bottleneck for the realisation of the nature objectives set within the framework of the Habitats and Birds Directives (see also thematic chapter **Agriculture**). The Programmatic Approach to Nitrogen (PAN) was created to address this problem through both source- and effect-oriented measures (so-called recovery management). In the framework of the PAN, an area analysis was carry out in 2018 for the dune area (incl. Yser estuary and the Zwin) (Provoost et al. 2018) and polders (Vriens et al. 2018), which proposes specific recovery measures for each habitat type.

1.4.2.7 Water Framework Directive (2000)

The European Water Framework Directive (WFD, Directive 2000/60/EC) stipulates that all European 'natural' surface waters must have at least a good ecological status (GES) and a good chemical status (GCS) by 2015. For 'heavily modified' or 'artificial' surface waters/water bodies[26], the ecological objectives have been adjusted, and a good ecological potential (GEP) is mentioned. The deadline (2015) for achieving these objectives may be conditionally extended up to a maximum of two updates of the river basin management plan (2021/2027). For the purposes of the GES, the WFD extends to 1 nautical mile on the seaward side of the baseline and for the objectives of the GCS up to 12 nautical miles on the seaward side of the baseline.

In order to achieve the objectives of the WFD, member states are required to develop river basin management plans every six years. The first plans were drafted in 2009. In the Decree of 18 December 2015, the Government of Flanders adopted the second version of the river basin management plans for the rivers Scheldt and Meuse for the period 2016-2021, including the programme of measures for the river basin management plans (website Coordination Committee on Integrated Water policy, Programme of measures for the river basin management plans for Scheldt and Maas 2016-2021). All the surface waters of the coastal zone of Flanders belong to the international river basin district of the Scheldt: in accordance with the competences of the Flemish and federal authorities, the river basin management plans have been divided into a river basin management plan for the Scheldt (River basin management plan for the Scheldt 2016-2021) and a river basin management plan for the

[26] Artificial water bodies have been created by humans in places where no natural water was present. A heavily modified water body is a natural water body that has been severely modified by human activity.

Belgian coastal waters (River basin management plan for the Belgian coastal waters 2016-2021). The coordination between the managing authorities of the river basin district (the Netherlands, France, the three regions and the federal Government of Belgium) takes place via the International Scheldt Commission (ISC) and on the Belgian level via the Coordination Committee International Environment Policy (CCIEP). In September 2020, the public consultation of the third version of the Flemish river basin management plans for the period 2022-2027 was started. At the end of 2021, these plans were reviewed by the Flemish Government. The proposed plans contain measures and actions to improve groundwater and surface water and to protect against flooding and drought.

The WFD is supplemented by the Subsidiary Directive on Groundwater (Directive 2006/118/EC) (on the protection of groundwater against pollution and deterioration) and the Subsidiary Directive on Priority Substances (Directive 2008/105/EC) (on environmental quality standards in the field of water policy for surface water for a number of hazardous substances). Furthermore, the WFD is closely related to a number of other directives that are further discussed in the various thematic chapters. These include the Urban Waste Water Directive (Directive 91/271/EC), the Nitrates Directive (Directive 91/676/EC) (see thematic chapter **Agriculture**), the Bathing Water Directive (Directive 2006/7/EC) (see thematic chapter **Tourism and recreation**) and the Floods Directive (Directive 2007/60/EC) (see thematic chapter **Safety against flooding**).

The WFD is implemented by the RD of 23 June 2010 on the surface water status on a federal level and by the Decree Integral Water Policy (Decree of 18 July 2003), coordinated on 15 June 2018 (Water Code) on a Flemish level. The Flemish government is also making efforts to tackle water scarcity and droughts through the implementation of the Blue Deal.

1.4.2.8 Marine Strategy Framework Directive (2008)

The European Marine Strategy Framework Directive (MSFD, 2008/56/EC) is the environmental pillar of the European Union's Integrated Maritime Policy (IMP) (COM (2007) 575). The aim of the MSFD is to achieve a good environmental status (GES) of European marine waters by 2020 and to protect the resources on which economic and social activities depend. The GES is defined in Article 9 of this Directive on the basis of 11 descriptors (table 2) for which member states are required to develop indicators with associated environmental targets (DG Leefmilieu 2012, OD Nature). The European Union shall support member states in developing the methodology of the indicators through a technical report, scientific opinions by descriptor (table 2) and Decision (2017/848/EU) establishing criteria and methodological standards on GES of marine waters and specifications and standardised methods for monitoring and assessment. An overview of relevant legislation, guidelines, technical and scientific reports can be found on the website of the Directorate-General for Environment of the EC. Subsequent to the adoption of the MSFD, OSPAR assumed a key role in harmonising the environmental objectives and the programmes of measures drawn up and implemented by the EU Contracting Parties in the North Sea and the North-East Atlantic.

Table 2. An overview of the 11 descriptors and associated technical reports included in the MSFD.

Descriptors MSFD		
1	Biological diversity	Cochrane et al. (2010); 2017/848/EU
2	Non-indigenous species	Olenin et al. (2010); 2017/848/EU
3	Commercially exploited species of fish, crustaceans and molluscs	Piet et al. (2010); 2017/848/EU
4	Marine food webs	Rogers et al. (2010); 2017/848/EU
5	Eutrophication	Ferreira et al. (2010); 2017/848/EU
6	Seafloor integrity	Rice et al. (2010); 2017/848/EU
7	Hydrographical conditions	2017/848/EU
8	Contaminants	Law et al. (2010); 2017/848/EU
9	Contaminants in fish and other seafood	Swartenbroux et al. (2010); 2017/848/EU
10	Marine litter	Galgani et al. (2010); 2017/848/EU
11	Energy, including underwater noise	Tasker et al. (2010); 2017/848/EU

Following the implementation of the MSFD (RD of 23 June 2010 - marine strategy) and first six-yearly review, Belgium has prepared an update of the initial assessment of the state of the marine environment (Belgian State 2018a) for the BNS, including an actualisation of the socio-economic analysis of the users of the BNS (Belgian State 2018b) (OD Nature). Furthermore, the description of the good environmental status and determination of the environmental targets (Belgian State 2018c) was also updated. On this basis, an update of the monitoring programme (Belgian State 2020) was drawn up by MUMM to measure the evolution of the state of the environment's health. Subsequently, based on the analysis of the monitoring results during the first cycle, a programme of measures was developed by the Marine Environment division (Belgian State 2016), describing additional measures necessary to achieve a good environmental status. A new programme of measures is expected in 2022. In the meantime, studies are being carried out in this context to restore and strengthen the gravel beds and the (lost) oyster beds. Every six years (2024, 2030, etc.), the evaluation must be reviewed and, if necessary, revised in the light of the results obtained on the basis of the monitoring programme and the programme of measures (DG Leefmilieu 2012).

1.4.2.9 Law on the marine environment (1999) and marine spatial planning

The federal Law on the marine environment and marine spatial planning (MMM Law of 20 January 1999) aims to maintain the nature, biodiversity and integrity of the marine environment through protective measures (including the establishment of marine protected areas) and through measures to repair damage and environmental disturbance. In addition to a ban on a number of activities, this law introduces objective liability for damage and environmental disturbance (Goffin et al. 2007). The MMM Law also lists the activities that are subject to a prior licence or authorisation granted by the minister. Furthermore, the law links this licence or authorisation for existing and new activities at sea to a preceding environmental impact assessment (EIA). Since 20 July 2012, the law also regulates the organisation and procedure of marine spatial planning (MSP). Currently, the MSP is in a second cycle and valid from 2020 till 2026 (RD of 22 May 2019, see also Verhalle and Van de Velde 2020, Marine Atlas, Coastal Portal). The policy statement of the Deputy Prime Minister and minister for Justice and the North Sea announced the revision of the MMM Law followed by an evaluation of the procedures leading to the revision of the MSP (Van Quickenborne 2020).

1.4.2.10 Decree of the dunes - Flemish Ecological Network - Spatial Implementation Plans

Besides the aforementioned Ramsar Convention and the Habitats and Birds Directives, other policy instruments for the protection of nature areas in the coastal zone are of importance. At the Flemish level, the Decree of 21 October 1997 on nature conservation and the natural environment steers the overall objectives of the nature policy and the elaboration of policy instruments with regard to species as well as certain areas. The spatial basis for these instruments is constituted by the regional spatial plans of the seventies. In the context of the Dunes Decree (Decree of 14 July 1993 and following), additional areas have been protected, either as 'protected dune area' for the hard destinations or as 'agricultural area important for the dune area' for the agricultural land (Provoost 1999).

The Flemish Ecological Network (VEN) comprises valuable nature in Flanders, supplemented by areas with high potential as nature centres or as nature links. In these areas, nature is additionally protected and users and owners are given additional resources and opportunities to enable a nature- and people-friendly environment.

Finally, space for nature development is provided by spatial planning through the demarcation of the natural structures in the spatial structure plans (Spatial Structure Plan for Flanders, Provincial Spatial Structure Plan for West Flanders), subsequently implemented as spatial implementation plans (SIPs).

1.4.2.11 Long term vision of the Scheldt estuary (2001)

The policy and management of the Scheldt estuary is a cross-border matter in which both Flanders and the Netherlands are involved. For the policy context, including cross-border treaties and memorandums for the Scheldt estuary, we refer to the thematic chapter **Scheldt estuary** (and the website VNSC). Within the framework of the Long-Term Vision of the Scheldt estuary (LTV, Directie Zeeland and AWZ 2001), the Agenda voor de Toekomst of the Flemish-Dutch Scheldt Commission was established. The working group Research and Monitoring coordinates a long-term monitoring and research programme (MONEOS, Meire and Maris 2008) to support the policy and management of the Scheldt estuary. This includes the six-yearly evaluation of the estuary (evaluation method: Holzhauer et al. 2011, Maris et al. 2014, Barneveld et al. 2018). Within this evaluation method, each indicator is individually supported according to a pyramid structure in which the relevant test parameters, calculation

parameters and explanatory variables are included (see also: Indicators for sustainable management in Goffin et al. 2015). The evaluation method a dynamic document that is reviewed after each evaluation report. The first evaluation report (T2009 report: Depreiter et al. 2014) serves as a reference for the subsequent evaluations, with T2015 evaluating data on the Scheldt estuary from 2010 to 2015 (Barneveld et al. 2018). A new update (T2021) of the evaluation methodology is expected by mid-2022. This update will focus on increasing the coherence between the various pyramids for 'nature', a broader interpretation based on narratives on ecology and the relevant human activities in the Scheldt estuary.

1.4.3 Protected areas

Belgium has several statutes for the protection of nature areas in the coastal and marine region: Wetlands or Ramsar areas, Natura 2000 areas, Flemish and recognised nature reserves, areas of the Dunes Decree, protected landscapes and the Flemish Ecological Network (VEN) (see **1.4.2 Policy instruments**). The working areas of two or more of the mentioned regulations often overlap. In total, more than 1,200 km² or about 37% of the BNS has been designated as a marine protected area (table 3, figure 3).

Table 3. An overview of the marine protected areas in the BNS, their surface, status and legal anchoring.

Protected area	Surface area	Status	Legislation
Special Protection Area SPA-1 (Birds Directive)	110.01 km²	Conservation objectives (COs) adopted Management plan drawn up and adopted on 19 January 2018	RD of 14 October 2005 - special protection zones and special zones for nature conservation RD of 27 October 2016 MD of 2 February 2017
Special Protection Area SPA-2 (Birds Directive)	144.80 km²	COs adopted Management plan drawn up and adopted on 19 January 2018	RD of 14 October 2005 - special protection zones and special zones for nature conservation RD of 27 October 2016 RD of 2 February 2017 RD of 22 May 2019 - nature conservation areas
Special Protection Area SPA-3 (Birds Directive)	57.71 km²	COs adopted Management plan drawn up and adopted on 19 January 2018	
Special Protection Area *Vlakte van de Raan* (Habitats Directive)	64.92 km²	Included in the MSP for the period 2020-2026	RD of 14 October 2005 - special protection areas and special zones for nature conservation RD of 22 May 2019 - nature conservation areas
Special Protection Area 'Flemish Banks' (Habitats Directive)	1,099.94 km²	COs adopted Management plan drawn up and adopted on 19 January 2018	RD of 14 October 2005 - special protection zones and special zones for nature conservation RD of 16 October 2012 amending the RD of 14 October 2005 RD of 27 October 2016 MD of 2 February 2017
Ramsar site Western Coastal Banks	19 km² (list Ramsar-areas)		

Natura 2000 comprises a European network of sites designated by the member states of the European Union as Special Protection Areas (SPAs) for the implementation of the Birds and Habitats Directives (see **1.4.2 Policy instruments**). The target date for achieving all nature objectives is 2050, for which six-yearly cycles are used. The Natura 2000 programme describes the actions within a single cycle and is included in the Nature Decree of 21 October 1997 (Pecceu et al. 2016, Belgian State 2018d).

On 27 October 2016, a new RD was adopted on the procedures for the designation and management of marine protected areas in the BNS (see **1.4.2 Policy instruments**, the Habitats and Birds Directives). As mentioned above,

the MD of 2 February 2017 sets the conservation objectives of the marine protected areas. For activities that are likely to have a significant impact on marine protected areas, the impact should be determined through an appropriate assessment, and activities will only be allowed where there is no risk of negative impacts on marine protected areas. Activities that may have negative consequences may be authorised when there is a compelling motive of great public interest, but only when there are no alternatives available and if compensation is provided.

In the marine spatial plan (MSP) (RD of 22 May 2019, see also Verhalle and Van de Velde 2020, Marine Atlas, Coastal Portal) a new habitats directive area, *Vlakte of the Raan*, located on the Dutch border, was included (table 3, figure 3). The MSP aims to better align the activities in the BNS with the protection of the environment. For example, a number of subareas within the nature area of the Flemish Banks are delimited to improve soil integrity. Within these areas, zones can be defined in which certain restrictions for fisheries can be established. Currently, a study is being conducted to identify the most valuable areas for the introduction of fishery restricting measures (Visnat2 project). The current MSP is valid for a period of six years (2020-2026).

Furthermore, Belgium tries to contribute to the protection of the ocean at an international level. At the UN Climate Summit (COP26) in Glasgow (2021), Belgium, together with 12 other countries, launched the Blue Leaders Call for the Ocean. This declaration calls on heads of state worldwide to take action and commit to a new international goal of protecting at least 30% of the oceans by 2030 ("30x30").

Approximately 22% of the surface of the coastal communities has been assigned some kind of protection with regard to nature conservation (figures 4, 5 and 6). This share is higher compared to the hinterland (+/- 16%) and Flanders (+/- 14%) (Dauwe et al. 2019, Vriens et al. 2019). The maps and the surface area of the Natura 2000 sites in the coastal zone can be consulted on the website of Natura 2000 in Flanders and the Coastal Portal.

The remaining ecologically valuable dune areas, with a total surface area of approximately 2,830 ha, are almost entirely protected (Dauwe et al. 2019). Only 5% of these domains do not belong to nature areas of the regional spatial plan or are not protected by 'higher' protection statutes (protected dune area, nature protocol for military domains or nature reserves). It mainly concerns inner-dune areas and areas at the edge of the dunes, e.g. at Cabour (old dunes of Adinkerke), Sandeshoved (the 'dune tongue' of Nieuwpoort) and Oude Hazegraspolder in Knokke. However, these areas have been marked as special protection areas and belong to the 'agricultural areas important for the dune area' of the Dunes Decree (chapter 9 of the Law of 12 July 1973) (Dumortier et al. 2003). In 2013, the Provincial Spatial Implementation Plan (PSIP) 'Strand en Dijk' was approved. It indicates a division of the different beach zones, which allows a better licensing policy to be implemented and vulnerable zones to be better protected. These statutes only provide spatial protection, but do not guarantee that the natural values present will be safeguarded. This usually requires active nature management (Maelfait et al. 2012). The Nature Decree (Decree of 21 October 1997) provides an appropriate legal framework for this purpose, providing for the designation of nature reserves and the drafting of management plans.

According to De Saeger et al. (2013), there are approximately 12,000 ha of historical permanent grasslands (HPGs) in the coastal polders. The Nature Decree stipulates a prohibition or authorisation with regard to alterations of the vegetation and specific physical properties of these grasslands. In 2015, the Government of Flanders decided to protect 8,000 ha of grasslands of which a part being protected by nature legislation and the other by European agricultural policy (see thematic chapter **Agriculture**).

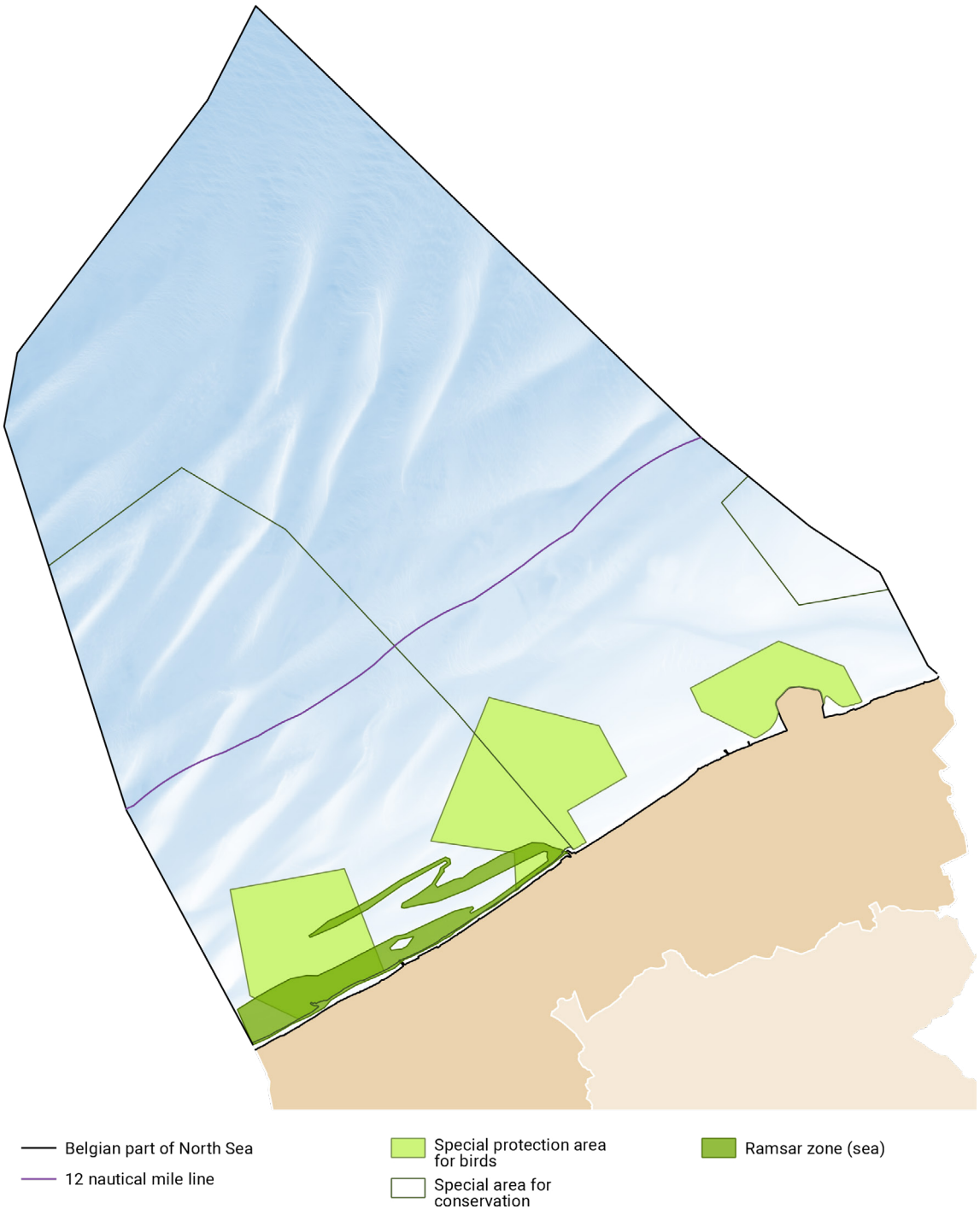


Figure 3. Demarcation of the protected areas in the BNS (Source: RBINS, MarineAtlas.be (based on RD 22 May 2019 (MSP 2020-2026)), Coastal Portal).

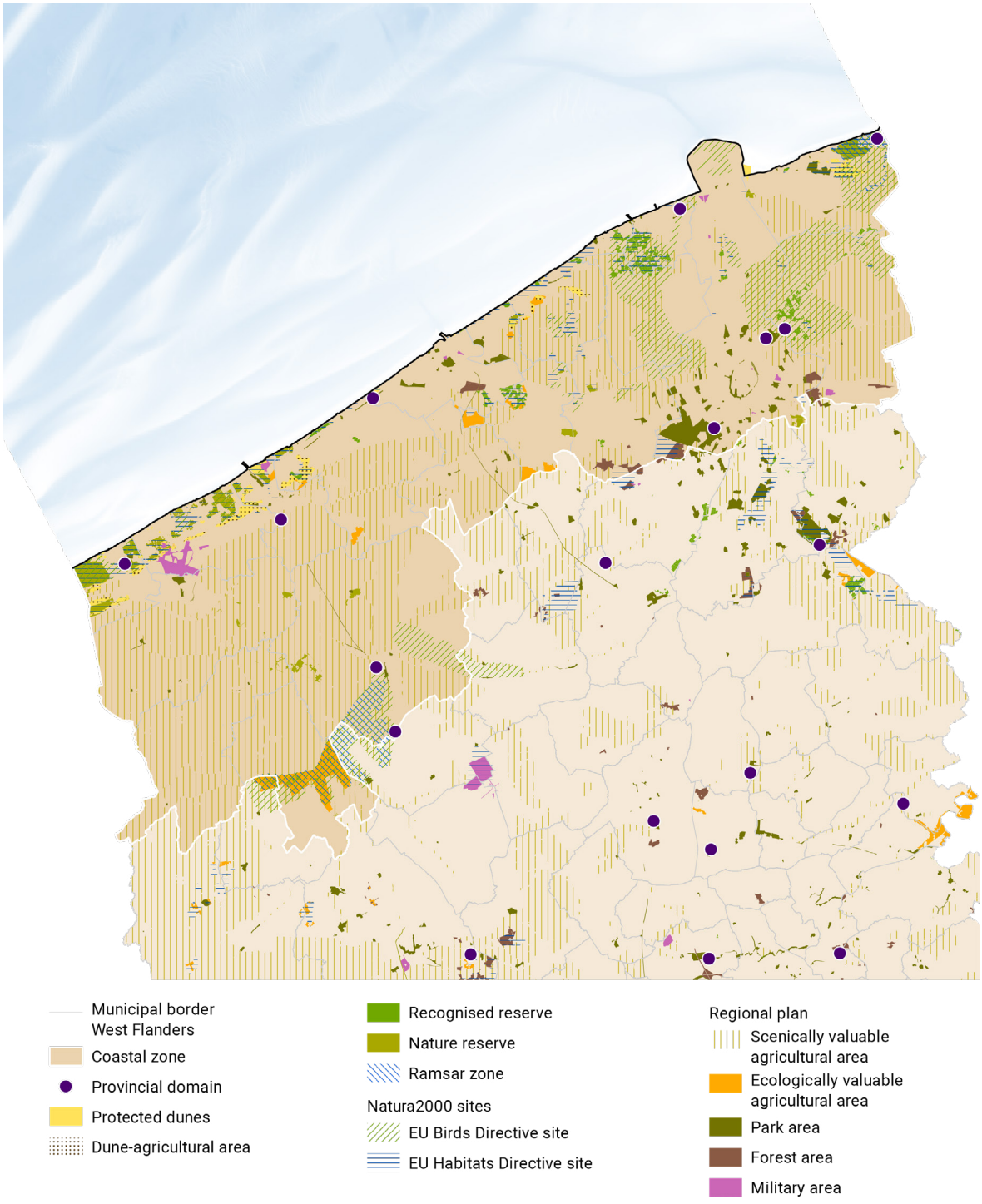


Figure 4. Protected areas and nature area in the coastal zone (Source: Province of West Flanders, Agency for Nature and Forest, Natura 2000, Flemish Department of Environment and Spatial Development – Section Vlaams Planbureau voor Omgeving, Coastal Portal).

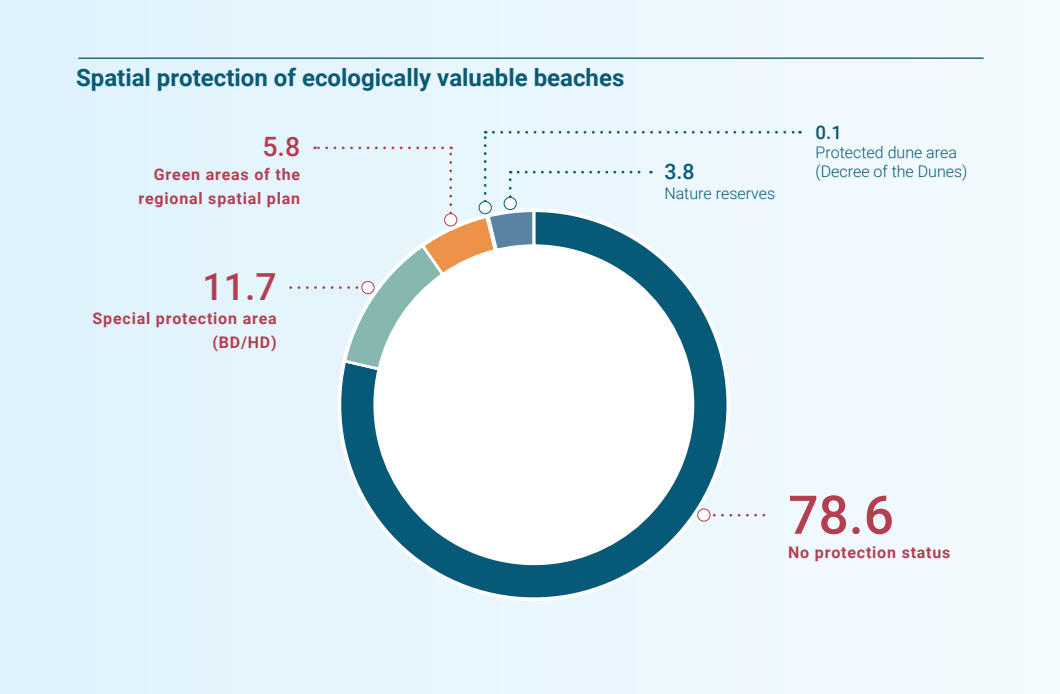


Figure 5. Area-based protection of ecologically valuable beaches according to different nature conservation statuses. Here, both protection categories under the Dune Decree were added to the analysis (Dumortier et al. 2003).

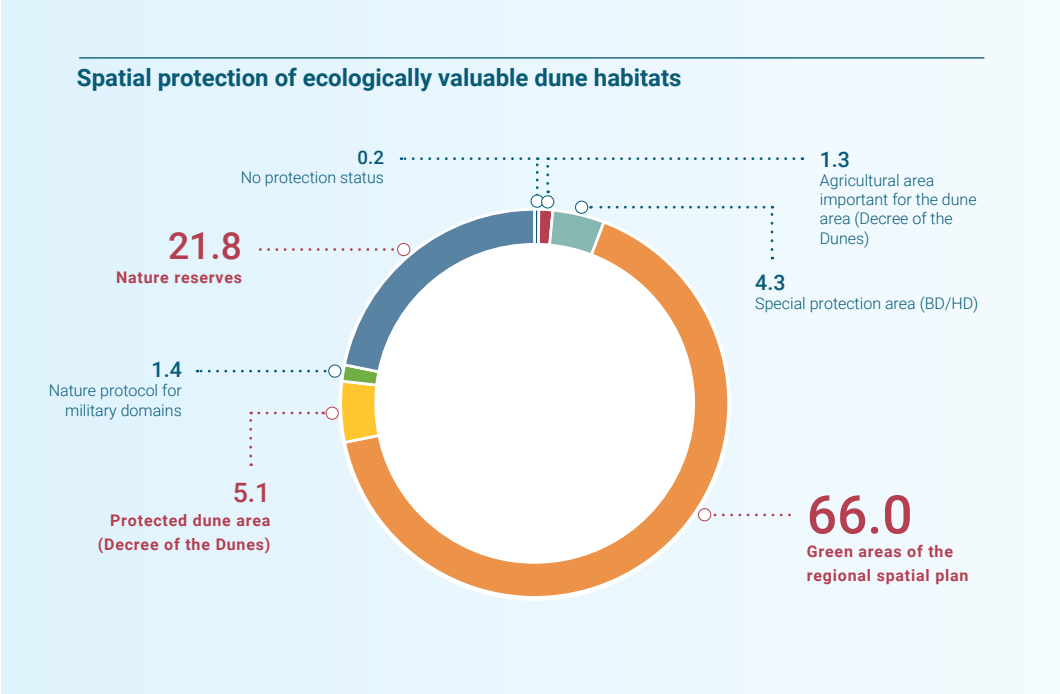


Figure 6. Area-based protection of ecologically valuable dune habitats according to different nature conservation statuses. Here, both protection categories under the Dune Decree were added to the analysis (Dumortier et al. 2003).

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
RAMSAR	Convention on wetlands of international importance, especially as waterfowl habitat	1971	1975
MARPOL	International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978	1973	1978
UNCLOS	United Nations Convention on the law of the sea	1982	1994
CBD	Rio de Janeiro Convention on biological diversity	1992	1996
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Decisions			
Decision (EU) 2017/848	Commission Decision laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU	2017	848
Communications			
COM (2007) 575	Communication from the Commission - An Integrated Maritime Policy for the European Union	2007	575
COM (2021) 240	Communication from the Commission on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future	2021	240
Directives			
Directive 91/271/EEC	Directive concerning urban waste water treatment	1991	271
Directive 91/676/EEC	Directive on the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive)	1991	676
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2006/7/EC	Directive concerning the management of bathing water quality and repealing Directive 76/160/EEC (Bathing Water Directive)	2006	7
Directive 2006/118/EC	Directive on the protection of groundwater against pollution and deterioration (Groundwater Directive)	2006	118
Directive 2007/60/EC	Directive on the assessment and management of flood risks (Floods Directive)	2007	60
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2008/105/EC	Directive on environmental quality standards in the field of water policy, amending and subsequently repealing Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC of the Council, and amending Directive 2000/60/EC (Priority Substances Directive)	2008	105

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 17 July 2000	Besluit van de Vlaamse regering tot wijziging van het besluit van de Vlaamse regering van 17 oktober 1988 tot aanwijzing van speciale beschermingszones in de zin van artikel 4 van de richtlijn 79/409/EEG van de Raad van de Europese Gemeenschappen van 2 april 1979 inzake het behoud van de vogelstand betreffende de speciale beschermingszone «3.2. Poldercomplex»	2000-07-17/70
Decision of the Government of Flanders of 24 May 2002	Besluit van de Vlaamse regering tot vaststelling van de gebieden die in uitvoering van artikel 4, lid 1, van Richtlijn 92/43/EEG van de Raad van de Europese Gemeenschappen van 21 mei 1992 inzake de instandhouding van de natuurlijke habitats en de wilde flora en fauna aan de Europese Commissie zijn voorgesteld als speciale beschermingszones	2002-05-24/44
Decision of the Government of Flanders of 27 November 2015	Besluit van de Vlaamse Regering houdende definitieve vaststelling van de kaarten van de historisch permanente graslanden in de landbouwstreek de Polders en houdende vaststelling van bijhorende beschermingsbepalingen	2015-11-27/19
Decision of the Government of Flanders of 18 December 2015	Besluit van de Vlaamse Regering houdende de vaststelling van de stroomgebiedbeheerplannen voor Schelde en Maas (2016-2021), met inbegrip van het maatregelenprogramma bij de stroomgebiedbeheerplannen, de herziene zoneringsplannen en de gebiedsdekkende uitvoeringsplannen	2015-12-18/41
Decision of the Government of Flanders of 20 January 2017	Besluit van de Vlaamse Regering tot wijziging van het besluit van de Vlaamse Regering van 18 december 2015 houdende de vaststelling van de stroomgebiedbeheerplannen voor Schelde en Maas (2016-2021), met inbegrip van het maatregelenprogramma bij de stroomgebiedbeheerplannen, de herziene zoneringsplannen en de gebiedsdekkende uitvoeringsplannen, wat betreft de herziene zoneringsplannen en de gebiedsdekkende uitvoeringsplannen voor Landen, Oostende, Sint-Katelijne-Waver en Zandhoven	
Decrees		
Decree of 14 July 1993	Decreet houdende maatregelen tot bescherming van kustduinen	1993-07-14/31
Decree of 21 October 1997	Decreet betreffende het natuurbehoud en het natuurlijk milieu	1997-10-21/40
Decree of 18 July 2003	Decreet van 18 juli 2003 betreffende het integraal waterbeleid	2018-06-15/23
Royal Decrees		
RD of 21 December 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 13 November 2012	Koninklijk besluit betreffende de instelling van een raadgevende commissie en de procedure tot aanneming van een marien ruimtelijk plan in de Belgische zeegebieden	2012-11-13/07
RD of 27 October 2016	Koninklijk besluit betreffende de procedure tot aanduiding en beheer van de mariene beschermde gebieden	2016-10-27/11
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
Ministerial Decrees		
MD of 2 February 2017	Ministerieel besluit betreffende de aanname van instandhoudingsdoelstellingen voor de mariene beschermde gebieden	2017-02-02/07
Laws		
Law of 12 July 1973	Wet op het natuurbehoud: Vlaamse Gewest	1973-07-12/35
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 20 July 2012	Wet tot wijziging van de wet van 20 januari 1999 ter bescherming van het marine milieu in de zeegebieden onder de rechtsbevoegdheid van België, wat de organisatie van de mariene ruimtelijke planning betreft	2012-07-20/39

2 Maritime transport, shipping and ports

Authors Frank Maes[1], Jean-Pierre Merckx[2], Jonas Lescroart[3], Hans Pirlet[3], Thomas Verleye[3]

Lectors Jan Blomme[4], Ronny Schallier[5], Guido Fidlers[6], Mario Calbert[7], Ulrike Vanhessche[8]

[1] Ghent University (UGent), Maritime Institute
[2] Mobility Council Flanders (MORA)
[3] Flanders Marine Institute (VLIZ)
[4] Department of Mobility and Public Works (MOW)
[5] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature) / Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM)
[6] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[7] Port Oostende
[8] Coast Guard secretariat

Maes, F., Merckx, J.P., Lescroart, J., Pirlet, H., Verleye, T. (2022). Maritime transport, shipping and ports. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 31-55.

Currently, more than 80% of global trade (by volume) is transported by sea, accounting for 11.1 billion tonnes of goods in 2019 (+0.5% vs. 2018) (UNCTAD 2020, UNCTADSTAT). The economic and social disruptions caused by COVID-19 negatively impacted world trade in 2020 with an average decline in value of 9%. The greatest negative impact was recorded in the first half of 2020 with a 15% value reduction. From the third quarter onwards, world trade started to recover, mainly due to the increase in trade in goods, while trade in services remains far below average (Pallis et al. 2021, UNCTAD 2021a, UNCTAD 2021b). In the first quarter of 2021, total world trade was already at a higher level (+3%) than in the same quarter of 2019 (i.e. before the crisis), mainly driven by the strong export performance of the East Asian economies (UNCTAD 2021b).

In early 2020, the world merchant fleet consisted of 98,140 commercial vessels with a gross tonnage of more than 100 GT, equaling a total of of 2.1 billion DWT (dead-weight tonnage) (UNCTAD 2020). The top three countries in terms of ship ownership within the world merchant fleet (in DWT) are Greece (17.8%), Japan (11.4%) and China (11.2%). The main flag states are Panama, Liberia and the Marshall Islands, together accounting for 42.0% of the global DWT. Belgium had 301 seagoing vessels in 2020 accounting for 1.5% of global DWT, of which 188 were sailing under a foreign flag (UNCTAD 2020; see also list Belgian seagoing ships). The evolution of the Belgian merchant fleet is also covered in the triennial study of the Royal Belgian Shipowners' Association (RBSA 2017).

The Belgian seaports are situated along one of the busiest shipping routes in the world. The total cargo throughput in the Le Havre - Hamburg range[1] amounted to 1.2 billion tonnes in 2019. The share of the Flemish seaports amounted to 318.0 million tonnes (26.1%), of which Antwerp accounted for 238.5 million tonnes (Merckx 2020).

Maritime transport and shipping in the Belgian part of the North Sea (BNS) are discussed in detail below. For ports, only seaports (mainly for handling sea-going vessels) are considered in the current thematic chapter, whereas fishing ports (berths for fishing vessels, see thematic chapter **Fisheries**) and marinas (berths for recreational boats, see thematic chapter **Tourism and recreation**) are not considered (Port jargon Mobility Council).

2.1 Policy context

The United Nations Convention on the law of the sea (UNCLOS 1982) is of primary importance for the policy context for maritime transport, shipping and ports. This convention is considered as the constitution of the sea, discussing the general rights and obligations of nations (flag states, coastal states and port states). On an international level, shipping and maritime transport are covered by several international treaties and resolutions of the International Maritime Organization (IMO, Brochure IMO 2013). Those instruments deal with safety and security at sea, traffic regulations, the training of crew members and pollution prevention (accidental as well as operational discharges) (see IMO website). Some of these conventions are discussed further under **2.5 Sustainable use** and are explained in more detail in Verleye et al. (2018).

The Paris Memorandum of Understanding on Port State Control (MoU Paris 1982) states that each authority shall maintain an effective port state control system so that foreign seagoing vessels calling at its ports comply with the standards set out in the international conventions referred to above and the European Directive on Port State Control (Directive 2009/16/EG).

On a European level, the Directorate-General for Mobility and Transport (DG MOVE) is competent for maritime transport and ports. In December 2020, the European Commission published its Strategy for sustainable and smart mobility (COM (2020) 789) which focuses on greenhouse gas emission reductions, connectivity and digitalisation. The level of ambition of the emission reduction targets is mainly driven by the provisions within the European Green Deal (COM (2019) 640). Furthermore, the European Maritime Safety Agency (EMSA) is of relevance in the context of maritime transport and shipping. This agency aims to reduce the risk of maritime incidents, pollution from ships and the loss of life at sea. An overview of European regulations and policies relevant to ports and maritime transport is given, among others, in Merckx et al. (2012) and Verleye et al. (2018).

In Belgium, maritime transport is a federal matter, covered by the FPS Mobility, Directorate-General of Maritime Transport (other federal actors are listed in table 1). DG Shipping ensures that vessels sailing under a Belgian flag, or vessels entering Belgian ports, comply with the international maritime standards concerning shipping safety, such as the construction and equipment standards, but also the crew standards and the environmental regulations, both technically and administratively. DG Shipping represents Belgium within the IMO. The regulations with which the vessels must comply are briefly listed on the website of the FPS Mobility and Transport. The Belgian

[1] Le Havre - Hamburg range: includes the seaports between Hamburg and Le Havre. France: Le Havre, Dunkirk. Flanders: Antwerp, Zeebrugge, North Sea Port Flanders (Ghent), Ostend. The Netherlands: Amsterdam, Rotterdam. Germany: Hamburg, Bremen.

Shipping Code ('*Belgisch Scheepvaartwetboek*') of 8 May 2019 codifies Belgian maritime and inland navigation law. Strengthening 'blue shipping' is one of the central pillars of the North Sea Policy Statement 2020 (Van Quickenborne 2020) in which the reduction of greenhouse gas emissions and air pollution, waste management and the improvement of working conditions and safety on board are the main focus areas.

The Special Law of 8 August 1980 on the institutional reform defines that waterways and their appurtenances, ports and their appurtenances, pilotage services, coastal defence and beaconing services to and from the ports, as well as rescue and towing services at sea fall under the competence of the Flemish Region within the policy area of Mobility and Public Works (MOW, Policy paper MOW 2019-2024) (see overview of Flemish actors in table 1). The legislative framework regarding the Flemish ports[2] is covered by the Port Decree (2 March 1999, as amended) which forms the basis for the current port policy. The most important basic principles, as included in the Port Decree, are greater autonomy for the port authorities, uniform operating conditions, a more flexible personnel policy, compulsory legal personality for the port authorities, a clear definition of the roles of the ports and the Government of Flanders and an objectification of the financing policy. In December 2020, the Concept paper on the Flemish Port Strategy was presented to the Government of Flanders in the form of a communication. The concept note lays down the mission of the Government of Flanders with regard to the Flemish seaports and describes the overall strategic objectives and priorities of the Flemish port policy. These objectives are grouped around three basic themes: (1) maintaining the competitive position of the ports, (2) achieving sustainable growth and (3) increasing the added value of the port sector. Because ports and the logistics sector are facing important new challenges (digitalisation, green transition, unmanned shipping, etc.), the concept exceeds the intentions of an infrastructure strategy. The new port strategy does not question the current legal frameworks, but mainly aims to complement and strengthen the individual strategies of the ports, and to bring the strategy of the individual ports in line with the Flemish policy on these challenges. Another fundamental development in the Flemish port landscape is the tendency to cooperate extensively and, through increases in scale and the development of synergies, to make the ports more resilient and give them new opportunities for development. In this context, reference can be made to the cross-border merger between the port of Ghent and Zeeland Seaports (North Sea Port) in 2018 and the planned merger (early 2022) between ports of Antwerp and Zeebrugge (Port of Antwerp-Bruges).

The coordination and the consultation between the competent federal and Flemish services (table 1) and the gourvernor of the province of West Flanders is carried out by the Coast Guard (cooperation agreement of 8 July 2005). The organisational structure of the Coast Guard consists of a policy-making body, a consultation body and a secretariat. The policy-making body coordinates the collaboration between the different partners and advises the responsible ministers (article 6 of the cooperation agreement of 8 July 2005). The consultation body of the Coast Guard investigates certain files and gathers information for the policy-making body (article 12 of the cooperation agreement of 8 July 2005). The consultation body is chaired by the Governor of the Province of West Flanders who also manages the coordination of the General Emergency and Intervention Plan (ANIP) North Sea (see Belgian official journal of 20 October 2016). The Coast Guard cooperation agreement also includes the creation of the Coast Guard Centre.

The Coast Guard Centre is the operational section of the Coast Guard and consists of two services, which collaborate intensively: the Maritime Rescue and Coordination Centre (MRCC) in Ostend (acting as the national IMO Coastal Station, the first point of contact for vessels in distress and in charge of the coordination of rescue operations) and the Maritime Security Centre Belgium (MIK) in Zeebrugge (cooperation between the Naval Component, the Shipping Police, Border control and the DG Shipping to ensure compliance with the laws applicable on the BNS). Their tasks were laid down in the Decree of 16 June 2006, the Decision of the Government of Flanders of 26 October 2007 and the RD of 6 February 2009.

Other relevant organisations and clusters that were not included in table 1 are:

- The Mobility Council of Flanders (MORA) is the strategic advisory council for the policy domain of Mobility and Public Works (MOW). In March 2019, the operations of the Flemish Ports Commission (VHC), which until then had an advisory and informative function with regard to the socio-economic aspects of ports and port policy, were integrated into the MORA.
- The Environment and Nature Council of Flanders (Minaraad) is a strategic advisory council for the policy area Environment of the Government of Flanders. The advices of the Minaraad sometimes include port- and shipping-related topics.

[2] The Flemish ports include the ports of Antwerp, Ghent, Zeebrugge and Ostend. Since December 2017, the port of Ghent has merged with Zeeland Seaports (Terneuzen and Vlissingen) to form North Sea Port. The Ghent part is referred to as North Sea Port Flanders.

An overview of the legislation related to shipping and ports is also given in the Codex Coastal Zone, themes Shipping and Port and Industry. The environmental legal context of port policy, management and operation is outlined in detail in Van Hooydonk et al. (2003).

Table 2. Overview of the Flemish and federal partners of the Coast Guard structure.

Flemish partners of the Coast Guard	Federal partners of the Coast Guard
Strategy, International Policy and Animal Welfare Department	FPS Home Affairs (Civil Protection, Crisis Centre and Maritime Police)
Fisheries service	FPS Foreign Affairs
AMSC (*MDK*) - Coastal division	FPS Economy, SMEs, Self-employed and Energy
AMSC (*MDK*) - Shipping Assistance division	FPS Finance (Customs and Excises)
AMSC (*MDK*) - Pilotage	FPS Mobility and Transport (DG Shipping)
AMSC (*MDK*) - Fleet	FPS Public Health, Safety of the food Chain and Environment (Marine Environment division)
MOW - Department of Policy	Ministry of Defence
MOW - Maritime Access Department	Federal Institute for Sustainable Development
	POD Science Policy (Management Unit Mathematical Model of the North Sea (MUMM))

2.2 Spatial use

2.2.1 Offshore

In the marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020), the most important shipping routes to reach the Belgian ports and the Scheldt ports are legally demarcated (figure 1). Within these areas, shipping has priority over other activities, but vessels are not obliged to follow these routes. The current navigational routes in Belgian and Dutch waters have been applied since 1 June 2017, and are mainly necessary for the safety of the Belgian offshore wind farms on, and in the surroundings of, the Thornton Bank (no access for vessels) and to promote the safety of shipping and to limit the risk of collisions with possible environmental pollution as a result (figure 1). The shipping routes also consider the offshore wind farms in Dutch waters (including Borssele). Other activities may be allowed within these demarcated zones, as long as they do not hinder shipping. For a number of these routes, a routeing system (ship's routeing, IMO) has been adopted within the IMO:

- Traffic separation scheme Noordhinder South;
- Precautionary area (where vessels have to navigate carefully) Noordhinder Junction;
- Traffic separation scheme Westhinder;
- Precautionary area Westhinder;
- Area to avoid Westhinder;
- Deepwater route (specifically for vessels with a limited maneuverability due to their draught) for approaching the Western Scheldt;
- Precautionary area north of the Deepwater route;
- Traffic flow Westpit, along the southern side of the zone delineated by the domain concession for the windmills in east-western direction.

In addition to the frequently used routes for which IMO has created routeing systems, other important and frequently used shipping routes towards the ports or the Scheldt area exist in the BNS. These routes are used by vessels because they are marked and/or dredged, guaranteeing a safe water depth for shipping. Most of these routes within the territorial sea are also pilotage routes (most merchant ships are subject to compulsory pilotage). Furthermore, a precautionary area is defined around the zone reserved for the construction and operation of renewable energy production facilities. A safety zone of 500 m is established around individual fixed structures, which will be counted from the boundaries of the concession zones as the offshore wind farm becomes operational cf. RD of 4 February 2020 (see also thematic chapter **Energy (including cables and pipes)**). The anchor areas Oostdyck and Westhinder are also delineated in the MSP 2020-2026.

The provisions and information concerning navigation in the BNS are communicated via the Notices to Mariners (NtM, more information: general provisions NtM 2020 nr. 1).

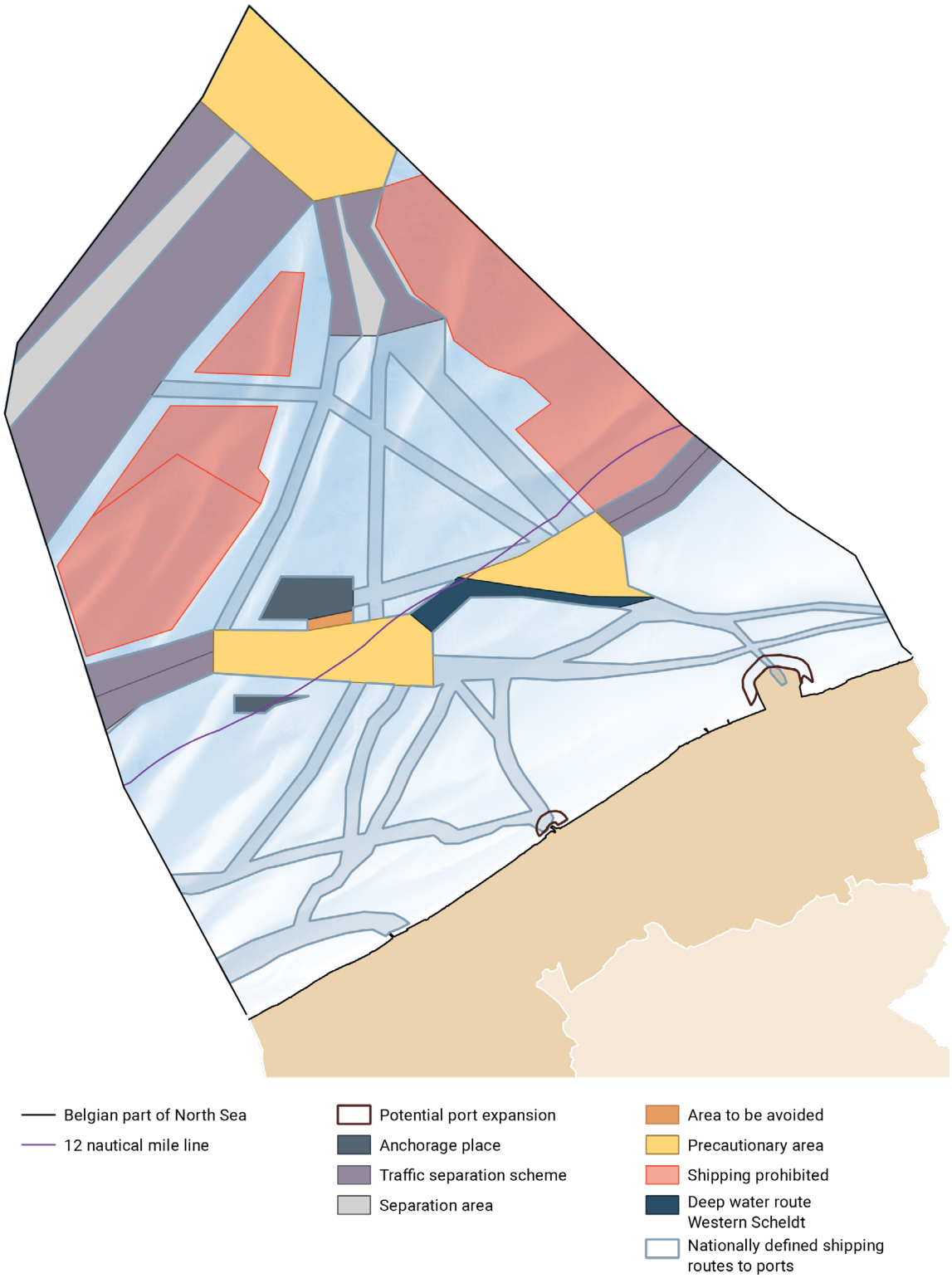


Figure 1. Indication of IMO shipping routes, anchorage areas, areas to be avoided and potential port expansions (Source: RBINS, MarineAtlas.be (based on the RD of 22 May 2019 (MSP 2020-2026)), Coastal Portal).

2.2.2 Port zones

In accordance with the provisions in the Spatial Structure Plan for Flanders (*Ruimtelijk Structuurplan Vlaanderen*; RSV), the Port Decree and consecutive coalition agreements, every Flemish seaport should have a strategic plan (including environmental impact assessments (plan-EIA) (see also **2.4 Impact**) and spatial safety reports) in which it is investigated how the economic interests can be sustainably aligned with other societal interests when the port area is further developed. This plan is the basis of the demarcation of seaports in a regional spatial implementation plan (RSIP): RSIP Ghent Seaport (2005), Ghent Seaport Phase 2 (2012), Zeebrugge (2009), Ostend (2013) and Antwerp (2013). The spatial development and accessibility of seaports is also addressed in Groenboek Vlaanderen 2050: mensenmaat in een metropool (2012), the White Paper Beleidsplan ruimte Vlaanderen (2017) and the Strategische visie beleidsplan ruimte Vlanderen (2018).

When the port development causes a loss of natural sites, this will usually be compensated by the creation and establishment of new natural sites in other areas. These nature compensation areas are delineated in agreement with the Flemish Land Agency (VLM) and are inter alia located in the area behind the Port of Zeebrugge (website VLM) and in the basin of the Scheldt estuary, as stipulated in the Sigmaplan.

The demarcation of the different port zones has been stipulated in the RD of 2 February 1993 and in the Decision of the Government of Flanders of 13 July 2001. The total surface and the water surface of the Flemish seaports are presented in table 2.

Ports are not only dealt with in spatial planning on land. For example, the MSP 2020-2026 (RD of 22 May 2019, see also Verhalle and Van de Velde 2020) provides space on the seaside to further expand the ports of Zeebrugge and Ostend.

Table 2. Overview of the Flemish seaports and their total surface and water area (Merckx 2020).

Port	Total surface area	Water surface
Port Oostende	658 ha	199 ha
Port of Ghent (North Sea Port Flanders)	4,648 ha	623 ha
Port of Zeebrugge	2,857 ha	986 ha
Port of Antwerp	11,246 ha	2,028.4 ha

2.3 Societal interest

2.3.1 Corona pandemic and Brexit

In recent years, disruptive events, such as the Corona pandemic and the Brexit, have caused profound changes in the maritime sector. For example, the Corona pandemic and the associated lockdown period in 2020 resulted in a significant decrease in vessel movements (see **2.3.4 Vessel movements**), goods transhipment (see **2.3.5 Transshipment of goods**) and passenger traffic (see **2.3.6 Passenger traffic**) to the Flemish ports.

Additionally, the Brexit has been a fact since 1 January 2021. Belgium is one of the four main trade partners with the UK (besides the Netherlands, Germany and France). Currently, UK-based companies mainly use accompanied trucks and ferries for transport (Port of Antwerp 2020). In order to facilitate smooth customs handling and reduce transit times, companies are advised to consider alternative transport modes, such as short-sea shipping (SSS). SSS is the movement of cargo mainly by sea along a coast, without crossing an ocean. It includes the unaccompanied movements of liquid and dry bulk cargo, containers and conventional cargo, lifted on board of a cargo vessel by cranes. These recommendations were published in a Brexit white paper (2020) by the Port of Antwerp.

The Port of Zeebrugge is a hub for UK traffic, with about 70 vessels a week connecting the port with various regions in the UK. With an annual volume of 16.4 million tonnes (2020), 35% of the total handled volume in the Port of Zeebrugge, the UK is the port's largest trading partner (70% export, 30% import), of which the bulk (14.8 million tonnes) concerns roll-on/roll-off traffic (Port of Zeebrugge). Flanders Investment and Trade has developed a roadmap for the export of goods to the UK after the Brexit. The development of the Port of Zeebrugge as a Brexit-proof logistical gateway, by setting up a customs help desk, is also one of the objectives of the West

Flanders Fund for Regional Reconversion (WVFR) that was set up by the West Flanders Development Agency, together with the social partners, the federations, the sector funds and Flanders Investment and Trade.

2.3.2 Employment

Total employment in the Flemish seaports in 2019 was 239,049 full-time equivalents (FTE), of which 108,542 were direct FTE (Figure 2). Antwerp is the leading Flemish port in terms of direct employment with 64,121 direct jobs (59,1%). This is followed by North Sea Port Flanders (29,112 FTE; 26.8%), Zeebrugge (10,031 FTE; 9.2%) and Port Oostende (5,278 FTE; 4.9%). This difference in employment is partly linked to the nature of the industry and the goods traffic in the different ports (see below).

At sector level, more than one third of the personnel is employed in the maritime sector[3]. The total employment (direct + indirect) in the ports accounted for 5.9% of the total Flemish employment in 2019 (including the self-employed) (Rubbrecht et al. 2021).

The ports of Liège and Brussels together accounted for a total direct employment of 11,856 FTE. This brings the total direct employment for Belgium to 120,398 FTE of which Liege and Brussels jointly account for 9.8%. The total Belgian employment (direct + indirect) amounts to 250,905 FTE (Rubbrecht et al. 2021).

The workforce in Belgian ports has remained relatively unchanged for several years and concerns mainly male employees (83%). Blue collar workers make up the majority of the port workforce with a 52% share in 2015, followed by white collar workers (44%) and other staff (4%) (Mathys 2017).

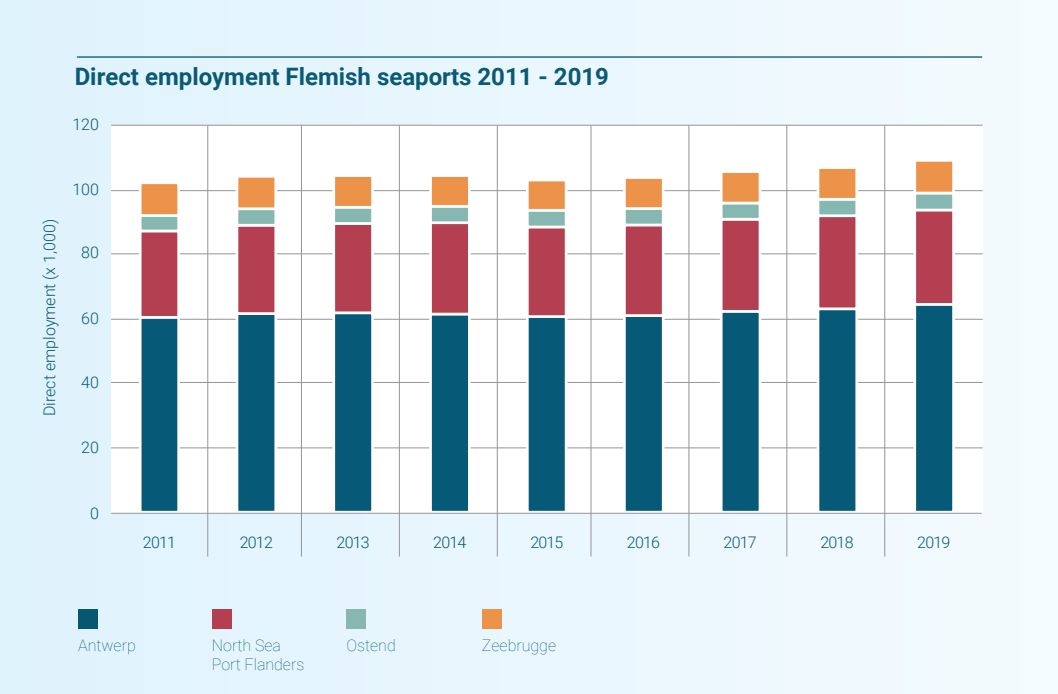


Figure 2. Direct employment in the Flemish seaports in FTEs (Source: Merckx 2020, *figures 2019 pers. comm.*, Rubbrecht et al. 2021).

2.3.3 Added value

The total added value of the Flemish ports in 2019 was 30.4 billion euro, of which 17.4 billion euro was direct added value (figure 3). Between 2013 and 2019, the direct added value of the ports increased by 18.4%. The Port of Antwerp generates the highest direct added value and accounts for 11.2 billion euro (64.5%), followed by North

[3] The maritime sector comprises those branches of industry that are specific to ports and whose existence is essential to them. Maritime branches of activity are shipping companies, shipping agents and forwarders, cargo handling, storage, shipbuilding and repair, port construction, dredging, fishing, maritime and pilotage services, locks, etc.

Sea Port Flanders (4.5 billion euro; 25.8%), Zeebrugge (1.1 billion euro; 6.2%) and Port Oostende (0.6 billion euro; 3.5%) (Merckx 2020; *figures 2019 pers. comm.*).

The ports of Liège and Brussels have a direct added value of 1.0 billion euro and 0.8 billion euro, respectively, and thus have a relative share of 9.8% of the total of Belgian ports (Rubbrecht et al. 2021).

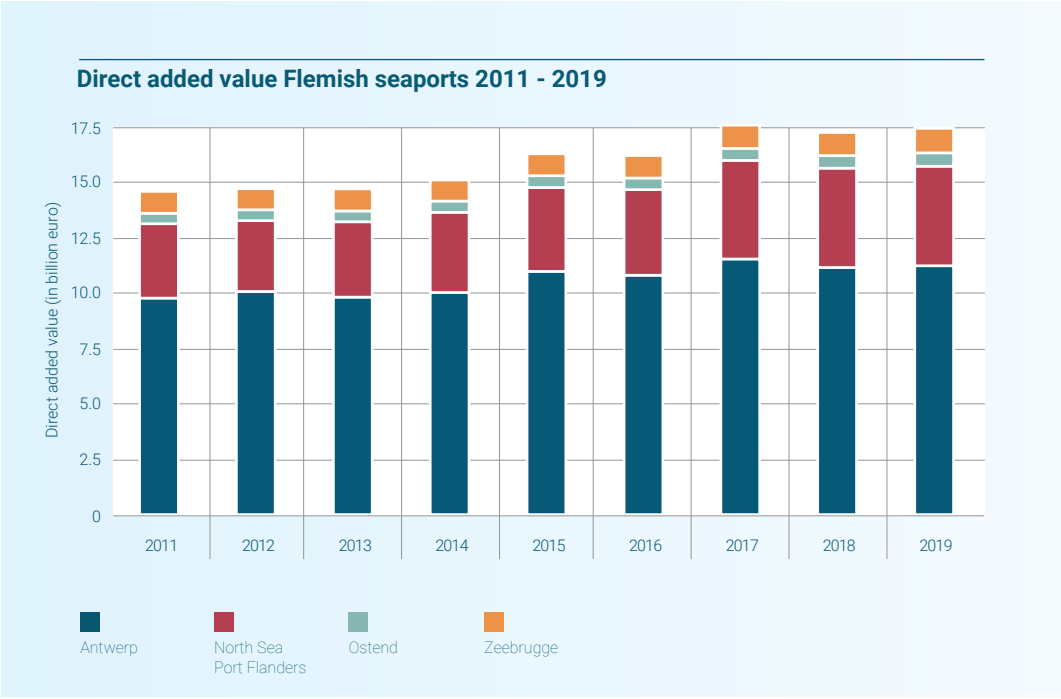


Figure 3. Direct added value in the Flemish seaports in million euro (Source: Merckx 2020, *figures 2019 pers. comm.*).

2.3.4 Vessel movements

In 2020, 30,163 seagoing vessels visited a Flemish seaport (-4.1% compared to 2019), accounting for a total of 636.9 million GT (-6.6% compared to 2019). The decrease compared to 2019 can be attributed to the corona pandemic (see also Verleye et al. 2020). In addition, the number of seagoing vessels calling at a Flemish seaport on an annual basis has been characterised by a decrease over the past four decades (-17.9% since 1980). This decline is however compensated by the increasing size of vessels, as a result of which the total Gross Tonnage (GT) today exceeds the amount from 1980 by more than 3.5 times (figure 4). At the level of individual vessels, this means an average increase from 5,237 GT to 21,115 GT (Merckx 2020; *figures 2020 pers. comm.*).

The average GT per vessel varied considerably between ports in 2020, with the average GT of vessels calling at Zeebrugge (29,840 GT) and Antwerp (28,850 GT) being remarkably higher than those calling at North Sea Port Flanders (11,322 GT) and Port Oostende (984 GT) (Merckx 2020; *figures 2020 pers. comm.*).

2.3.5 Transshipment of goods

The total maritime traffic in the Flemish ports has been characterised by a gradual increase over the past decades. Since the year 2000, only four setbacks have been recorded compared to the previous year. The main decrease in maritime traffic (-14.3% compared to the previous year) occurred in 2009, as a result of the global financial and economic crisis. In 2010, this decline was almost completely compensated (+13.6%), but the total traffic in the Flemish ports remained almost unchanged until 2015 compared to the 2008 level. It was only after 2015 that strong growth rates returned, but this upward trend was abruptly interrupted by the outbreak of the Corona pandemic in 2020, and the associated global measures and lockdowns (see also Verleye et al. 2020). In 2020, 308.6 million tonnes of goods were handled in the Flemish seaports, a drop of 3,0% compared with 2019 (figure 5). Antwerp comes out on top with 231.0 million tonnes (74.8%), followed by Zeebrugge (47.0 million tonnes; 15.2%), North Sea Port Flanders (29.1 million tonnes; 9.4%) and Ostend (1.5 million tonnes; 0.5%) (Merckx 2020; *figures 2020 pers. comm.*).

In terms of volume, the Port of Antwerp is the leading Flemish port for liquid bulk (69.0 million tonnes; 80.1%), containers (139.1 million tonnes; 88.4%) and conventional general cargo (6.6 million tonnes; 62.8%). Zeebrugge is the leading port for roll-on roll-off (14.2 million tonnes; 68.2%) while North Sea Port Flanders handles the largest amount of dry bulk (19.1 million tonnes; 56.8%) (Merckx 2020; *figures 2020 pers. comm.*).

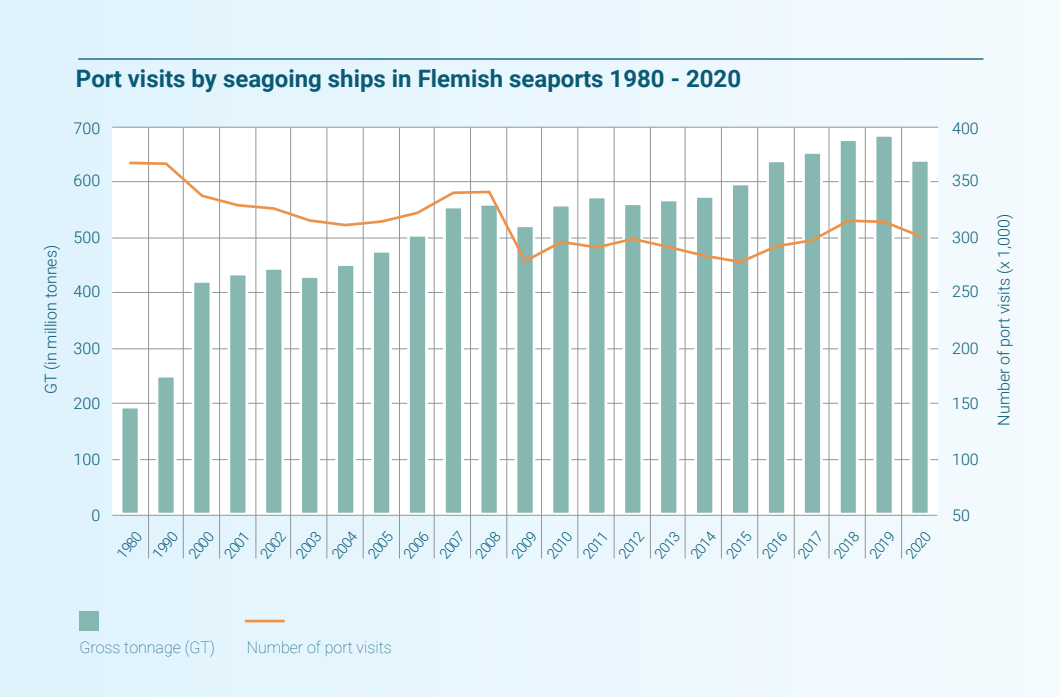


Figure 4. The number of port calls by seagoing vessels and the associated total gross tonnage (GT) (Source: Merckx 2020, *figures 2020 pers. comm.*).

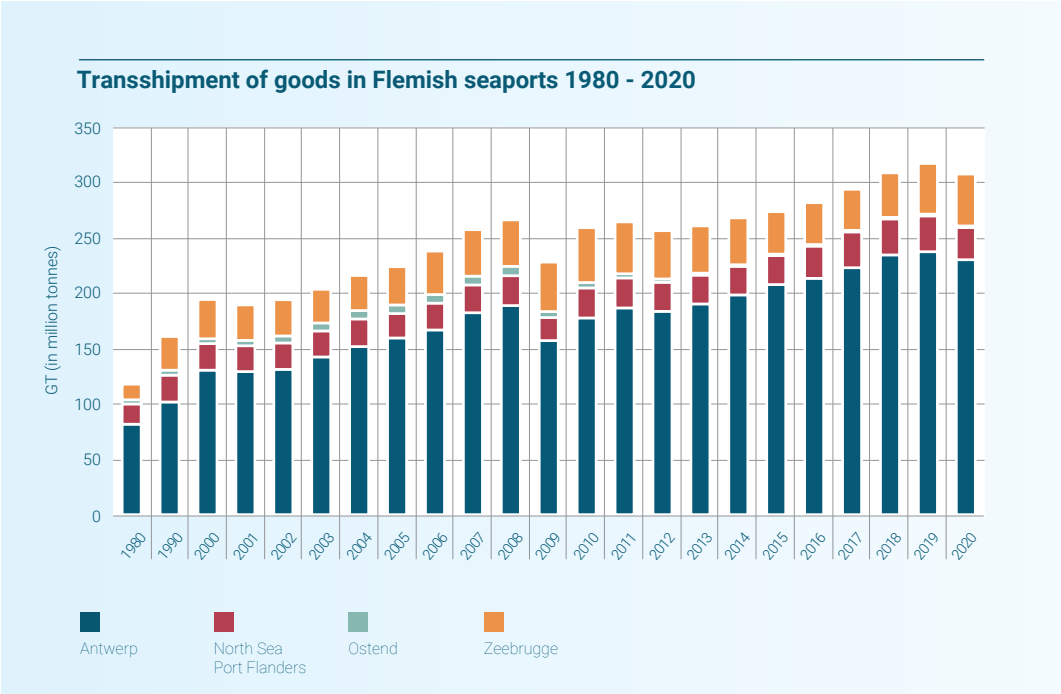


Figure 5. Transshipment of goods in the Flemish seaports (tonnes) (Source: Merckx 2020, *figures 2020 pers. comm.*).

2.3.6 Passenger traffic

Passenger traffic from and to the Flemish ports experienced a sharp decline between 1980 (over 5 million passengers) and 2004 (816,516 passengers) as a result of the opening of the Channel Tunnel, the cessation of the *Regie voor Maritiem Transport* (RMT), a company that provided a ferry connection between Ostend and the UK, and the termination of certain ferry lines to the UK (Notteboom 2004). In 2020, passenger traffic suffered greatly from the corona crisis and decreased by 93.6% compared to 2019 (figure 6). Only 66,303 people embarked or disembarked in a Flemish seaport, compared with over 1 million in 2019 (Merckx 2020; *figures 2020 pers. comm.*). In addition, on 1 January 2021, the ferry line between Zeebrugge and Hull was scrapped.

Passenger traffic in 2020 was almost entirely attributable to Zeebrugge (64,816 passengers; 97.8%). Until 2001, Port Oostende represented more than half of the passenger traffic to and from the Flemish ports, which has now fallen to 0.0% (Merckx 2020; *figures 2020 pers. comm.*).

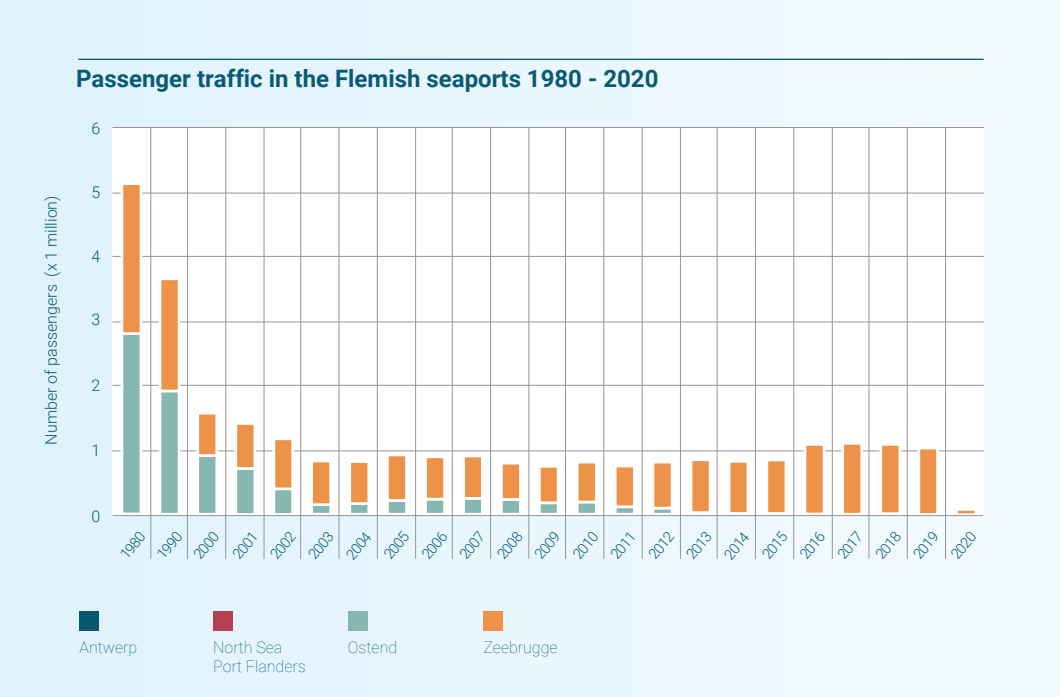


Figure 6. Passenger traffic in the Flemish seaports (Source: Merckx 2020, *figures 2020 pers. comm.*).

2.3.7 Inland navigation to and from Flemish seaports

In 2020, 125.1 million tonnes of goods were loaded and unloaded into and from inland vessels in the Flemish seaports, a decline of 0.5% compared to 2019. This represents 73.5% of the total cargo traffic by inland navigation in Flanders (170.2 million tonnes). Antwerp (101.0 million tonnes) and North Sea Port Flanders (22.9 million tonnes) together account for 72.8% of the total Flemish goods traffic by inland navigation and represent 99.0% of the share of the seaports (figure 7) (Merckx 2020; *figures 2020 pers. comm.*). The accessibility of Zeebrugge for inland navigation remains problematic, but is partly compensated by the development of the estuary shipping[4] via the Scheldt to the hinterland.

2.3.8 Investments

In 2019, direct investments in the Flemish seaports amounted to 4.5 billion euro, an increase of 45.7% since 2013, but a decrease of 23.6% compared to 2018 (figure 8). The high investment volume in 2018 (especially for Antwerp) results from a merger among shipping companies. The Port of Antwerp accounts for 72.6% of total investments in 2019, accounting for 3.3 billion euro. This is followed by North Sea Port Flanders (802.2 million euro; 17.8%), Zeebrugge (315.9 million euro; 7.0%) and Port Oostende (111.3 million euro; 2.5%) (Rubbrecht et al. 2021).

[4] Estuary shipping is sailing with reinforced inland navigation vessels at sea along the coastline, between the mouth of the Scheldt and the Port of Zeebrugge. This special mode of transport is the solution for a better connection of the Port of Zeebrugge.

Investments in the ports of Liège and Brussels amounted to 205.4 million and 102.8 million euro, respectively, in 2019. Together, they represent 6.4% of the total investments in Belgian ports (4.8 billion euro) (Rubbrecht et al. 2021).

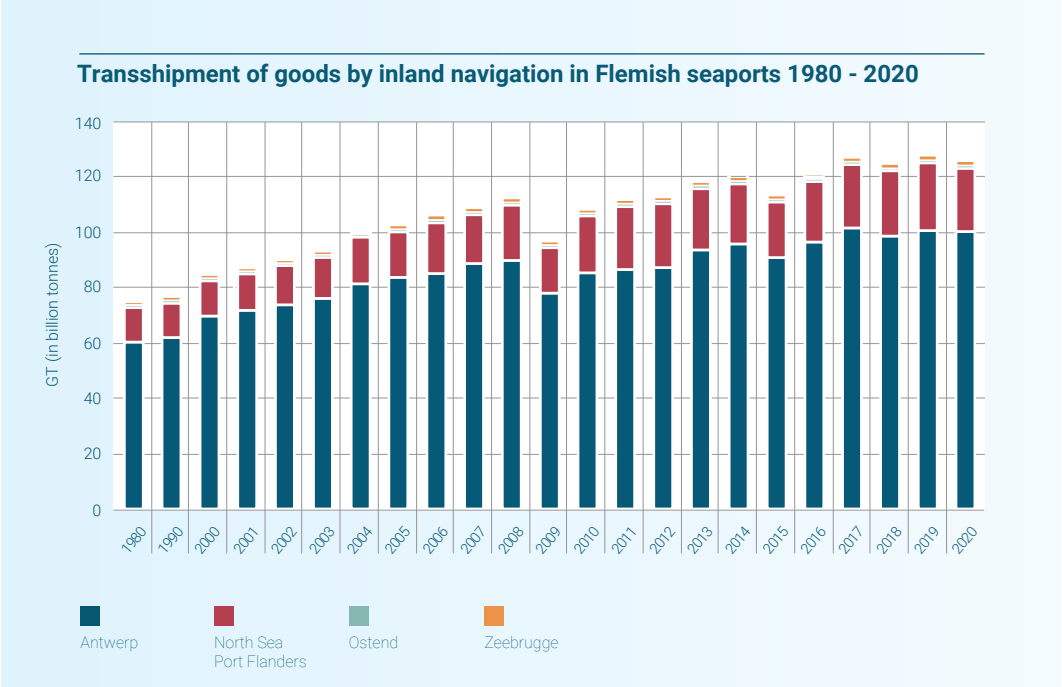


Figure 7. Transhipment of goods by inland navigation in the Flemish seaports (Source: Merckx 2020, *figures 2020 pers. comm.*).

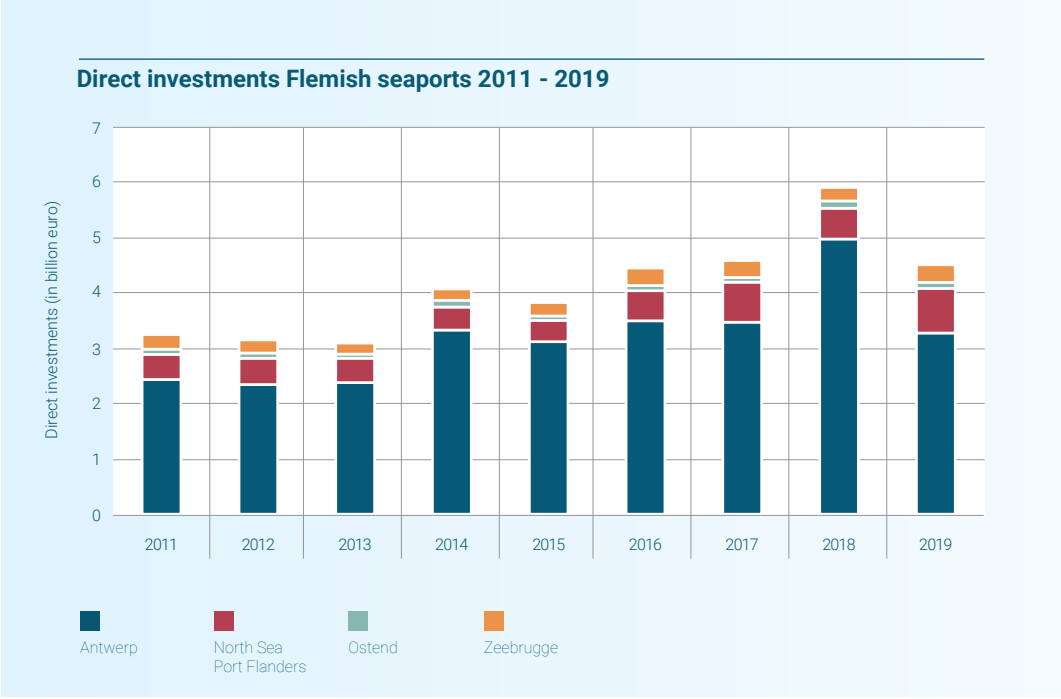


Figure 8. Direct investments in the Flemish seaports in million euro (Source: Merckx 2020 (*figures 2019 pers. comm.*), Rubbrecht et al. 2021).

2.3.9 Government expenditure

Total public spending on the Flemish seaports amounted to 462.2 million euro in 2020. 'Maritime access', with its 256.0 million euro, immediately accounts for 55.4% of total public spending. This includes maintenance dredging at sea and on the Western Scheldt, various deepening programmes, wreck removal, vessel traffic services (VTS) and sludge processing. Among the port-related expenditures (185.7 million euro), the largest budget was provided for the Port of Antwerp (149.3 million euro), followed by Zeebrugge (30.3 million euro), Port Oostende (3.2 million euro) and North Sea Port Flanders (2.9 million euro) (figure 9) (Merckx 2020; *figures 2020 pers. comm.*).

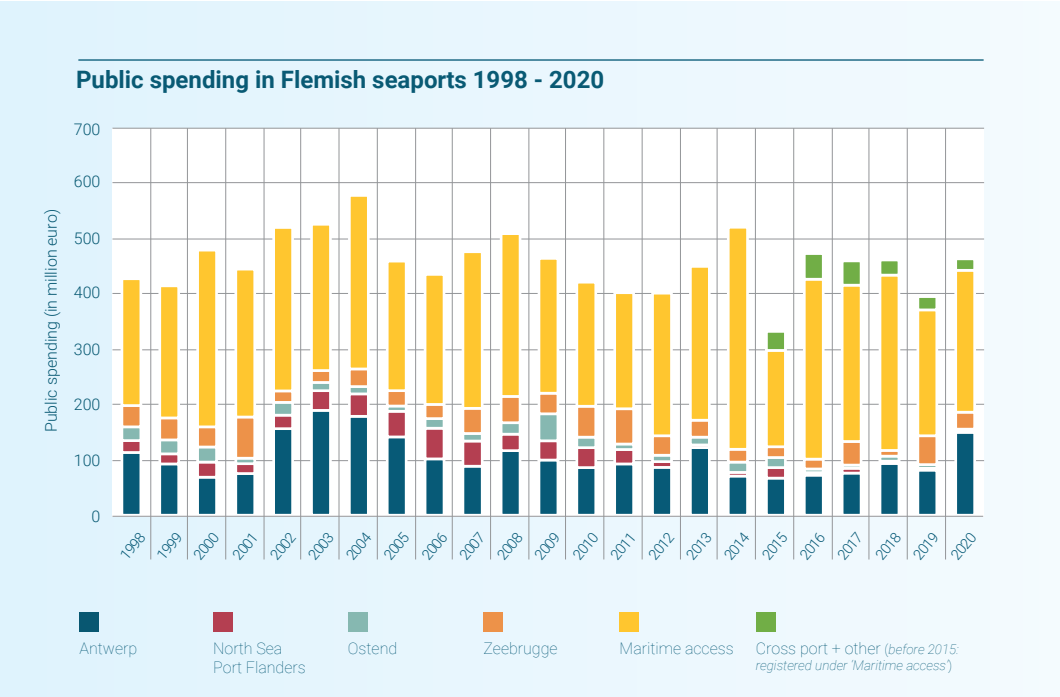


Figure 9. Public expenditure in the Flemish seaports (in million euro) (Source: Merckx 2020. *figures 2020 pers. comm.*).

2.4 Impact

Shipping has a series of effects on the marine environment. Table 3 gives an overview of the possible impacts and the relevant literature.

In addition, the port locations and operations also have an impact on the environment. These effects are listed in the (plan-) environmental impact assessments (EIAs) of the ports' strategic plans (table 4, non-exhaustive list, see also EIA file database, Department of Environment and Spatial Development).

2.5 Sustainable use

2.5.1 Roadmap towards a sustainable EU maritime transport

COM (2009) 8 developed strategic objectives and recommendations for the EU's maritime transport policy until 2018, followed by the Resolution 2009/2095(INI) of 5 May 2010 in which the European Parliament called on the Commission to take further action against the misuse of flags of convenience, to draw up new rules on state aid, to propose guidelines for ports, to take more account of maritime transport in the context of the Trans-European Transport Networks (TEN-Ts), to reduce emissions form vessels, and to develop European maritime transport within a common maritime space. Following the White Paper 'Roadmap to a Single European Transport Area' (COM (2011) 144), which proposed 40 concrete initiatives to achieve a competitive and resource efficient European transport system, the Resolution 2011/2096(INI) was adopted at the end of 2011. Specifically for maritime transport, the European Parliament called in this resolution, among other things, for the introduction of a European policy for short and medium distance shipping and a proposal for the development of a European maritime space without barriers (the so-called 'Blue Belt'). The latter was followed up by COM (2013) 510 which

aims to simplify customs formalities in order to reduce costs and facilitate trade. Regulation (EU) 1315/2013 provides guidelines for the establishment of a long-term strategy for the development of a TEN-T by road, rail, air and water. Through the Connecting Europe Facility for Transport (CEF Transport) financing channel, TEN-T projects can be financed to remove bottlenecks in this network. 'Motorways of the Sea', with Shortsea Shipping (SSS; see also **2.3.1 Corona pandemic and Brexit**) as the main transport mode (COM (2004) 453), is the maritime component of TEN-T and contributes to the creation of a European transport area without barriers.

Table 3. Overview of the environmental impact related to shipping.

Impact	Literature
Pollution by oil and other harmful substances due to accidental, operational or illegal spills	Maes et al. 2004 (MARE-DASM project BELSPO), Schrijvers and Maes 2005 (GAUFRE project BELSPO), Le Roy et al. 2006 (RAMA project BELSPO), Volckaert et al. 2006 (MIMAC project BELSPO), Goffin et al. 2007, OSPAR QSR 2010, Dittman et al. 2012, Lagring et al. 2012, Maebe et al. 2012, Dulière et al. 2013 (OSERIT project BELSPO), Bonn Agreement 2014 (BE AWARE I Summary Report), Second Federal Environmental Report 2015, Hjorth et al. 2015 (BE AWARE II Summary Report), Schallier and Van Roy 2016, OSPAR IA 2017, Stienen et al. 2017, Third Federal Environmental Report part 1 (Belgian State 2018), Third Federal Environmental Report part 2 (Belgian State 2019)
Air pollution from the emission of particles in the exhaust gas of ship engines (NOx, SOx, CO_2, etc.)	Maes et al. 2004 (MARE-DASM project BELSPO), Schrijvers and Maes 2005 (GAUFRE project BELSPO), Goffin et al. 2007, Maes et al. 2007 (ECOSONOS project BELSPO), Gommers et al. 2007 (MOPSEA project BELSPO), OSPAR QSR 2010, Bencs et al. 2012 (SHIPFLUX project BELSPO), Van Roy and Scheldeman 2016
Accidental or illegal discharge of waste or material	Goffin et al. 2007, OSPAR QSR 2010, Claessens et al. 2013 (AS-MADE project BELSPO), Second Federal Environmental Report 2015, Devriese and Janssen 2017, Third Federal Environmental Report deel 1 (Belgian State 2018), Third Federal Environmental Report part 2 (Belgian State 2019)
Leaching of harmful antifouling substances (e.g. tributyltin (TBT))	Maes et al. 2004 (MARE-DASM project BELSPO), Schrijvers and Maes 2005 (GAUFRE project BELSPO), Goffin et al. 2007, OSPAR QSR 2010, OSPAR IA 2017
Introduction of non-indigenous species by attachment to the keel or discharge of ballast water	Maes et al. 2004 (MARE-DASM project BELSPO), Schrijvers and Maes 2005 (GAUFRE project BELSPO), Goffin et al. 2007, Kerckhof et al. (2007), OSPAR QSR 2010, Vandepitte et al. 2012, State of Europe's Seas 2015, Saelens and Verleye 2015, OSPAR IA 2017, Third Federal Environmental Report part 1 (Belgian State 2018), Third Federal Environmental Report part 2 (Belgian State 2019)
Pollution and physical impact due to loss of vessels and cargo	Le Roy et al. 2006 (RAMA project BELSPO), De Baere et al. 2010, OSPAR QSR 2010
Other possible physical impact including noise and collision with marine mammals	Maes et al. 2004 (MARE-DASM project BELSPO), OSPAR QSR 2010, State of Europe's Seas 2015, compilation national reports ASCOBANS, Jomopans project, Farcas et al. 2020
Impact on other users (safety, spatial impact, etc.)	Maes et al. 2004 (MARE-DASM project BELSPO), Schrijvers and Maes 2005 (GAUFRE project BELSPO), Le Roy et al. 2006 (RAMA project BELSPO), Volckaert et al. 2006 (MIMAC project BELSPO), Nilsson et al. 2018 (NorthSEE project Interreg)

Table 4. An overview of the documents relations to the EIAs of the various Flemish seaports.

Port	(Plan-)EIAs
Oostende	Plan EIA strategic plan for the Port of Oostende (notification memorandum) 2004 Plan EIA coastal defence and maritime accessibility Ostend 2007 Project EIA flooding measures rear port Ostend 2019
Antwerp	Notification of plan EIA Port of Antwerp Strategic Plan 2006 Plan EIA strategic plan Port of Antwerp (non-technical summary) 2008 Notification of widening of navigation channel in the Lower-Zeescheldt and Western Scheldt 2006 Interim strategic plan Port of Antwerp 2006 Project EIA excavations in the Zeeschelde to Wintam 2009 Project EIA deepening and construction of soil protection at the North Sea Terminal in Antwerp 2010 Project EIA renovation Royers Lock 2014 Alternatives study note Complex project "Realisation of additional container handling capacity in the Antwerp port area" 2017 Project EIA deepening Europa Terminal 2018 Project EIA new quay wall Canal Dock B2 - Insertion Dock (non-technical summary) 2020
Zeebrugge	Plan EIA strategic plan Port of Zeebrugge 2004 Notification project EIA of the strategic port infrastructure project (SHIP) in the western inner Port of Zeebrugge 2011 Strategic environmental assessment Improving nautical accessibility to the (inner) Port of Zeebrugge 2017 Plan EIA as part of the municipal RUP 'Vissershaven' in Zeebrugge (non-technical summary) 2018
North Sea Port Flanders	Project EIA design sea port site Langerbruggekaai/De Nest (non-technical summary) 2008 Regional spatial implementation plan 'Afbakening Zeehavengebied Gent - Fase 2 EIA New Lock Terneuzen 2015

As a follow-up to COM (2009) 8, the European Commission published its Strategy for sustainable and smart mobility (COM (2020) 789) in December 2020, in which greenhouse gas emission reductions, connectivity and digitalisation are central. The emission targets are to a large extent driven by the previously formulated ambitions within the European Green Deal (COM (2019) 640). Also in the area of connectivity, the European Commission will ensure that the TEN-T guidelines are in line with the European Green Deal and that infrastructure is adapted to climate change. To this end, a revision of Regulation (EU) 1315/2013 is also envisaged. The Commission will take the necessary measures to complete the transport corridor throughout the European continent by 2030, which will require a budget of 300 billion euro. In addition to the above objectives, in its new approach to a sustainable blue economy (COM (2021) 240), the EU proposes to set up a Blue Forum for maritime users to coordinate a dialogue between offshore operators and to encourage the use of EU funds for the greening of maritime transport by promoting SSS, upgrading the ship fleet to improve their energy efficiency and developing highly advanced production and technological capacity.

On the Flemish level, Multimodaal.Vlaanderen was established in 2017 and acts as an independent advisory point for companies regarding the optimal transport mode choice (including SSS) per freight flow.

2.5.2 Safety at sea: construction, equipment and crew of seagoing vessels

There are many regulations governing maritime safety, the prevention of maritime disasters and the safety of human life at sea. Table 5 lists the most relevant international conventions, which are explained in more detail in Verleye et al. (2018). The principal convention on the safety of merchant vessels is the SOLAS Convention (Safety of Life at Sea). The first version of the convention was adopted in 1914 after the Titanic disaster. The current version dates from 1974. In 2004, the amendment providing for an International Ship and Port Facility Security Code (ISPS-code) came into force. The code defines the minimum requirements and responsibilities of governments, companies, vessel's personnel and port facility personnel for detecting security threats to vessels and port facilities involved in international trade and for taking preventive measures to avoid security incidents.

Table 5. Most relevant international conventions in the field of maritime safety.

Convention	Goals
LL 1966 (*Load Lines*)	This convention regulates the determination of the freeboards of ships, i.e. the distance from the top of the deck line to the top of the applicable line of the outfall mark.
TONNAGE 1969 (*Tonnage Measurement*)	The Tonnage Measurement Convention provides a universal tonnage measurement system for ships.
COLREG 1972 (*Collision Regulations*)	This convention provides guidelines for determining safe speeds, reducing the risk of collision and for escorting ships operating in, or in the vicinity of, traffic separation schemes.
SOLAS 1974 (*Safety of Life at Sea*)	The SOLAS Convention is considered to be the most important international convention relating to the safety of merchant ships. The main objective of the convention is to specify the minimum standards for the construction, equipment and operation of ships to ensure the safety of human life at sea.
STCW 1978 (*Standards of Training, Certification and Watchkeeping for Seafarers*)	The STCW Convention is an international convention that sets out the minimum requirements that seafarers must meet as regards training, certification and watchkeeping. The convention aims to protect the marine environment as well as to promote the safety of human life and property. The EU directives on the minimum level of training of seafarers are described in Directive 2008/105/EC.
SAR 1979 (*Search and Rescue*)	The International Convention on Maritime Search and Rescue aims to establish an international SAR-plan so that, wherever a person is in distress at sea, rescue operations are coordinated by an SAR-organisation. Today, there is also more emphasis on the regional approach and coordination between sea and airborne SAR-operations.
MLC 2006 (*Maritime Labour Convention*)	The Maritime Labour Convention brings together all existing maritime and other labour conventions of the International Labour Organisation (ILO).

At European level, the legal framework concerning ship and port facility security is provided by Regulation (EC) 725/2004, while Directive 2005/65/EC specifically focuses on enhancing port security. At national level, the aforementioned EU legislation is implemented via the Belgian Shipping Code of 8 May 2019.

The topic 'Safety requirements and safety certificates of seagoing vessels' is covered in Book 2, Title 2 – Chapter 3 of the Belgian Shipping Code of 8 May 2019. Title 4 relates to persons on board and Title 5 – Chapter 3 deals with prevention of pollution. DG Shipping (FPS Mobility and Transport) ensures that vessels sailing under the Belgian flag comply with international maritime regulations on shipping safety and the protection of the marine environment (via, among others, the Shipping Inspection Regulations - RD of 20 July 1973 and frequently amended).

Belgian Port State Control (FPS Mobility and Transport) inspects foreign-flagged vessels calling at Belgian ports to check whether they comply with the applicable international ILO (International Labour Organisation) and IMO standards. In case of infringements, departure from the port may be refused or conditions may be imposed, such as sailing to the nearest shipyard, if the deficiencies cannot be repaired in a Belgian port and are of such a nature that the safety of the ship and crew may be endangered. For more information on regional cooperation on port state control, see Memorandum of Understanding on Port State Control (MoU Paris) and the European Port State Control Directive (Directive 2009/16/EG).

The Shipping Assistance division (Agency for Maritime and Coastal Services, MDK) is responsible for the safe and smooth operation of shipping on the maritime access routes to and from the Belgian seaports by organising and offering Vessel Traffic Services (VTS). The Fleet and Pilotage Service (DABL) departments are responsible for piloting the routes to and from the Flemish ports that are subject to compulsory pilotage.

2.5.3 Preventing and combating pollution from shipping

There are numerous regulatory instruments to prevent and combat pollution of the marine environment from shipping. The UN Convention on the law of the sea (UNCLOS 1982) provides the general international legal framework addressing, *inter alia*, marine pollution (Part XII). The MARPOL Convention is the main international convention on accidental or operational pollution of the marine environment from shipping. In addition, there are a number of important treaties under the umbrella of the IMO (table 6, more detailed explanations of the relevant regulations in Verleye et al. 2018).

Table 6. Most relevant IMO-conventions on marine pollution.

Convention	Goals
CLC 1969/1992 (*Civil Liability for Oil Pollution Damage*)	This convention describes the civil liability for pollution damage caused by persistent oil.
FUND 1971/1992 (*Fund for Compensation for Oil Pollution Damage*)	This convention provides for the establishment of an international fund for the compensation of pollution damage cause by persistent oil.
MARPOL 1973/1978 (*Prevention of Pollution from Ships*)	The purpose of this convention is to prevent the voluntary and accidental discharges of oil, chemicals, noxious substances in packaged form, sewage and household wastes, and certain types of air pollution from ships, either directly by means of stringent operational discharge conditions or prohibition of discharge, emission conditions or indirectly by imposing technical measures on the construction and equipment of the ship.
LLMC 1976 (*Limitation of Liability for Maritime Claims*)	This conventions establishes a regime of limitation of liability for maritime claims.
OPRC 1990 (*Oil Pollution Preparedness, Response and Co-operation*)	The convention deals with oil pollution preparedness, response and cooperation.
OPRC-HNS protocol 2000 (*Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances*)	The protocol covers preparation for, response to and cooperation in dealing with pollution incidents involving harmful and potentially dangerous substances.
AFS 2001 (*Anti-fouling Systems*)	The AFS Convention bans the use of harmful organotin in anti-fouling paints for ships and introduces a mechanism to prevent the future use of other harmful substances in anti-fouling systems.
BUNKER 2001 (*Bunker Oil Pollution Damage*)	This BUNKER Convention regulates the civil liability for bunker oil pollution damage.
BWM 2004 (*Ballast Water Management*)	The BWM Convention aims to prevent the further spread of invasive aquatic organisms from one region to another by introducing standards and procedures for the management and control of ballast water and sediments on board ships.
WRC 2007 (*Removal of Wrecks*)	This WRC Convention regulates the clearing of wrecks.
HNS 2010 (*Hazardous and Noxious Substances*)	The HNS Convention regulates liability and compensation for damage in connection with the carriage of hazardous and noxious substances by sea (not yet entered into force).

Other relevant international conventions and agreements that do not emanate from the IMO are the Bonn Agreement and the OSPAR Convention. The Bonn Agreement regulates the cooperation between the coastal states of the North Sea in detecting, reporting and combating pollution in the North Sea caused by oil and other harmful substances from vessels and offshore installations. Since 1991, aerial surveillance has been organised in the BNS under this agreement in order to detect illegal discharges by vessels and to provide evidence for a potential prosecution. The observation programme is carried out by the Management Unit of the North Sea Mathematical Models of the Royal Belgian Institute of Natural Sciences (RBINS-MUMM) in cooperation with the Ministry of Defence. The annual results of air monitoring are reported on the MUMM-website. Since the beginning of the aerial surveys in 1991, there has been a downward trend in the number of oil discharges and the estimated oil volume (figure 10), which shows that the measures taken within the European directive on port reception facilities (Directive 2019/833/EU) and MARPOL, as well as the increased monitoring, are having a positive effect (Lagring et al. 2012, MUMM). The number of operational discharges of hazardous substances other than oil remains a common problem and has even shown a slight upward trend since 2015 (MUMM). Within the Coast Guard, action was taken to address this by constructing a more detailed follow-up procedures in a MARPOL roadmap. The annual surveillance reports under the Bonn Agreement show that the increasing trend is also observed in the neighbouring countries (the Netherlands, France). This has led to an initiative by North Sea countries at the Marine Environment Protection Committee (MEPC), whereby a proposal for a new definition for so-called 'Persistent Floaters' within MARPOL Annex II was accepted. These are persistent floating liquids for which a new mandatory prewash procedure applies since 2021.

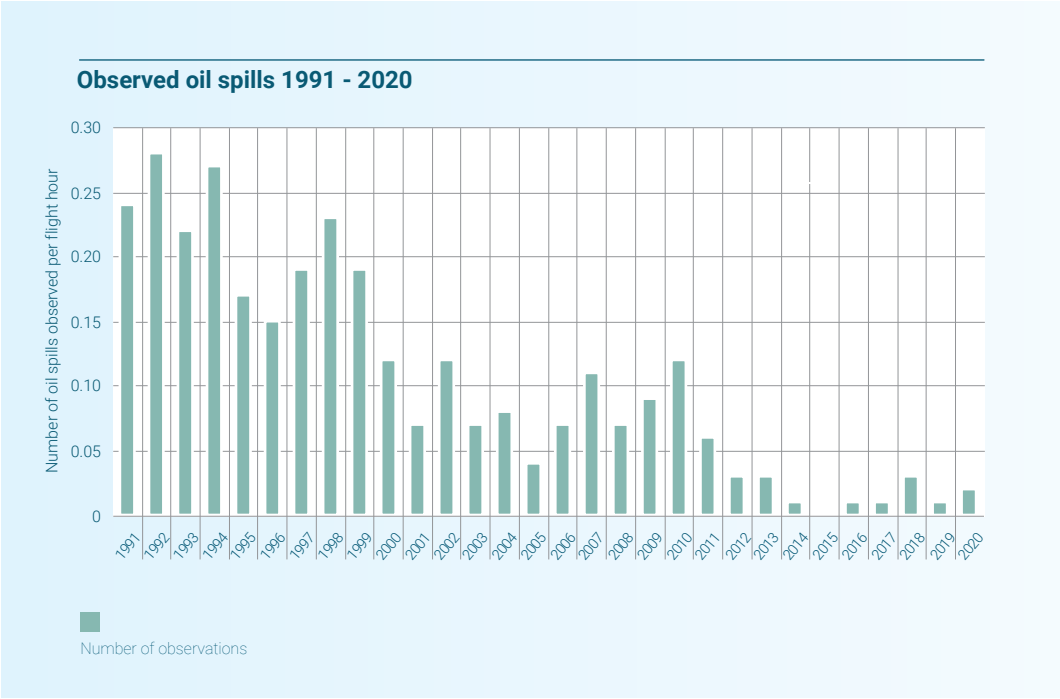


Figure 10. Number of observed oil spills per flight hour (RBINS-MUMM).

Under the OSPAR Convention (see also thematic chapter **Nature and environment**), which aims to protect the marine environment of the North-East Atlantic through international cooperation, the oil pollution rate of guillemots is recognised as an indicator of the degree of chronic oil pollution of the marine environment, a so-called EcoQO (Ecological Quality Objective). The oil pollution rate of the birds washed up on the Belgian beaches is reported by the Research Institute for Nature and Forest (INBO) (i.e. Stienen et al. 2014, Stienen et al. 2017) and can be consulted online on the website of bird victims. In the update of the initial assessment for the Belgian marine waters (Belgian State 2018), the oil pollution is evaluated (e.g. oil-covered guillemots, illegal oil discharges, acute oil pollution from the 'Flinterstar' incident in 2015) with regard to descriptor 8 of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC). Furthermore, under the umbrella of OSPAR, operational discharges are dealt with by a network of police experts and prosecutors called NSN (North Sea Network of Prosecutors and Investigators).

After the Erika incident in 1999, a series of measures known as Erika I (COM (2000) 142), Erika II (COM (2000) 802) and Erika III (COM (2005) 585) were adopted by Europe in order to increase maritime safety. Several EU directives

and regulations implement these measures (table 7). In addition, the MSFD includes concentrations of pollutants as one of the descriptors for assessing good environmental status and identifies pollution from vessels as a pressure (more information: Law et al. 2010).

Table 7. Selection of European measures taken in the framework of the Erika initiatives.

Selection of measures	Goals
Directive 2002/59/EC	Establishment of a vessel traffic monitoring and information system to enhance the safety and efficiency of maritime traffic within the EU.
Directive 2005/35/EC	Introducing Community rules for the imposition of sanctions for discharges of oil or other polluting substances from ships in EU waters.
Framework Decision 2005/667/JBZ	Strengthening the criminal law framework for ship-source pollution response.
Directive 2009/15/EC	Formulating common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations.
Directive 2009/16/EC	Reforming port control mechanisms in order to efficiently verify that ships comply with the applicable regulations on maritime safety, maritime security, protection of the marine environment and living and working conditions.
Directive 2009/18/EC	Establishing fundamental principles governing the investigation of accidents in the maritime transport sector.
Directive 2009/20/EC	Insuring shipowners against maritime claims.
Directive 2009/21/EC	Compliance with flag State requirements.
Directive 2010/65/EU	Simplify and harmonise the different administrative procedures applicable to maritime transport through the introduction of electronic data transmission (by 1 June 2015) and the rationalisation of reporting formalities.
Directive (EU) 2019/883	Directive on port reception facilities for ship-generated waste and cargo residues.
Regulation (EC) 1406/2002	Establishment of a European Maritime Safety Agency (EMSA). This agency aims to reduce the risk of maritime accidents, pollution by ships and loss of life at sea. EMSA promotes initiatives such as SafeSeaNet (a centralised European information platform for the exchange of maritime data between competent authorities) and CleanSeaNet (satellite service to detect oil pollution from ships).
Regulation (EC) 391/2009	Establishment of common rules and standards for ship inspection and survey organisations.
Regulation (EC) 392/2009	Regulating the liability of carriers of passengers by sea in the event of accidents.
Regulation (EU) 530/2012	Establish an accelerated phasing-in scheme for the application of the double hull or equivalent design requirements of the MARPOL Convention to single hull oil tankers, with a deadline of 2015.

At Belgian level, the prevention of pollution from vessels is dealt with in Title 5 - Chapter 3 'Prevention of pollution' and Title 7 - Chapter 3 'Pollution caused by shipping accidents' of the Belgian Shipping Code of 8 May 2019. This Code provides the legal framework for the implementation of the MARPOL Convention. In case of a serious pollution in the BNS, the action is regulated by the General Emergency and Intervention Plan (ANIP) North Sea (see Belgian official journal of 20 October 2016) in accordance with the principles of the RD of 16 February 2006 on emergency and intervention plans.

The advanced 3D model OSERIT (Oil Spill Evaluation Response Integrated Tool, developed by MUMM) provides science-based support to decision-makers in the event of an oil spill. This integrated model provides an estimate of the environmental impact of oil pollution in the short term (1 to 5 days) and can be used to identify a polluter via backtracking (Dulière et al. 2013, OSERIT project BELSPO). This tool is made available to the Coast Guard 24/7. In addition, since the disaster with the Erika (1999), the Belgian government has a more extensive core of specific oil spill response resources at its disposal. It is the Enforcement Unit of the Marine Environment division (FPS Public Health, Food Chain Safety and Environment) that maintains and deploys this equipment in cooperation with the *Hulpverleningszone 1* and the Coast Guard partners. In case the response capacity of Belgium is insufficient, it can call on support from neighbouring countries via the Bonn Agreement (see also Verleye et al. 2018). In addition, through a specific European activation procedure, Belgium can also call on complementary stand-by oil-combating vessels and other anti-pollution services provided by EMSA. The application for additional resources is centralised in the European Commission's Common Emergency Communication and Information System (CECIS Marine Pollution) (European Civil Protection and Humanitarian Aid Operations).

In 2005 (updated in 2007), an intervention plan was also drawn up for the rescue and rehabilitation of birds affected by oil pollution at sea (Intervention plan Birds 2007). For the clearing of sea-based pollution on the beach, there is a roadmap '*Propere stranden*' that is currently being revised under the guidance of the cabinet of the Governor of West Flanders. This scenario describes the interventions in case oil or a sea mammal washes ashore on the beach and brings more structure to the actions of the public services involved, from the notification to the damage claim.

Ahead of MEPC 76, Belgium made an analyses (March 2021) on the potential impact of wash water discharges from flue gas cleaning systems (scrubbers) on the acidification of sea water in the southern North Sea. The study focused on the emission of sulphur oxides (SOx) in sea water from vessels using scrubbers and how this contributes to the decrease in pH of sea water. This study aims to support the evaluation and harmonisation of rules and guidelines for the discharge of wash water from flue gas cleaning systems into the aquatic environment.

2.5.4 Measures against the disposal of ship-generated waste

The MARPOL Convention is the main international convention for the prevention and control of marine pollution from shipping. In case of operational spills, the convention limits pollution by setting discharge standards (or prohibiting discharges). At EU level, the problem of ship-generated waste is addressed by the Directive on port reception facilities for ship-generated waste and cargo residues (Directive (EU) 2019/883/EC). This directive obliges the industry to ensure responsible delivery of ship-generated waste to ports. In the MSFD (Directive 2008/56/EC), marine litter is one of the descriptors for assessing good environmental status and has been identified as a physical disturbance to the environment. The criteria and methodological standards for the determination of good environmental status with regard to marine litter were established in Galgani et al. (2010) (see also thematic chapter **Nature and environment**, Decision of the European Commission 2017/848/EU and actualisation of the initial assessment for the Belgian marine waters, Belgian State 2018).

In Flanders, the policy regarding the reception of waste from shipping in the ports is regulated by the Materials Decree of 23 December 2011 (Article 41) and VLAREMA (Article 5.2.10 Maritime waste and Article 5.2.11 Waste from inland navigation). The collected quantities of waste have a positive evolution (OVAM 2017) and can be consulted in the waste management plan for the port Bruges-Zeebrugge (2021-2022), the waste management plan for the Port of Antwerp (2021), the waste management plan for North Sea Port Flanders (2021) and the waste management plan for the Port of Oostende (2021).

In the past, waste streams specifically from fishing vessels were mapped by Maes and Douvere (2004) and Belpaeme (2006). Through the Fishing for Litter project, the waste caught by fishing vessels can be brought ashore and its composition evaluated (see also Devriese and Janssen 2021). In addition, there is a European cooperation with fishermen whereby the collected waste is evaluated and processed for upcycling (Waste Free Oceans).

2.5.5 Measures against air emissions from shipping

Air pollution from seagoing vessels is regulated by MARPOL Annex VI. The revision of the Annex in 2008 provides for stricter limits on the sulphur content of the fuel to 0.1% since 1 January 2015 in low emission zones (Sulphur Emission Control Areas, SECAs), such as the North Sea and Baltic Sea. In 2017, the latter areas were also designated as Low Emission Nitrogen Oxide Areas (NOx Emission Control Areas (NECAs) - entering into force on 1 January 2021), within which stricter limits on NOx emissions for diesel engines apply. Different emission standard levels are used based on the date of construction of the vessel (so-called Tier I, Tier II and Tier III standards), with a gradual, significant reduction of NOx emissions from vessels operating in NECAs between 2021 and 2040. The MARPOL Convention also bans emissions of ozone-depleting substances, including halons and CFCs.

In 2011, IMO adopted a package of technical measures on energy efficiency technology for new vessels (Energy Efficiency Design Index – EEDI) and operational greenhouse gas reduction measures in the form of a Ship Energy Efficiency Management Plan (SEEMP) for all vessels above 400 GT. In 2018, the 72th session of IMO's MEPC adopted a strategy with the goal of reducing total greenhouse gas emissions from international shipping by at least 50% by 2050 compared to 2008. In order to achieve this objective, the Intersessional Working Group on Reduction of GHG Emissions from Ships developed new draft amendments to MARPOL Annex VI in 2020 during MEPC 75, building on EEDI and SEEMP, with the aim of assessing and measuring the energy efficiency of all vessels and setting targets. To this end, both technical and operational requirements to reduce CO_2 emissions are elaborated, based on the new Energy Efficiency Existing Ship Index (EEXI) and the new operational Carbon Intensity Indicator

(CII), respectively. The measures were formally adopted during MEPC 76 (2021). The amendments to MARPOL Annex VI are expected to enter into force on 1 November 2022, with the requirements for EEXI and CII certification coming into effect from 1 January 2023.

The EU has also adopted a number of measures to combat air pollution from shipping by means of Directive (EU) 2016/802. As a result, the same conditions as those in MARPOL Annex VI apply within the EU. In addition, the directive also imposes the 0,10% fuel sulphur content standard on vessels in EU ports located outside of a SECA zone (Mediterranean, Atlantic, Black Sea). Implementing Decision (EU) 2015/253 provides for the adoption of rules on sampling and reporting of the sulphur content of marine fuels. In addition, in its strategy for sustainable and smart mobility (COM (2020) 789), the EU aims to become climate neutral by 2050, by reducing dependence on fossil fuels and developing a package of measures for the decarbonisation of maritime transport.

At national level, the measures against air pollution from vessels are addressed in the RD of 15 July 2020 on environmentally friendly shipping (transposition of the MARPOL Convention and the European measures at Belgian level). Specially trained inspectors from DG Shipping regularly carry out MARPOL Annex VI controls on board vessels in ports (including fuel sampling and analysis). Since September 2015, MUMM has been measuring sulphur emissions from vessels during offshore monitoring flights using a sniffer sensor. These results are systematically communicated to the inspectors of DG Shipping so that targeted controls can be carried out within the framework of port inspections (CompMon project, Schallier et al. 2018). Since 1 January 2021 (entry into force of North Sea NECA), after a test period in 2020, MUMM has also been carrying out offshore NOx emissions monitoring with a NOx sniffer sensor. This pioneering work contributes to the international approach to air pollution from shipping within the framework of the Bonn Agreement (Bonn Agreement Strategic Action Plan 2019-2025). The North Sea Policy Statement 2020 (Van Quickenborne 2020) states that Belgium wants to continue its pioneering role by also starting controls on soot (black carbon) emissions in 2021. The results of the tests carried out by Belgium will be used to develop new regulations at the international level.

At the Flemish level, the Government of Flanders decided on 23 April 2014 to set up a Programmatic Approach to Nitrogen Deposits (PAS). The PAS is a program that aims to tackle the problem of deposition of nitrogen in special protection areas under the European Habitats Directive (Directive 92/43/EEC) by means of source-oriented (on the emission side) and effect-oriented measures. However, on 25 February 2021, the Council for Permit Disputes stated that the assessment of a possible significant deterioration of nitrogen deposition on nitrogen-sensitive nature cannot be based exclusively on the assessment framework ('significance framework') as included in the roadmaps '*Eutrofiëring via de lucht*' (Eutrophication through air) and '*Verzuring via de lucht*' (Acidification through Air) (RvVb-A-2021-0697). The Council for Permit Disputes states that a case-by-case assessment is required, in which, based on the specific characteristics and effects of the project and the environmental characteristics and conditions of the Special Protection Area (SPA) in question, it is investigated whether a significant deterioration of the natural characteristics of this SPA can be excluded. This appropriate assessment must also take into account the conservation objectives of the SPA and any cumulative effects. As a result of this judgement, the significance framework of the aforementioned practical roadmaps can no longer be used with legal certainty for the granting of permits. A new assessment framework will be laid down in the PAS. In anticipation thereof, a Ministrial Instruction and accompanying guidelines with a temporary character apply (see also Natura2000.Vlaanderen).

In addition, the provision of shore power facilities (cold ironing) (e.g. Margarino 2014) and the transition to alternative fuels cf. Directive 2014/94/EU (LNG, electricity, biodiesel, methanol, LPG, ethanol, biogas, hydrogen, etc.) are important measures against air emissions from shipping (see also EMSA website). These fuels are virtually sulphur-free and can be used to comply with the sulphur content requirements (Directive (EU) 2016/802). They can be used in combination with conventional oil-based ship fuels, meeting only part of a ship's energy needs, or as a complete replacement for conventional fuels. The type of alternative fuel chosen and the proportion of conventional fuel that is replaced have a direct effect on the ship's greenhouse gas, NOx and SOx emissions. Preparations are being made in all Flemish seaports to make LNG supply possible (see also thematic chapter **Energy (including cables and pipes)**).

The shore-based power facilities in turn ensure that vessels can switch off their engines or generators while moored. In several Flemish ports and at quays on the inland waterways network, shore-based power facilities are provided for pleasure craft, inland navigation and sea-going vessels, supported by projects such as Shore Power in Flanders (TEN-T), Zero Emission Ports North Sea (ZEM Ports NS) and Innovation-driven Collaborative European Inland Waterways Transport Network (IW-NET). Furthermore, within the framework of European Directive (EU) 2019/883, a dossier can be submitted to the Public Waste Agency of Flanders (OVAM) for a reduced contribution for vessels that run on environmentally friendly fuel.

Furthermore, Port Oostende is involved in the ISHY project in which, with a view to the decarbonisation of the shipping industry, the effectiveness of low-carbon propulsion technologies and the feasibility of H2 bunkering facilities in ports will, among other things, be investigated.

2.5.6 Measures against the introduction of alien species

To combat the spread and introduction of alien species through ships' ballast tanks, the Ballast Water Convention (2004) requires vessels to produce a ballast water and sediment management plan and to carry a ballast water record book in which all ballast operations are recorded. In addition, ballast water management shall be performed according to standard procedures (website IMO) and ballast water treatment shall be performed by IMO recognised systems. The convention entered into force on 8 September 2017 and was implemented into Belgian law by the RD of 11 August 2017. More information about the convention can be found in Verleye et al. (2018). Exceptions to the application of this convention may be granted under certain circumstances. Prior to the entry into force, a harmonised procedure was developed by HELCOM/OSPAR so that exemptions can be granted in an unambiguous manner without harming the environment, human health, property or resources. A first risk analysis for Belgium was elaborated in accordance with the HELCOM/OSPAR procedure by Saelens and Verleye (2015).

In addition to transport via ballast water, biofouling (adhesion on the hull) also plays a role in the spread and introduction of alien species. In contrast to ballast water transport, no binding regulations have yet been developed on this matter. However, at MEPC 62 in 2011, the Biofouling Guidelines (Resolution MEPC.207(62)) were adopted. These were expanded in 2012 at MEPC 64 with guidelines (MEPC.1/Circ.792) aimed at recreational navigation. In addition, the International Convention on the control of harmful anti-fouling systems on ships (AFS) was adopted in 2001. However, the focus of this convention is the prevention of harmful effects resulting from the use of anti-fouling systems and the biocides they may contain, rather than on preventing the transfer of invasive aquatic species through hull fouling.

The International Council for the Exploration of the Sea (ICES) established two working groups to study biological invasions and alien species: The ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) and the Working Group on Introduction and Transfers of Marine Organisms (WGITMO). In 2005, ICES published a new version of the 1995 Code of Practice on the Introduction and Transfer of Marine Organisms.

At European level, Regulation (EC) 1143/2014 regulates the prevention and control of the (intentional and unintentional) introduction and spread of invasive alien species. This is based on a hierarchical approach at three levels: (1) prevention; (2) early detection and rapid eradication and (3) management of widespread invasive species. Under this regulation, which applies to terrestrial, freshwater and marine species, a Union list of priority species is established and frequently updated. Furthermore, the introduction of alien species is labelled as a biological disturbance in the MSFD and is also included as a descriptor for the definition of good environmental status. The criteria and methodological standards for determining good environmental status with regard to alien species were established in Olenin et al. (2010).

In Belgium, both the intentional and unintentional introduction (through ballast water) of marine alien species are prohibited by the Law of 20 January 1999 and the RD of 21 December 2001 on the protection of species. Invasive species are also included as one of the ten processes with the largest negative impact on ecosystem components in the Ecosystem Vision for the Flemish Coast (2017) (Van der Biest et al. 2017b). The coordinated implementation of Regulation (EC) 1143/2014 by the federal State, the Communities and the Regions, as well as the necessary exchange of information between the parties concerned, is regulated through the IAS Cooperation Agreement of 30 January 2019 which entered into force on 16 July 2020. For this purpose, a National Committee, a National Scientific Council and a National Secretariat for Invasive Alien Species were established. Protocols have been developed within the framework of the Belgian forum on invasive species (invasive species environmental impact assessment (ISEIA - Branquart 2009) and the 'Harmonia+'-protocol – D'hondt et al. 2015) to assess the impact of species on the environment and their dispersal and colonisation. The alien species in the BNS are reported by ILVO and MUMM to the Marine Environment division (FPS Public Health, Food Chain Safety and Environment) within the framework of the monitoring programme for Belgian marine waters (Belgian State 2014, MSFD) and the ICES working group WGITMO. An overview of the established alien species in the BNS and Scheldt estuary is given in Verleye et al. (2020) (see also website Alien species).

Projects such as RINSE, MEMO, SEFINS and TrIAS focus, among others, on the problem of invasive alien species in the Southern Bight of the North Sea and adjacent estuaries through research, development of tools, exchange of good practice examples, etc.

2.5.7 Measures against harmful anti-fouling substances

On 5 October 2001, the International convention on the control of harmful anti-fouling systems on ships (AFS) was adopted in the IMO and entered into force on 17 September 2008. This convention prohibits the use of harmful substances, including organotin compounds, in antifouling paints used on ships. Organotin compounds have also been included by OSPAR in the list of chemicals requiring priority action (OSPAR List of Chemicals for Priority Action 2013, more information: the Background document on organotin compounds 2011).

At the European level, the use of organtin compounds in antifouling agents on ships as active biocides is prohibited by Regulation (EC) 782/2003 and Regulation (EC) 1907/2006 (REACH). In the Water Framework Directive (WFD, Directive 2000/60/EC) organtin compounds are included in the indicative list of main pollutants.

In Belgium, the transposition of the AFS Convention is ensured by the Law of 16 February 2009 and the Decree of 9 May 2008.

2.5.8 Measures against underwater noise from ships

At international level, the IMO's MEPC has formulated recommendations for reducing underwater noise effects on cetaceans (Guidelines MEPC 2014). In addition, measures against the impact of the underwater noise of ships on small cetaceans are also adopted in the framework of ASCOBANS (Resolution ASCOBANS 2003, Resolution ASCOBANS 2006, CMS Family Guidelines - Prideaux 2016).

At European level, the problem of underwater noise is included in the MSFD which identifies the supply of energy, including underwater noise, as one of the descriptors for good environmental status (Tasker et al. 2010) (see also thematic chapter **Energy (including cables and pipes)**). The RD of 23 June 2010 provides for the transposition of the MSFD measures into national legislation. Furthermore, within the framework of the Interreg project JOMOPANS, a network for the monitoring of (anthropogenic) underwater noise in the North Sea is being set up.

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
FAL	Convention on facilitation of international maritime traffic	1965	1967
LL	International Convention on load lines	1966	1968
TONNAGE	International Convention on tonnage measurement of ships	1969	1982
Bonn Akkoord	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	(1969) - 1983	1989
CLC	International Convention on civil liability for oil pollution damage	(1969) - 1992	(1975) - 1996
FUND	International Convention on the establishment of an international fund for compensation for oil pollution damage	(1971) - 1992	(1978) - 1996
COLREG	Convention on the international regulations for preventing collisions at sea	1972	1977
MARPOL	International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978	1973	1978
SOLAS	International Convention for the safety of life at sea	1974	1980
LLMC	Convention on limitation of liability for maritime claims	1976	1986
STCW	International Convention on standards of training, certification and watchkeeping for seafarers	1978	1984
SAR	International Convention on maritime search and rescue	1979	1985
UNCLOS	United Nations Convention on the law of the sea	1982	1994
MoU Parijs	Paris Memorandum of Understanding on port state control	1982	1982
OPRC	International Convention on oil pollution preparedness, response and co-operation	1990	1995
ASCOBANS	Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998
OPRC-HNS protocol	Protocol on preparedness, response and co-operation to pollution incidents by hazardous and noxious substances	2000	2007
AFS	International Convention on the control of harmful anti-fouling systems on ships	2001	2008
BUNKER	International Convention on civil liability for bunker oil pollution damage	2001	2008
BWM	International Convention for the control and management of ships' ballast water and sediments	2004	2017
MLC	Maritime labour Convention	2006	2013
WRC	Nairobi international Convention on the removal of wrecks	2007	2015
HNS	International Convention on liability and compensation for damage in connection with the carriage of hazardous and noxious substances by sea	2010	-

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Decisions			
Implementing Decision (EU) 2015/253	Implementing Decision laying down the sampling and reporting requirements under Council Directive 1999/32/EC as regards the sulphur content of marine fuels	2015	253
Communications			
COM (2000) 142	Commission communication on the safety of the seaborne oil trade (Erika I)	2000	142
COM (2000) 802	Commission Communication on a second set of Community measures on maritime safety following the sinking of the oil tanker Erika (Erika II)	2000	802
COM (2004) 453	Commission communication on short sea shipping	2004	453
COM (2005) 585	Communication from the Commission - third Maritime Safety Package (Erika III)	2005	585
COM (2009) 8	Communication from the Commission - Strategic goals and recommendation for the EU's maritime transport policy until 2018	2009	8
COM (2011) 144	WHITE PAPER Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system	2011	144
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2002/59/EC	Directive establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC (Monitoring Directive)	2002	59
Directive 2005/35/EC	Directive on ship-source pollution and on the introduction of penalties for infringements	2005	35
Directive 2005/65/EC	Directive on enhancing port security	2005	65
Directive 2008/56/EC	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2008/106/EC	Directive on the minimum level of training of seafarers (recast)	2008	106
Directive 2009/15/EC	Directive on common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations	2009	15
Directive 2009/16/EC	Directive on Port State Control (Port State Control Directive)	2009	16
Directive 2009/18/EC	Directive establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council	2009	18
Directive 2009/20/EC	Directive on the insurance of shipowners for maritime claims	2009	20
Directive 2009/21/EC	Directive on compliance with flag State requirements	2009	21
Directive 2010/65/EU	Directive on reporting formalities for ships arriving in and/or departing from ports of the Member States and repealing Directive 2002/6/EC (Reporting Directive)	2010	65
Directive 2014/90/EU	Directive on marine equipment and repealing Council Directive 96/98/EC	2014	90
Directive 2014/94/EU	Directive on the roll-out of alternative fuels infrastructure	2014	94
Directive (EU) 2016/802	Directive on a reduction of the sulphur content of certain liquid fuels	2016	802
Directive (EU) 2019/883	Directive on port reception facilities for ship-generated waste and cargo residues	2019	883

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
Regulations			
Regulation (EC) 1406/2002	Regulation establishing a European Maritime Safety Agency	2002	1406
Regulation (EC) 782/2003	Regulation on the prohibition of organotin compounds on ships	2003	782
Regulation (EC) 725/2004	Regulation on enhancing ship and port facility security	2004	725
Regulation (EC) 1907/2006	Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency	2006	1907
Regulation (EC) 391/2009	Regulation on common rules and standards for ship inspection and survey organisations	2009	391
Regulation (EC) 392/2009	Regulation on the liability of carriers of passengers by sea in the event of accidents	2009	392
Regulation (EU) 530/2012	Regulation on the accelerated phasing-in of double hull or equivalent design requirements for single hull oil tankers	2012	530
Regulation (EU) 1315/2013	Regulation on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU	2013	1315
Regulation (EU) 1143/2014	Regulation on the prevention and control of the introduction and spread of invasive alien species	2014	1143
Implementing Regulation (EU) 2021/1158	Implementing decision laying down the sampling and reporting requirements under Council Directive 1999/32/EC as regards the sulphur content of marine fuels	2021	1158

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 13 July 2001	Besluit van de Vlaamse Regering houdende de aanduiding van de voorlopige begrenzing van de havengebieden	2001-07-13/93
Decision of the Government of Flanders of 26 October 2007	Besluit van de Vlaamse Regering betreffende het Maritiem Reddings- en Coördinatiecentrum	2007-10-26/30
Decision of the Government of Flanders of 26 October 2007	Besluit van de Vlaamse Regering betreffende de begeleiding van de scheepvaart	2007-10-26/31
Decision of the Government of Flanders of 17 February 2012	Besluit van de Vlaamse Regering tot vaststelling van het Vlaams reglement betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen (VLAREMA)	2012-02-17/18
Decrees		
Decree of 2 March 1999	Decreet houdende het beleid en het beheer van de zeehavens (Havendecreet)	1999-03-02/37
Decree of 16 June 2006	Decreet betreffende de begeleiding van de scheepvaart op de maritieme toegangswegen en de organisatie van het Maritiem Reddings- en Coördinatiecentrum	2006-06-16/51
Decree of 9 May 2008	Decreet houdende instemming met het Internationaal Verdrag betreffende de controle van schadelijke aangroeiwerende systemen op schepen, opgemaakt in Londen op 5 oktober 2001	2008-05-09/53
Decree of 23 December 2011	Decreet betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen (Materialendecreet)	2011-12-23/33
Royal Decrees		
RD of 20 July 1973	Koninklijk besluit houdende zeevaartinspectiereglement	1973-07-20/30
RD of 2 February 1993	Koninklijk besluit tot vaststelling van de lijst van de havens en hun aanhorigheden overgedragen van de Staat aan het Vlaamse Gewest	1993-02-02/31

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
RD of 21 December 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
RD of 6 February 2009	Koninklijk besluit tot oprichting en organisatie van het maritiem informatiekruispunt	2009-02-06/39
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
RD of 11 August 2017	Koninklijk besluit ter uitvoering van het Internationaal Verdrag voor de controle en het beheer van ballastwater en sedimenten van schepen, gedaan te Londen op 13 februari 2004 en ter wijziging van het koninklijk besluit van 22 december 2010 betreffende havenstaatcontrole	2017-08-11/11
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
RD of 4 February 2020	Koninklijk besluit tot instelling van veiligheidszones in de zeegebieden onder Belgische rechtsbevoegdheid	2020-02-04/12
RD of 15 July 2020	Koninklijk besluit inzake milieuvriendelijke scheepvaart	2020-07-15/12
Cooperation agreements		
Cooperation agreement of 8 July 2005	Samenwerkingsakkoord tussen de Federale Staat en het Vlaamse Gewest betreffende de oprichting van en de samenwerking in een structuur Kustwacht	2005-07-08/62
Laws		
Special law of 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Law of 20 January 1999	Wet ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 16 February 2009	Wet houdende instemming met het Internationaal Verdrag van 2001 betreffende de controle op schadelijke aangroeiwerende systemen op schepen, en met de Bijlagen, gedaan te Londen op 5 oktober 2001	2009-02-16/51
Law of 25 December 2016	Wet tot instelling van administratieve geldboetes van toepassing in geval van inbreuken op de scheepvaartwetten	2016-12-25/38
Law of 8 May 2019	Wet tot invoering van het Belgisch Scheepvaartwetboek	2019-05-08/15

3 Dredging and dumping

Authors Dries Van den Eynde[1], Brigitte Lauwaert[1*], Gert Van Hoey[2], Laurens Hermans[3], Chantal Martens[4], Lisa Devriese[4], Hans Pirlet[4]

Lectors Tomas Sterckx[5], Bernard Malherbe[6], Marc Vantorre[7]

[1] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature) / *Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM)
[2] Research Institute for Agriculture, Fisheries and Food (ILVO)
[3] Department of Mobility and Public Works (MOW), Maritime Access division
[4] Flanders Marine Institute (VLIZ)
[5] DEME Group
[6] Jan De Nul Group
[7] Ghent University (UGent), Maritime Technology division

Van den Eynde, D., Lauwaert, B., Van Hoey, G., Hermans, L., Martens, C., Devriese, L., Pirlet, H. (2022). Dredging and dumping. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 57-66.

Dredging comprises all activities required to remove sand, silt and other bottom layers of waterbodies for the maintenance of shipping channels and harbours, but also for land reclamation and nature development. For more information on the extraction of raw materials from the sea, for example for the construction industry, reference is made to the thematic chapter **Sand and gravel extraction**. With respect to dredging, a distinction should be made between capital dredging and maintenance dredging. Capital dredging is dredging for the creation of new or the widening of existing waterways, docks and locks. Maintenance dredging is dredging in which the sediment in waterways and port basins is removed without enlarging the waterway or the port basin beyond their original dimensions[1] (Verslag van het Rekenhof 2016).

This thematic chapter elaborates on the dredging for and dumping of sediment to maintain and deepen maritime access routes. This includes the access routes to the seaports of Ostend, Zeebrugge, Ghent and Antwerp. The current text specifically focuses on the dredging and dumping activities in the Belgian part of the North Sea (BNS). The Scheldt estuary is not only an important ecosystem, it also forms the operating area of a number of functions, such as shipping, for which dredging is required (see also ScheldeMonitor and the VNSC website). A different context applies to the dredging works in the Scheldt estuary, and as such we refer to the thematic chapter **Scheldt estuary** for this topic.

Between 2008 and 2014, more than 1,000 million tonnes (dry weight) of sediment were deposited in the OSPAR[2]-region (North East Atlantic and North Sea) (OSPAR IA 2017). A large portion of this sediment is dredged and disposed of in the southern part of the North Sea, mainly due to the maintenance of the shipping channels to major seaports such as Hull, Zeebrugge, Rotterdam, Bremen, Emden, Hamburg, Esbjerg, etc. (OSPAR QSR 2010). In the Belgian part of the North Sea, 10.9 million tonnes (dry weight) of dredged material were dumped at sea in 2017 (Lauwaert et al. 2019). The evolution of the amount of dredged material in the BNS has been monitored by the Scientific Service Management Unit of the Mathematical Model of the North Sea (RBINS-MUMM) since 1991 (figure 1). It is possible that more sediment will be dredged and dumped in the future due to the increasing size of ships and the associated widening and deepening of the navigation and port channels (OSPAR QSR 2010). At the same time, large-scale hydraulic engineering works offer opportunities for the sustainable reuse of sediment in, for example, coastal defence projects. A current example of this approach is the foreshore nourishment between 2020 and 2023 in Knokke, with material from the dredging works for the New Lock Terneuzen.

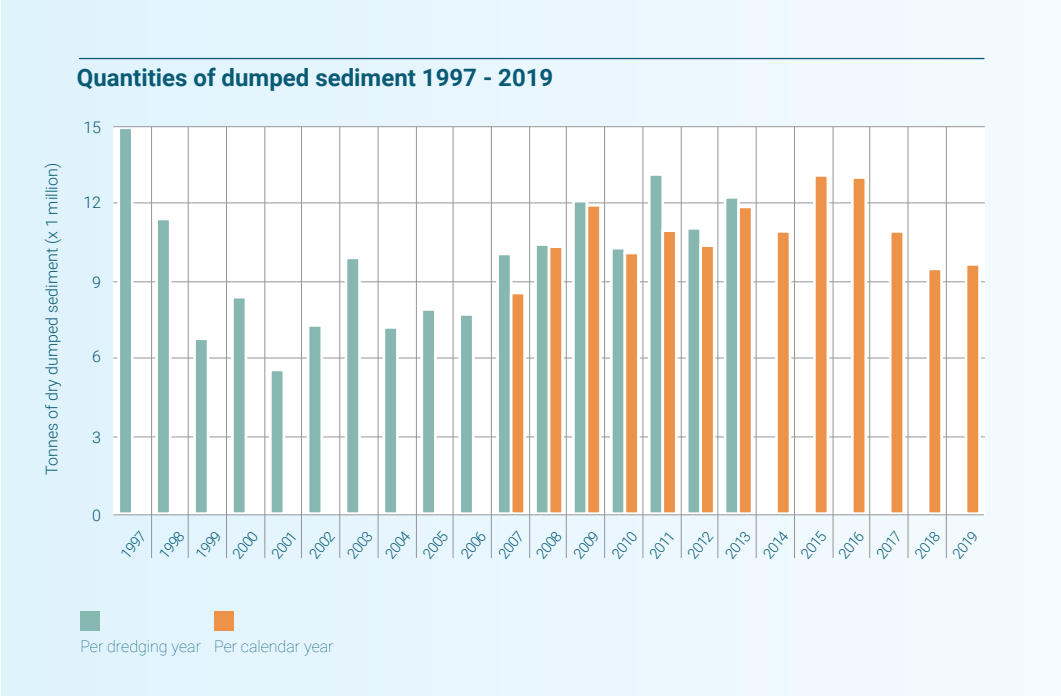


Figure 1. Quantities of sediment dumped in the BNS, expressed in tonnes of dry matter (Source: RBINS-MUMM). A dredging year in the figure above is defined as the period between 1 April and 31 March of the following year; from 2015 onwards, dredging years run concurrently with the calendar years.

[1] The minimum dimensions or clearance profile required for ships of a certain size to navigate a waterway.
[2] OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.

3.1 Policy context

The maintenance and deepening of the maritime access channels to ports and the maintenance of the depth in the ports is a Flemish competence. The Department of Mobility and Public Works (MOW), Maritime Access division, is responsible for the fairways, as well as for the engineering structures and properties located along the maritime access routes to the Flemish ports, including Zeebrugge and Ostend. The Agency for Maritime Services and Coast (MDK), Coastal division, is charged with the maintenance of the Flemish marinas of Ostend, Blankenberge, Zeebrugge and Nieuwpoort. The management of dredging works is a mixed competence in Belgium for which a cooperation agreement was made between the Flemish Region and the federal state on 12 June 1990, as amended by the Cooperation Agreement of 6 September 2000. The competence for dumping dredged material at sea lies with the federal Government. The conditions for the re-use of dredged material from waterways or water bodies (including fairways, harbours and docks) as soils or building material are included in the Code of Good Practice for Dredging and Clearing Material (Government of Flanders s.d.). These also implement Article 5.3.4.3. of the Decision of the Government of Flanders, establishing the Flemish regulation on the sustainable management of material cycles and waste materials (Decision of 17 February 2012) and were also included in the Ministerial Decision of 5 November 2015.

The procedure for obtaining a permit to dump dredged material at sea, necessary for carrying out the tasks of the Government of Flanders, has been stipulated by the RD of 12 March 2000. The maximum amount of dredged sediment and the location of the dredging and disposal sites that have been granted to the Maritime Access division and the Agency for Maritime Services and Coast since 2004, can be found in various Ministerial Decrees published in the Belgian official journal.

3.2 Spatial use

In the marine spatial plan (MSP 2020-2026, RD of 22 May 2019 see also Verhalle and Van de Velde 2020), five zones for the disposal of dredged material were delimited: *Bruggen en Wegen (Br&W) Zeebrugge Oost* (ZBO), *Br&W* Ostend (OST), *Br&W* Nieuwpoort (NWP), S1 and S2 (figure 2). In addition, the MSP also defines a number of exploration zones for the dumping of dredged material, which can be used to relocate or optimise the existing dumping zones S1, *Br&W* Ostend, *Br&W* Nieuwpoort and *Br&W Zeebrugge Oost*. The designation of new zones for dumping is linked in the MSP to site-specific conditions, such as the impact on fisheries and shipping (MSP 2020-2026).

Dumping at a location to the west of Zeebrugge was prompted by the results of research conducted in the 2009-2016 period, which looked into the optimisation of dredging operations (Lauwaert et al. 2019). On behalf of the Maritime Access division, a pilot was carried out between October and November 2013 to further investigate an alternative dumping site west of Zeebrugge (Fettweis et al. 2016, Lauwaert et al. 2016). From 2017 onwards, a study about the practical implementation was started and, considering the environmental aspects, co-use and practicality, a number of possible scenarios were defined. The next step is to set up a long-term pilot, which will allow the scenarios to be thoroughly tested before finalisation (Lauwaert et al. 2019). For the dredging works in the port of Blankenberge, the use of a dumping zone to the west of Zeebrugge also provides an efficiency gain.

In addition to the existing zone for dumping in the vicinty of the Port of Zeebrugge, the MSP also includes reservation zones for the S1 dumping site. This site is located on the Sierra Ventana, however the accretion of this zone in a NW direction and the proximity of the offshore wind farm zone may limit the space for navigation. The remaining capacity of the dumping site, which has been at the present location since 2000, is also limited. A study programme will be initiated to examine the possible relocation of the site (Lauwaert et al. 2019).

An alternative disposal method, using a fixed pressure pipeline close to the coast, was proposed for the marinas of Nieuwpoort and Blankenberge (Lauwaert et al. 2016). Because the use of a possible dumping zone west of Zeebrugge (see above) already provides an efficiency gain for the port of Blankenberge, the research into alternative dumping methods for the port of Blankenberge was discontinued (Lauwaert et al. 2019). For the marina of Nieuwpoort, research has shown that the preconditions and the limited expected profitability do not justify the use of alternative methods. For Nieuwpoort, the alternative dumping site defined in the MSP 2020-2026 will be further investigated (Lauwaert et al. 2019).

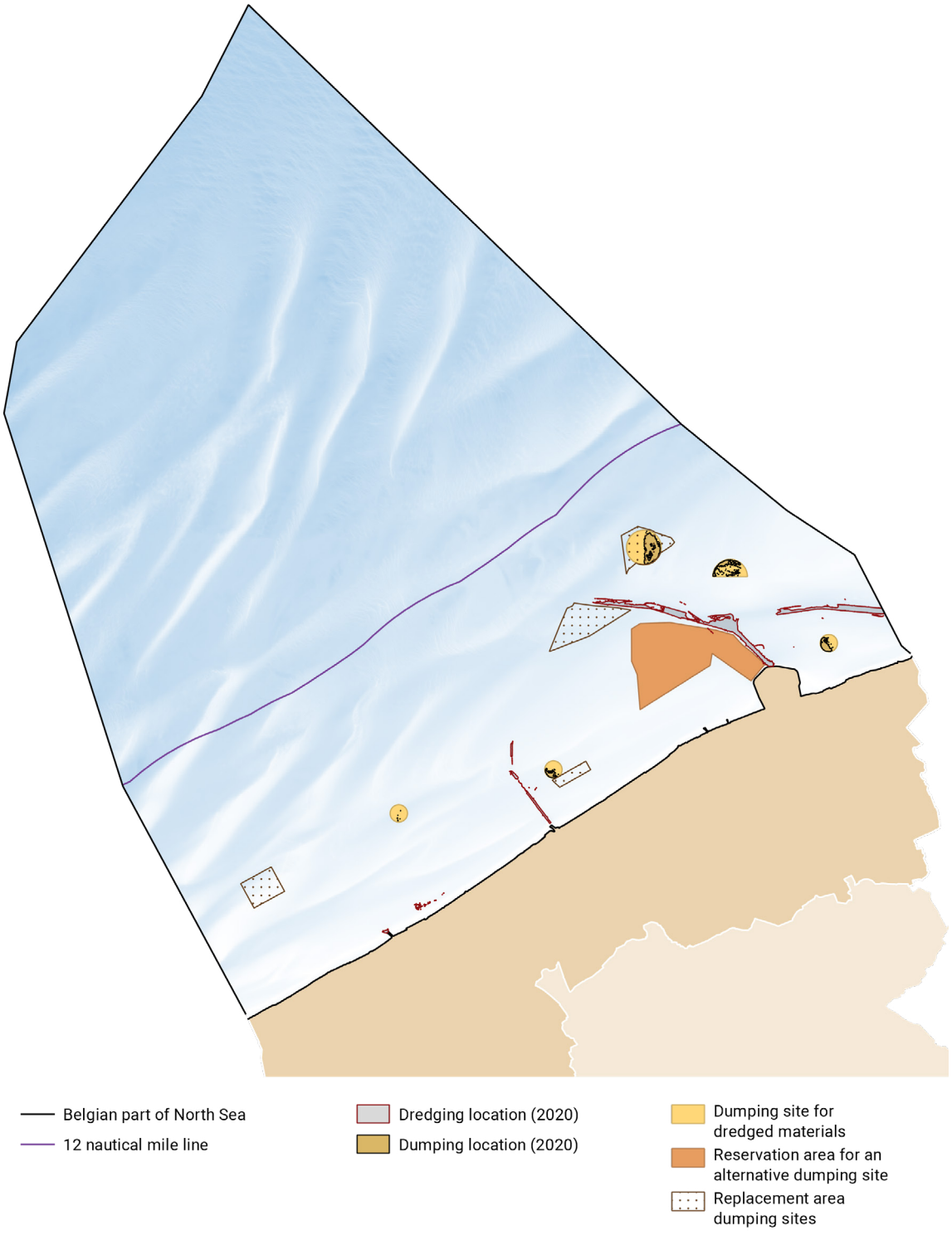


Figure 2. The location of the dredging and dumping sites at the BNS (source: RBINS, MarineAtlas.be (based on the RD of 22 May 2019 (MSP 2020-2026), Coastal Portal).

3.3 Societal interest

The Flemish ports are important economic gateways (see thematic chapter **Maritime transport, shipping and ports**). Due to the increase in scale of the ships, it is necessary to maintain the channels to these ports continuously and to widen them on certain occasions. In 2019, the Government of Flanders invested 219.9 million

euro to ensure the accessibility of the Flemish ports (including the Scheldt estuary, figure 3). Starting in 2016, an annual amount of 59.5 million euro is included for the financial contribution from Flanders to the Netherlands on behalf of the new lock in Terneuzen (Merckx 2020).

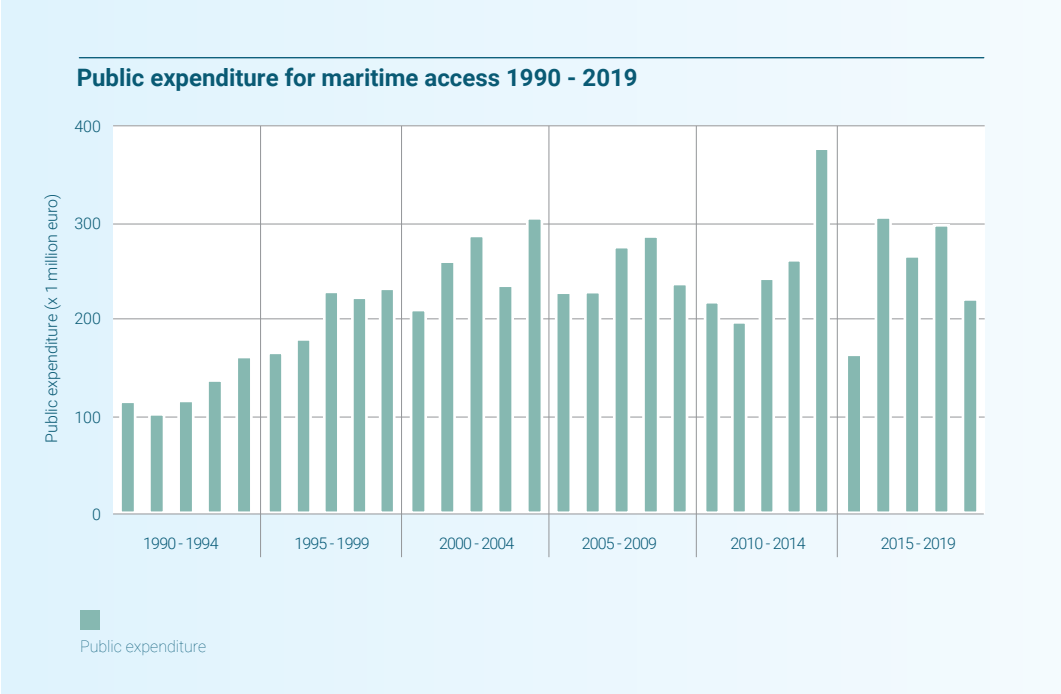


Figure 3. Public expenditure for maritime access by the Flemish Community in million euro for the period 1989-2019, in 2019 prices, Merckx 2020).

The Ministerial Decisions of 22 December 2016 determined that from 1 January 2017 until 31 December 2021, the Maritime Access division had a total of four permits, allowing to dump a total maximum of 26,450,000 tonnes of dry matter at four sites in the BNS (on an annual basis). In addition, the Agency for Maritime Services and Coast also had four permits allowing it to dump a total maximum of 700,000 tonnes of dry matter per year (Ministerial Decisions of 22 December 2016) from 1 January 2017 to 31 December 2021. For the disposal of dredged material from the maintenance of the Sea Scheldt and the Western Scheldt, the Maritime Access division also has permits from the provinces of East Flanders and Antwerp (Sea Scheldt) and the necessary removal and disposal permits from the competent Dutch authorities (Western Scheldt) (see also the thematic chapter **Scheldt estuary**).

3.4 Impact

The most common type of vessel used for maintenance dredging is the trailing suction hopper dredger. This dredger is equipped with one suction tube (exceptionally two) and a large suction nozzle (the 'drag head') that act like a huge hoover hose to remove sediment from the channels. This type of vessel has the advantage that it is very mobile, so that it does not hinder navigation, while it is still able to transport the dredged sediment over longer distances. In these maintenance dredging operations, the sediment is removed until the minimum guaranteed depth is achieved, including a small margin to anticipate future sedimentation. Once the sediment has been loaded and the vessel has arrived at the designated dump site, the dredged material can be unloaded by means of a system of bottom doors or slides. In certain cases, it is also possible to mix the dredged material with water in order to pump it hydraulically via a bow coupling and a system of (floating) pipelines to land.

In addition to the trailing suction hopper dredger, a cutter suction dredger or cutter head dredger is also often used for capital or construction dredging work. This is a stationary dredging vessel that uses a rotating cutter head to loosen material from the bottom. The hydraulic pumping system on board ensures suction of the sediment mixture and its hydraulic transport. Nowadays, feasibility studies and demonstration projects are also conducted to evaluate alternative methods (e.g. fixed pressure pipelines) (Lauwaert et al. 2016). An exploratory study using the alternative technique of Water Injection Dredging (WID) was carried out by Van Oyen et al. (2016). This involves moving the sediment by applying natural forces according to the principle of gravity-driven density flows. Fluidising the sediment allows it to flow out of the harbour under certain conditions.

The nature of the dredged sediment varies depending on the location along the coast. The composition of the dumped material may influence the sediment composition of the dump sites (e.g. lumps of silt in the sediment). In addition, the natural sediment composition on the various deposit sites also varies. For example, the Nieuwpoort site is characterised by a large fraction of sand and a small fraction of silt. The Br&W Ostend and Br&W Zeebrugge sites have the lowest average grain size (<200 µm) and the highest concentration of silt (Van Hoey et al. 2012, Lauwaert et al. 2016).

The impact of dredging and dumping activities on the marine environment is monitored and studied in terms of physical, chemical and biological aspects (Lauwaert et al. 2019, Belgian State 2018; table 1 and figure 4, the latter outlining the general framework, not specific to the BNS). For the period 2013-2016, research was conducted about the occurrence of marine litter at the dredged material dump sites (Lauwaert et al. 2016, De Witte et al. 2021). Further research will focus on the origin and baseline of this marine litter also in the context of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) (Lauwaert et al. 2019). The impact of dredging and dumping on other users is addressed in studies such as, Verfaillie et al. (2005) (GAUFRE project BELSPO) and Van Hoey et al. (2014a).

Table 1. An overview of the effects of dredging and dumping activities on the environment.

Environmental impact	Literature
Physico-chemical impact: changes in soil morphology and composition (grain size) and sedimentological effects (sediment plumes, turbidity, pollutant release, etc.)	Verfaillie et al. 2005 (BELSPO GAUFRE project), Fettweis et al. 2007b (BELSPO MOCHA project), Goffin et al. 2007, Du Four and Van Lancker 2008, Van Hoey et al. 2009, André et al. 2010, Fettweis et al. 2011, Lauwaert et al. 2011, Lauwaert et al. 2014, Vanhellemont and Ruddick 2015, Fettweis et al. 2016, De Witte et al. 2016, Lauwaert et al. 2016, Decrop et al. 2018, Vanlede et al 2019, Lauwaert et al. 2019
Biological impact: effects on fauna and flora (disturbance of benthos, influence of released pollutants, etc.)	Verfaillie et al. 2005 (BELSPO GAUFRE project), André et al. 2010, Lauwaert et al. 2011, Lauwaert et al. 2014, De Backer et al. 2014, Lauwaert et al. 2016, Lauwaert et al. 2019, Mestdagh et al. 2020

3.5 Sustainable use

In order to address the impact of the dumping of dredged material on the marine environment, the activity is globally governed by the London Convention (1972) and the London Protocol (1996), which address the pollution caused by the dumping of material at sea. At regional level, the OSPAR Convention (1992), which aims to protect the marine environment of the North-East Atlantic (including the North Sea), provides a relevant regulatory framework. OSPAR also issued guidelines for the sustainable management of dredged material (OSPAR Commission 2014). Currently there is no obligation under the OSPAR Convention to monitor the environmental impacts of the dumping of dredged material, but many OSPAR countries have national monitoring programmes in place which also take this topic into account (OSPAR IA 2017).

At European level, the Water Framework Directive (WFD, Directive 2000/60/EC) and the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) identify human-induced changes in the concentration of sediment in the water column as one of the major pressures on the marine environment. The MSFD also defines a number of descriptors for a good environmental status which are relevant for dredging and dumping (Lauwaert et al. 2016, OSPAR IA 2017, Lauwaert et al. 2019): the condition of benthic habitats, soft substrate (descriptor 6, Seafloor integrity, Rice et al. 2010), concentrations of contaminants (descriptor 8, Contaminants and pollution effects, Law et al. 2010), marine litter (descriptor 10, Marine litter, Galgani et al. 2010), and the permanent alteration of hydrographical characteristics (descriptor 7, Hydrographical conditions, EC website). In addition, descriptors 1 (Biological diversity, Cochrane et al. 2010) and 4 (Marine food webs, Rogers et al. 2010) are (indirectly) affected by the disposal of dredged material. In the MSFD, the change in silt deposition due to dredging and dumping activities is no longer directly included in the list of anthropogenic impacts on the marine environment (Directives 2008/56/EC and 2017/845/EC). Since the 2017 revision, dredging and dumping of materials has been included as 'uses and human activities in or affecting the marine environment' under the theme of 'physical restructuring of rivers, coast or seabed'. In the revision of the initial assessment for the Belgian marine waters (Belgian State 2018), the impact in the context of the dumping of dredged material is evaluated with respect to MSFD descriptors 1, 6, 10 & 11. The implementation of the MSFD in Belgian legislation is done by the RD of 23 June 2010 (see thematic chapter **Nature and environment**). The possible application of the MSFD evaluation scheme in the assessment of the activity 'dumping of dredged material' was elaborated in Lauwaert et al. (2016). Hereby, ten relevant MSFD environmental targets were selected. In addition, the Birds Directive (2009/147/EC) and the Habitats Directive (92/43/EEC) are also an important framework to address the impact of dredging and dumping activities. In Van Hoey et al. (2014b), a Benthic Ecosystem Quality Index (BEQI) was developed in the framework of the WFD, MSFD

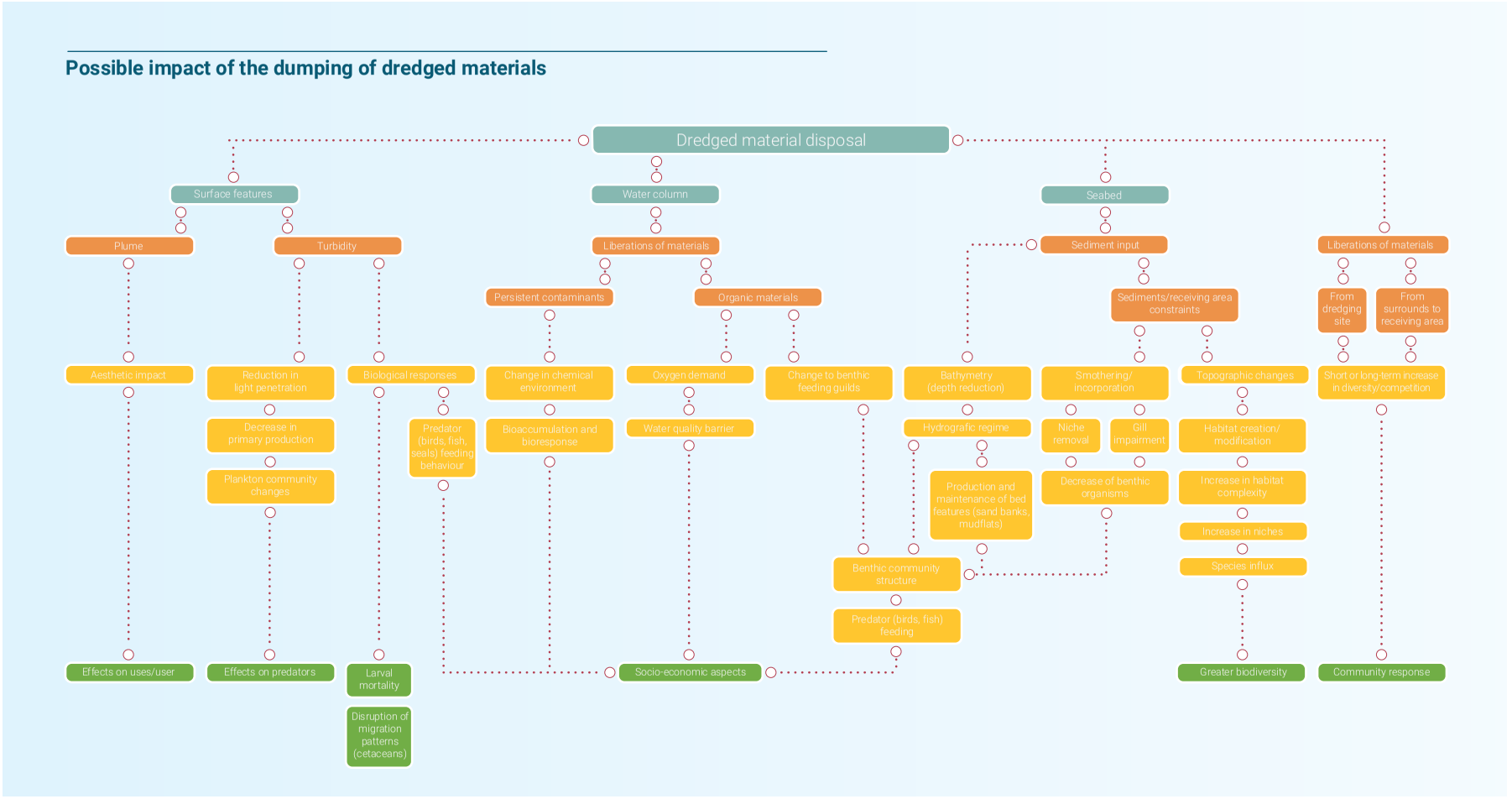


Figure 4. Conceptual diagram of the possible impact of dumping dredged material (not everything is applicable to the BNS) (derived from Elliot and Hemingway 2002).

and Habitats Directive for the assessment of the status of the soft substrate fauna. This index is applied, among others, in the monitoring of the dumping of dredged material.

In the BNS, dredging and dumping are bound by the Law of 20 January 1999. Specifically, for works carried out by the Government of Flanders, the RD of 12 March 2000 (amended by the RD of 18 October 2013) stipulates that a synthesis report must be submitted to the competent minister every five years. In these reports, the effects of the dredging and dumping activities are discussed and recommendations are made to the competent minister to underpin the environmental policy at sea (synthesis reports: Lauwaert et al. 2002, Lauwaert et al. 2004, Lauwaert et al. 2006, Lauwaert et al. 2008, Lauwaert et al. 2009, Lauwaert et al. 2011, Lauwaert et al. 2016, Lauwaert et al. 2019). Furthermore, the quality of the dredged material itself must meet certain sediment quality criteria (Goffin et al. 2007, OSPAR 2008). This quality is checked every 10 years by taking and analysing *in situ* samples at the dredging sites. In this context, a campaign was conducted in 2018 (Lauwaert et al. 2019). In addition, samples of the dredged sediment are taken from inside the hold or hopper of the dredges on a regular basis (approximately every four months) and analysed against the limit and target values stated in the granted permits.

In the framework of the permits, a monitoring and scientific programme is imposed to the Government of Flanders. In the MOMO programme, RBINS-MUMM is responsible for the monitoring and modelling of the cohesive sediment transport and the evaluation of the effects on the marine ecosystem as a result of dredging and dumping operations (see, among others, Fettweis et al. 202). The Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) studies the biological and chemical aspects at the various dump sites. In doing so, attention is paid to knowledge gaps such as the presence of marine litter, microplastics and other emerging contaminants in the dredged material, as well as to possible cumulative effects (OSPAR IA 2017, Lauwaert et al. 2016, Lauwaert et al. 2019). In addition, new monitoring technologies are used (sediment profile imaging, cf. Van Hoey et al. (2014a)). Furthermore, functional ecosystem changes are included to evaluate the biological aspects. For the implementation of plans or projects with possible significant effects on Natura2000 sites, an appropriate assessment (*passende beoordeling*) must be made (RD of 27 October 2016). For this purpose, an overarching framework for all dump sites will be elaborated (Lauwaert et al. 2019).

Steps are also being taken by the contracting authority to reduce the environmental impact of dredging. In the tenders (2019) for the nourishment of the Flemish coast, also the reduction of the environmental impact and CO_2 emissions in particular were a criterion for the granting of the contract, besides other criteria such as price and quality.

In the dredging industry there is currently a movement going - in cooperation with knowledge institutions - (i) to align and base dredging activities on natural processes, (ii) to sustainably reuse dredged material, or (iii) to deliberately create certain ecosystems (see among others the so-called Nature Based Solutions-concept, in the thematic chapter **Safety against flooding**). In addition, the feasibility of the use of dredged material is also examined for the suppletion of beaches in function of coastal safety, the creation of room for rivers to increase drainage and storage capacity, land reclamation, nature development etc. (Temmerman et al. 2013, de Vriend et al. 2015). These activities are also grouped under the term "beneficial use" (OSPAR 2014). In addition to suppletion methods, recent research is also looking into the possibilities of integrating CO_2 capture into dredging practices (Meysman and Montserrat 2017).

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
London Convention	Convention on the prevention of marine pollution by dumping of wastes and other matter	1972	1975
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998
London protocol	The Protocol to the 1972 Convention on the prevention of marine pollution by dumping of wastes and its Annexes 1, 2 and 3	1996	2006

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitat Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2008/56/EC	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 13 July 2001	Besluit van de Vlaamse Regering betreffende de aanduiding van de maritieme toegangswegen en de bestanddelen van de haveninfrastructuur	2001-07-13/90
Decision of the Government of Flanders of 17 February 2012	Besluit van de Vlaamse Regering tot vaststelling van het Vlaams reglement betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen	2012-05-23/464
Royal Decrees		
RD of 12 March 2000	Koninklijk besluit ter definiëring van de procedure voor machtiging van het storten in de Noordzee van bepaalde stoffen en materialen	2000-03-12/40
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 18 October 2013	Koninklijk besluit tot wijziging van het koninklijk besluit van 12 maart 2000 ter definiëring van de procedure voor machtiging van het storten in de Noordzee van bepaalde stoffen en materialen	2013-10-18/20
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan (2020-2026)	2019-05-22/23

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
Ministerial Decrees		
MD of 7 October 1999	Ministerieel besluit betreffende het storten in zee van baggerspecie	1999-10-07/31
MD of 28 October 1999	Ministerieel besluit houdende wijziging van de ministeriële besluiten houden machtiging tot het storten in zee van baggerspecie door het Ministerie van de Vlaamse Gemeenschap, Departement Leefmilieu en Infrastructuur, Administratie Waterwegen en Zeewezen, Afdeling Waterwegen Kust met referenties BS/97/01, BS/97/02, BS/97/03 en BS/97/04 en verlengd bij ministerieel besluit van 20 maart 1999.	1999-10-28/31
MD of 28 December 2011	Machtiging tot het storten in zee van baggerspecie door de Vlaamse overheid, Departement Mobiliteit en Openbare Werken, afdeling Maritieme Toegang en voor Maritieme Dienstverlening en Kust, afdeling Kust	
MD of 28 December 2011	Machtiging voor het storten van baggerspecie bij ministeriële besluiten van 28 december 2011	
MD of 19 December 2013	Machtiging voor het storten van baggerspecie - verlenging bij ministerieel besluit van 19 december 2013	
MD of 5 November 2015	Ministerieel besluit houdende vaststelling van de algemene code van goede praktijk inzake bagger- en ruimingsspecie	2015-11-05/04
MD of 22 December 2016	Machtiging voor het storten van baggerspecie bij ministeriële besluiten van 22 december 2016	
Cooperation agreements		
Cooperation agreement of 12 June 1990	Samenwerkingsakkoord tussen de Belgische Staat en het Vlaamse Gewest ter vrijwaring van de Noordzee van nadelige milieu-effecten ingevolge bagger-specielossingen in de wateren die vallen onder de toepassing van de Conventie van Oslo	1990-06-12/38
Cooperation agreement of 6 September 2000	Samenwerkingsakkoord tot wijziging van het Samenwerkingsakkoord van 12 juni 1990 tussen de Belgische Staat en het Vlaamse Gewest ter vrijwaring van de Noordzee van nadelige milieu-effecten ingevolge bagger-specielossingen in de wateren die vallen onder de toepassing van de Conventie van Oslo	2000-09-06/31
Laws		
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33

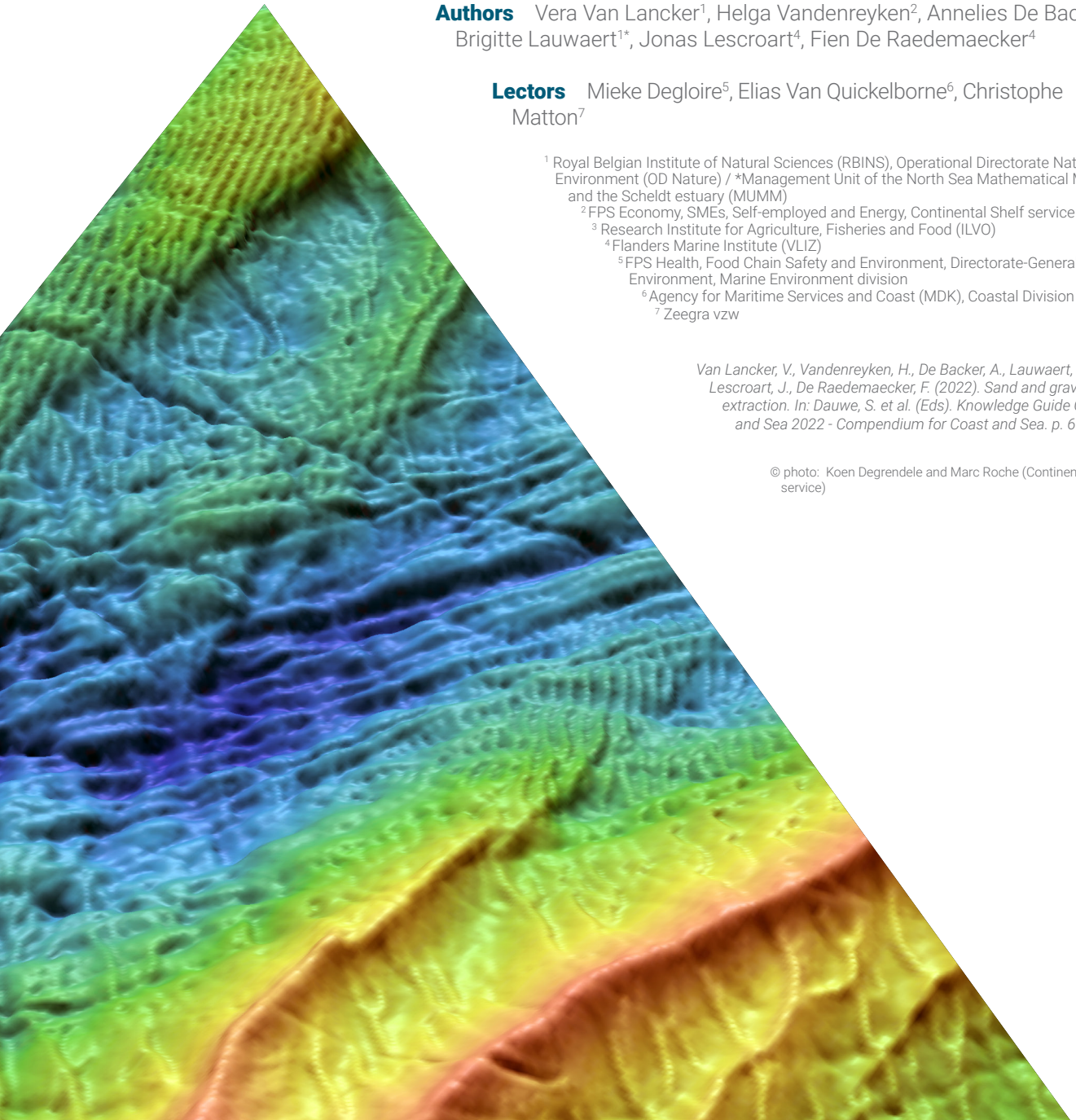
4 Sand and gravel extraction

Authors Vera Van Lancker[1], Helga Vandenreyken[2], Annelies De Backer[3], Brigitte Lauwaert[1*], Jonas Lescroart[4], Fien De Raedemaecker[4]

Lectors Mieke Degloire[5], Elias Van Quickelborne[6], Christophe Matton[7]

[1] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature) / *Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM)
[2] FPS Economy, SMEs, Self-employed and Energy, Continental Shelf service
[3] Research Institute for Agriculture, Fisheries and Food (ILVO)
[4] Flanders Marine Institute (VLIZ)
[5] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[6] Agency for Maritime Services and Coast (MDK), Coastal Division
[7] Zeegra vzw

Van Lancker, V., Vandenreyken, H., De Backer, A., Lauwaert, B., Lescroart, J., De Raedemaecker, F. (2022). Sand and gravel extraction. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 67-78.



Between 40 and 82 million m³ of marine sediment has been extracted annually in the OSPAR region (North-East Atlantic and North Sea) between 2015-2018 (ICES 2019). This mainly concerns the extraction of sand and gravel for the construction industry and coastal protection. Furthermore, marl was extracted for use in agricultural land improvement and water filtering (OSPAR 2010).

Most of the marine sediment in the OSPAR region is extracted by countries such as the Netherlands (24.6 million m³ in 2018), the United Kingdom (9.4 million m³ in 2018), Denmark (5.7 million m³ in 2018) and France (3.7 million m³ in 2018) (ICES 2019). In the Belgian part of the North Sea (BNS), sand is the most extracted type of sediment in recent decades, with an annual volume that fluctuated between 2 and 4 million m³ over the past ten years. In 2014, this volume was considerably higher at almost 6 million m³, 60% of which was used for beach nourishments (FPS Economy, S.M.Es, Self-employed and Energy 2020). In 2018, approximately 3.8 million m³ was extracted, of which 26% was used for coastal protection (ICES 2019). Gravel is generally not extracted in the BNS due to the extremely limited presence, the small grain size and the heterogeneity of the material in the permitted areas (FPS Economy, S.M.Es, Self-employed and Energy 2020).

4.1 Policy context

The sand and gravel extraction in the BNS is a federal competence that belongs to the FPS Economy, SMEs, Self-employed and Energy and is regulated by the Law of 13 June 1969 (see also General Direction Quality and Safety 2020). Coordination with and alignment between the public administrations involved in the management of the exploration and exploitation on the continental shelf (CS) and in the territorial sea is done within an Advisory Committee (RD of 12 August 2000).

4.2 Spatial use

The zones for sand and gravel extraction are legally demarcated in the marine spatial plan (MSP 2020-2026, as stipulated in the RD of 22 May 2019, see also Verhalle and Van de Velde 2020). Prior to a previous demarcation in 2004, a study on the possible control zones[1] for sand extraction was conducted (Schotte 1999). A total of three control zones were demarcated in 2004 and divided into sectors for which concessions can be obtained. A fourth control zone was demarcated in 2010, in which four new sectors were defined on the basis of new exploration data. Given the expectation that the demand for sand will further increase (e.g. in function of the needs for coastal protection and the demand for construction sand on land), a new exploration zone[2] was designated in the MSP (2020-2026) (RD of 22 May 2019) in the northern part of the BNS and a fifth control zone is provided on the Blighbank, consisting of a single sector (see also Belgian State 2018). In addition, some minor changes have been made compared to the previous MSP (2014-2020) (RD of 20 March 2014) regarding the delineation of the sectors: Thortonbank, Sierra Ventana (b) and Oosthinder-Zuid.

In addition, a reference zone for monitoring[3] was also demarcated, similar to the sand extraction areas in terms of sediment and habitat composition. In this reference zone, sand and gravel extraction is prohibited in order to monitor the impact on the environment. This closed zone is located on the Thornton Bank (THBREF zone in figure 1, MSP 2020-2026) and also serves as a reference area for wind turbine activities in the BNS (see also thematic chapter **Energy (including cables and pipes)**). To assess the impact of sand extraction more accurately, several monitoring areas[4] were defined, which are mapped (at least twice) annually (FPS Economy, S.M.Es, Self-employed and Energy 2020).

If a negative seabed evolution occurs due to extraction, parts of the sectors may be closed (figure 1 and table 1). In the period prior to 2021, a maximum of 5 m of sediment was allowed to be removed below a predefined bathymetric reference model (Degrendele et al. 2014). As a result, a number of areas on the Kwintebank (BBMA and KBMB) and on the Buiten Ratel (BRMC) have been closed for exploitation (Degrendele and Vandenreyken 2017). Since 2021, the Continental Shelf service has applied new criteria for closing subareas based on the new

[1] A control zone is an area stipulated by law where sand extraction is permitted (delimitation stipulated in the MSP 2020-2026, RD of 22 May 2019).
[2] An exploration zone is an area stipulated by law where qualitative sand and gravel can be searched for (delimitation stipulated in the MSP 2020-2026, RD of 22 May 2019). If the results of the exploration research are positive, the minister of Economy, after advice from the minister responsible for maritime mobility, can define new sectors for exploitation within this zone.
[3] A reference area for monitoring the impact of sand extraction and wind farms on the environment is located in control zone 1 on the Thorntonbank. Sand and gravel extraction have been prohibited in this area since 1 October 2010. Provided that the advice of the Advisory Commission is favourable, extraction can resume from 1 May 2023 (General Direction Quality and Safety 2020).
[4] A monitoring area is an area that is assessed on a regular basis in order to accurately follow the evolution and evaluate the impact of sand extraction on the sea bed. Such a monitoring area can be located both inside and outside a control zone. In this way, the evolution of the seabed in a reclamation area can be compared to the natural evolution of the seabed (FPS Economy, S.M.Es, Self-employed and Energy 2020).

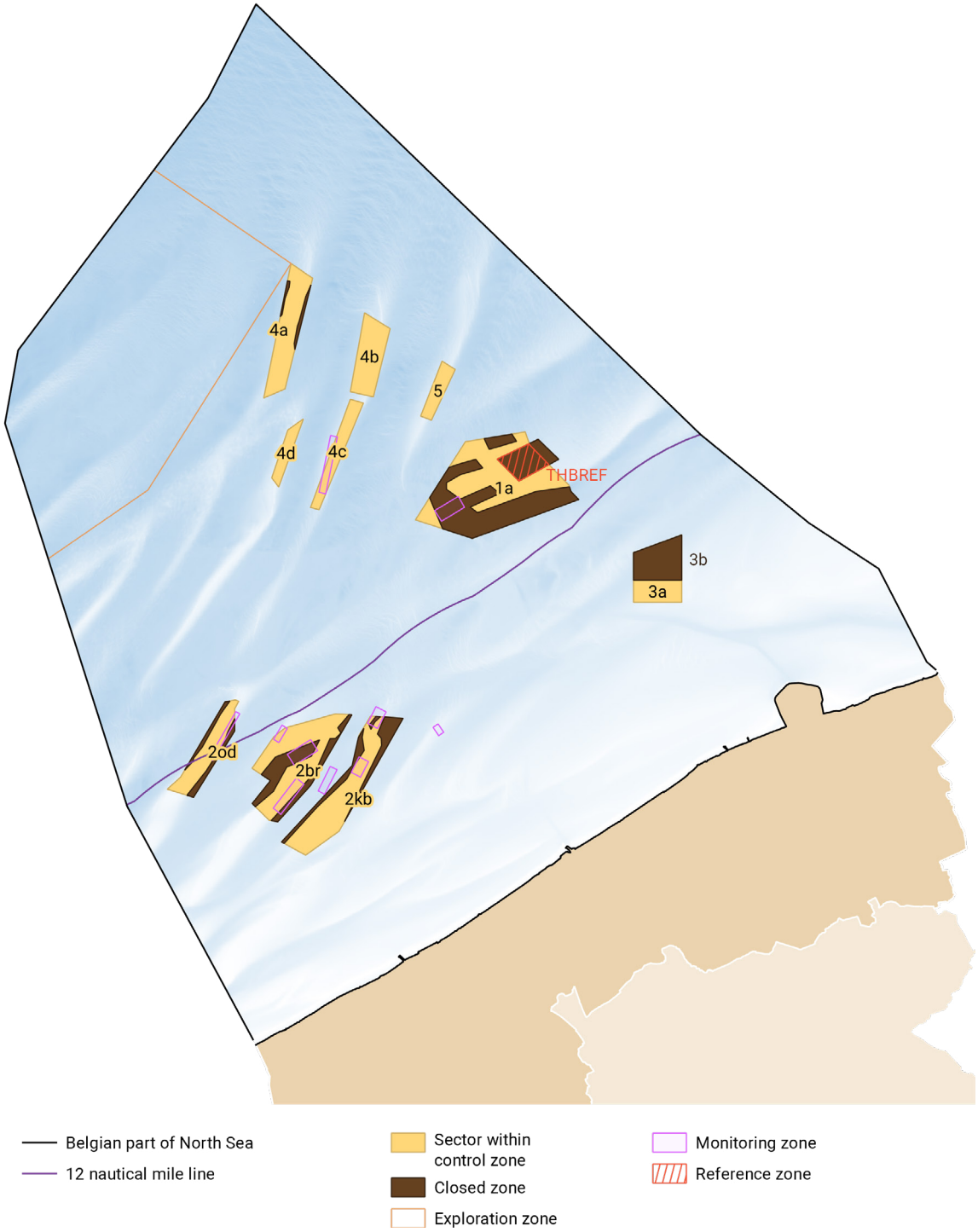


Figure 1. The demarcation of the sectors within the control zones for sand extraction in the BNS with the location of the closed sub-zones in 2022, the exploration zone, the monitoring zone and the reference zone (Sources: BNS, 12 nautical mile line: Flemish Hydrography, sector within control zone, exploration zone, reference zone (based on RD of 22 May 2019): MarineAtlas.be, Closed zone, monitoring area: FPS Economy, Coastal Portal).

reference surface and the available volume of sand within the various sectors (FPS Economy). Exploitation will no longer be allowed if the limit is reached within a certain area. The new reference surface was defined based on scientific and legal criteria (De Mol et al. 2014, Degrendele 2016, Degrendele et al. 2017, Degrendele et al. 2021) and aims to limit the impact of extraction in the most sensitive areas and to increase economic sustainability taking into account the availability of quality sand. In 2021, this resulted in the closure of 11 subareas, spread over control zones 1, 2 and 4, which cover 24% of the total area, but contain only 2% of the stock of sand. The demarcation of these closed zones is re-evaluated annually and adjusted if necessary.

Table 1. An overview of the different control zones for sand extraction in the BNS by location and accessibility.

Control zone	Sector	Location	Accessibility
Zone 1	1a	Thorntonbank	Open, except for the area THBREF
Zone 2	2kb	Kwintebank	Open
	2br	Buiten Ratel	Open
	2od	Oostdyck	Open
Zone 3	3a	Sierra Ventana	Open*
	3b	Sierra Ventana	Closed
Zone 4	4a	Noordhinder	Open**
	4b	Oosthinder-Noord	Open
	4c	Oosthinder-Zuid	Open
	4d	Westhinder	Open
Zone 5	5	Blighbank	Open

* Sectors 3a and 3b are alternately open for extraction. Currently, sector 3b is being used as a disposal site for dredged materials (see also General Direction Quality and Safety 2020).
** Sector 4a overlaps with a zone dedicated to the production and transmission of electricity from renewable sources. This sector remains open, as long as sand and gravel extraction are reconcilable with it.

The offshore extraction of sand and gravel requires a concession permit (figure 2). In order to obtain a permit, an application form has to be submitted to the director of the General Direction Quality and Safety of the FPS Economy, according to the procedure stipulated in the RD of 1 September 2004 concerning the granting procedure. Furthermore, the RD of 21 October 2018 about the environmental impact assessment (EIA) defines that an EIA-report has to be submitted to the Management Unit of the Mathematical Model of the North Sea of the Royal Belgian Institute of Natural Sciences (RBINS-MUMM). MUMM's assessment of the Environmental Impact Report (EIR) is subsequently transferred to the minister/secretary of state competent for the Marine Environment, who in turn formulates a binding recommendation to the federal minister competent for economy (Belgian State 2018, General Direction Quality and Safety 2020).

The concessions that have been granted for the exploration and exploitation of the mineral and other non-living resources in the BNS can be found in the ministerial decrees in the Belgian official journal (table 2). Each concessionaire pays a fee in line with the volume he has extracted, with an annual minimum of 18,592.02 euro (FPS Economy, S.M.Es, Self-employed and Energy 2020). The amounts of the fees are adjusted annually and vary according to the type of material. In 2022, sand from control zones 1, 2 and 4 will be worth 0.70 euro/m³; sand from control zone 3 (lower quality) 0.46 euro/m³ and gravel 1.49 euro/m³. A new concessionaire will be granted a minimum volume of 100,000 m³/year for the first year per concession. Every year, an Advisory Committee advises the minister competent for economy on the quantities that each concessionaire can extract in the following year (FPS Economy, S.M.Es, Self-employed and Energy 2020). For Belgium, the effective surface with actual extraction was about 32% of the legal concession zone in 2015, only 12% in 2016, and 33% in 2017 (ICES 2016, ICES 2017, ICES 2019). Between 2015 and 2019, more than 48% of the total volume extracted occurred in control area 1, 21% in control area 2, 13% in control area 3 and 18% in control area 4 (FPS Economy, S.M.Es, Self-employed and Energy 2020).

4.3 Societal interest

The extraction of sand in the BNS has strongly increased since the first reporting year, i.e. 1976 (figure 3). At that time, a sediment volume of approximately 29,000 m³ was extracted and this further increased to 3.8 million m³ in 2020, with a peak of almost 6 million m³ in 2014 (Source: FPS Economy, Continental Shelf service). Between 1976 and 2018, a total of 73 million m³ of sea sand was extracted. Since 2003, three phases can be distinguished in the evolution of sand extraction on the BNS (Roche et al. 2017). Between 2003 and 2010, more than 75% of the sediment was extracted in control zone 2, especially on the Kwintebank (sector 2kb). After the closure of two regions on the Kwintebank (2kb), a shift took place since 2007 to zone 2br (Buiten Ratel). A section of this zone was also closed for extraction in 2015. From 2014 onwards, extraction shifted to three sectors: Thorntonbank (1a), Sierra Ventana (3a) and the Oosthinder (4c). Currently, a maximum of 15 million m³ of sediment can be extracted from the control zones over a period of five years (not considering exceptional projects such as coastal protection).

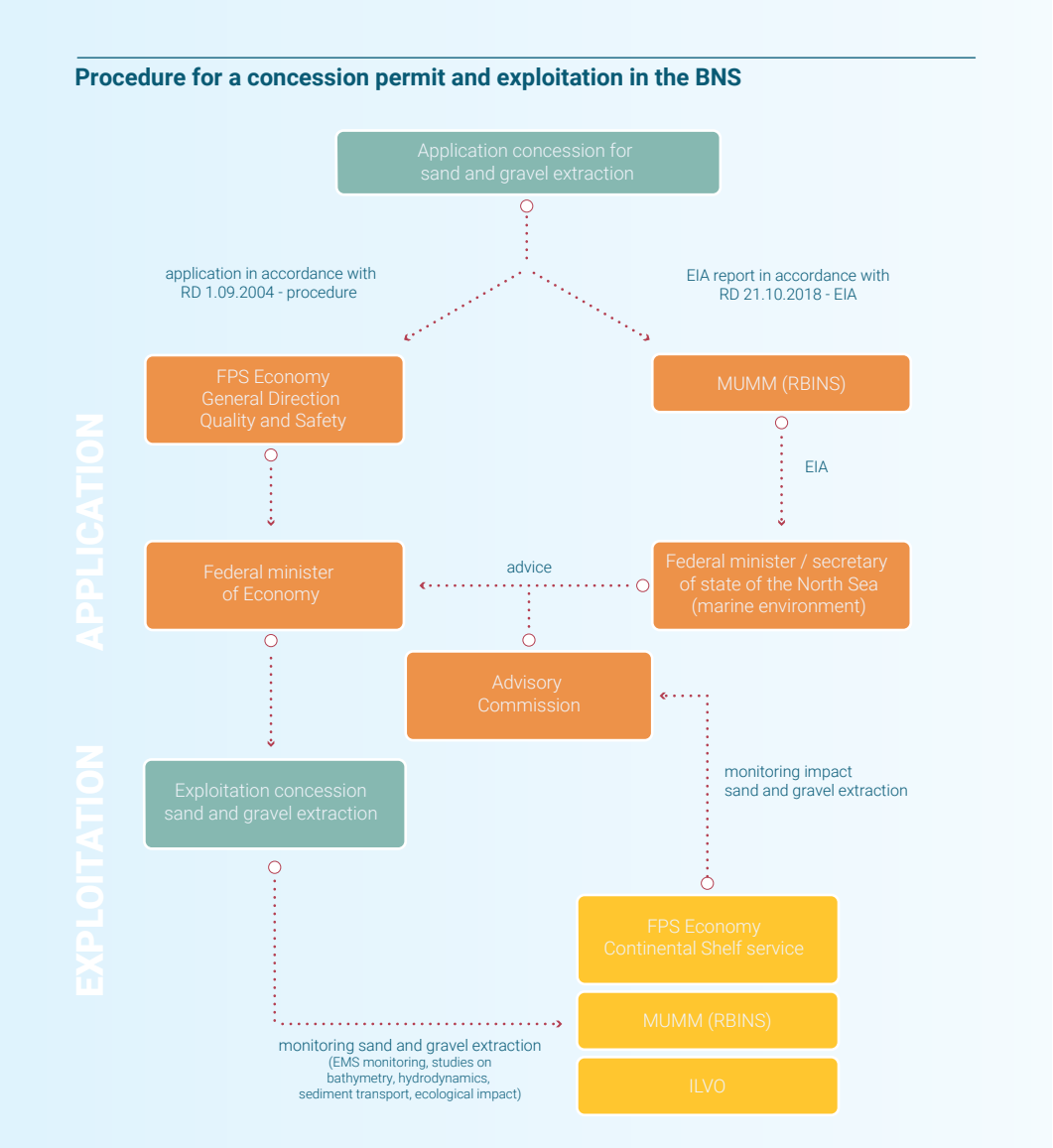


Figure 2. Flowchart of the procedure for a concession permit and the exploitation of sand and gravel extraction in the BNS (Law of 13 June 1969 and Implementation Decrees).

In 2019, about 55% of this sediment was landed in Flanders, 15% was used for beach nourishments and 30% was unloaded in Dutch, French and UK ports (FPS Economy, S.M.Es, Self-employed and Energy 2020). The share of exported sand to the Netherlands that is landed in Vlissingen, is ultimately destined for the Belgian market (ICES 2019). The Long-Term Vision North Sea 2050 estimates that 8.75 million m³ of sand will be needed annually in 2050, calculated on a steady annual increase of 6% (De Backer 2017).

In cooperation with Zeegra vzw, the professional association of importers and producers of sea aggregates, the Continental Shelf service has attempted to assess the direct economic impact of the sea aggregates sector (see below). Naturally, there is also a major indirect impact, such as the economic growth of port activities, the Belgian construction industry, road transport, suppliers, etc. Some relevant figures are listed below:

- 12 private companies with a concession permit employ 90 people in Belgium and 175 people in the rest of Europe. These employees are mainly active in the extraction of marine sand;
- The annual turnover from the sale of sea sand and gravel in Belgium amounted to more than 70 million euro in 2020;
- The concession holders do not only mine sand on the BNS, but also extract or buy sand in our neighbouring countries (table 3). The sand extracted in Belgium amounted to more than 3 million m³ in 2020. In the Netherlands, over 2.5 million m³ of sand was extracted or purchased that year. In the United Kingdom and

Table 2. An overview of the concession holders for sand extraction in the BNS with the maximum extraction volume granted for 2021 (Source: FPS Economy, Continental Shelf service).

Concessionaire	Maximum extraction volume allocated for 2022
Charles Kesteleyn nv	119,000 m³
Dranaco nv	33,000 m³
SATIC nv	152,000 m³
TV Zeezand Exploitatie	97,000 m³
Alzagri nv	86,000 m³
Belmagri nv	30,000 m³
CBR - Sagrex	307,000 m³
De Hoop Bouwgrondstoffen bv c.o. SATIC nv	144,000 m³
DEME Building Materials nv	772,000 m³
Government of Flanders – MDK – Coastal Division *	700,000 m³
Government of Flanders – MDK – Coastal Division **	700,000 m³
Government of Flanders – Maritime Access division ***	200,000 m³
DC Industrial nv	567,000 m³
NHM nv	523,000 m³
Betoncentrale Van den Braembussche nv	168,000 m³
Total	**4,598,000 m³**

** The concession of the Coastal Division for sand extraction in zone 3 ends on 31 July 2022.*
*** The Coastal Division is allowed to extract 7 million m³ in zones 4 and 5 for ten years. On average this is 700,000 m³ per year.*
**** The Maritime Access division can extract 3.5 million m³ in zone 3 over a period of ten years. On average this is 350,000 m³ per year. The concession of the Maritime Access division for sand extraction in zone 3 ends on 31 July 2022.*

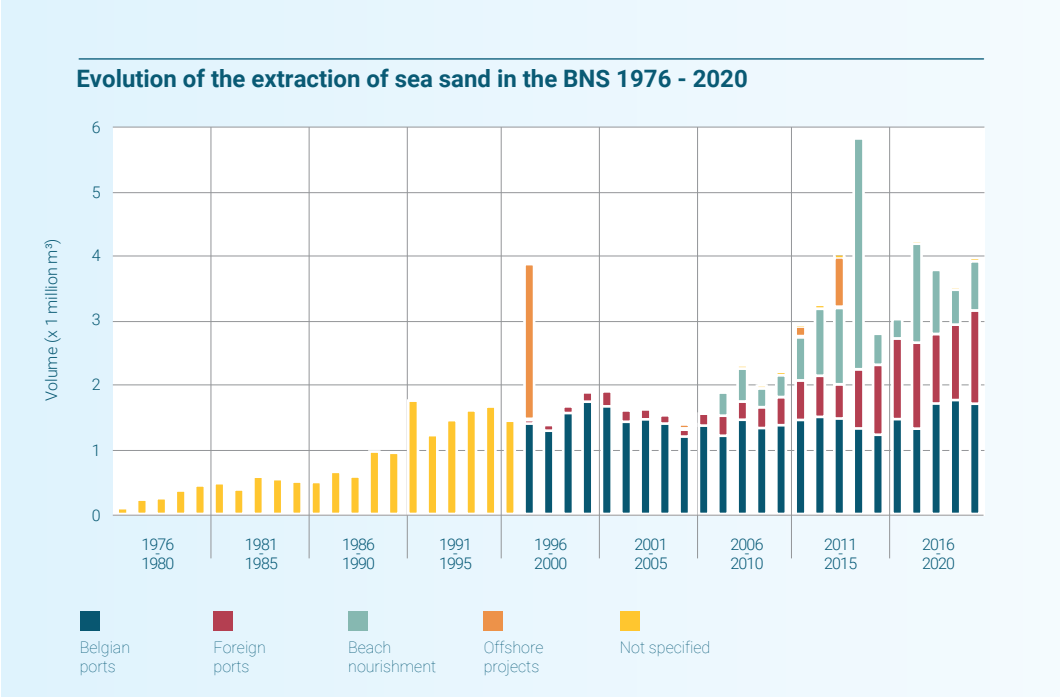


Figure 3. The evolution of the extraction of marine sand in the BNS between 1976 and 2020. Note on a number of outliers in this evolution: construction of submarine gas pipelines in 1991 and 1997 and coinciding nourishments following the *Sinterklaas* storm in 2014 (Source: FPS Economy, S.M.Es, Self-employed and Energy 2020).

Germany, more than 1 million m³ and about 20,000 m³ of sand were extracted or purchased respectively. In the United Kingdom, in addition to sand, gravel is also extracted;

- Sea sand has many applications (figure 4). Most of the extracted sea sand is medium-grade sand for use in: ready-mixed concrete (67%), precast concrete (11%) and other concrete products (12%). In addition, sea sand is also used for the production of asphalt, as sand filling used for e.g. drainage, foundation and embankment sand and for beach works;
- In addition to the use of sea sand in the construction sector, sea sand is also used for coastal protection (see thematic chapter **Safety against flooding**). The implementation of beach nourishment is currently the most important coastal protection measure in Belgium. Beach nourishment ensures that the beaches are sufficiently wide and high to protect the coast against flooding in the event of very heavy storm surges. For beach nourishment, sand with a median grain size of 250-350 µm[5] is used, while this is ± 200 µm for forshore nourishment. The required quantities of sediment have been provided for within the framework of the Master Plan Coastal Safety (2011) since 2011. In addition, the Coastal Vision project will determine the most desirable societal measures needed to protect the coast against a sea level rise of up to 3 m, which may lead to an increased need for sand;
- The indirect economic impact of the sand extraction sector is difficult to quantify. In addition to the purchase of marine granulates, nearly 29 million euro was spent in the private sector in Belgium in 2020 on the required infrastructure and 46 million euro in the rest of Europe. Investments were also made in the public sector, such as ports and pilotage, with almost 3.5 million euro in Belgium and over 7.5 million euro in the rest of Europe;
- It can be said that the extraction of marine aggregates is not only of strategic importance, but also comprises an important economic activity with high added value that contributes greatly to the growth and prosperity of Belgian construction companies (Source: FPS Economy, Continental Shelf service).

Table 3. Volumes (m³) of sand extracted or purchased, by concession holders for sand extraction in the BNS, in Belgium and neighbouring countries in 2020 (Source: FPS Economy, SMEs, Self-employed and Energy, Continental Shelf service).

Country	Extracted or acquired volumes in 2020
Belgium	3,172,963 m³
The Netherlands	2,579,396 m³
United Kingdom	1,223,712 m³
Germany	19,432 m³

Good quality sand is a finite resource and in Belgium, its use in the construction sector is twice as high compared to the production (Vrijders 2021). Therefore, the concept of a circular economy is gaining increasing attention in this sector in order to sustain the future of this economic activity for generations to come (Demoulin 2021, Hammöhner and Fincke 2021, Janssens 2021, Pirard and Courard 2021).

4.4 Impact

The most commonly used method for sand extraction is the trailing suction hopper dredger which draws grooves in the seabed that are typically 1-3 m wide and 0.2-0.5 m deep (Degrendele et al. 2010, Newell and Woodcock 2013). The RD of 21 October 2018 regarding the environmental impact assessment (EIA), stipulates the various effects of sand extraction on the marine environment that need to be considered in the EIA (Environmental impact report for the extraction of marine aggregates at the BNS in 2006, 2010, 2016 and 2020). Tables 4 and 5 list studies related to the impact of sand and gravel extraction in the BNS, supplemented by publications that are widely applicable or provide a general overview (e.g. ICES reports). Sediment extraction is also included in the 'Ecosystem vision for the Flemish Coast' (Van der Biest et al. 2017) as one of the processes that can have a major impact on the health of the ecosystem components and on other ecosystem services.

The monitoring approach as described in **4.5 Sustainable use** aims to prevent any irreversible or long-term negative effects as a result of sand extraction.

[5] Micrometer

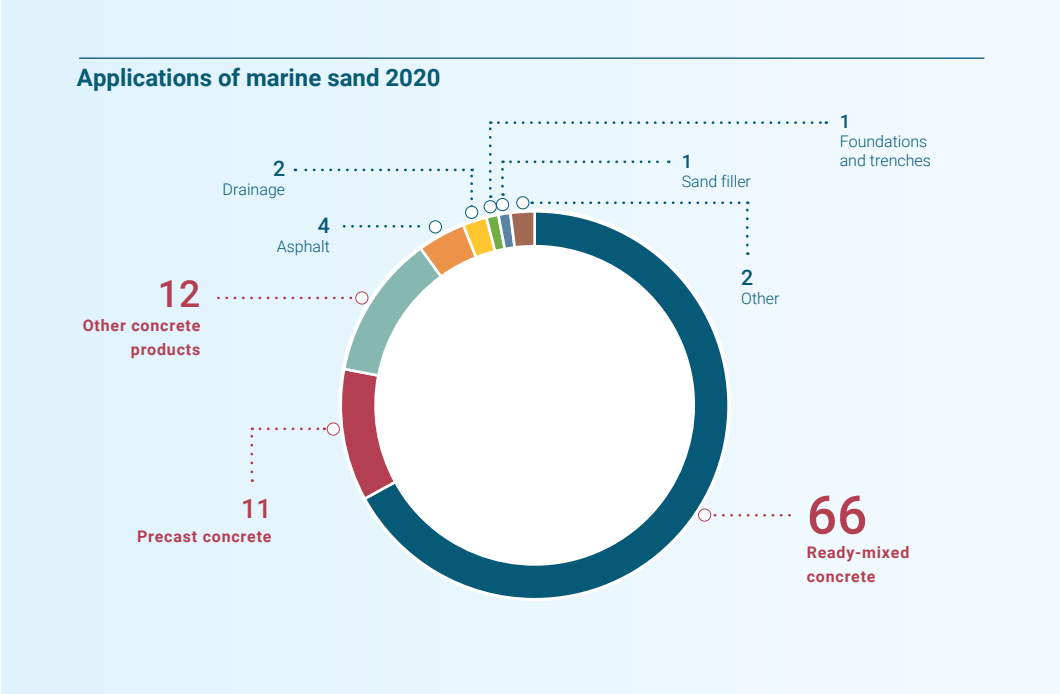


Figure 4. The different applications (with their % share) of sea sand in 2020 (private sector) (Source: FPS Economy, S.M.Es, Self-employed and Energy 2020).

Table 4. A literature overview of the impact of sand extraction on the environment where extraction takes place, considering near- and far-field effects.

Environmental impact	Literature
Seabed and water (changes in the bathymetry, sedimentology, sediment plumes, turbidity, hydrodynamic regime, etc.)	Van Lancker et al. 2007, Vanaverbeke et al. 2007, Van Lancker et al. 2009, Van Lancker et al. 2010, Bellec et al. 2010, Degrendele et al. 2010, Van den Eynde et al. 2010, Garel 2010, Roche et al. 2011, De Sutter and Mathys 2011, Van Lancker et al. 2014a, Degrendele et al. 2014, Van Lancker et al. 2014b, Francken et al. 2014, Van Lancker et al. 2015, Van Lancker and Baeye 2015, Van Lancker et al. 2016a, Walker et al. 2016, Van den Eynde et al. 2017, Van Lancker et al. 2017a, Baeye et al. 2017, Van Lancker et al. 2017b, Van Lancker et al. 2017c, Montereale-Gavazzi et al. 2018, Hademenos et al. 2019, Van den Eynde et al. 2019a, Van den Eynde et al. 2019b, Van Lancker et al. 2020a, Rommens and Hauquier 2020, Van Lancker et al. 2020b, Vandenreyken 2020, Van den Eynde et al. 2021, Van Lancker et al. 2021, Wyns et al. 2021
Fauna, flora and biodiversity	Vanaverbeke et al. 2007, Van Lancker et al. 2010, Bonne 2010, De Backer et al. 2011, De Sutter and Mathys 2011, De Backer et al. 2014a, De Backer et al. 2014b, De Backer and Hostens 2014, Van Lancker et al. 2014a, Van Lancker et al. 2014b, Van Lancker et al. 2015, Van Lancker et al. 2016a, Walker et al. 2016, De Backer et al. 2017, Van Lancker 2017, Rommens and Hauquier 2020, Van Lancker et al. 2020b, Vandenreyken 2020, Wyns et al. 2021, Derycke et al. 2021
Air quality and climate	De Sutter and Mathys 2011, Walker et al. 2016, Francken et al. 2017, Rommens and Hauquier 2020
Sound and vibrations	De Sutter and Mathys 2011, Heinis et al. 2013, Walker et al. 2016, Jones and Marten 2016, Durinck and Casteleyn 2017, Rommens and Hauquier 2020

4.5 Sustainable use

4.5.1 Nature and environmental guidelines for the sustainable extraction of sand

Within the OSPAR region, all countries that extract sand and gravel on a large scale have a legislation that complies with the European Directive 85/337/EEC concerning the environmental impact assessment of specific public and private projects, as well as with the European Habitats Directive (Directive 92/43/EEC). With regard to the management of marine sediment extraction, the OSPAR countries have agreed to apply the directives as proposed by the International Council for the Exploration of the Sea (ICES) (see annex 10 of the ICES 2003). These directives

Table 5. An overview of the impact of sand extraction on other users.

Impact on users	Literature
Risk and safety (shipping, oil pollution, coastal safety, etc.)	Verwaest 2008, De Sutter and Mathys 2011, Liste Muñoz et al. 2011, Walker et al. 2016, Van den Eynde et al. 2017, Rommens and Hauquier 2020
Seascape and cultural heritage	De Sutter and Mathys 2011, Van Haelst and Pieters 2014, Walker et al. 2016, Missiaen et al. 2016, Rommens and Hauquier 2020
Interaction with other human activities (including coastal protection)	Verwaest and Verelst 2006, Verwaest 2008, De Sutter and Mathys 2011, Vandenborre 2014, Walker et al. 2016, Van Lancker et al. 2016a, Van den Eynde 2017, Van den Eynde et al. 2019a, Rommens and Hauquier 2020, Van Lancker et al. 2020b
Cumulative effects (e.g. in combination with the activities in the offshore wind parks)	Van Lancker et al. 2010, De Sutter and Mathys 2011, Van Lancker et al. 2015, Walker et al. 2016, Van Lancker et al. 2016a, Van Lancker et al. 2017a, Rommens and Hauquier 2020, Van Lancker et al. 2020b

also discuss nature conservation and spatial conflicts among users. Belgium, Denmark, Germany, France, the Netherlands and the United Kingdom demand the use of a so-called EMS system (Electronic Monitoring System), which allows the monitoring of the extraction in space and time. The effects of the sand and gravel extraction on the marine environment are examined by the ICES working group WGEXT, in which Belgium is represented by RBINS-MUMM and Flanders Research Institute for Agriculture, Fisheries and Food (ILVO).

The Marine Strategy Framework Directive (Directive 2008/56/EC) (MSFD; see also RD of 23 June 2010) and the Habitat Directive (Directive 92/43/EEC) (see thematic chapter **Nature and environment**) provide an important framework for the sustainable sand exploitation in the BNS.

- In the MSFD, several descriptors for a good environmental status (GES) are identified (Belgian State 2012, for Belgian waters), some of which are relevant for the extraction of marine sediments (Degraer and Vanden Berghe 2014). In this respect, descriptor 6 on the seafloor integrity is of course important (more information: Rice et al. 2010, ICES 2019b) but also the direct and indirect effects of sand extraction on the conservation of biodiversity (descriptor 1, more information: Cochrane et al. 2010), and marine food webs (descriptor 4, more information: Rogers et al. 2010) should be considered. Also relevant to sand extraction are descriptor 7 on the hydrographical conditions (Walker et al. 2016, ICES 2016, ICES 2017, Fettweis et al. 2020) and descriptor 11 on the introduction of energy, including underwater noise (more information: Tasker et al. 2010). For each descriptor, a number of environmental targets are set (Decision (EU) 2017/848) and trends and changes are evaluated every six years. A first assessment was conducted in 2018 (MSFD cycle 2012-2018) and the results are included in the update of the initial assessment for the Belgian marine waters (Belgian State 2018). The selective extraction of living and non-living resources on the seabed and subsoil was included in the list of pressures. At the request of the European Commission, the quantification of physical loss and disturbance was further elaborated in ICES working groups leading to an ICES advice on the assessment of human pressures on the seabed (ICES 2019b). This is part of a revision of the guidelines for the MSFD assessments in the second cycle (EU Commission Technical Group TG Seabed with experts from ILVO and RBINS). Belgium is also committed to innovative methodological developments for the monitoring of descriptors 6 and 7 (Montereale Gavazzi 2019, Montereale-Gavazzi et al. 2019, Fettweis et al. 2020, Derycke et al. 2021).
- Furthermore, the European Habitats Directive (Directive 92/43/EEC) deals with the protection of a number of habitats including the gravel beds (Degrendele et al. 2008, Houziaux et al. 2008, Degraer et al. 2009, Raeymaekers 2011, De Mesel et al. 2017). The most ecologically valuable natural gravel beds are located just south of the extraction areas of the Hinder banks. Therefore, these were also incorporated into the monitoring programme linked to the extraction on the Hinder banks (Van Lancker et al. 2014a, Van Lancker et al. 2014b, Van Lancker et al. 2015, Van Lancker et al. 2016a, Van Lancker et al. 2017b, Montereale-Gavazzi et al. 2018, Van den Eynde et al. 2019b, Van Lancker et al. 2020a, Van Lancker et al. 2020b). In order to determine reference conditions, gravel areas with different pressures on the seabed are also studied (Belgian State 2018, Montereale-Gavazzi et al. 2021). From a management perspective, the MSP 2020-2026 (RD of 22 May 2019, see also Verhalle and Van de Velde 2020) demarcates a reference zone for monitoring the impact on the environment and sand and gravel extraction activities within the Habitats Directive area of the Flemish Banks are strongly restricted (control zone 2). The maximum extraction volume in this zone amounts 1,578,000 m³ per year in the period 2020-2025 and gravel extraction is prohibited.

4.5.2 Monitoring of the environmental impact

The sand and gravel extraction in the BNS is monitored by the Continental Shelf service (FPS Economy), MUMM and ILVO. This research is ongoing and is financed by the fees paid by the operators, which are based on the extracted volume (see **4.2 Spatial use**) (Degrendele 2008, FPS Economy, SMEs, Self-employed and Energy 2020). The results of this monitoring are presented at a three-yearly conference organised by the Continental Shelf service (e.g. website FPS Economy, Degrendele and Vandenreyken 2017, Vandenreyken 2020, Vandenreyken 2021).

Over the years, the European guidelines have helped to determine the monitoring approach (Van Lancker 2011). An important part of the monitoring programme of sand extraction in the BNS is the monitoring of the extraction operations. This is done both by checking the registers kept on board of the dredging vessels, and by a black-box system (Electronic Monitoring System, EMS) on board of those vessels (Van den Branden et al. 2017, FOD Economie, K.M.O., Middenstand en Energie 2020, General Direction Quality and Safety 2020). This system was introduced in 1996 and subsequently modernised in 2014 and is managed by MUMM as commissioned by the Continental Shelf service (Degrendele et al. 2014, Roche et al. 2017). An additional monitoring system for sand extraction based on Automatic Identification System (AIS) data was developed. Since the implementation of the new reference level for sand extraction in 2021, this monitoring approach has proven to be efficient in verifying that sand extraction activities are in compliance with the regulation on the new closed sub-zones (Barette et al. 2021).

In addition, the physical impact of extraction on the seabed is closely monitored by the Continental Shelf service (FPS Economy), ILVO and MUMM. The sediment volumes in the control areas are monitored using the research vessels RV Belgica and RV Simon Stevin. MUMM is also responsible for monitoring the hydrodynamics and the sediment transport in the BNS by means of models and measurements (Van Lancker et al. 2014a, Van Lancker et al. 2014b, Francken et al. 2014, Francken et al. 2017, Van Lancker et al. 2017a, Van den Eynde et al. 2017, Van den Eynde et al. 2019a, Van den Eynde et al. 2019b, Van Lancker et al. 2020a, Van Lancker et al. 2020b, Van den Eynde et al. 2021, Van Lancker et al. 2021). ILVO examines the ecological impact of the extraction activities as well as the biological evolution after cessation of the activities (De Backer et al. 2014, De Backer and Hostens 2014, De Backer et al. 2017, Wyns et al. 2020, Wyns et al. 2021). In exploitation zone 4, demarcated in the Hinder banks in 2010, a comprehensive 'baseline study' has been executed to better assess the impact of the current extraction activities (Mathys et al. 2011, Van Lancker et al. 2014a, Van Lancker et al. 2015, Van Lancker et al. 2016a, Van Lancker et al. 2017a, Van den Eynde et al. 2019b, Van Lancker et al. 2020a, Van Lancker et al. 2020b, Van Lancker et al. 2021).

4.5.3 Research in Belgium

Many studies and research projects have already been carried out that contribute to a better understanding of the impact and sustainable management of sand and gravel extraction: e.g. the BUDGET project (1999-2001, BELSPO) (Lanckneus et al. 2001), the SPEEK project (2003-2006, BELSPO) (Vanaverbeke et al. 2007), the MAREBASSE project (2002-2006, BELSPO) (Van Lancker et al. 2007), the EUMARSAND project (2002-2006, EU-FP6 project) Van Lancker et al. 2010), the RESOURCE-3D project (2006-2007, BELSPO) (Van Lancker et al. 2009), the QUEST4D project (2006-2010, BELSPO) (Van Lancker et al. 2009) and the TILES project (2012-2017, BELSPO) (Van Lancker et al. 2014c, Van Lancker et al. 2017c, Van Lancker et al. 2019, figure 5) contribute to a better understanding of the impact and sustainable management of sand and gravel extraction. A project such as CREST (2015-2019, IWT-VLAIO) provides more insight in the broader framework. Furthermore, other studies and projects focus on the ecological effects of beach nourishments such as Speybroeck et al. 2006, the 4SHORE project (2013-2016, ILVO) and the GEANS project (2019-2022, Interreg) (Derycke et al. 2021). Through the Seabed4U project (2019-2021, BELSPO), aimed at communicating the sustainability of sand extraction in a changing world, a web portal (release December 2021) will explain seabed-related data and information, as well as initiatives that place resource availability in a broader international framework (e.g. UNEP 2019).

In the TILES project, a harmonised geological knowledge-base was developed to support resource management in the Belgian and Dutch part of the North Sea in the long term. The approach is explained in figure 5. First, available drillings (Kint et al. 2016, RBINS SediLITHO database, TILES Dataportal) and seismic data were combined into 3D geological models that map the quality and quantity of the exploitable geological layers (the raw material or resource) (Hademenos et al. 2019, Van Lancker et al. 2019). After linking the resource models with numerical impact models, parameters were calculated that can support a more sustainable exploitation strategy (Terseleer et al. 2016, Terseleer et al. 2017, Van Lancker et al. 2018). The final 'reserve' that can be extracted is mainly determined by all types of restrictions that do not permit extraction, such as the use of space by other activities. The generated knowledge and information is offered in a multi-criteria decision support system (TILES

Consortium 2019) in which data quality is taken into account (De Tré et al. 2018, Kint et al. 2021). The information obtained from such a system contributes to a better support of the evaluation of sand extraction in the BNS. Specifically, the determination of the thickness of the (homogeneous) quaternary sand layer has contributed to the definition of the new reference surface (Degrendele et al. 2017). The research into the granulometry of the sediments present in the available layers in the concession zones is used for drawing up forecasts about the evolution of the sand stocks. RBINS manages the subsurface models developed in TILES, and is committed to further valorisation including data addition.

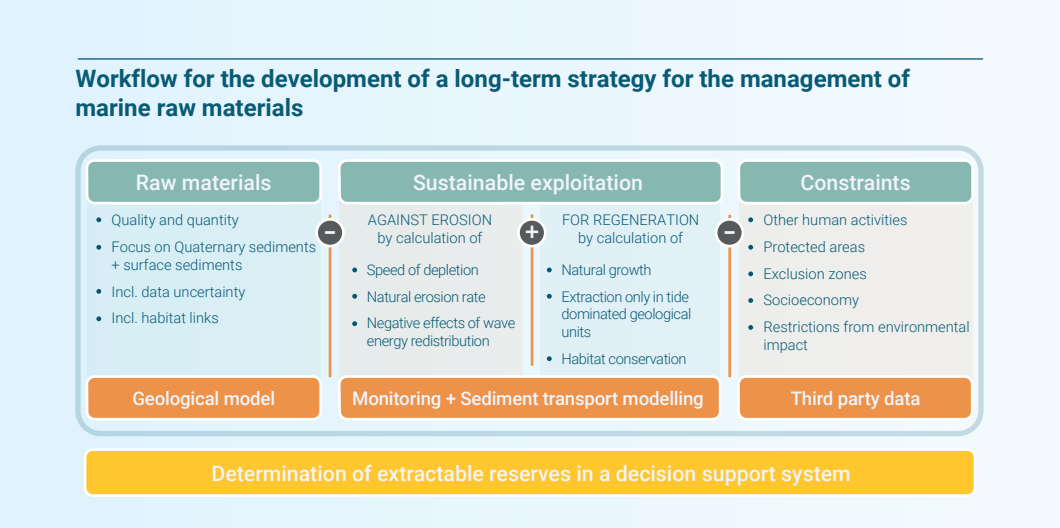


Figure 5. Conceptual workflow for the development of a long-term strategy for the management of marine raw materials at the BNS (Van Lancker et al. 2017c, Van Lancker et al. 2019).

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2008/56/EC	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2011/92/EU	Directive on the assessment of the effects of certain public and private projects on the environment	2011	92

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Royal Decrees		
RD of 12 August 2000	Koninklijk besluit tot instelling van de raadgevende commissie belast met de coördinatie tussen de administraties die betrokken zijn bij het beheer van de exploratie en de exploitatie van het continentaal plat en van de territoriale zee en tot vaststelling van de werkingsmodaliteiten en -kosten ervan	2000-08-12/83
RD of 1 September 2004	Koninklijk besluit betreffende de voorwaarden, de geografische begrenzing en de toekenningsprocedure van concessies voor de exploratie en de exploitatie van de minerale en andere niet-levende rijkdommen in de territoriale zee en op het continentaal plat	2004-09-01/51
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 19 April 2014	Koninklijk besluit tot wijziging van verscheidene koninklijke besluiten betreffende de exploratie en de exploitatie van de minerale en andere niet-levende rijkdommen in de territoriale zee en op het continentaal plat	2014-04-19/49
RD of 27 October 2016	Koninklijk besluit betreffende de procedure tot aanduiding en beheer van de mariene beschermde gebieden	2016-10-27/11
RD of 21 October 2018	Koninklijk besluit houdende de regels betreffende de milieueffectenbeoordeling in toepassing van de wet van 13 juni 1969 inzake de exploratie en exploitatie van niet-levende rijkdommen van de territoriale zee en het continentaal plat	2018-10-21/03
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
Laws		
Law of 13 June 1969	Wet inzake de exploratie en exploitatie van niet-levende rijkdommen van de territoriale zee en het continentaal plat	1969-06-13/30

5 Energy (including cables and pipes)

Authors Angelo Goethals[1], Jeroen Mentens[2], Pieter Mathys[3], Bob Rumes[4], Diederik Moerman[5], Benjamin Heylen[5], Ludovic Mouffe[5], Senne Gabriëls[5], Pieter Deleu[5], Pierre Paladin[5], Wout Weijtjens[6], Pieter-Jan Jordaens[7], Ine Moulaert[8], Steven Dauwe[8]

Lectors Annemie Vermeylen[9], Geert Dangreau[10], Riet Durinck[11]

[1] Ghent University (UGent) - PhairywinD (ETF), Centre for Environmental and Energy Law
[2] Elia, Environment & CSR
[3] Ghent University (UGent), EnerGhentIC
[4] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature)
[5] FPS Economy, SMEs, Self-employed and Energy, Directorate-General for Energy – Offshore cell
[6] Vrije Universiteit Brussel (VUB), Offshore Wind Infrastructure Application Lab (OWI-Lab)
[7] Sirris
[8] Flanders Marine Institute (VLIZ)
[9] Belgian Offshore Platform (BOP)
[10] West Flanders Development Agency (POM West-Vlaanderen)
[11] Elia

Goethals, A., Mentens, J., Mathys, P., Rumes, B., Moerman, D., Heylen, B., Mouffe, L., Gabriëls, S., Deleu, P., Paladin, P., Weijtjens, W., Jordaens, P.-J., Moulaert, I., Dauwe, S. (2022). Energy (including cables and pipes). In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 79-102.

5.1 Offshore wind energy

Europe is the world leader in offshore wind energy production. By 2020, 5,402 wind turbines were installed and connected to the grid in European seas, with a total installed capacity of 25,014 MW[1]. These turbines are spread across 116 wind parks in 12 different countries (Offshore wind in Europe: Key trends and statistics 2020). Most wind turbines are located in the North Sea, with the United Kingdom, Germany, the Netherlands, Belgium and Denmark as the main European players in the production of offshore wind energy.

In Belgium, at the end of 2020, eight wind parks were operational (C-Power, Belwind, Nobelwind, Northwind, Rentel, Norther, Seamade and Northwester 2), consisting of 399 wind turbines spread over an area of 238 km² and accounting for a total installed capacity of 2,262 megawatt (MW). This puts us in 2020 in fourth place within Europe (behind the United Kingdom, Germany and the Netherlands) and fifth worldwide, behind China. When the production capacity is compared to the number of inhabitants, Belgium is second in the world, behind Denmark (BOP 2021). This capacity corresponds to 10% of the total Belgian electricity consumption and about 50% of the electricity consumption of households (BOP, MUMM, Van Quickenborne 2020, Rumes and Brabant 2020). With the marine spatial plan 2020-2026 (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020), a new zone for offshore energy production of 281 km² was demarcated in 2020. This zone, the Princess Elisabeth zone (composed of: Fairybank, Noordhinder-Noord, Noordhinder-Zuid), should increase the offshore wind capacity on the Belgian part of the North Sea (BNS) to at least 4,000 MW (figure 1) (BOP, Coastal Portal, MSP 2020-2026, Rumes and Brabant 2020). By installing more powerful turbines, the target is to obtain a total capacity between 5,400 and 5,800 MW of offshore wind energy by 2030 (website federal minister for Energy).

5.1.1 Policy context

On 19 November 2020, the European Commission published its strategy on exploiting the potential of renewable offshore energy (COM (2020) 741) within the framework of the European Green Deal (COM (2019) 640). To achieve the overarching EU goal of climate neutrality by 2050, the Commission aims to increase offshore wind capacity from the current level of approximately 12 gigawatt (GW = 1,000 MW)) to at least 60 GW by 2030 and to 300 GW by 2050 (excluding UK) (DG Energy). The Commission intends to complement this with 40 GW of ocean (wave and tidal) energy production by 2050. The EU climate targets are now legally binding following the adoption of the Climate Law (see below).

Prior to this strategy, the EU already took other measures to promote renewable energy production (see **5.1.1.1 The development of offshore wind energy – bottlenecks and measures**). A Strategic Energy Technology Plan (SET-Plan) has been drawn up to try to achieve these energy objectives. The implementation of this plan is driven by European Technology and Innovation Platforms (ETIPs). With regard to (offshore) wind energy, there is ETIPWind, which focuses its activities on offering a public platform for wind energy. Its activities focus on providing a public platform for stakeholders in the sector to share common research and innovation priorities (R&I) and promote breakthrough innovations in the sector.

In the National Energy and Climate Plan 2021-2030, Belgium envisages a renewable energy production of 17.5% of the gross final energy consumption by 2030, as well as an increase in the offshore wind production to at least 4 GW, paired to a strengthening of the role of the North Seas Energy Cooperation (see **5.7.3 Societal interest**) (federaal regeerakkoord 2020, Van Quickenborne 2020).

The BNS falls largely under federal jurisdiction. Consequently, the policy on the production of electricity from water, currents or winds and the transmission grid at sea is drawn up by the federal minister responsible for energy and the federal minister (or state secretary) responsible for the North Sea (FPS Economy, SMEs, Self-employed and Energy)[2]. More information on the division of authorities can be found in the National Energy and Climate Plan 2021-2030. An overview of the European and national legislation relating to the electricity market is given on the website of the CREG and the FPS Economy, SMEs, Self-employed and Energy.

5.1.1.1 The development of offshore wind energy – bottlenecks and measures

On the European level, some policy initiatives have already been taken to promote the development of wind energy, including offshore. These include:

[1] The production capacity within EU27 is 14,583 MW.
[2] The offshore energy policy framework for the North Sea region is summarised on the website of the NorthSEE project.

- The Strategic Energy Technology Plan (SET-Plan, COM (2007) 723) – A strategic plan to accelerate the development of cost-effective low-carbon technologies. Ideas for a new, integrated strategy for the coming years were communicated in 2015 (C (2015) 6317);
- In the framework of the Integrated Maritime Policy (COM (2007) 575), a long-term strategy for more sustainable growth in the marine and maritime sectors (Blue Growth, COM (2012) 494) was developed. Specifically for the blue energy sector (including offshore wind energy), COM (2014) sets out eight measures for exploiting the potential of energy in Europe's seas and oceans by 2020 and beyond. A new approach in realising a sustainable Blue Economy has been communicated in (COM (2021) 240), here the expansion of offshore wind, in combination with making maritime transport and port activities more sustainable, play an important role in achieving European climate neutrality;
- COM (2016) 860 on Clean Energy for All Europeans Package (CEP) - Communication of a European regulatory framework to achieve the transition towards clean energy (including offshore), based on three pillars (energy efficiency, renewable energy leadership and affordable energy for consumers);
- In 2016, the countries of the North Sea region signed a political declaration in which they agreed to pursue a cooperation policy. Within the North Seas Energy Cooperation (NSEC) (see **5.7.3 Societal interest**), the aim is to facilitate the cost-effective deployment of wind energy and to improve the interconnection of the power grid between the North Sea countries;
- In support of the European energy policy, the Horizon Europe research and innovation funding programme and at the request of the European Commission, ETIPWind (initiative of the SET Plan) developed a Strategic Research and Innovation Agenda (SRIA 2018). It sets out visions for reducing costs, facilitating network integration, maintaining technological leadership and retaining expertise in Europe;
- Directive (EU) 2018/2001 concerns a revision of Directive 2009/28/EC and tightens the renewable energy targets for the EU to 32% of total energy consumption by 2030. This Directive contains provisions that simplify authorisation procedures in order to encourage the start-up of renewable energy projects, while also taking into account the concerns of citizens and the environmental effects;
- European strategy to harness the potential of offshore renewable energy (COM (2020) 741). EU strategy aiming at 300 GW of offshore wind and 40 GW of ocean energy production by 2050;
- COM (2021) 218 concerns an amending proposal of Directive (EU) 2018/2001 to increase the renewable energy targets to 40% of the total energy production by 2030. This communication fits within the EC fit for 55 package, which encompasses a set of policy measures to realise the target stipulated by EU's Climate Law (Regulation (EU) 2021/1119) (55% CO_2-reduction by 2030 compared to 1990-levels).

Furthermore, at the European level, research into offshore wind energy is being promoted (COM (2008) 534, EC). For instance, there are several funding instruments that support projects addressing the different aspects of offshore wind, from development to decommissioning. Horizon Europe, the world's most ambitious research and innovation programme, is also strongly committed to the climate and energy issue. As part of the Horizon Europe programme, the Commission has launched Mission Starfish 2030: Restore our Ocean and Waters. This Mission aims to make the European Green Deal a reality by restoring ecosystems and biodiversity, eliminating pollution and making the Blue Economy carbon-neutral and circular (see also thematic chapter **Integrated maritime policy**). Finally, in 2021, the European Commission, European Parliament and EU leaders agreed on a recovery plan to address the socio-economic damage caused by the Corona pandemic and lay the foundation for a greener, more digital and more sustainable Europe. The majority of the funds will be dedicated to the fight against climate change, including the development of renewable energy.

In addition to measures at EU level, the federal government has taken a series of measures to promote power production from renewable energy in the BNS:

- The Electricity Act of 29 April 1999 provides the possibility of adopting market organisation measures to ensure the sale of a minimum volume of power from renewable energy sources - at a minimum price. Among other things, this Act states that the transmission system operator shall finance one-third of the cost of the submarine cable connecting the turbines to the coast with a ceiling of 25 million euro per project (see also **5.7 Pipes and cables**). This Act was amended by the Act of 12 May 2019 to introduce a competitive tendering procedure for the construction and operation of generation facilities in the Princess Elisabeth zone (see **5.1.2 Spatial use** - **5.1.2.1 Procedure**);
- The RD of 16 July 2002 provides for a system for granting certificates of guarantee of origin and green certificates (GCs) for power generated from water, streams or wind in the BNS. The Commission for the Regulation of Electricity and Gas (CREG) grants the GCs to producers who hold a domain concession and a certificate of guarantee of origin. Minimum prices are set for the resale of certificates issued in connection with green power production. The transmission grid operator is obliged to purchase the GCs of offshore wind producers at a minimum price if requested to do so:
  - For the Belwind, C-Power and Northwind wind parks, this is set at 107 euro/MWh for the production

that follows from the first 216 MW installed capacity. This minimum price drops to 90 euro/MWh for production from an installed capacity above the first 216 MW;
- For Nobelwind, the minimum price is 107 euro/MWh for the first 45 MW installed capacity and 90 euro for the remaining 120 MW;
- For Rentel, Norther, Seamade and Northwester 2, the minimum price per GC depends on the power price. The minimum price is set by the CREG in accordance with the applicable provisions of the RD of 16 July 2002[3]. It provides for an LCOE (levelised cost of energy) of 124 euro/MWh for Norther and 129.8 euro/MWh for Rentel. For the Seamade and Northwester 2 wind parks, the LCOE amounts to 79 euro/MWh for a maximum of 17 years or 63,000 full-load hours, which is also variable with correction factors, as determined by the CREG. The support period and purchase obligation is set at 19 years for Rentel and Norther and at 17 years for Seamade and Northwester 2.

Furthermore, several platforms and clusters have been established to represent the interests of the sector and promote the research- and innovation development of offshore (wind) energy:

- Belgian Offshore Platform (BOP) unites the main Belgian actors that invest in renewable (wind) energy on the BNS (concession holders and direct investors). The BOP wants to promote further development by, among other things, representing the interests of its members to the government, utility companies and other bodies or persons;
- Belgian Offshore Cluster (BOC) wants to promote the interests of the offshore industry (suppliers) and ensure that Belgian expertise is represented and put on the international map. The BOC wants to create a broad and independent (industrial) support base that maintains the necessary links between the sector, the government and international institutions with a view to improving the quality of the offshore industry and achieving relevant results for the Belgian offshore industry;
- The Blue Cluster (DBC), a spearhead cluster of the Government of Flanders for sustainable and innovative economic developments at the BNS, has included Renewable Energy and Freshwater Production as one of its innovation domains. The cluster facilitates numerous offshore energy projects and also acts as a network organisation for the Blue Economy in Flanders and supports the offshore energy sector in this capacity. After the termination of the three-year support for the Innovative Business Network (IBN) Offshore Energy, the activities of this network were taken over by the Blue Cluster;
- OWI-Lab, a partnership between Sirris, Vrije Universiteit Brussel (VUB), and Ghent University (UGent) with the aim of supporting the Belgian wind energy value chain in their industry-driven research, development and innovation through open platform operation. As a research- and technology organisation, OWI-lab wants to play a leading role in both fundamental and applied research. It has specific test- and monitoring infrastructure for this purpose and also coordinates and participates in various projects to reduce the cost of offshore wind energy along the entire value chain (from development to decommissioning) through research and innovation. The consortium also provides courses (master classes) and workshops to share its knowledge with the industry.

There are also other entities that support the development of the offshore wind sector and facilitate innovation from a regional perspective:

- West Flanders Development Agency (POM West-Vlaanderen) and TUA West aim to connect companies, scientific institutions and governments. The focus is on selected knowledge domains within West Flanders, including Blue Energy. These knowledge domains are part of the Factories for the Future programme - an initiative of POM West Flanders (Dangreau 2014). The West Flanders Development Agency also runs the Blue Accelerator test platform, a multifunctional maritime innovation and development platform that allows companies, organisations and knowledge institutions to carry out tests at sea;
- Ostend Science Park in the inner port of Oostende is an initiative of Port Oostende, West Flanders Development Agency and UGent, and focuses on the theme of Blue Growth. The park operates on the interface between policy, science and industry and also houses Bluebridge. Ostend Science Park has several test facilities, including a Coastal Ocean Basin (see below) for testing new technologies at sea.

Finally, in recent years, specific training courses in an academic and non-academic context related to offshore renewable energy have emerged, such as the continued training Offshore Wind (UGent, UGain, OWI-Lab, TUA -West) and the 'Introduction to Onshore and Offshore Wind Technicians' (SBM).

[3] The (last) offshore support regime was included in the RD of 16 July 2002, which was promulgated and ratified on 9 February 2017. This is a guaranteed minimum price whereby the amount of aid decreases as the price of electricity increases. The calculation of the minimum price is now based on the following formula: minimum price = LCOE - [(electricity reference price x (1 - correction factor) + the value of the guarantees of origin) x (1 - grid loss factor)].

5.1.2 Spatial use

The European strategy on offshore renewable energy (COM (2020) 741) states that offshore renewable energy can and should be developed alongside other marine user functions. Member states should take this approach into account when drawing up a marine spatial plan, taking a comprehensive, multifunctional and multiple (space) user perspective.

The MSP 2020-2026 puts sustainable offshore energy production with maximum utilisation of compatible green energy forms at the forefront with a minimum environmental impact as a precondition. In addition to preserving the first zone for offshore energy production (RD of 20 March 2014), a new zone, the Princess Elisabeth zone, has been demarcated[4]. This demarcation covers ca 281 km² and is located 35-40 km off the western part of the coastline (see figure 1 and table 1). Within this demarcation, three zones have been designated: Fairybank, Noordhinder-Zuid and Noordhinder-Noord. Once fully developed, this zone should realise the objective of at least 4 GW of offshore generated energy by 2030 (National Energy and Climate Plan 2021-2030, Law of 22 April 2019 amending the Law of 29 April 1999). The future wind parks in the Fairybank and Noordhinder-Zuid zones require a Natura 2000 permit for commissioning, as these zones partly overlap or are in the immediate vicinity of the Flemish Banks Habitat Directive area. The reconciliation of renewable energy production with the protection objectives of the area is currently the subject of research (Rumes and Brabant 2020). Space is also provided in the Princess Elisabeth zone for the necessary reinforcement of the transmission grid (see **5.7.3 Societal interest**). A safety zone of 500 metres from the external borders is established around each energy construction, from the moment construction starts until the energy construction is completely decommissioned (RD of 4 February 2020). Within the current legislature (2020-2025), in addition to the further expansion of offshore wind energy production, attention will also be paid to the possibility of storing energy offshore (see **5.6 Energy storage and green hydrogen**).

Parallel to the production of offshore renewable energy, different types of multiple use of space are theoretically conceivable, as long as they are in line with the long-term vision and regulations, provided that they are thoroughly researched and that the existing regulations are evaluated accordingly (MSP 2020-2026). For example, research is undertaken on whether offshore wind energy can be combined with wave and tidal energy or the installation of floating solar panels (Van Quickenborne 2020, Van der Straeten 2020, Unlocking the potential of the North Sea). The way in which multiple use of space in offshore wind parks can be organised in our North Sea has already been reflected upon within the framework of the vision platform Noordzeevisie 2050, the Think Tank North Sea and in the innovation roadmap renewable energy and freshwater production - DBC 2020.

Table 1. An overview of the location and utilised area of the domain concessions for wind turbines in the BNS (2020) (MUMM, BOP, FPS Economy, SMEs, Self-employed and Energy, see also figure 1).).

Project	Location	Total area (excl. safety zone) (km²)	Water depth (m)	Capacity density (MW/km²)	Distance to coast (km)
C-Power	Thornton Bank	19.8	12-28	16.4	30
Belwind	Bligh Bank	17.0	15-37	10.1	49
Northwind	Lodewijk Bank	14.5	16-29	14.9	37
Nobelwind	Bligh Bank	18.0	15-37	8.3	47
Rentel	Southwest Schaar	22.7	26-36	13.6	33
Norther	South of Thornton Bank	44.0	14-30	8.4	23
Seamade-Mermaid	Northwest of Bligh Bank	16.7	24-50	14.1	54
Seamade-Seastar	Between the Lodewijk Bank and the Bligh Bank	18.4	22-38	12.9	40
Northwester 2	Northwest of Bligh Bank	11.7	24-40	18.3	51
Total area reserved for wind parks (incl. safety zones)		**238.0 km²**		**9.5 (Avg.)**	

[4] The Belgian wind parks are bordered on the Dutch side by the wind parks under construction in the Borssele Wind Energy Area (*Noordzeeloket*). On the French side, there are plans to build a wind park off the coast of Dunkirk (FPS Public Health, Food Chain Safety and Environment).

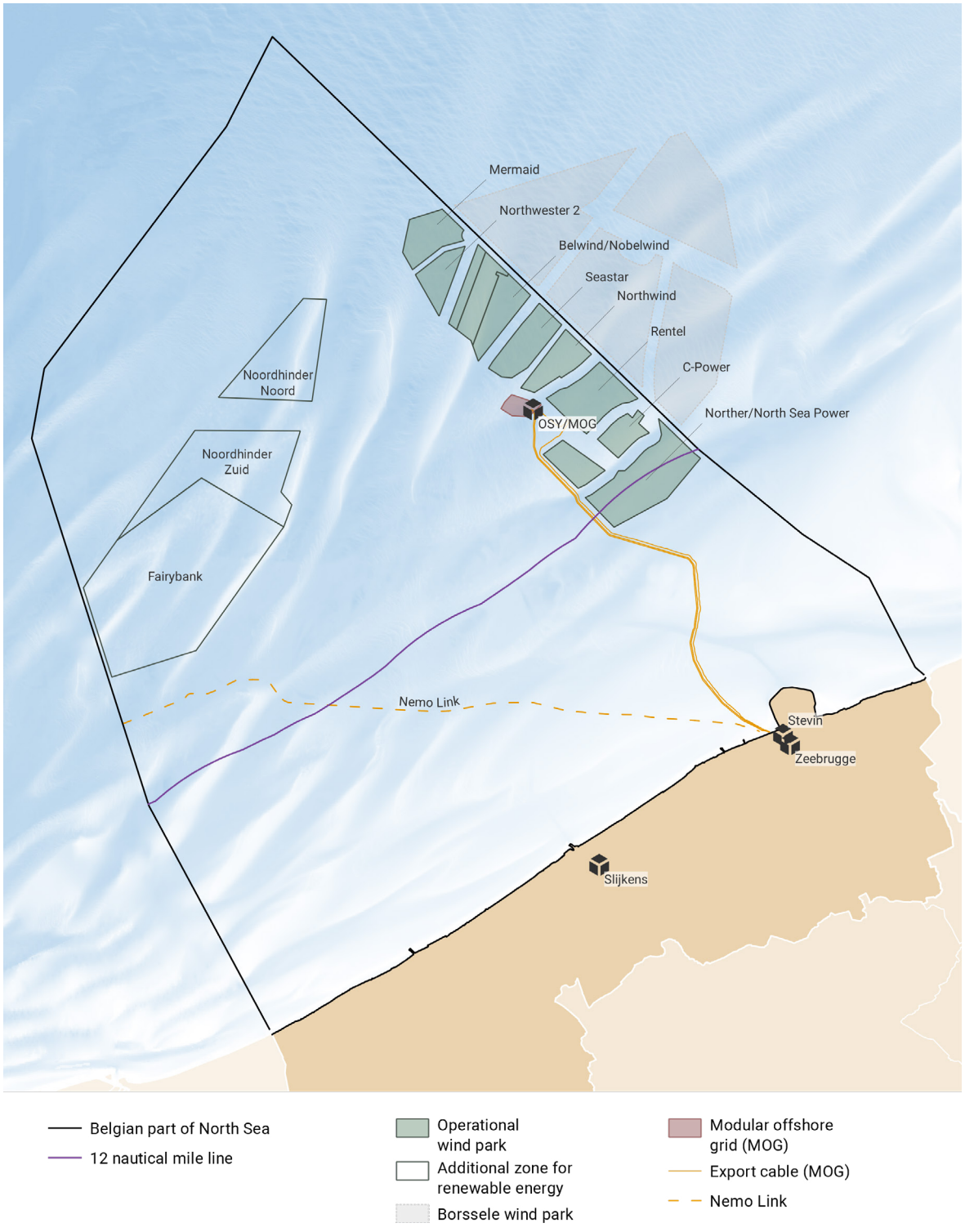


Figure 1. Overview of the current and planned concession zones for offshore renewable energy production, including onshore connections and adjacent wind parks (Source: Flemish Hydrography, Elia, RBINS-MUMM, Emodnet Human Activities, Coastal Portal)

5.1.2.1 Procedure

In order to realise an offshore wind park, the project must have several permits. The following federal permits are required:

- A ministerial decree (MD) for the award of a domain concession by the federal minister for Energy and the federal minister for the North Sea;
- A MD by the federal minister for the North Sea to, following a positive advice from the Management Unit of the Mathematical Model of the North Sea (RBINS-MUMM) and an environmental impact assessment (EIA), grant an authorisation for the construction of the wind park (including cabling) and a licence for its operation (for more details see Heylen et al. 2018);
- A MD for the granting of a permit for the installation of offshore cables by the federal ministers for Energy and for the North Sea (see also **5.7 Pipes and cables**).

So far, all wind parks in the BNS were developed with state aid obtained through a negotiation procedure. Belgium is an exception among the offshore wind producing countries in Europe. The procedure for granting a domain concession for the wind parks that have already been built has been laid down in the RD of 20 December 2000 (MUMM, CREG, FPS Economy, SMEs, Self-employed and Energy). The domain concessions awarded based on this RD can only be changed based on this decree. The concessions are valid for a period of 20 years, but are renewable (Norther up to 22 years, Mermaid-Seastar and NorthWester 2 up to 25 years). The procedures for obtaining a domain concession and an environmental permit within the framework of the marine spatial plan 2014-2020 were described in detail in the previous version of this thematic chapter (Heylen et al. 2018).

In the Princess Elisabeth zone, domain concessions will be awarded through a competitive tendering process. The concession is awarded for a period of 30 years - from installation to decommissioning. The outlines of this new regime were set out in the Electricity Law (Law of 29 April 1999 on the organisation of the electricity market) through the Law of 12 May 2019. This legal framework must allow the federal government to realise the 4 GW offshore renewable energy target (including already operational or planned wind parks) as described in the Interfederal Energy Pact, by 2030 at the latest[5]. This new law seeks to achieve the largest possible share of additional offshore energy production capacity from renewable energy sources after 2020 at the lowest possible cost to society and to optimise its transmission to the transmission grid. In addition to maximising offshore energy production, the federal government wants this framework to significantly reduce the financial support for the development of future offshore electricity production. Measures such as the aforementioned competitive tendering procedures, as well as putting larger lots on the market and conducting preliminary studies at the company's own expense should make this possible.

After the preliminary study phase (UXO-studies (unidentified ordnance), all environmental studies in the context of the environmental impact report (EIR), as well as geotechnical studies and the transmission aspects carried out by the system operator), a MD will determine the location, size and number of plots that will be subject to a competitive tendering procedure (the main conclusions of the preliminary studies will, in principle, be published as an annex to this decree). The winner of the competitive tendering procedure will receive the most comprehensive package of permits possible, together with the permission to use the lots concerned for the construction and private operation of offshore electricity production facilities.

However, the conditions and criteria for eligibility and granting are to date (late 2021) still to be determined by RD. It is planned that these will be laid down before the preliminary studies are completed (Belgian offshore wind energy - 4 GW by 2030 | FPS Economy). Meanwhile, guidelines have been adopted at EU level (Coordination of tenders for offshore wind in the North Seas - EC, Support schemes for offshore wind – Emerging best practices | EC, AURES project).

5.1.3 Societal interest

5.1.3.1 Energy production by offshore wind parks

The European strategy on offshore renewable energy (COM (2020) 741) foresees to increase the production capacity of offshore wind to 60 GW by 2030 and further to 300 GW (excl. UK) by 2050 (see **5.1.1 Policy context**). These targets would form a cornerstone of the European pathway to climate neutrality.

[5] Keeping in mind technological advances, the aim is to increase the total wind energy production to 5.4-5.8 GW by 2030 by installing more powerful turbines (cabinet federal minister for Energy).

In the Belgian North Sea, eight wind parks were operational in 2020 with a total installed capacity of 2,262 MW for 399 turbines (MUMM, BOP). The estimated annual production capacity provides power for more than 2.3 million households (table 2). As a result of this increase, approximately 18.6% of the Belgian electricity mix is renewable and new production records have been set in recent years (BOP, Elia 2021).

Table 2. An overview of the status, number of turbines and total power of the wind parks in the BNS (MUMM, BOP, 4C Offshore, see also EIRs of the respective parks at **5.1.4 Impact on the marine environment**).

Project	Status	Number of turbines	Power/turbine (MW)	Total power (MW)	Annual production
C-Power	Operational since 2013	54	6	325	1,050 GWh/year (power for 300,000 households)
Belwind	Operational since 2011 + GE Haliade (6 MW) (2013)	56	3,1	171	560 GWh/year (power for 160,000 households)
Northwind	Operational since 2014	72	3	216	875 GWh/year (power for 250,000 households)
Nobelwind	Operational since 2017	50	3,3	165	679 GWh/year (power for 194,000 households)
Rentel	Operational since 2018	42	7,4	309	1,140 GWh/year (power for 300,000 households)
Norther	Operational since 2019	44	8,4	370	1,340 GWh/year (power for 400,000 households)
Seamade-Seastar	Operational since 2020	30	8,4	252	power for 263,000 households
Seamade-Mermaid	Operational since 2020	28	8, 4	235	power for 263,000 households
Northwester 2	Operational since 2020	23	9,5	219	770 GWh/year (power for 220,000 households))

5.1.3.2 Employment

The European offshore wind sector currently employs about 210,000 people (European Parliament 2020), and it is estimated that this might triple by 2030 (COM (2021) 240). The offshore employment can be divided into the construction phase (including preliminary research and development) and the exploitation phase. The FTE (full-time equivalent) during the construction phase, direct and indirect, comes to approximately 6,600 per wind park. The FTE for the existing projects (in operation phase), come to approximately 235 per year. The estimate for the parks that still need to be exploited is 500 FTE per year, for 20 years of operation (appendix 1 - MSP 2020-2026). It is estimated that in 2020, some 14,000 people were working (directly + indirectly) in the Belgian offshore wind sector (BOP 2021). If a scenario is followed in which production capacity is increased to 6 GW by 2030, this would result in additional employment for 10,000 people (BOP 2021). In addition to an increase in employment, there are also noticeable positive effects on the economic added value and the trade balance (CLIMACT 2017, on behalf of BOP). For example, the economic added value in the long term (2024-2030) is estimated to increase by over 1 billion euro in GDP/year (CLIMACT 2017, BOP 2021). This trend is expected to continue in the future as maintenance, decommissioning or repowering[6] activities increase. Work is also being carried out to strengthen the transmission grid or activities within new international projects. If the production capacity is increased to 4.4 GW by 2030, this would result in an economic added value of approximately 9 billion euro (BOP 2021). More figures on the socio-economic side of Belgian offshore wind, can be found in CLIMACT (2017) and BOP (2021).

The construction of offshore wind turbines also creates new jobs in the ports, with port Oostende specifically profiling itself as a renewable energy port (Mathys et al. 2013, Port Oostende 2020). For example, in 2020, the port recorded more than 6,000 calls linked to wind park activities and the port counts 622 FTEs active in the Blue Economy (see also thematic chapter **Blue Economy and Innovation**). In addition to port Oostende, economic activities relating to offshore wind parks are also developed in the Port of Zeebrugge (Maatschappij van de Brugse Zeehaven 2020).

[6] Strategy where old wind turbines are partly or completely replaced. Repowering usually provides a cheaper and more sustainable alternative to the complete decommissioning of the wind park (Gokhale 2021).

5.1.4 Impact on the marine environment

The presence of wind parks in the BNS brings forth various positive and negative effects on the ecosystem and users of the sea (table 3). The RD of 9 September 2003 on environmental impact assessment (EIA) stipulates which effects on the marine environment must be dealt with in the environmental impact report (EIR) and the EIA. The EIRs, EIAs and any additional documents and amendments can be consulted on the relevant website of the RBINS - Operational Directorate Natural Environment (RBINS-OD Nature). A non-exhaustive overview of the scientific knowledge on the environmental impact of offshore wind energy is given in table 3. A holistic overview, not specific to the Belgian situation, of the environmental impact of wind energy and ocean energy can be consulted via the Thetys research database.

Table 3. A non-exhaustive overview of scientific studies on the environmental effects of offshore wind parks and other users with the BNS as focus area.

Impact on the environment/other users	Literature
Effects on the hydrodynamic regime	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Van den Eynde et al. 2010, Van den Eynde et al. 2013, Vanhellemont and Ruddick 2014, Baeye and Fettweis 2015
Effects on sediment transport and geomorphology	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Van den Eynde et al. 2010, Verhaeghe et al. 2011, Van den Eynde et al. 2013, Vanhellemont and Ruddick 2014
Underwater noise	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Norro et al. 2010, Norro et al. 2011, Norro et al. 2012, Norro et al. 2013, Haelters et al. 2013a, Debusschere et al. 2014, Debusschere 2016, Norro 2017, Norro 2018, Norro 2019, Kok et al. 2019, Norro 2020, Rumes and Degraer 2020, Kellet et al. 2021
Effects on fish and benthos (introduction of hard substrate, loss of habitat, disturbance, etc.)	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Reubens et al. 2010, Coates and Vincx 2010, Derweduwen et al. 2010, Kerckhof et al. 2011, Reubens et al. 2011b, Van Hoey et al. 2011, Verhaeghe et al. 2011, Kerckhof et al. 2012, Vandendriessche et al. 2012, Coates et al. 2013a, Vandendriessche et al. 2013a, De Mesel et al. 2013, Vandendriessche et al. 2013b, Reubens et al. 2013, Reubens 2013, Rumes et al. 2013, Coates 2014, Debusschere et al. 2014, De Mesel et al. 2015, Debusschere et al. 2016, Kerckhof and Degraer 2016, Derweduwen et al. 2016, Vandendriessche et al. 2016, Derweduwen et al. 2016, De Backer et al. 2017, Colson et al. 2017, De Backer and Hostens 2017, Kerckhof et al. 2017, ICES Interim Report WGMBRED 2017, De Backer and Hostens 2018, De Backer and Hostens 2018, Lefaible et al. 2018, Kerckhof et al. 2018, Lefaible et al. 2019a, Lefaible et al. 2019b, Kerckhof et al. 2019, Buyse et al. 2020, Braeckman et al. 2020, De Backer et al. 2020, Mavraki et al. 2020
Effects on birds and bats	Stienen et al. 2002a, Stienen et al. 2002b, De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Everaert and Stienen 2007, Stienen et al. 2007, Vanermen et al. 2009, Brabant and Jacques 2009, Vanermen et al. 2011, Verhaeghe et al. 2011, Brabant et al. 2012, Vanermen et al. 2013a, Vanermen et al. 2013b, Vanermen et al. 2013c, Brabant et al. 2015, Vanermen et al. 2016, Brabant et al. 2016, Brabant et al. 2016, RAVEN project BELSPO, Vanermen et al. 2017, Brabant and Degraer 2017, Vanermen et al. 2018, Brabant et al. 2018, Vanermen et al. 2019, Vanermen et al. 2019, Vanermen and Stienen 2019, Brabant et al. 2019, Brabant and Vanermen 2020, Vanermen et al. 2020
Effects on marine mammals	Stienen et al. 2002a, De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Evans 2008, Haelters et al. 2010, Haelters et al. 2011, Verhaeghe et al. 2011, Haelters et al. 2012, Haelters et al. 2013a, Haelters et al. 2013b, Haelters et al. 2014, Haelters et al. 2016, Rumes et al. 2017, Rumes and Debusschere 2018, Rumes et al. 2019
Impact on water and air quality	Maes et al. 2004 (MARE-DASM project BELSPO), De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Verhaeghe et al. 2011, De Witte and Hostens 2019
Disruption of the seascape	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Vanhulle et al. 2010, Houthaeve and Vanhulle 2010, Di Marcantonio et al. 2013
Maritime safety	De Wachter and Volckaert 2005 (GAUFRE project BELSPO), van Iperen and van der Tak 2009, Verhaeghe et al. 2011 (see also thematic chapter **Maritime transport, shipping and ports**)
Spatial impact (including bottlenecks with other users)	Maes et al. 2004 (MARE-DASM project BELSPO), De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Vandendriessche et al. 2011, Verhaeghe et al. 2011, Vandendriessche et al. 2013, Vandendriessche et al. 2016, North Sea Vision 2050-Multiple Use of Space (2018), De Backer et al. 2019, Degraer et al. 2020

5.1.5 Sustainable use

5.1.5.1 Measures concerning the impact on the marine environment

At the international level, OSPAR has produced a guide (OSPAR 2008) dealing with the impact of wind turbines on the marine environment. Within the framework of the ASCOBANS agreement the impact of wind turbines on marine mammals was assessed (Evans 2008). In 2009, a resolution was issued against the adverse effects on marine mammals due to underwater noise caused by the construction of installations (driving turbine foundations into the seabed, burying sea cables, etc.) for the generation of renewable energy at sea. Following this, reports were published with possible guidelines to reduce underwater noise (Prideaux 2016, Koschinski and Lüdeman 2020, CMS Guidelines 2020, Kellet et al. 2021). For example, all environmental permits issued from 2013 onwards contain a seasonal ban on piling from 1 January to 30 April in order to protect marine mammals in the BNS. Conditions and recommendations are also linked to the permit with the aim of minimising the impact (e.g. use of a bubble curtain) (Rumes and Degraer 2020).

The European strategy on offshore renewable energy (COM (2020) 741) states that offshore energy development must be in line with the European environmental legislation in force and the integrated maritime policy. Offshore energy development must be sustainable and compatible with the protection of biodiversity, taking into account the socio-economic impact on sectors that rely on a healthy marine ecosystem. In this respect, several existing legislative and policy instruments are relevant: the Habitats Directive (92/43/EEC), the Environmental Liability Directive (2004/35/CE), the Aarhus Convention (2005/370/EC), the Marine Strategy Framework Directive (MSFD, 2008/56/EC), the Birds Directive (2009/147/EC), the Maritime Spatial Planning Directive (2014/89/EU), the Circular Economy Action Plan (COM (2015) 0614), the Biodiversity Strategy (COM (2020) 380), etc. The MSFD is the main pillar of the European marine environmental policy (see thematic chapter **Nature and environment**), the Directive therefore provides a framework to reduce or avoid the impact of offshore wind parks. For example, energy inputs, including underwater noise, are identified as one of the descriptors for good environmental status (descriptor 11, Tasket et al. 2010). Other descriptors in the MSFD that are applicable to the siting of offshore wind turbines are: descriptor 6 (Seafloor integrity, Rice et al. 2010), descriptor 2 (Non-indigenous species introduced by human activities, Olenin et al. 2010), and descriptor 7 (Hydrographical Conditions, website EC).

In Belgium, a condition that by default is included in the environmental permit concerns the monitoring of the effects on the ecosystem (Degraer et al. 2020). In Belgium, this is monitored for all the parks combined by a consortium of research institutes under the coordination of the research group Ecology and Management of the Sea (*Ecologie en Beheer van de Zee*) (RBINS-MARECO).This monitoring has a twofold objective:

- Adapt, reduce or even stop the activities if there is extreme damage or a threat of extreme damage to the marine environment;
- Gaining a good understanding of the impact on the environment of offshore wind turbines in order to support policy, management and design of future wind turbines.

The monitoring programme studies both the physical, biological and socio-economic aspects of the marine environment (see monitoring reports MUMM) compared to a reference state (e.g. Van den Eynde 2005, De Maersschalck et al. 2006, Henriet et al. 2006). In the future, this monitoring will also increasingly be done remotely (Bilsen et al. 2019) and internationally (CEAF). For example, the North Sea countries are working together on a Common Environmental Assessment Framework (CEAF) for the assessment of cumulative ecological impacts of offshore renewable energy development.

5.1.5.2 Combination with other user functions

The MSP 2020-2026 leaves the possibility open for multiple use of space within the zones reserved for the construction and operation of infrastructure for the production, storage and transmission of energy from renewable sources (see also **5.1.2 Spatial use**). E.g., within the framework of the AQUAVALUE roadmap, the EDULIS project has already cultivated mussels between the C-Power and Belwind wind parks (Bilsen et al. 2019). In addition, within the Wier en Wind project, work is being done on a seaweed farm within the Norther concession zone. Some Belgian partners also investigate within the UNITED project whether nature restoration (e.g. oyster beds) and aquaculture are feasible within offshore wind parks and within the MARCOS project the potential of large-scale offshore aquaculture (LSOA) is investigated and analysed (see also thematic chapter **Marine aquaculture**). Furthermore, within some entities there are reflections on the multifunctional use of space in wind parks, such as in the Blue Cluster's innovation roadmap renewable energy and freshwater production 2020, Langetermijnvisie Noordzee 2050 and the Think Tank North Sea. However, the possibilities of certain activities are somewhat limited given the high density of the wind parks (9.5 MW/km², Rumes and Brabant 2020) (table 1).

5.2 Wave and tidal energy

Ocean energy (energy from waves, tides, salinity and temperature gradients) is the world's largest source of renewable energy, but is as yet hardly exploited (IEA, World energy resources marine energy 2016, OES 2019). Sector organisation Ocean Energy Europe (OEE) forecasts that, with the right research and development climate, ocean energy could provide 10% of Europe's power by 2050, creating 400,000 jobs (DG Research and Innovation, SETIS Ocean Energy). The European strategy on offshore renewable energy (COM (2020) 741) aims at 40 GW of ocean energy production by 2050. Under a high-growth scenario and, providing an adequate policy framework, it seems realistic to generate 2.6 GW of ocean energy from waves and tides within Europe in the medium term (2030) (OEE 2020).

Specifically for ocean energy, as part of the implementation of the SET-Plan, an advisory body, ETIPOcean, was established by the EC. This body consists of a working group of ocean energy experts and organises its activities around identifying research and innovation priorities for the ocean energy sector and promoting solutions to the industry and European and national policy makers. To this end, the working group draws up a Strategic Research and Innovation Agenda (SRIA Ocean Energy 2020). The coordination is done by Ocean Energy Europe.

Similar to offshore wind energy (see **5.1.1 Policy context**), the development of ocean energy has already been promoted in the past, notably through the European Commission's Blue Growth Strategy (DG MARE) (COM (2012) 494), including a communication of measures to make optimum use of the technique's potential (COM (2014) 8). However, with small exceptions, ocean energy production in European waters is still limited, as the technology, unlike wind energy, is still in the development phase. By the end of 2020, 11.2 MW of wave and tidal energy were operational in European waters, of which 10.1 MW of tidal energy (OEE 2020 key trends and statistics). For the time being, most activities focus on research and development (DG Research and Innovation, OEE). The status of research, production, projects and policies at the national level is monitored in the Annual Report Ocean Energy Systems (OES 2019).

At the Belgian level, the Blue Cluster (spearhead cluster of the Flemish innovation policy) is involved in the European ELBE project and facilitates the BluERA project. Within the ELBE project, the partners involved are trying to build a pan-European Blue Energy cluster to stimulate, among others, the development of wave and tidal energy. The BluERA project aims to build up a digital ocean energy atlas as well as an energy yield evaluation tool. To introduce wave and tidal energy in Flanders, the Gen4Wave action plan was developed in the past by partners from academia, industry and government. Gen4Wave resulted, under impulse of the Hydraulic Laboratory (WatLab, MOW), KULeuven and UGent, in the construction of a coastal and ocean basin (COB) as part of the Flanders Maritime Laboratory located in the Ostend Science Park. This basin provides testing opportunities for developers of wind, wave and tidal energy and land-sea interactions, etc. (Troch et al. 2017). The COB test infrastructure is complementary to the capabilities of the Blue Accelerator, a broadly deployable test platform at sea near port Oostende (MER Blue Accelerator 2017). This test platform has already been used within the NEMOS project project for the guidance and control of a wave energy convector. Furthermore, the development of wave energy is also supported by Fabriek voor de Toekomst Blue Energy of the West Flanders Development Agency (Dangreau 2014, Vanden Berghe 2014).

In the zones in the BNS reserved for energy production, the construction and operation of installations for the production of electricity from water and currents is also permitted (RD of 20 December 2000). In the Seamade zone for example, the possibilities of conducting a pilot project with wave energy converters with a capacity of 20 MW for commercial use, were examined (Application Mermaid 2014). However, due to the limited commercial feasibility of wave energy convectors at the time being, the deployment of such installations in this zone(s) is not expected in the near future (Rumes and Brabant 2020). Research also showed that the BNS is primarily suitable as a test site given its low wave climate (estimated potential within the first wind park concession zone 4.5 - 5.8 kW/m). Table 4 lists publications and research projects related to the development of ocean energy in the BNS. A general overview of the potential environmental impact of ocean energy technologies is compiled in Vanaverbeke and Coolen (2019) and the OES Environmental State of the Science Report (2020).

5.3 Solar energy at sea

Floating solar panels are a new innovative technology to produce offshore renewable energy, which Europe is stimulating by a.o. supporting R&D projects (COM 2020 (741). Also in the BNS the potential implementation is being considered (Van Quickenborne 2020). The production technology is still fully in the R&D phase, but several field tests in the BNS are on its way. For instance, within the MVPAqua project (2019-2022), research is being done into the feasibility of a possible commercial application in the BNS. Provided the results of this research are

favourable, the aim is to install floating solar panels between the Belgian offshore wind parks within five to ten years. Given that this technique is still in its early testing phase, it will not be discussed in more detail in this edition of the thematic chapter.

Table 4. An overview of the research being conducted into wave and tidal energy at the BNS.

Research topic		Literature
Wave energy	Technological and operational aspects	Mathys et al. 2009 (OPTIEP-BCP project BELSPO), De Backer et al. 2008, Beels 2010, Mathys et al. 2012 (BOREAS project BELSPO), De Backer 2009, Van Paepegem et al. 2011, Stratigaki 2014, BlueERA project
	Economic aspects	Beels 2010, Mathys et al. 2012 (BOREAS project BELSPO)
	Ecological aspects	MER Mermaid and Northwester 2, Rumes et al. 2015 – MEB Mermaid, Rumes et al. 2015, MER-NEMOS 2016, Haelters et al. 2017 – MEB NEMOS, MER Blue Accelerator 2017
	Potential (wave climate BNS)	Mathys et al. 2009 (OPTIEP-BCP project BELSPO), De Backer et al. 2008, Beels 2010, Fernandez et al. 2010, Mathys et al. 2012 (BOREAS project BELSPO), De Backer 2009, BlueERA project
	Prototype development	FlanSea project (FlanSea, Van In 2014), Laminaria (prototype tested on the North Sea), NEMOS, MER-NEMOS 2016
Tidal energy	Technological and operational aspects	Mathys et al. 2009 (OPTIEP-BCP project BELSPO), Mathys et al. 2012 (BOREAS project BELSPO), BlueERA project
	Economic aspects	Mathys et al. 2012 (BOREAS project BELSPO)
	Potential (tidal climate BNS)	Mathys et al. 2009 (OPTIEP-BCP project BELSPO), Mathys et al. 2012 (BOREAS project BELSPO), BlueERA project

5.4 Renewable energy in the coastal zone

Unlike energy at sea, renewable energy production on land concerns a Flemish competence (from the landward side of the baseline). The Flemish energy policy relies heavily on the European policy on energy and climate and is largely determined by the Energy Decree of 8 May 2009 and the Energy Decree of 19 November 2010 (Department of Environment and Spatial Development, Vlaamse beleidsnota energie 2019-2024, VREG). The Flemish Energy and Climate Agency (*Vlaams Energie- en Klimaatagentschap*) (VEKA, a merger between the Flemish Energy Agency and part of the Energy, Climate and Green Economy division of the Department of Environment and Spatial Development) implements this policy. An extensive overview of the laws and regulations concerning renewable energy can be found on the website of the VEKA.

Flanders is working towards a decentralised low-carbon energy system (based on local production, storage and consumption) that will increasingly rely on renewable energy sources such as wind and solar energy (National Energy and Climate Plan 2021-2030). In this respect, the coastal zone has natural advantages that make it an attractive region for the aforementioned forms of energy. For example, a study of average wind speeds in Flanders revealed (Een windplan voor Vlaanderen) that the coast has a significantly higher wind regime (see also Dehenauw 2002 and Debrie 2017). In our wind climate, a production factor[7] of ±11% inland, ±23% near the coast and ±38% at sea can be expected for wind power (Brouwers et al. 2011, BOP). In addition, measurements show that the duration of sunshine in the coastal zone averages 1,700 hours a year, compared to 1,550 hours in Uccle (inland). The differences are greatest in the summer half-year when the coast can monthly receive up to 20 more hours of sunshine (Dehenauw 2002). In the Royal Meteorological Institute's (RMI) climate atlas, parameters such as sunshine duration and solar radiation are given for Belgium, in which the increased values for the coast are clearly visible. The coastal zone hence has an increased solar energy potential. Other forms of energy production are also present in the coastal zone (e.g. biomass, biogas, etc.). However, as the coast does not constitute a specific climate for these, the techniques will not be discussed further here.

To stimulate the green energy transformation, the Government of Flanders offers incentives in the form of green certificates (GC) (VLAIO). In 2020, there were 61 incentive-granting green power and cogeneration power plants in the coastal zone (coastal municipalities and hinterland municipalities). The majority of the installed capacity is located in Bruges and Ostend (energiesparen.be).

[7] The production factor indicates, as a percentage of the maximum power, the average power by which energy is produced. It is used in determining the effective power (installed power x production factor).

In the coastal zone, 210 MW of solar energy was generated by the end of 2020 (grid operators - energiesparen.be) out of a total of 33,714 installations. This means that per inhabitant of the coastal zone in 2020 some 492.9 W of green power was produced from solar panels, or 623 W per installation (Rijksregister, energiesparen.be). In terms of wind turbines, 102.9 MW of energy was produced by onshore turbines in the coastal zone in 2020. This capacity accounts for approximately 7.5% of the Flemish onshore wind in that year. These turbines are located on the territory of Bruges, Diksmuide, Gistel, Knokke-Heist and Middelkerke. It concerns 52 onshore wind turbines that generate approximately 241.5 W per inhabitant of green electricity (Rijksregister, energiesparen.be). Notably on the territory of the Port of Zeebrugge additional wind turbines are planned in the near future. For instance, a cooperation of companies is planning the construction of the largest onshore wind park in Belgium (Maatschappij van de Brugse Zeehaven 2020).

5.5 Natural gas installations Zeebrugge

Belgium depends on natural gas for approximately one quarter of its energy supply. To this end, our country relies on a highly developed natural gas network that is connected to neighbouring countries by no fewer than 18 interconnection points. Belgium is hence a hub for natural gas transport in northwest Europe. (National Energy and Climate Plan 2021-2030). More than 19 kilotonnes (Ktonnes) of oil eq. are imported annually (Statbel), mainly from the Netherlands, Norway and Qatar (FEBEG). In addition, about half of the natural gas import is destined for border-to-border transmission. This concerns Dutch and Norwegian natural gas for France and Spain, British natural gas for continental Europe and, among others, Russian natural gas for the United Kingdom. The Port of Zeebrugge plays an important role in this respect, with a landing capacity corresponding to approximately 10% of the total border capacity needed to supply the European Union (België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010). The Port of Zeebrugge has two jetties at the liquefied natural gas (LNG) terminal, allowing the simultaneous handling of small and large LNG ships and a storage capacity of 566,000 m³ LNG spread over five storage tanks (Fluxys, Niet-technische samenvatting MER uitbreiding Fluxys LNG, Port of Zeebrugge).

5.5.1 Policy context

At the European level, the energy policy is developed by the DG Energy of the EC. The legal framework is a.o. provided by Directive No 2009/73/EC and Regulation (EC) 715/2009. A summary of the relevant (EU) legislation on natural gas is given on the website of the CREG and the FPS Economy, SMEs, Self-Employed and Energy.

The federal government (FPS Economy, SMEs, Self-Employed and Energy) is responsible for (large) energy storage, transmission and production infrastructures. The transport of gaseous products is regulated by the federal Law of 12 April 1965 (the Gas Law) and by a number of RDs relating, among other things, to safety, rates and the more technical aspects of network access (code of conduct) (CREG, Fluxys, FPS Economy, SMEs, Self-Employed and Energy, VREG). In addition, there is the federal regulator, the Commission for the Regulation of Electricity and Gas (CREG), which *inter alia*, sets the rate policy for the operators (in this case Fluxys and Fluxys LNG). The Regions are competent for, a.o., the public distribution of gas, which is managed by the intermunicipal companies, and the rational use of energy (special Law on institutional reform (BWHI) Law of 8 August 1980) (more information: FPS Economy, SMEs, Self-Employed and Energy, CREG).

5.5.2 Spatial use

The LNG terminal is located in the eastern part of the outer Port of Zeebrugge. The peninsula on which the LNG terminal is located covers an area of approximately 32 hectares. The site has two jetties and five storage tanks with a total capacity of 566,000 m³ and infrastructure allowing bi-directional transshipment (also between vessels), regasification and distribution on the gas grid (Fluxys, Open season: second capacity enhancement of the Zeebrugge LNG-terminal. Binding phase: offer description 2011, Non-technical summary EIR extension Fluxys LNG, Zeebrugge, Port of Zeebrugge). There are also plans for further expansion of regasification capacity (Fluxys). The MSP 2020-2026 provides space for the expansion of the Port of Zeebrugge, where in addition to the LNG terminal, the terminals of the Zeepipe and Interconnector gas pipes are located (see **5.7 Pipes and cables**).

5.5.3 Societal interest

The Port of Zeebrugge is a cornerstone in the security of supply of natural gas to Northwest Europe. In addition to the LNG terminal and the Zeepipe and Interconnector gas pipe terminals (see **5.7 Pipes and cables**), the Zeebrugge

Hub is one of the most important short-term markets in Europe (België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010, Brouwers et al. 2011). The facilities of the Zeebrugge LNG terminal are operated by Fluxys and are capable of unloading and loading LNG, bunkering LNG or regasifying LNG for international transport or storing LNG on trucks. After a fifth storage tank became operational in 2019, the terminal now has an annual throughput capacity of 11 billion m³ of liquefied natural gas (Indicatief Investeringsprogramma Fluxys 2017-2026). In 2019, approximately 7.6 million tonnes of natural gas were loaded or unloaded at the Zeebrugge LNG terminal (Maatschappij van de Brugse Zeehaven 2020).

Fluxys has also opted for a cooperation model for the development of an LNG terminal in Dunkirk and is participating in the project for 25%. The two terminals will be connected through an interconnection point in Alveringem and Maldegem, enabling up to 8 billion m³ of gas to be brought to Belgium and elsewhere in Europe from the Dunkirk LNG terminal.

5.5.4 Impact and sustainable use

The installation of the natural gas facilities in Zeebrugge entails a certain impact, both on the environment and on other users. These effects are dealt with in the relevant environmental impact reports (see EIR-databank Government of Flanders, Niet-technische samenvatting MER voor uitbreiding van de NV Fluxys LNG te Zeebrugge). In these EIRs, various measures have already been proposed to mitigate or avoid the impact of the LNG terminal on the surroundings.

The use of natural gas as an energy source brings a number of environmental advantages over other fossil fuels (Fluxys). In the National Energy and Climate Plan 2021-2030, for example, natural gas is still considered a "transition fuel" for the foreseeable future. The use of natural gas is also attractive in the maritime sector because of its lower pollutant emissions (especially sulphur) than diesel or heavy fuel oil (Margarino 2014, In-Focus LNG as ship fuel 2015, De Backer 2017, Safetysaf4Sea, Port of Zeebrugge see also thematic chapter **Maritime transport, shipping and ports**). However, the ultimate climate gain appears doubtful in view of the greenhouse gas potential of methane (Pavlenko et al. 2020).

5.6 Energy storage and green hydrogen

For some renewable energy sources, such as wind energy, there is a discontinuity in the amount of energy generated at a given time. To ensure a continuous supply of offshore energy that matches the temporal variation in use and production, options for the storage of power must be sought. One possible option in this context is the construction of an offshore energy island off the Belgian coast for hydroelectric energy storage (Federaal Ontwikkelingsplan van het transmissienet 2020-2030). The conditions and the procedure for awarding the domain concessions for such an energy island have already been laid down in the RD of 8 May 2014 implementing the Law of 29 April 1999. Two zones were defined for this purpose in the MSP 2014-2020 (RD of 20 March 2014) (Federaal Ontwikkelingsplan van het transmissienet 2020-2030). In the MSP 2020-2026, these zones have not been retained, but zones have been set aside for commercial and industrial activities (CIA zones) within which multiple use of space is pursued and energy storage is one of the possibilities. In the previous edition of this thematic chapter (Heylen et al. 2018), hydroelectric energy storage in the BNS was discussed in more detail. For this edition of the thematic chapter, we opted to further highlight another energy storage principle, power to gas.

A surplus of energy can also be used for the conversion of one energy carrier into another (Power to X). One promising option is the production of renewable (green) hydrogen by this principle, the so-called 'Power-to-Gas' principle (Unlocking the potential of the North Sea 2020).

Hydrogen (H_2) is considered a versatile, environmentally friendly fuel alternative and is being considered as a substitute for fossil fuels by various economic sectors worldwide. Interest in hydrogen as a means of making economies carbon-neutral is growing year on year, and more and more countries are taking steps to enable the production, transportation and management of hydrogen (IRENA 2019, Kosturjak et al. 2019). This is also the case in Europe, where hydrogen is an important component in policy strategies aimed at decarbonising the transport and energy sector (EU Green Deal (COM (2019) 640), strategy on offshore renewable energy (COM (2020) 741) and the Renewable Energy Directive (EU) (2018/2001)). Specifically for hydrogen, Europe recently unveiled its Hydrogen Strategy (COM (2020) 301) which can contribute to the realisation of the Green Deal objectives. In concrete terms, Europe wants to take a leading role in the production of green hydrogen and, through a number of measures, the EC is aiming for a smooth but systematic market integration of the technology (see **5.5.1 Policy context**). The sector is represented at EU level by Hydrogen Europe, and the development of green hydrogen is in turn supported by the European Clean Hydrogen Alliance.

At the national level, in the framework of the National Energy and Climate Plan 2021-2030, hydrogen is recognised as an essential technology in the Belgian energy transformation, especially since this energy carrier offers flexibility to companies that cannot (completely) electrify. An additional advantage of hydrogen is that it, barring minor adjustments, can be transported relying on existing natural gas infrastructure (Fluxys). The seaports and pipes in the BNS offer opportunities here (see **5.7 Pipes and cables**). The intention to produce green hydrogen and energy storage is also reflected in the federal Coalition Agreement (federaal Regeerakkoord 30 September 2020), where there is talk of shaping a hydrogen backbone and the adaptation of the legislative and regulatory framework is prioritised (repeated in the federal Coalition Agreement on Energy (Van der Straeten 2020)). Finally, the Policy Statement of the minister of the North Sea states that within the current legislature, attention will be paid to the technological developments that enable the storage of energy, including through conversion into hydrogen (Van Quickenborne 2020). Space is also provided for this in the MSP 2020-2026 within the zones reserved for commercial and industrial activities (CIA zones).

Flanders, too, is focusing its energy policy on greening the energy landscape and is pursuing a pioneering role in the hydrogen economy (Demir 2019). At the Flemish level, the feasibility and valorisation of the Power to Gas technology was already investigated by the former Innovative Business Network (IBN) 'Platform Power to Gas' within the 'Power-to-Gas' project (2014-2020) (Power-to-Gas Roadmap for Flanders 2016). This network now continues as the Hydrogen Industry Cluster and is coordinated by HydrogenNet. The cluster brings together some 60 industrial partners with knowledge institutes and governments who wish to cooperate on hydrogen as a storage medium for renewable energy and its use in industrial or social applications. A bottom-up vision with concrete ambitions of hydrogen companies for Flanders has been drawn up (Vlaamse Waterstofstrategie 2025-2030 – WIC 2020).

Within the coastal zone there are specific plans for (pilot) projects that should make the production of green hydrogen possible. For instance, within the Hyport project, Port Oostende, a private company and *Participatie Maatschappij Vlaanderen* (PMV) are working together on the construction of the world's first commercial power plant that will realise the production of green hydrogen by 2025 (Hyport project, Port Oostende 2020). The energy supply should be covered by power from the wind parks still to be built in the Princess Elisabeth zone.

In addition to the Hyport project, Port Oostende is involved in a number of European projects concerning hydrogen. In the ISHY project it is investigated how three types of ships can sail on green hydrogen. In the H2SHIPS project ports, industry partners, ship builders and knowledge institutions are investigating, together with Hydrogen Europe the added value of green or blue hydrogen for inland navigation[8].

In the Port of Zeebrugge too, activities concerning green hydrogen take place. For example, there was earlier collaboration with the Province of West Flanders and the West Flanders Development Agency in the project Hydrogen Valleys. This project aimed at accelerating the European market integration of hydrogen. The port is also involved in the Greenports study project with the aim of providing optimum technical solutions, as well as outlining economic preconditions and the legislative framework that will make the integration of large-scale power-to-gas installations into the energy system in Flanders/Belgium possible in an economically viable way (HydrogenNet, Maatschappij van de Brugse Zeehaven 2020). In cooperation with HydrogenNet, the Green Octopus/HyFLOW project examined the possibility of cooperation between Flemish and Dutch ports in the field of green hydrogen production. WaterstofNet is also working within a so-called 'hydrogen import coalition' on a pioneering study into the large-scale intercontinental import of hydrogen. The aim is to map out the financial, technical and regulatory aspects of the various links in the logistic chain (Benelux Energy Expertise Network). The feasibility study was recently positively assessed (Hydrogen Import Coalition 2020, Port of Zeebrugge). Finally, Eoly, Parkwind and Fluxys plan to build a plant at the Port of Zeebrugge that will use 25 MW of green electricity to produce hydrogen, the so-called Hyoffwind project (Fluxys, offshoreWIND). The feasibility study for this project was also evaluated positively and, by the end of 2021, the final investment decision is awaited.

Finally, North Sea Port Flanders is also active in the field of (sustainable) hydrogen. With the SeaH2Land project, the port aims to become one of the world's largest producers of green hydrogen in cooperation with the Danish Orsted. This hydrogen will be transported between Denmark and Belgium by pipeline. Power will be supplied by a yet-to-be-built offshore wind park in the Dutch North Sea. There are also plans to construct a network of pipes for the transport of hydrogen, CO_2 and heat through the port (Fluxys).

[8] The greening of shipping via hydrogen was previously explored in the LeanShips project where, among other things, the potential of hydrogen-produced methanol, a denser and more stable fuel than traditional marine fuel, was investigated.

5.7 Pipes and cables

In the OSPAR area (North-East Atlantic Ocean and the North Sea), more than 1,350 oil and gas platforms are connected by a network of over 50,000 km of pipes (OSPAR QSR 2010, OSPAR). In the BNS, there are three submarine pipes with a total length of 163 km that regulate the transport of gaseous products to our country (Verfaillie et al. 2005 (GAUFRE project BELSPO), Brouwers et al. 2011, MSP 2020-2026, Coastal Portal):

- The Seapipe-pipe (with a diameter of 40") connects the Gassco AS-terminal in the Port of Zeebrugge with a pipe in the Norwegian Sleipner area and has a total length of 814 km. Seapipe has been in operation since 1993 and has an annual capacity of approximately 13 billion m³ with a daily capacity of 42 million m³;
- The Franpipe-pipe (formerly Norfra) is an 840 km long pipe (with a diameter of 42") between the Norwegian Draupner E-platform and the French port of Dunkirk that partly crosses the BNS (Maes et al. 2000). This pipeline only passes through the BNS and does not call at a Belgian port. Franpipe has been in operation since 1998 and has an annual capacity of approximately 15 billion m³;
- The Interconnector-pipe is 215 km long (with a diameter of 40") and is operated by Interconnector UK Limited (IUK). This pipe has been transporting gas between the South coast of the United Kingdom and Zeebrugge since October 1998. The pipe is bidirectional and can therefore be used for the import/export of gas from/to England. In winter, gas is imported from England with a capacity of 20 billion m³ per year (personal communication, FPS Economy, SMEs, Self-employed and Energy) and in summer, gas is exported to England with a capacity of approximately 25.5 billion m³ per year.

In addition to gas pipes, the North Sea and the North-East Atlantic are intersected by telecommunication and power cables. Telecommunication cables are mainly found in the southern part of the North Sea, the Celtic seas and the transatlantic corridor. On the Belgian Continental Shelf (BCP), a total of 27 telecommunication cables are present, 16 of which are actively used, representing a length of 914 km (Verfaillie et al. 2005, GAUFRE project BELSPO). Power cables are mainly found in the North Sea and Celtic seas (OSPAR QSR 2010). The amount of power cables is increasing, linked to the implantation of new offshore wind parks. Since 2020, all existing wind parks in the BNS are connected to the power grid. This concerns power cables from C-Power, Norther, Northwind and Belwind that directly connect the wind park to the coast (landing in Ostend for C-Power, other parks in Zeebrugge). The Rentel, Seastar, Mermaid and Northwester 2 wind parks are connected to the Modular Offshore Grid (MOG) (see **5.7.3.1 Modular Offshore Grid I & II**). The MOG is connected to the coast via three cables that are connected to a power plant in the Port of Zeebrugge, after which the power is distributed onshore via a high-voltage connection (380 kV) between Zomergem and Zeebrugge, the so-called Stevin project (Elia - Stevin project, Rumes and Brabant 2020, Federaal ontwikkelingsplan van het transmissienet 2020-2030).

Finally, there is the NEMO Link, a submarine and underground power cable for the exchange of power between Belgium and the United Kingdom (Federaal Ontwikkelingsplan van het transmissienet 2020-2030) (see also **5.7.3 Societal interest**).

5.7.1 Policy context

The procedure for the installation of cables in the BCP is laid down in the RD of 12 March 2002 (see also MD of 8 May 2008) (FPS Economy, SMEs, Self-employed and Energy). Applications are addressed to the federal minister responsible for Energy or his delegate. The dossier is accompanied by the assessment of the environmental impact and the advice of all the administrations concerned. Authorisation is granted by a motivated MD, which particularly takes into account the conclusions of the EIA. The environmental impact is assessed by the Management Unit of the Mathematical Model of the North Sea on the basis of an EIR (RBINS-MUMM).

The procedure for the installation of pipes was laid down in the Law of 12 April 1965 on the transport of gaseous products and others by pipes. This basic law was supplemented by dozens of implementing decrees (FPS Economy, SMEs, Self-employed and Energy).

The Law of 13 May 2003 approved the agreement between Norway and Belgium relating to the Franpipe gas pipe and the Law of 19 September 1991 relating to the Seapipe gas pipe. The Law of 26 June 2000 provides consent to the agreement relating to the Interconnector pipe between the United Kingdom, Northern Ireland and Belgium. For an overview of the regulations concerning cables and pipes in the BNS, see the Codex Coastal Zone, theme Cables and Pipes and the annexes to the RD of 22 May 2019 establishing the MSP 2020-2026.

5.7.2 Spatial use

In the MSP 2020-2026, a zone (corridor) has been defined in which cables and pipes must be bundled as much as possible. Activities that endanger the installation or operation of these cables and pipes are prohibited in this zone. The spatial use around power cables in the BNS is further elaborated in the RD of 12 March 2002 (table 5). By analogy with the spatial regulations for electricity cables, there are also special provisions for the use of space around pipes (RD of 19 March 2017, table 6).

Table 5. An overview of the spatial use around power and telecom cables in the BNS (RD of 12 March 2002).

Spatial use around power and telecom cables (RD of 12 March 2002)	
Protected zone (250 m on either side)	Reserved zone (50 m on either side)
Anchoring prohibited	No installation, no construction of cable or pipe
No activity that poses a risk to the cable (except for the installation of another cable under specific conditions)	
Exception: interventions of cable owner for exploitation	Exception: single-pole cables at the same safety switch, arrival and departure cables to a wind turbine in parallel with other cables, arrival and departure point to an installation with one or more cables, convergence point of several cables forming part of the same return mechanism to the mainland, cables which have undergone repair

Table 6. An overview of the spatial use around offshore pipes in the BNS (RD of 19 March 2017).

Spatial use around offshore pipes (RD of 19 March 2017)	
General provision	**Explanation**
Protected zone (1,000 m on either side)	Each zone divided into two zones (500 m on both sides)
First zone reserved for exploitation and maintenance by the permit holder	Derogation granted subject to ministerial approval and written approval of the permit holder
Second zone can allow static structures (pipes, power and telecommunication cables, installations for the generation of power by wind, hydropower or sea waves and artificial islands having no influence on the stability on the seabed	Provided that written consent of the permit holder is obtained
The above provisions do not apply in the landing zone. There, a minimum distance of 0.50 m is respected between the submarine structures, both in case of crossing and in case of parallel route, in order to allow inspection and maintenance works. Crossings with another operator's pipes must be requested and approved in writing by the operator of the crossed pipes.	

5.7.3 Societal interest

5.7.3.1 Modular Offshore Grid I and II

Due to the increasing importance of offshore energy production (see also **5.1.3 Offshore wind energy - Societal interest**), there is a growing demand for submarine power cables for the transfer of power to land. The development of wind energy and, by extension, offshore energy in the BNS was initially accompanied by separate connections to the onshore grid. With the installation of a Modular Offshore Grid (MOG) for the Rentel, Seamade and Northwester 2 wind parks, this was done in a more clustered manner, which brought technical, economic and ecological benefits. The MOG can be seen as a meshed offshore power network, or 'plug at sea', by which the aforementioned wind parks in the first place, but also future other alternative energy sources, can be connected to high-voltage substations which subsequently connect to the onshore transmission grid (Elia, Federaal ontwikkelingsplan van het transmissienet 2020-2030, North Seas Energy Cooperation, offshoreWIND). This facilitates the further development, internationalisation and guaranteed supply of offshore energy via the BNS.

The MOG in its current configuration consists of one so-called Offshore Switch Yard (OSY) at the Rentel concession zone (figure 2) and installations located on the Rentel Offshore High Voltage Station, in Rentel's domain concession. The platform contains a 220 kV substation and is connected to the Stevin high-voltage station in Zeebrugge via two submarine cables and one cable connected to the Rentel platform (Tant 2014, Federaal ontwikkelingsplan van het transmissienet 2020-2030, Elia). The construction of the MOG happened modular and, after two years

of construction, was completed at the end of 2020 with the last wind parks becoming operational (vision Elia Offshore Grid 2012, MER - Belgian Offshore Grid 2013, Aanvraagdossier Belgian Offshore Grid 2013, Durinck 2017, Rumes and Brabant 2020, Federaal ontwikkelingsplan van het transmissienet 2020-2030, OffshoreWIND).

To facilitate the development of offshore wind energy at the BNS within the Princess Elisabeth zone, Elia launched the MOG-II project (Modular Offshore Grid II) in order to create additional offshore grid capacity (Elia, DMS projects, Federaal Ontwikkelingsplan van het transmissienet 2020-2030). The construction and location of the MOG-II project is currently in a conceptual phase, but the intention is to make MOG II a multifunctional energy island for the connection of power from the Princess Elisabeth zone, the Nautilus cable and the cable to and from Denmark (see **5.7.3.2 Interconnections**).

5.7.3.2 Interconnections

A safe and reliable power supply is essential. A sufficiently large and reliable production park that can meet the demand for power at all times is indispensable for this. To achieve this, the development of international connections is examined (Federaal Ontwikkelingsplan van het transmissienet 2020-2030).

Herein lies an important role for the Nemo Link. This cable is a submarine HVDC-connection (a high voltage direct current connection of about 1,000 MW) between Zeebrugge and Richborough (United Kingdom) (Milieueffectenrapport - NEMO LINK 2012, Mathys et al. 2013, Elia, Federaal ontwikkelingsplan van het transmissienet 2020-2030, Nemo Link). The Nemo Link is the first power link between the UK and Belgium and provides an improved connection between the UK's high-voltage grid and continental Europe. Economic studies have shown the value of such a link and its development was selected by the EC as a 'Project of Common Interest' within the framework of the Trans-European Energy Infrastructure (TEN-E, Regulation (EU) 347/2013). Grid integration on the Belgian side took place via a connection to the Gezelle high-voltage substation in Bruges (Federaal Ontwikkelingsplan van het transmissienet 2020-2030). The construction of the Belgian section of the Nemo Link began in 2018, with the cable becoming operational in 2019. Currently, the feasibility of a second HVDC-interconnection between the UK and Belgium in the so called Nautilus project is being looked into (Volckaert and Durinck 2018, Rumes and Brabant 2020, Elia, Federaal Ontwikkelingsplan van het transmissienet 2020-2030). The EC has already designated the project as a PCI project. Elia is currently carrying out a feasibility study together with National Grid Ventures (NGV) into the possible location, route, capacity, etc. of the project (Elia, Federaal Ontwikkelingsplan van het transmissienet 2020-2030). For the Nautilus project, the possibility of realising a hybrid interconnection (i.e. transmission and interconnection) is also being investigated, by which the interconnector can fulfil a double role: connecting offshore wind and connecting the two countries.

A connection can also be made with other North Sea countries. In a recently launched study, Elia and Energinet (the Danish high-voltage grid operator) are examining the technical and economic feasibility of a 500 km long hybrid interconnector that could transport 1.4 GW of green power from a Danish offshore wind energy island to Belgium by 2030 (Elia). The first results suggest that the multi-billion project is both technically and economically feasible. At the end of November, an agreement on the construction of the Triton Link was closed by the federal minister of Energy (De Tijd).

5.7.3.3 Onshore connections

The onshore connections of the power cables from the offshore wind parks are localised in Oostende (Slijkens) (C-Power) and Zeebrugge (Belwind, Norther, Nobelwind en Northwind). Rentel, Seamade and Northwester 2 connect to the Stevin station (Zeebrugge) (figure 2).

Realisation of the Stevin high-voltage line between Zeebrugge and Zomergem (Federaal Ontwikkelingsplan van het transmissienet 2020-2030) constituted the first step in the expansion of the 380 kV grid towards the coast. The development of this power connection was necessary to be able to connect the first Belgian offshore energy production zone (eight wind parks in total) and the first interconnection (Nemo Link) with the United Kingdom to the Belgian high-voltage grid. Now that the first offshore production zone is fully operational, the capacity of the Stevin high-voltage link is fully used, transporting up to 3 GW of electrical power inland. Power production and import from the BNS hence constitutes a major share of the Belgian power supply.

To connect the power generated by the yet to be build wind parks in the new concession zone to the Belgian power grid, an additional high-voltage connection between the hinterland and the coast has been included in the Federaal Ontwikkelingsplan van het transmissienet 2020-2030. This project, the Ventilus project, will connect to

the existing Stevin station in order to increase the reliability of the high-voltage grid in West Flanders and thus improve a guaranteed power supply in Belgium. The procedure to draw up the regional spatial implementation plan is currently ongoing (Department of Environment and Spatial Development 2019). The intention is to submit the environmental permit application in 2023 and to complete the construction in 2028 (Elia, Federaal Ontwikkelingsplan van het transmissienet 2020-2030).

In addition to the Ventilus project, Elia is pursuing a similar objective with the Boucle Du Hainaut project. The project provides for the construction of a new high-voltage aboveground connection between the high-voltage substations of Avelgem and Courcelles. The majority (1,400 MW) of the offshore capacity of the Princess Elisabeth zone will be distributed via Boucle du Hainaut (Boucle Du Hainaut, Elia, Federaal ontwikkelingsplan van het transmissienet 2020-2030).

5.7.3.4 North Seas Energy Cooperation

As part of the creation of a European integrated energy network (COM (2010) 677), Europe already stimulated the development of a North Sea Offshore Grid between the ten North Sea countries (Mathys et al. 2009, OPTIEP-BCP project BELSPO, Offshore Electricity Grid Infrastructure in Europe 2011). A first initiative in this direction was the establishment of the North Sea Countries Offshore Grid Initiative (NSCOGI). In this context, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden and the United Kingdom concluded a Memorandum of Understanding (MoU) to evaluate the possibility of a coordinated development of an offshore grid in the North Sea and associated onshore connections. This with a view to ensure economic viability and meeting the renewable energy targets in 2020 (Offshore Electricity Grid Infrastructure in Europe 2011). The progress of the initiative was tracked in progress reports (Benelux – NSEC). The initiative for intensive regional cooperation on affordable European offshore energy has received a new impetus under the North Seas Energy Cooperation[9],[10] (Federaal Ontwikkelingsplan van het transmissienet 2020-2030). The intention of closer cooperation has already been confirmed in a political declaration (2016). The current work programme (2020-2023) places a strong emphasis on concretising international offshore wind and grid projects in order to rationalise the use of space and resources. Furthermore, in July 2020, a joint statement called for a European offshore wind framework that would address the current obstacles slowing the efficient and effective development of international hybrid (production + transmission + interconnection) offshore wind projects. *Inter alia*, it was advocated that this framework should provide guidance to EU countries on project implementation, electricity market regulation and efficient EU funding. The work of the North Seas Energy Cooperation was also taken into account in the new European strategy on offshore renewable energy (COM (2020) 741).

Furthermore, the EU Green Deal (COM (2019) 640) also mentions the importance of international cooperation in the field of renewable energy. In addition, the Promotion project recently investigated how the European offshore power network can be further stimulated. Finally, it should be noted that there is already a long tradition of international cooperation on offshore energy in the North Sea Region that is multifaceted and thus does not only envision a connected energy landscape (NorthSEE-Energy).

At the national level, recent policy documents show a continued intention and concretisation to integrate the Belgian offshore power grid into a European power grid with direct current connections (MSP 2020-2026, National Energy and Climate Plan 2021-2030, Van Quickenborne 2020). Such connections make it possible to transport larger capacities over longer distances and hence secure the power supply.

5.7.4 Impact on the marine environment

The installation and exploitation of cables and pipes has both a temporary and permanent impact on the environment in the direct vicinity of the cable or pipe. This impact is included in the EIRs that must be attached to permit applications for cables and pipes. Furthermore, a number of studies and EIRs that deal specifically with the environmental impact of cables and pipes are listed in table 7. Taormina et al. (2018) provides a general overview of the potential environmental impact of submarine power cables.

[9] Regarding the Brexit, the European Commission decided that it will invoke Article 128(5) of the Withdrawal Agreement of the North Seas Energy Cooperation Declaration. This means that, by rule, the UK can no longer be part of this group, but that in exceptional cases of European interest, the UK can be invited to participate.
[10] The chairmanship of the NSEC was held by Belgium in 2021.

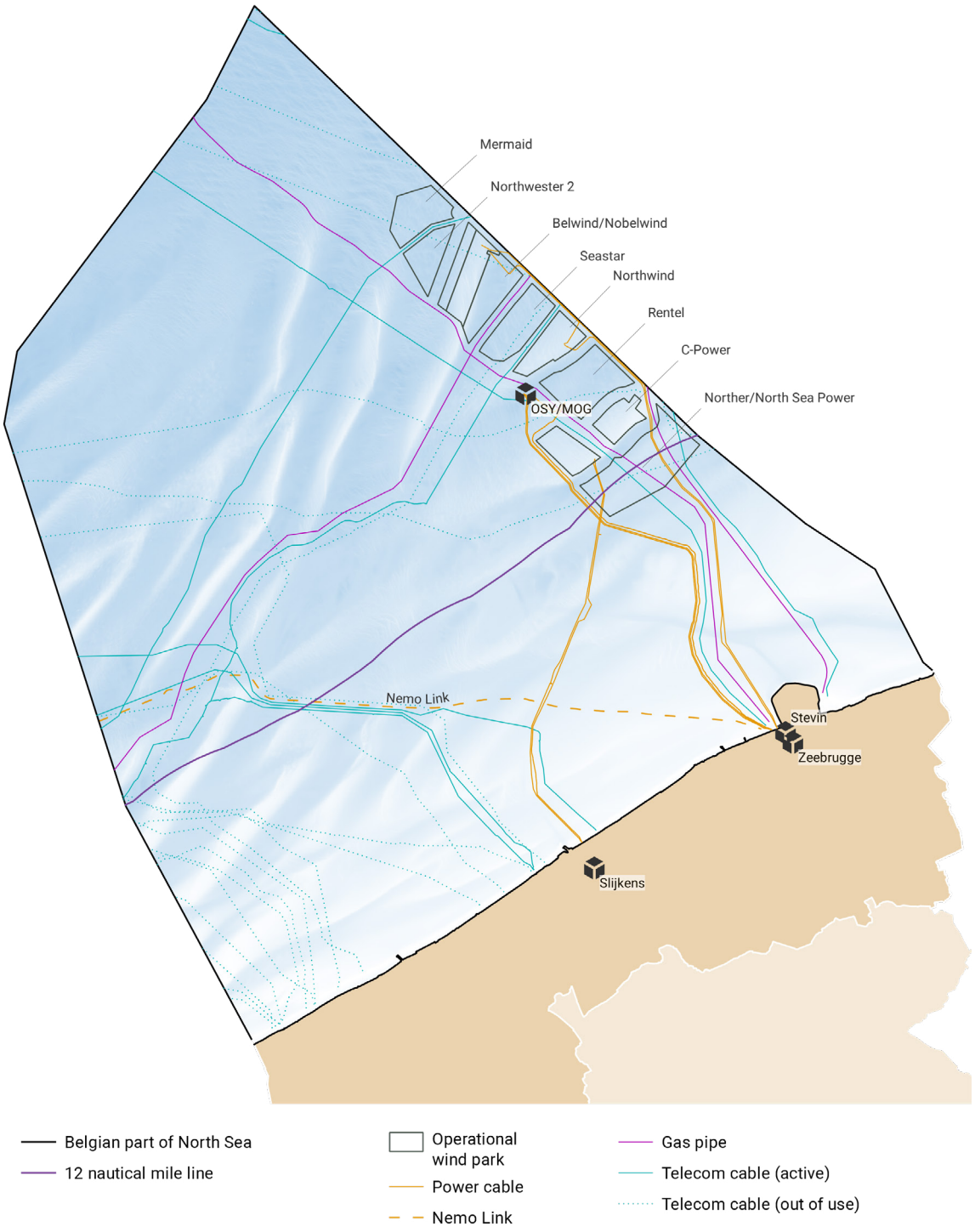


Figure 2. Geographic location of the submarine pipes and cables on the BNS (Source: RBINS, MarineAtlas.be (based on RD of 22 May 2019 (MSP 2020-2026), Flemish Hydrography, Elia, Marine Environment division, Emodnet Human Activities, Coastal Portal).

Table 7. An overview of the environmental effects of the installation and exploitation of cables and pipes in the BNS.

Impact	Literature
Toxic pollution from zinc-coated pipes	Maes et al. 2004 (MARE-DASM project BELSPO)
Introduction of hard substrate on the seabed (pipe) => non-indigenous species	Maes et al. 2004 (MARE-DASM project BELSPO), OSPAR QSR 2010, MER - Belgian Offshore Grid 2013, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017
Sediment disturbance during construction and removal of cable/ substrate (including increased turbidity and release of pollutants adsorbed to soil particles)	MER - NEMO LINK 2012, MER - Belgian Offshore Grid 2013, Van den Eynde et al. 2013, Rumes et al. 2013 – MEB NEMO, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017
Effect on temperature of the surroundings	OSPAR QSR 2010, Environmental Impact Report - NEMO LINK 2012, MER - Belgian Offshore Grid 2013, Rumes et al. 2013 – MEB NEMO, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017
Elektromagnetism	OSPAR QSR 2010, MER - NEMO LINK 2012, MER - Belgian Offshore Grid 2013, Rumes et al. 2013 – MEB NEMO, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017
Underwater noise when installing cables/pipes	MER - NEMO LINK 2012, MER - Belgian Offshore Grid 2013, Rumes et al. 2013 – MEB NEMO, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017
Impact on other users	Verfaillie et al. 2005 (GAUFRE project BELSPO), MER - NEMO LINK 2012, MER - Belgian Offshore Grid 2013, Rumes et al. 2013 – MEB NEMO, Rumes et al. 2014 – MEB Belgian Offshore Grid, Durinck 2017

5.7.5 Sustainable use

5.7.5.1 Measures to address the impact on the marine environment

At the international level, there is the International Cable Protection Committee (ICPC) that is committed to the realisation of SDG 14[11] by promoting sustainable practices in the submarine cable community and by pointing seabed users and policy makers to the importance and practical implications of the provisions of UNCLOS for submarine cables and for the protection and preservation of the marine environment. A report with best practice guidelines as well as a scientific analysis of the impact of cables on the marine environment are under preparation (ICPC).

To date, no common programmes or measures exist at the international level to address the impact of pipes and cables on the marine environment (OSPAR QSR 2010), but states do often opt for a certain licensing procedure, such as a necessary environmental permit. OSPAR has, however, developed guidelines to allow the most sustainable installation of submarine cables (OSPAR 2012). In addition, non-cable specific measures may be applicable, such as noise reduction measures in offshore activities OSPAR 2016 (see also **5.1.5 Sustainable use**).

At the European level, however, the MSFD (Directive 2008/56/EC) can be seen as a framework to monitor and counteract the negative impact of submarine cables and pipes. This Directive contains, a.o., the following descriptors for a good environmental status of the marine environment: descriptor 11 (Energy, including Underwater Noise), descriptor 6 (Seafloor integrity) and descriptor 2 (Non-indigenous Species). In 2017, however, a reference environmental assessment study was prepared at the request of the EC for the development of power production, energy storage and power cable projects in the North Sea and Irish Sea (BEAGINS 2017). In addition to analysing the risks and potential limitations, the study also included recommendations for mitigation to provide a framework to ensure that environmental issues are properly considered in the development of offshore energy systems.

At the Belgian level, the effects of power cables on the marine environment are addressed in the EIAs and monitoring programmes of the different cables for wind parks (MUMM, monitoring reports MUMM). The assessment of potential environmental impacts during the installation of pipes is reflected in the relevant EIRs.

[11] Sustainable Development Goal 14: Promotes the conservation and sustainable use of the ocean and its resources by implementing the international law as reflected in UNCLOS, which constitutes the legal framework for the conservation and sustainable use of the ocean and its resources, as stated in paragraph 158 of The Future We Want.

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
UNCLOS	United Nations Convention on the law of the sea	1982	1994
ASCOBANS	Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Decisions			
Decision 2005/370/EC	Council Decision on the conclusion, on behalf of the European Community, of the Convention on access to information, public participation in decision-making and access to justice in environmental matters (Aarhus Convention)	2005	370
Communications / opinions			
COM (2007) 575	Communication from the Commission - An Integrated Maritime Policy for the European Union	2007	575
COM (2007) 723	Communication from the Commission - A European strategic energy technology plan (SET-plan) - 'Towards a low carbon future'	2007	723
COM (2008) 534	Communication from the Commission - A European strategy for marine and maritime research : a coherent European research area framework in support of a sustainable use of oceans and seas	2008	534
COM (2010) 677	Communication from the Commission: Energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network	2010	677
COM (2012) 494	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
COM (2014) 8	Communication from the Commission: Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond	2014	8
COM (2015) 614	Communication from the Commission: Closing the loop - An EU action plan for the Circular Economy	2015	614
C(2015) 6317	Opinion of the European Economic and Social Committee on the 'Communication from the Commission - Towards an integrated Strategic Energy Technology (SET) Plan: accelerating the European energy system transformation	2015	6317
COM (2016) 860	Communication from the Commission: Clean Energy For All Europeans	2016	860
COM (2019) 640	Communication from the Commission: The European Green Deal	2019	640
COM (2020) 301	Communication from the Commission: A hydrogen strategy for a climate-neutral Europe	2020	301
COM (2020) 380	Communication from the Commission: EU Biodiversity Strategy for 2030 Bringing nature back into our lives	2020	380
COM (2020) 741	Communication from the Commission: An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future	2020	741
COM (2021) 240	Communication from the Commission on a new approach for a sustainable Blue Economy in the EU Transforming the EU's Blue Economy for a Sustainable Future	2021	240

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
COM (2021) 557	Proposal for a Directive amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652	2021	557
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2004/35/EC	Directive on environmental liability with regard to the prevention and remedying of environmental damage	2004	35
Directive 2008/56/EC	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2009/73/EC	Directive concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC	2009	73
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89
Directive (EU) 2018/2001	Directive on the promotion of the use of energy from renewable sources	2018	2001
Regulations			
Regulation (EC) 715/2009	Regulation on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005	2009	715
Regulation (EU) 347/2013	Regulation on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009	2013	347
Regulation (EU) 1119/2021	Regulation establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (the 'European Climate Law')	2021	1119

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decrees		
Decreet of 8 May 2009	Decreet houdende algemene bepalingen betreffende het energiebeleid (Energiedecreet)	2009-05-08/27
Royal Decrees		
RD of 20 December 2000	Koninklijk besluit betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor de productie van elektriciteit uit water, stromen of winden, in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht	2000-12-20/35
RD of 12 March 2002	Koninklijk besluit betreffende de nadere regels voor het leggen van kabels die in de territoriale zee of het nationaal grondgebied binnenkomen of die geplaatst of gebruikt worden in het kader van de exploratie van het continentaal plat, de exploitatie van de minerale rijkdommen en andere niet-levende rijkdommen daarvan of van de werkzaamheden van kunstmatige eilanden, installaties of inrichtingen die onder Belgische rechtsmacht vallen	2002-03-12/37
RD of 16 July 2002	Koninklijk besluit betreffende de instelling van mechanismen voor de bevordering van elektriciteit opgewekt uit hernieuwbare energiebronnen	2002-07-16/39
RD of 9 September 2003	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling in toepassing van de wet van 20 januari 1999 ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-09/30

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
RD of 8 May 2014	Koninklijk besluit betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor hydro-elektrische energie-opslag in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht	2014-05-08/28
RD of 19 March 2017	Koninklijk besluit betreffende de veiligheidsmaatregelen inzake de oprichting en de exploitatie van installaties voor vervoer van gasachtige producten en andere door middel van leidingen	2017-03-19/07
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
RD of 4 February 2020	Koninklijk besluit tot instelling van veiligheidszones in de zeegebieden onder Belgische rechtsbevoegdheid	2020-02-04/12
Ministerial Decree		
MD of 19 November 2010	Besluit van de Vlaamse Regering houdende algemene bepalingen over het energiebeleid (Energiebesluit)	2010-11-19/05
Laws		
Law of 12 April 1965	Wet betreffende het vervoer van gasachtige producten en andere door middel van leidingen	1965-04-12/30
Special Law of 8 August 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Law of 19 September 1991	Wet houdende goedkeuring van de overeenkomst tussen de regering van het Koninkrijk België en de regering van het Koninkrijk Noorwegen inzake het vervoer per pijpleiding van gas van het Noorse Continentaal Plat en uit andere gebieden naar het Koninkrijk België, en van wisseling van brieven inzake de uitlegging van artikel 2, §2 van deze overkomst, ondertekend te Oslo op 14 april 1988	
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 22 April 1999	Wet betreffende de exclusieve economische zone van België in de Noordzee	1999-04-22/47
Law of 29 April 1999	Wet betreffende de organisatie van de elektriciteitsmarkt, inzonderheid op artikel 6	1999-04-29/42
Law of 26 June 2000	Wet houdende instemming met de Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van het Verenigd Koninkrijk van Groot-Brittannië en Noord-Ierland inzake het vervoer van aardgas door middel van een pijpleiding tussen het Koninkrijk België en het Verenigd Koninkrijk van Groot-Brittannië en Noord-Ierland, ondertekend te Brussel op 10 december 1997	2000-06-26/57
Law of 13 May 2003	Wet houdende instemming met de Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van het Koninkrijk Noorwegen inzake het leggen van de « Norfra » gaspijpleiding op het Belgische continentaal plat, en de Bijlagen 1, 2 en 3, ondertekend te Brussel op 20 december 1996	2003-05-13/40
Law of 22 April 2019	Wet tot wijziging van de wet van 29 april 1999 betreffende de organisatie van de elektriciteitsmarkt, teneinde een capaciteitsvergoedingsmechanisme in te stellen	2019-04-22/21

6 Fisheries

Authors Hans Polet[1], Els Torreele[1], Matthias Sandra[2], Thomas Verleye[2]

Lectors Pieter De Graef[3], Koen Carels[3], Karel Vanhulle[4], Peter Blancquaert[4], Yana Deschutter[5], Tom Van Bogaert[6]

[1] Flanders Research Institute for Agriculture, Fisheries and Food (ILVO)
[2] Flanders Marine Institute (VLIZ)
[3] Strategic Advisory Council for Agriculture and Fisheries (SALV)
[4] Department of Agriculture and Fisheries, Fisheries service
[5] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[6] Department of Agriculture and Fisheries

With valued contribution of:
Lies Vansteenbrugge and Sofie Nimmegeers (ILVO)

Polet, H., Torreele, E., Sandra, M., Verleye, T. (2022). Fisheries. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 103-121.

In 2019, global production of fisheries products, including aquaculture, amounted to 177.9 million tonnes (excluding marine mammals and aquatic plants, FAO Fisheries and Aquaculture Information and Statistics Service). Marine fishery products account for 63.1% (112.2 million tonnes) of which 71.7% (80.4 million tonnes) are wild catch. In the EU, the share of wild catch in marine fishery products is 81.5% (FAO Fisheries and Aquaculture Information and Statistics Service).

Total landings of marine fishery products (including aquaculture but excluding marine mammals and aquatic plants) within the EU in 2019 (including the United Kingdom) amounted to 5.1% (5.7 million tonnes) of global marine fishery production. Spain, the United Kingdom, Denmark and France provided over half of the EU landings. EU marine wild catch amounted to 5.8% (4.7 million tonnes) of the global marine wild catch. In the same year, Belgian landings represented 0.4% (19,309 tonnes) of the EU total (FAO Fisheries and Aquaculture Information and Statistics Service 2020). The number of Belgian fishing vessels in 2020 (64 fishing vessels) represented less than 0.1% of the total European fleet, the tonnage and engine power represented 0.8% and 0.6% respectively (Velghe et al. 2020, Fishing fleet capacities).

The global or European catch by recreational sea anglers is unknown. The number of individual boat anglers within Europe is estimated at around 9 million. Together, they undertake almost 78 million fishing trips at sea on an annual basis, which corresponds to over 200,000 fishing trips per day. The total economic activity related to this sector is estimated at 10.5 billion euro on an annual basis, of which 5.1 billion euro are direct expenditures (Hyder et al. 2017a, Hyder et al. 2017b). Belgium is a small player in the European recreational sea fishing context. The number of days at sea by vessels was estimated at 7,700 in 2019. The landings of fishery products by the entire recreational sea fishing community were estimated at around 150 tonnes for 2019 (Verleye et. al. 2020a). A first estimate of direct expenditures (purchase of equipment, boat maintenance, etc.), as part of the wider national monitoring programme for marine recreational fisheries (see website marine recreational fisheries), amounted to at least 8.6 million euro per year (Verleye et al. 2019). Hyder et al. (2017b) previously estimated the total expenditure by Belgian recreational sea anglers (direct, indirect and induced) at around 33 million euro per year based on an input-output model.

6.1 Policy context

6.1.1 Commercial sea fisheries

The management of the European fishing fleet and the conservation of fish stocks are primarily governed by the Common Fisheries Policy (CFP) (Regulation (EU) 1380/2013) as imposed by Articles 38 to 44 of the Treaty on the Functioning of the European Union (TFEU). The European fisheries policy is implemented by the Directorate General for Maritime Affairs and Fisheries (DG MARE) of the European Commission (EC) and by the EU member states (more information Overview of European legislation relating to the CFP). The CFP was developed within the framework of the European Union's Sustainable Development Strategy (COM (2001) 264, renewed in 2016 (10917/06)) and Sustainable Development Goal 14 (SDG 14) of the United Nations, aimed at an ecosystem-based approach and a sustainable exploitation of living marine biological resources. The formulation of European fisheries policy relies on contributions from advisory councils (see Articles 43 to 45 and Annex III of the CFP), as well as from a number of national services and international bodies such as the EC's Scientific, Technical and Economic Committee for Fisheries (STECF) and Joint Research Centre (JRC), and the International Council for the Exploration of the Sea (ICES). European fisheries management relies on scientific data collected by EU member states under the data collection framework (Directive 2017/1004, Implementing Decision (EU) 2019/909 and Delegated Decision (EU) 2019/910) (see **6.5 Sustainable use**).

The Brexit (1 January 2021) significantly reshapes the European fishing landscape. In concrete terms, the Brexit means that European regulations, including the CFP, will no longer apply to British waters. The UK-EU trade and cooperation agreement (24 December 2020) states that European vessels will continue to have access to UK waters (200 nautical mile (nm) zone) for at least 5.5 years, in return for a quota transfer that will be phased in over time until 2026. Access to the 6 to 12 nm zone is restricted to 'qualified vessels' holding the necessary fishing authorisation. In total, the EU will transfer 1.6 billion euro on fishing rights to the UK. After the transitional period, the EU may have to negotiate access to UK waters on an annual basis. These measures may have a major impact on Belgian fisheries as more than 50% of Belgian landings come from UK waters (Van Bogaert et al. 2021).

At national level, Flanders has the exclusive authority with regard to sea fisheries (Decree of 28 June 2013 on agricultural and fisheries policy), with the exception of crew and inspection conditions for vessels for which the federal Government is still the competent authority (FPS Mobility). For commercial sea fishery, the policy is determined by the Flemish Department of Agriculture and Fisheries (Crevits 2019). The Department of Agriculture

and Fisheries is primarily responsible for policy preparation at European and Flemish level. Within this department, the Policy Coordination and Environment division has a broader mission because it is not only responsible for formulating policy proposals and drafting regulations, but also for the translation of European policy and the implementation of fisheries policy. The Fisheries service is part of the Policy Coordination and Environment division and is responsible for the coordination, implementation and control of fisheries policy. This also includes the legal tasks of collecting economic data, including the landing statistics.

The implementation of the European policy for investments and actions in favour of the fisheries sector is regulated among others through the European Maritime and Fisheries Fund (EMFF; Regulation (EU) 508/2014) and the subsequent European Maritime, Fisheries and Aquaculture Fund (EMFAF, Regulation (EU) 2021/1139). The Belgian Operational Programme (2014-2020; renewed OP expected in 2022) (see **6.5.4 Sustainable fisheries sector**) creates a framework and a manual for the funds of the EMF(A)F. The Flemish *Financieringsinstrument voor de Visserij- en Aquacultuursector* (Financial Instrument for the Fisheries and Aquaculture Sector, FIVA) provides the necessary co-financing (decision of the Government of Flanders of 5 February 2016 and MD of 19 May 2016). The modalities and legislative frameworks for the latter will be adjusted at the start of the new fund.

The implementation of the fisheries policy also includes the monitoring of fishing activities and data collection, including the publication of part of the collected data in annual reports (see also Data Collection Framework).

The Flemish fisheries policy is scientifically supported by the Flanders Research Institute of Agriculture, Fisheries and Food (ILVO). The Strategic Advisory Council for Agriculture and Fisheries (SALV) advises the Government of Flanders and the Flemish parliament on agriculture and fisheries in a broad sense. The advices, as adopted by the stakeholders represented in the SALV, are part of a supported political decision-making process. The fisheries related advice is prepared by a permanent working committee: the Technical Working Committee on Fisheries (TFC) of the SALV. The Environmental and Nature Council of Flanders (Minaraad) also provided advice on a number of fishery-related matters. The Rederscentrale is recognised as the producer organisation of fisheries products and as the professional association of specialists representing the employers. The Flanders' Agricultural Marketing Board (VLAM) coordinates the promotion campaigns of fish produced in Flanders (e.g. fish of the year, seasonal fish). The policy context in which the Belgian fishing industry operates is further outlined in Vanderperren and Polet (2009) (CLIMAR project phase 1 and phase 2 BELSPO), the Belgian Operational Programme (EMFF) 2014-2020 and Van Bogaert et al. (2021). A comprehensive overview of the legislation relating to fishing is given in the Codex Coastal Zone, theme Fisheries.

6.1.2 Marine recreational fisheries

Marine recreational fishing is subject to European, federal, Flemish and communal regulations. At European level, the emergency catch limits for sea bass apply, which were introduced in 2016 and are reviewed annually. The federal level mainly deals with aspects related to safety, vessel registrations and licences (Law of 5 July 2018, RD of 28 June 2019), as well as spatial measures at sea (e.g. RD of 4 August 1981, RD of 22 May 2019) and catch restrictions for certain species (RD of 21 December 2001). At the Flemish level, both technical, temporal and spatial restrictions are imposed by the Government of Flanders' Decision of 9 September 2016 and an explicit ban on the use of trammel nets and gill nets was introduced by the Government of Flanders' Decree of 13 March 2015. Municipal police ordinances provide for additional provisions for beach fishing. An overview of the relevant regulations is available on the website for marine recreational fisheries.

6.2 Spatial use

The CFP applies in the Belgian fishing zone (Law of 10 October 1978), the borders of which in Belgium correspond with the exclusive economic zone (EEZ; Law of 22 April 1999). In this zone, the practicing of fishing activities is subject to Belgian jurisdiction (fishing is however a Flemish competence, see above), taking into account the rights of foreign vessels in the context of the CFP (Regulation (EU) 1380/2013 Article 5 and Annex I).

In the territorial waters (the zone from the baseline up to 12 nm), fishing is regulated by national legislation (Law of 19 August 1891). This legislation defines that only fishing boats of <221 kW are allowed to fish in the territorial waters if they use a beam trawl, while between 0 and 3 nm, only ships with a gross tonnage (GT) below 70 GT are allowed to fish (see **6.3.2 Belgian fishing fleet**).

In the territorial sea, fishing is reserved exclusively for Belgian fishermen, although Dutch and French fishermen are also allowed, on the basis of multilateral agreements and European regulations (Douvere and Maes 2005,

GAUFRE project BELSPO). The CFP (Annex I) grants the Netherlands unlimited access to the Belgian 3 to 12 nm zone. The treaty revising the treaty establishing the Benelux Economic Union concluded on 3 February 1958 (2008) also gives the Netherlands the right to fish without restriction in the 0 to 3 nm zone. Furthermore, the Belgian-French convention on 'ijle haring' (herring caught between December and April) and sprat fisheries in French and Belgian territorial waters (1975) provides, under certain conditions, an authorisation for French fishing vessels to catch these fish in the Belgian territorial sea (see also CFP Annex I).

The marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020) prohibits bottom trawling near the '*Paardenmarkt*' site, a dumpsite for war ammunition (see also Maes et al. 2000) (see thematic chapter **Military use**). The MD of 4 October 2016 prohibits certain fishing activities around some shipwrecks to protect the underwater cultural heritage. In addition, the RD of 4 February 2020 imposes a ban on regular shipping (and thus *de facto* fishing) in a safety zone of 500 m around wind parks (see thematic chapter **Energy (including cables and pipes)**). A similar safety zone has been implemented by the MD of 15 June 2021 around the first phase of the sea farm in CIA-zone C (zone for commercial and industrial activities). This area will be closed to fishing from the day the construction phase starts.

Three search zones are designated in the BNS by the MSP 2020-2026, two of which are within the Flemish Banks, in which the most valuable zones will be protected by imposing restrictions on bottom-disturbing activities, with the aim of restoring and maintaining soil integrity (figure 1) (see VISNAT2 project). These zones were designated after previous measures, aimed at restoring and maintaining soil integrity and encouraging alternative/sustainable fishing, were rejected by the European Parliament (2018/2614(DEA)). Recreational fisheries are allowed in the Flemish Banks area as long as the activities have no impact on the seabed, with some exceptions for the existing recreational shrimp fisheries, including manually towed gear.

Further, the MSP 2020-2026 defines new renewable energy zones, in which passive fishing (fishing with static gear such as fish cages) activities will be allowed under certain conditions. The compatibility of offshore wind farms and passive fishing and mariculture was extensively investigated in the framework of the MARIPAS project (Verhaeghe et al. 2011). This topic was also investigated within the AquaValue project, the subsequent research project EDULIS and the project Wier en Wind (see also thematic chapter **Marine Aquaculture**). The SYMAPA project is studying the possible synergies between mariculture and passive fishing.

A detailed overview of the fishing activities of the Belgian (see also GeoFish), Dutch and British vessels in the BNS, i.e. the spatial distribution of the fleet (vessel monitoring system (VMS) data) and information about the target species for the period 2010-2012 (log data), is given in Pecceu et al. (2014). The results of the analyses of fisheries intensity and the landings of target species in the BNS are shown for each flag state, for each fishing technique and for each quarter (3 months). In any case, the BNS is of minor importance for the Belgian commercial fishing fleet as only 11% of the total landings in 2019 originated from ICES region IVc, of which the BNS is part of (Velghe et al. 2020). In contrast, the Belgian coastal fishing vessels as well as the Dutch beam trawlers and pulse trawlers were quite active in the BNS. Note that since the summer of 2019 (MD of 19 July 2019) the use of the electric pulse trawl has been prohibited in Belgian territorial waters and from 1 July 2021 in all Union waters (Regulation (EU) 2019/1241), which may cause spatial shifts in fishing activity (see also 6.4.2 Impact of fishing gear). Belgian fishermen are mainly active outside the BNS (see also GeoFish), such as in the southern and central North Sea, the Celtic Sea, the English Channel, the Irish Sea and the Bay of Biscay. In the context of the CFP and through multilateral conventions, Belgian fishing boats have acquired access to the coastal waters of a few other EU member states (see Van Bogaert et al. 2021). In addition, Belgian fishermen also have limited quotas in Norwegian waters. A list of these sea areas is provided in Van Bogaert et al. (2021). However, due to the Brexit, mid-term fishing opportunities in UK waters are uncertain (see **6.1 Policy context**).

A map of the historical fishing grounds (1929-1999) can be found on the website 'One Century of Sea Fishing in Belgium' of the Flanders Marine Institute (VLIZ). The historical spatial occurrence of various West-European marine fish species can be consulted via Olsen's Piscatorial Atlas (1883), which can be found on the portal HisGISKust.

Marine recreational anglers and trawlers (beam trawl, otter trawl) are mainly active within the 3 nm zone. Marine recreational fishing from land (beach angling or angling from piers or breakwaters, passive nets, wading using a small shrimp net, horseback shrimp fishing) is characterised by a strong spatial variability along the Flemish coast (website marine recreational fisheries).

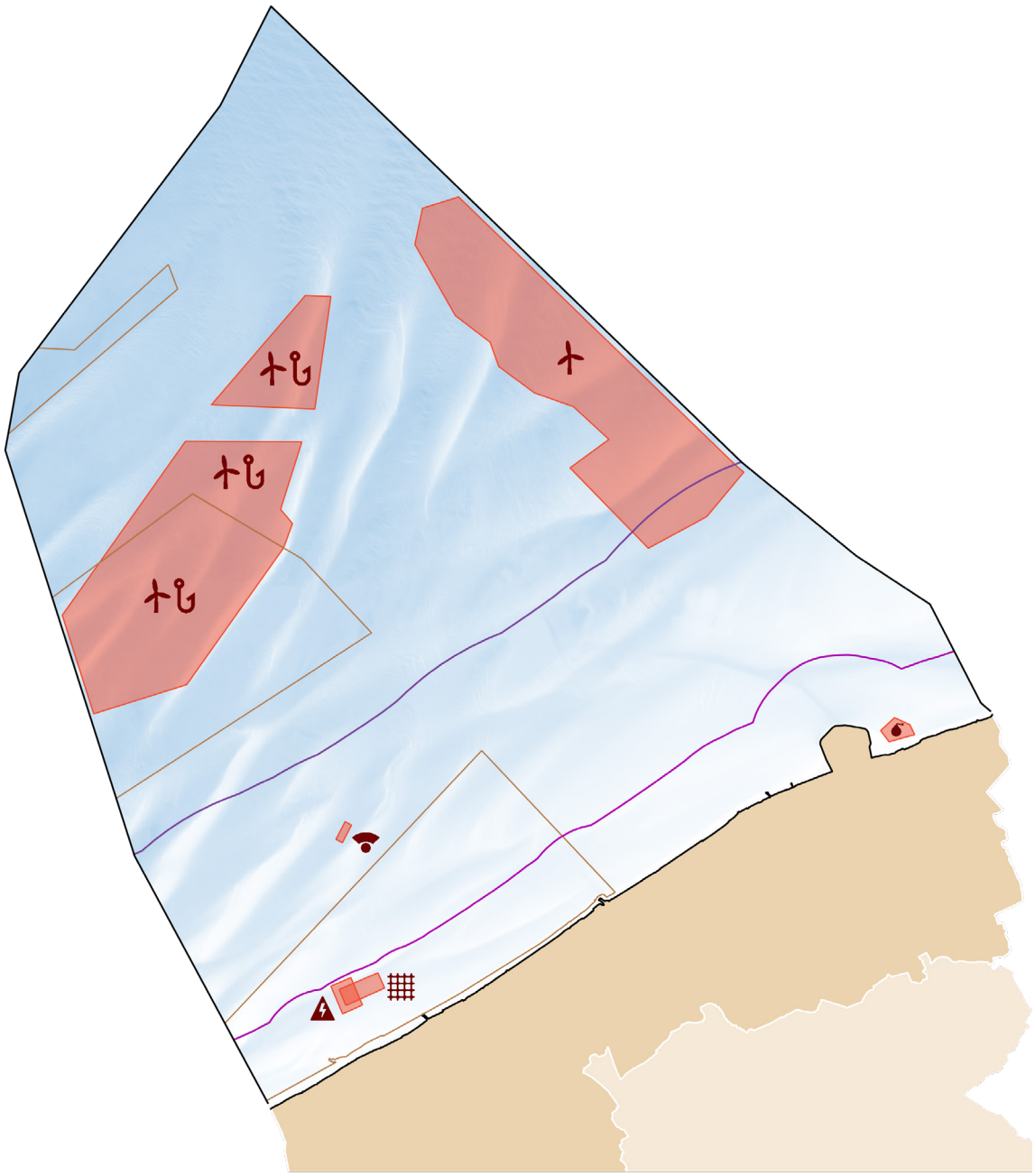


Figure 1. The delineation of fishing zones and sites prohibited for fishing activities in the BNS (Source: RBINS, MarineAtlas.be (based on RD 22 May 2019 (MSP 2020-2026)), Coastal Portal).

6.3 Social interest

6.3.1 Employment

Employment in the fisheries sector is declining, which relates to the crisis that has affected the sector (see **6.5 Sustainable use**). In 2020, the fisheries sector in Belgium consisted of 370 accredited sea fishermen, with an average age of 39.5 years (Van Bogaert et al. 2021). In 2017, 246 Belgian companies were processing fish, of which 66 companies had fish processing as their main activity. These companies are mainly located at the coast and in the Brussels region. In the year 2018, companies with fish processing as their main activity provided employment to 1,227 full-time equivalents (FTE). The vast majority (92%) had fewer than 50 employees, while the average employment per company was around 21 FTEs. The employees are predominantly male (60.4% in 2018) (De Peuter 2020).

One of the main challenges within the sector is to increase the attractiveness of the sea fishing profession and to find well-trained young people, as the number of young fishermen has been declining in recent years (SALV 2015, SALV 2016, Van Bogaert et al. 2021). This is partly due to the hard work, the long time away from home and the increased risk of work accidents (28 in 2019), even though there are many regulations in place to improve working conditions on board and to optimise safety (Van Bogaert et al. 2021). Previs is responsible for, among other things, promoting a preventive policy and raising awareness of health and safety on board fishing vessels. Efforts are being made to improve the influx of young people into the sector by, for example, setting up the Fund for young ship crew members, in which Belgian ship owners annually deposit a mandatory contribution (for 2021: Decision of the Government of Flanders of 2 April 2021).

6.3.2 Belgian fishing fleet

6.3.2.1 The commercial fishing fleet

Based on the decision of the Government of Flanders of 16 December 2005, the fishing fleet is divided into three segments:

- Large fleet segment: All fishing vessels with an engine power capacity between 221 kW and 1,200 kW;
- Small fleet segment: All fishing vessels with an engine power capacity of 221 kW or less, except for the coastal fleet segment;
- Coastal fleet segment: All fishing vessels with an engine power capacity of 221 kW or less, a tonnage of maximum 70 GT and undertaking fishing trips of maximum 48 hours with both the start and end points in a Belgian port (MD of 16 March 2012). Joining the coastal fleet segment occurs on a voluntary basis and has to be agreed on by the Fisheries Service.

At present, the possibility and desirability for the establishment of a new small-scale professional fishing segment is being studied. The usefulness of a small-scale professional fishing segment is also emphasised by SALV (2019). The bottlenecks which inhibit the flow from the recreational fishery sector to the commercial segment are discussed in van Winsen et al. (2016) (LIVIS project, GIFS project).

In 2020, the Belgian sea fishing fleet consisted of 64 vessels with a total engine power of 41,229 kW and a gross tonnage of 12,478 GT (Belgian fleet report 2021; Statistics Flanders). The reported engine power differs from the one in the Official List of Belgian Fishing Vessels of the FPS Mobility because the latter does not consider the additional fictive engine power. Between 1950 (457 vessels) and 2000 (127 vessels), there was a sharp decrease in the number of active fishing vessels. Compared to 2000, the number has now again halved. However, the total engine power did not experience a similar decrease and remained relatively stable (figure 2). This is mainly due to the trend towards larger vessels in the beam trawling fisheries (Rijnsdorp et al. 2008) which was made possible by the aggregation of engine powers (Operational Programme implementing the National Strategic Plan for the Belgian Fisheries Sector 2007-2013).

Another major challenge for the Belgian fishing industry is to rejuvenate the fleet. In 2019, the average age of the hull of Belgian fishing vessels was 33 years. Only two vessels were younger than 10 years. However, in the meantime investments have been made to improve the engine and fishing gear. There are also eight new ships in the pipeline that will gradually be brought into service as of 2021 (Rederscentrale 2021). EMFAF and FIVA will make 4 million euro available for extra-legal investments to improve safety, comfort and energy efficiency (Van Bogaert et al. 2021).

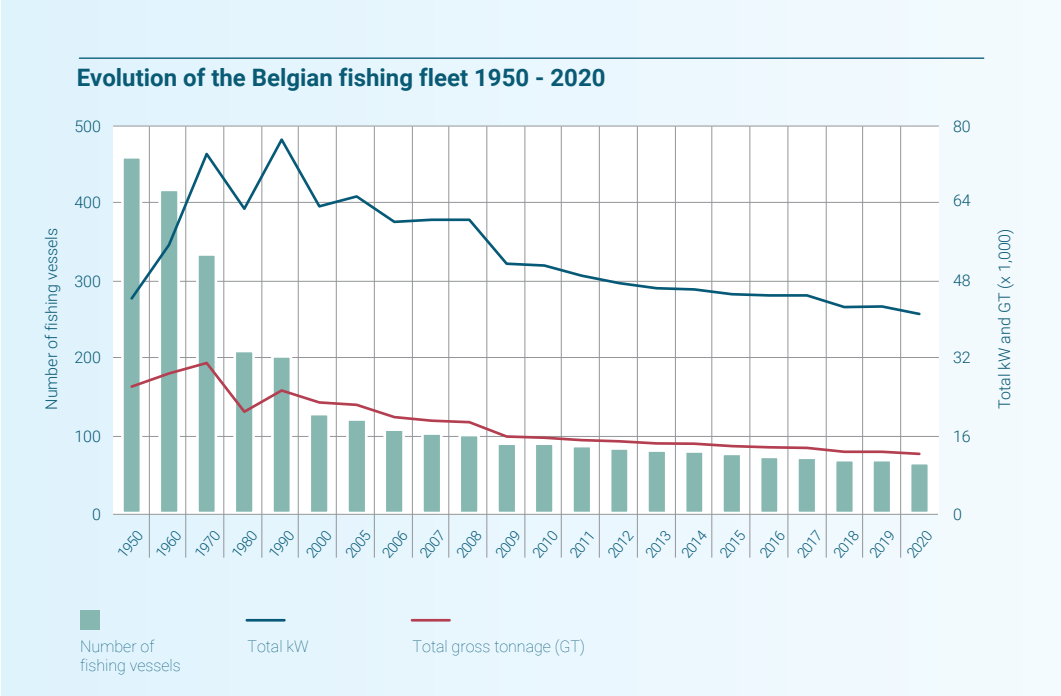


Figure 2. Evolution of the Belgian fishing fleet, number of vessels and capacity (GT and kW) on 31 December of the year, 1950-2020 (Velghe et al. 2020, Maertens 2020).

The dynamics of the Belgian fishing fleet with changing owners, immatriculation numbers, ports of registration and technological equipment can be consulted in a database on the website One Century of Sea Fishing in Belgium of VLIZ and in Lescrauwaet et al. (2013). A reference work on the key aspects of the wider fishing industry during 500 years of Flemish sea fishing has recently been published (Lescrauwaet et al. 2018).

6.3.2.2 The recreational fishing fleet

In the Flemish coastal ports, 814 unique vessels were identified in 2016 that are visibly equipped to undertake marine recreational fishing activities. The majority (87%) are angling vessels, while the other 13% are equipped for trawl fishing (otter trawl (7%) and beam trawl (6%)). These vessels are characterised by a high variability in sailing frequency. The average power of the angling vessels is 118 kW (160 hp) (Verleye et al. 2019).

6.3.3 Landings and value

6.3.3.1 Commercial landings and value

The historical landings (1929-1999) by Belgian fishing vessels per species and per fishing ground are registered on the website A Century of Sea Fishing in Belgium of VLIZ. The landings show a peak after World War II when more than 70,000 tonnes of fish per year were landed in the Belgian ports. Since then, landings dropped almost constantly until 2009 (19,175 tonnes), and reached a new low in 2020: 18,306 tonnes (Flemish agriculture and fisheries in figures). The long-lasting decrease of the landings until 2009 can be explained, amongst others, by a change in the species composition of the catch (Platteau et al. 2014), but the fuel crisis, the declining fish stocks, the declining fishing fleet, the limiting quota, the technological evolutions and the fishing effort limits all played a significant role (see **6.5 Sustainable use**). In 2020, 12,796 tonnes of the Belgian catch were landed in Belgian ports and 5,510 tonnes in foreign ports. The port of Zeebrugge is responsible for 53% of the landings in Belgian ports, followed by Port Oostende (45%) and Nieuwpoort (2%). In terms of landing volumes, plaice, sole, skates, squids and gurnards were the most important species in 2020 (Flemish agriculture and fisheries in figures).

The value of landings or turnover is the value of landed fish and fish products sold by public auction (calculated on the total of both traded and non-traded products). The total value of landings of fish by Belgian fishing vessels increased almost constantly after World War II from approximately 80 million euro (indexed value with respect to the reference year 2007) to peaks of approximately 130 million euro at the end of the eighties and in the early

nineties (A Century of Sea Fishing in Belgium, VLIZ). Afterwards, the annual turnover decreased until 2009 (68.4 million euro). In 2020, the turnover was 74.3 million euro. Sole remained by far the most important fish species for the Belgian fishery in 2020, accounting for 42.3% of the turnover (Flemish agriculture and fisheries in figures). For the recent years, the landing values per species can be found on the website of the Department of Agriculture and Fisheries, as well as on GeoFish. In spring 2020, the Covid-19 pandemic caused a temporary significant drop in fish prices. This was due to a constant supply of fish products while market demand (catering, export, etc.) fell. The Government of Flanders therefore supported the Flemish shipowners in a temporary halt so that the supply could decrease and prices could recover (SALV 2020, Van Bogaert et al. 2021).

6.3.3.2 Recreational landings

Total landings (i.e. fish retained on board) from the recreational sea fishing sector in 2019 amounted to 150 tonnes. In terms of landings volume, brown shrimp (24%), whiting (20%), mackerel (19%), dab (14%), sole (9%) and sea bass (8%) were the main species. Angling vessels account for 60% of the landings (91 tonnes), followed by trawlers (31 tonnes), beach/dam anglers (20 tonnes), waders for shrimp (6 tonnes) and passive fisheries (3 tonnes) (Verleye et al. 2020a). Notwithstanding the ban on commercialisation of the catch, the marine recreational fisheries sector has an economic interest in terms of direct expenditures (8.6 million euro) (Verleye et al. 2019). The total economic value (including indirect value added such as tourism, jobs, etc.) is estimated at 33 million euro per year (Hyder et al. 2019). The Covid-19 crisis also impacted marine recreational fishing in 2020. For example, the loss in catch volume during the spring lockdown was estimated to be at least 18 tonnes, and direct expenditures at the daily level decreased by about 84% (Verleye et al. 2020b). The absence of recreational vessels at sea during the lockdown was also demonstrated in Verleye et al. (2020c).

6.3.4 Trade and consumption of fish products

In Belgium, there are three active fish auctions: Zeebrugge, Ostend and Nieuwpoort. Zeebrugge and Ostend together constitute the Vlaamse visveiling (Flemish fish auction). The average prices of fish caught by Belgian fishing vessels have increased almost constantly after World War II with a peak of 4.48 euro per kilo in 2006. In 2020, the average fish price in Belgian ports was 4.06 euro per kg (Flemish agriculture and fisheries in figures).

Figures from GfK Panel Services Benelux for VLAM reveal that in 2019, Belgians consumed on average 9.0 kg of fish products at home per capita, for an amount of 114 euro (VLAM 2020). Belgium's self-sufficiency rate for fishery products is 8.8% according to the Food Balances (FAO). In 2019, the import value of fishery products amounted to 1.6 billion euro, with 58% of the imported products coming from EU member states. The Netherlands are the main supplier, with a 27% market share. Exports clocked in at 860 million euro (95% within the EU), with the Netherlands (31%) and France (28%) as the main EU markets, followed by Germany (9%) (Van Bogaert et al. 2021).

6.3.5 Fishing communities

6.3.5.1 Commercial and small-scale fisheries

The social dimension of the fisheries sector (training, employment, wellbeing, etc.) is discussed in detail in Van Bogaert and Platteau (2018). One of the issues raised in the SALV analysis on the socio-economic aspects within the fisheries sector (SALV 2016) was the absence of local fishing communities. The impact of the CFP on the social and economic aspects of fishing communities was examined in a European study in 2011 (Fish/2006/06) with a case study in Ostend (Delaney et al. 2010). The GIFS project examined the socio-economic and cultural importance of inshore fishing for coastal communities. Within ILVO, the VISEO socio-economic research unit aims to bring together knowledge about technology, ecosystems and society in integrated and goal-oriented social-scientific research that meets the needs of the fishery sector and the policy (VISEO 2012). The research themes include research on company and sector level, value chain research, research on the sector in an international market environment and research on the impact of policy on the competitiveness of the sector and the environment.

Complementary to the 'FAO Code of Conduct for Responsible Fisheries' (FAO 1995), the FAO published the 'Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication' (FAO 2015). These guidelines aim to contribute to the visibility, recognition and reinforcement of the already important role of small-scale fishing, to the promotion of international efforts to combat hunger and poverty, as well as to the promotion of responsible fishing and sustainable socio-economic development.

Furthermore, Stobberup et al. (2017) discussed the potential role of small-scale fisheries in the 'Blue Growth' story, including the potential impact on coastal communities in terms of economic growth, employment and innovation. In Pascual-Fernández et al. (2020), a comprehensive overview is given of the situation of small-scale fisheries in Europe, including the challenges they face and the potential for economic growth and synergies with other sectors. This book also includes a chapter specifically devoted to the Belgian situation (Verlé et al. 2020).

6.3.5.2 Recreational fisheries

FAO published technical guidelines for the sustainable and socially-responsible management of recreational fisheries in 'FAO Technical Guidelines for Responsible Fisheries – Recreational Fisheries' (FAO 2012). The size of the Belgian marine recreational fishing community is estimated at over 2,000 individuals, of which 32% are affiliated with one of the many marine fishing clubs. The majority of the population are men (98%) and the average age is 56. About 67% lives in the province of West Flanders (Verleye et al. 2019). Within the context of marine recreational fishing, 15 horseback shrimp fishermen (recognised as a UNESCO World Heritage Site) and three '*kruier*' associations (shrimp fishing in the intertidal zone with a small manually towed net) are active in Oostduinkerke. In the first place, they can be considered as a folklore tradition (see Paardevissers and Province West Flanders 2008, see thematic chapter **Maritime and coastal heritage**).

6.4 Impact

Fishing activities have an impact on the (marine) ecosystem, but the precise impact is still subject to debate. In addition to killing, displacing, influencing and extracting marine organisms, some fishing techniques cause a certain amount of disturbance of the seabed (BENTHIS project, Depestele et al. 2014, Teal et al. 2014, Depestele et al. 2016, Depestele et al. 2019, National BENTHIS project). This causes changes in the natural equilibrium after fishing. Furthermore, factors such as the energy consumption of fishing vessels, which consists solely of fossil fuels, and waste production also have an impact on the environment. (i.e. Van Bogaert et al. 2021). An overview of the impact of fishing activities is provided in Polet and Depestele (2010), Adriaens et al. (2013) and Helsen et al. (2021). A Strategic Environmental Assessment (SEA) is required for the Operational Programme (OP) on the basis of the RD of 18 May 2008 and will also be made up for the new OP. Some of the effects are discussed in more detail below.

6.4.1 Overfishing and illegal, unreported and unregulated fishing

The CFP stipulates that each member state must provide an annual overview of their fleet, quotas, catches, fishing methods and fishing activity (the 'fleet report'). This is necessary to manage fishing capacity and to adjust where necessary (CFP Article 22.2). The fleet report describes the balance between fishing capacity and fishing opportunities. In other words: between the total possible catch with the number of vessels and the engine power of the Belgian fleet and the quantity of fish available, given the restrictions such as quotas, fishing days and (temporarily) closed areas. Both factors are described using economic and biological indicators, such as number of vessels, quota uptake, landings in Belgian and foreign ports and catches per day at sea. The methodologies used to carry out the calculations are defined by a group of European experts and are in accordance with the European requirements (JRC and STECF).

The fleet report is made up by the Department of Agriculture and Fisheries and submitted to the European Commission, who checks and analyses the quality of the report provided. In case of an unbalanced fleet, an action plan is drawn up by the Department containing measures to rebalance the fleet. Such measures may be economic or biological, such as limiting the number of days at sea, banning the catch of a certain species or adjusting the minimum length of a fish species. According to the Belgian fleet report (2021), the Belgian fleet capacity has decreased by 39% in kW and by 48% in GT compared to the reference year 2003. As a result, fishing capacity is well below the reference levels.

Quota lists and additional quota measures are published on the website of the Fisheries Service of the Department of Agriculture and Fisheries. Exceedances of the Belgian quota are rather exceptional. The legal basis for possible measures in case of violations on the imposed quotas is Regulation (EC) 1224/2009 and Article 16 of the Decision of the Government of Flanders of 16 December 2005.

The impact on marine biological communities is exacerbated by illegal, unreported and unregulated (IUU) fishing (handbook on IUU Regulation 2010, website Fisheries service, website DG MARE) and discarding species that are

not wanted or have less economic value (so-called unwanted by-catch). Illegal practices such as high-grading, where the value of the catch is maximised by discarding smaller individuals of a given species in favour of larger ones (more information: Vandendriessche et al. 2008, CFP manual 2009), also contribute to this. Therefore, a landing obligation was introduced through the CFP (Article 15). In the Global Atlas of Marine Fisheries (Pauly and Zeller 2016), fishery data from 273 countries is reported from independent sources and not based on member state reporting to the FAO. Lescrauwaet et al. (2013) provides an estimate of the unreported catch and bycatch of Belgian marine fisheries between 1929 and 2010.

In 2010, ICES introduced the principle of maximum sustainable yield (MSY) as the basis for its advice. A healthy MSY means that the biomass levels of a particular stock is sufficiently high and the fishing mortality sufficiently low to ensure that maximum sustainable yield can be achieved in the long term (e.g. Van Bogaert and Platteau 2018). An evolution of the status of the various fish stocks can be visualised per sea area in the online GIS tool GeoFish. For the North Sea stocks assessed by ICES in 2020, 61% (28 out of 46) of the stocks are exploited at or below the FMSY level (i.e. fishing pressure corresponding to MSY). Average fishing mortality for the crustacean, demersal and benthic groups has been declining since the late 1990s (ICES 2020a).

For cod however, the spawning stock biomass in the North Sea is far below MSY level (ICES 2020b). There is also a downward trend in spawning biomass over the last six years below the limit. This hampers future reproduction. Fishing pressure is increasing, above MSY and even above the limit. This is far too high to allow sustainable management of this stock. The slow recovery of this stock is facilitated by the low reproductive success and the high natural mortality. Finally, several subpopulations in the North Sea have recently been discovered to exhibit different dynamics. ICES tries to incorporate these most recent findings in their estimates and advice for this fish stock.

The sole stock in the North Sea shows a decrease in fishing pressure, but is still above MSY level (ICES 2020c). The spawning stock biomass has fluctuated around the limit (below MSY) for several years. However, as the reproductive success was recently estimated to be high, a positive advice for 2021 was given for this stock. The sole stock in the Celtic Sea is in better shape. Fishing pressure is around sustainable levels and spawning stock biomass is well above sustainable levels.

6.4.2 Impact of fishing gear

The impact of fisheries on the ecosystem and biological communities depends to a large extent on the fishing gear used, the duration of the activity, the time and place where fishing takes place, although factors such as the mesh size of the nets and the experience of the fishermen also play an important role. The BENTHIS project (2012-2017) has brought together all knowledge on seabed disturbance. It provides an in-depth understanding of the problem and also proposes a method for quantifying seabed disturbance as a function of fishing gear and habitat. One case study focused on the North Sea. The results already point to a more nuanced story regarding seabed disturbance and associated mortality of benthic organisms, especially as scientific understanding improves with the availability of high-resolution fishery distribution data (Teal et al. 2014, Eigaard et al. 2016). Table 1 provides an overview of studies on the impact of the gear types used by Belgian fisheries. Current Belgian research on the impact of otter trawling is limited, but the technique has been studied by some international partners within the BENTHIS project. Some alternative fishing techniques are discussed in Polet and Van Peteghem (2010).

Sys et al. (2016) studied whether the variations in landings by Belgian fishing vessels active in the Southern Bight of the North Sea were subject to competitive interactions with the Dutch beam trawl/pulse trawl fleet. The study demonstrated that after the establishment of the Dutch pulse trawler fleet in 2011, there was an increased negative weekday effect in the Flemish landings for sole. Further research is also being conducted into the possible negative ecosystem effects of pulse fishing (VLIZ 2014, Soetaert et al. 2015, Soetaert et al. 2016a, Soetaert et al. 2016b, Soetaert et al. 2016c, Soetaert et al. 2016d, Desender et al. 2016, Verschueren and Lenoir 2016, Desender et al. 2017a, Desender et al. 2017b, Desender 2018, Depestele et al. 2018, WGELECTRA 2018, Verschueren et al. 2018, Vansteenbrugge et al. 2020 (*Pulsvisserij Vlaamse Kust Deel 1)*). An overview of the scientific findings can also be found in Sandra et al. (2019) and on the European Pulse Fishing website. This fishing technique was frequently used by Dutch vessels in the Belgian part of the North Sea. The MD of 19 July 2019 banned pulse fishing in the Belgian 12 nm zone. From 1 July 2021 onwards, a general ban on the use of electric pulse fishing in all Union waters applies in accordance with Regulation (EU) 2019/1241 (Annex V - Part D).

6.4.3 Marine litter and impact on fisheries products

The presence of marine litter is a global problem that continues to grow in all seas and the ocean. The EU states in its new approach to a sustainable blue economy (COM (2021) 240) that 70% of marine litter in EU waters is plastic and fishing gear. Therefore, in addition to focusing on the energy efficiency of the fishing fleet, the EU will act to develop standards for the circular design of fishing gear in order to facilitate its reuse and recyclability. Furthermore, EMFAF will continue to support fishermen for the retrieval and collection of litter and lost fishing gear and will continue to invest in its proper treatment in ports and landing sites, in accordance with Directive (EU) 2019/883.

The first findings of the EMFF project Marine Plastics show that the fishery-related waste is fairly evenly spread across the area where the Belgian fleet operates (De Witte et al. 2020). Within the framework of a student project, the origin of litter on the beach (Oosteroever), the Visserijdok and the port of Ostend was traced (Lescroart 2018-2019). About 57% of the litter could be linked to a source (e.g. sector), of which 42% could be linked to fishing and offshore activities. Research on stranded birds on the Belgian coast showed that 0.6% was entangled in litter, mainly fishery-related (Claessens et al. 2013). De Witte et al. (2021a) showed that fishery-related waste in the BNS mainly consists of synthetic ropes (including fishing lines), fishing nets, fishery-related metal and rubber bobbins (see also Devriese and Janssen 2021). The highest absolute concentrations of fishing waste were observed near the coast. The relative share of fishing waste in the total number of observed items was lower in the coastal zone (31%) compared to the zone beyond 12 nm (52%). At the level of microplastics in fishery products, De Witte et al. (2021b) showed that the exposure to microplastics during the consumption of Belgian fish products is limited. For more information on microplastics in food and the potential impact on food safety, we refer to Devriese and Janssen (2021).

The Belgian fishing industry contributes to combating waste at sea within the Fishing for Litter project, linked to the international Seas-at-Risk project. Since 50% of the collected fishery waste is made up of old nets and 25% of rubber waste, the shipowners, in cooperation with a material supplier, are actively looking for a way to recycle it (Van Bogaert et al. 2021). Between 2013 and 2014, the SPEKVIS project investigated possible alternatives to the polyethylene dolly ropes (loose ropes that protect the bottom trawling nets against wear and tear) (see also **6.5.4 Sustainable fisheries sector**). Additionally, divers of the non-profit organisation Ecodivers are removing fishing nets, lead, lines and hooks from and around shipwrecks off the Belgian coast. The fishing nets go to an organisation that recycles marine waste into among others swimwear and socks.

Within recreational fishing, efforts are also being made to prevent waste from ending up in the sea and inland waters via the Flemish Fishing Line Recycling Project. Furthermore, both at European level (ECHA) and in Belgium, steps are being taken together with the sector to phase out the use of fishing lead in marine (recreational) fishing (Verleye and Dauwe 2021). Lead is a persistent, bio-accumulative toxic element whose annual loss in Belgian marine waters is estimated at 2 tonnes. A first pilot project with lead alternatives at sea was carried out within the framework of the study Verleye and Devriese (2019).

6.4.4 Impact on other users

The spatial impact of fishing activities on other users of the sea was addressed in the GAUFRE project (BELSPO). In Maes et al. (2004) (MARE-DASM project (BELSPO)), a bottleneck analysis of professional fishing was carried out. The compatibility with other users in the BNS is also addressed in the MSP 2020-2026. On the other hand, other human activities in the BNS also have impact on fisheries (spatial claims, changing fish populations, etc.), these effects are dealt with in the respective thematic chapters.

6.4.5 Marine recreational fisheries

With the exception of passive beach fisheries (nets), marine recreational fishing in Belgium does not require any licence. As a consequence, it is difficult to determine the scale of this type of fisheries. The national monitoring programme (VLIZ, ILVO, FPS Environment, Province of West Flanders), in which cooperation with the marine recreational fishermen is the central pillar, has been generating extensive insights into the recreational catch, fishing effort, population size and economic impact (Verleye et al. 2015, Verleye et al. 2019, Verleye et al. 2020a). There was also intensive cooperation with marine recreational fishermen on other projects, such as the impact of Covid-19 on recreational fisheries on a national (Verleye et al. 2020b) and global level (Pita et al. 2021), alternatives to fishing lead (Verleye and Devriese 2019; Verleye and Dauwe 2021) and the marking of sea bass (Population dynamics of sea bass on the Belgian continental shelf - Part 2).

Table 1. An overview of studies into the impact on the ecosystem of the most common types of fishing gear used in Belgian fisheries.

Fishing gear	Ecosystem impact	Literature
Beam trawling	Soil disturbance and associated impact on benthos and habitat	Lindeboom en de Groot 1998, Houziaux et al. 2008 (BELSPO), Polet et al. 2008, Rabaut et al. 2008, Depestele et al. 2008, Polet et al. 2010, Polet en Depestele 2010, Depestele et al. 2012 (WAKO-II project BELSPO), Van Lancker et al. 2012 (QUEST-4D project BELSPO), Depestele et al. 2014 (WAKO-II project BELSPO), Depestele 2015, Operationeel Programma EFMZV 2014-2020, Eigaard et al. 2016 (see also corrigendum), Eigaard et al. 2016, Depestele et al. 2016, Rijnsdorp et al. 2016, Depestele et al. 2018
	By-catch and discards	Depestele et al. 2008, Vandendriessche et al. 2008, Polet et al. 2010, Polet en Depestele 2010, Depestele et al. 2011, Depestele et al. 2012 (WAKO-II project BELSPO), Verschueren et al. 2012, Depestele et al. 2014, Depestele 2015, Theunynck en Verschueren 2015, Operationeel Programma EFMZV 2014-2020, Uhlmann et al. 2016, Verschueren en Lenoir 2016, van Marlen et al. 2016
	The food chain based on discards	Sotillo et al. 2012, Depestele et al. 2014 (BENTHIS), Sotillo et al. 2014, Depestele 2015, Depestele et al. 2016
	Consumption of fuels and raw materials	Depestele et al. 2007, Polet et al. 2008, Polet et al. 2010, Polet en Van Peteghem 2010, Polet en Depestele 2010, Operationeel Programma EFMZV 2014-2020
	Litter (see also **6.4.3 Marine litter and impact on fisheries product**)	Bekaert et al. 2015 (SPEKVIS)
Sign trawling	Soil disturbance and associated impact on benthos and habitat	Buhl-Mortensen et al. 2016, Gislason et al. 2017
	Sediment suspension	Mengual et al. 2016
	By-catch of seabirds and marine mammals	Haelters en Kerckhof 2004, Depestele et al. 2006, Depestele et al. 2008, Haelters en Camphuysen 2009, Depestele et al. 2012 (WAKO-II project BELSPO), Depestele et al. 2014 (WAKO-II project BELSPO)
Trammel nets (a type of standing rigging)	Ghost fishing	Depestele et al. 2006, Depestele et al. 2008, Depestele et al. 2012 (WAKO-II project BELSPO), Depestele et al. 2014 (WAKO-II project BELSPO)
	By-catch and discards	Depestele et al. 2012 (WAKO-II project BELSPO), Depestele et al. 2014 (WAKO-II project BELSPO)

6.5 Sustainable use

6.5.1 Common fishery policy (CFP)

The CFP (Regulation (EU) 1380/2013) manages European fisheries and aims for a sustainable exploitation of marine resources as well as the creation of jobs and growth in coastal areas (see also European Commission 2016). This policy has to ensure that both fisheries and aquaculture are ecologically, economically and socially sustainable and form a healthy food source for the European citizens. There is a focus on the improvement of the scientific knowledge of the fish stocks.

The EC strives towards long-term management, by drafting multiannual plans that will contribute to a sustainable exploitation of the fish stocks and the protection of the marine ecosystems. The multiannual management plan for demersal fish stocks in the North Sea (Regulation (EU) 2018/973) provides a further implementation of the principles (i.e. sustainability, regionalisation) of the CFP. The aim of this regulation is to strive for sustainable fisheries and achieve a stable arrangement that can serve as a guideline for future decisions about catch possibilities in the North Sea. An overview of all multiannual plans is given on the website of the EC.

A few elements included in the CFP include the gradual introduction of the landing obligation (ban on discards), the achievement of maximum sustainable yield (MSY) for fish stocks (by 2020) and the focus on regional decision-making through new Advisory Councils (website DG MARE). To achieve the objectives of the CFP, the EU applies a number of conservation measures which can be divided into four groups (Adriansens 2009, website DG MARE):

- Europe defines the Total Allowable Catch (TAC) of specific fish stocks within a certain period. These TACs are divided among the member states by means of quota. The Flemish quota measures are kept up to date on the website of the Fisheries service. An overview of the quota and the related degree of utilisation is shown on the website of the *Redercentrale*. The quota can be swapped among the member states. At the World Summit on Sustainable Development in Johannesburg (UN 2002), the international community committed itself to adopt a new management system for fish stocks based on the MSY concept at the latest by 2015, where possible (Adriansens 2009, CFP manual 2009). At present, MSY is determined for the important commercial fish species for which solid data is available. For certain species such as skates, the level of MSY cannot yet be calculated. ICES must provide quantitative TAC advice for Europe based on all available information for all stocks for which there is no management plan and no MSY value. The current Belgian fleet mainly focuses on typical mixed fisheries. In order to face this challenge, fisheries management is evolving towards 'multi-species management'. This issue is discussed in the ICES working group on mixed fisheries (WGMIXFISH). In addition, the effects of extensive selective fishing are being pointed out and some authors (e.g. Garcia et al. 2012) advocate a balanced fishery in which the fish are caught in accordance with their natural occurrence (i.e. even distribution of the fishing effort over the entire ecosystem);
- Technical measures have been introduced, such as a minimum mesh size, selective fishing gear, closed areas, minimum landing sizes and a gradual introduction of a ban on discards;
- The fishing effort is limited by restricting the number of days on which fishing boats are allowed to fish at sea. In addition, the fishing effort is reoriented by closing certain zones (temporarily) for fishing activities;
- Fleet measures have been set with maximum kW and GT capacities for every EU member state. For fleet segments with overcapacity, the member states can take measures.

EMFAF (Regulation (EU) 2021/1139) was established in order to support the implementation of the member states' operational programmes comprising, inter alia, the measures referred to above and giving effect to the EU priorities listed in the EMFAF Regulation (see also **6.5.4 Sustainable fisheries sector**). In doing so, EMFAF strives for competitive, environmentally sustainable, economically viable and socially responsible fishing and aquaculture. For the period 2021-2027, 40.3 million euro is reserved for Belgium, which corresponds to 0.8% of the total EMFAF budget under shared management (5.3 billion euro).

Since 1 January 2010, the control system for ensuring compliance with the CFP has been settled by Regulation (EC) 1224/2009, which refers to Regulation (EC) 1005/2008 (see also Verleye et al. 2018) in order to prevent and eliminate IUU-fisheries (see **6.4.1 Overfishing and illegal, unreported and unregulated fisheries**). As a result, fishing activities of all fishing vessels, with the exception of the small traditional vessels (<12 m), can be monitored by means of a satellite tracking system (VMS). Additionally, all ships have to be equipped with an electronic logbook, in which fishermen need to report the date, place, catch method and size of the catch for every species (website DG MARE). The possibility of on-board weighing is currently being explored so that the weight of catches can be recorded more accurately in the future. In order to organise cooperation and coordination between member states with regard to fisheries control and inspection, the Community Fisheries Control Agency (CFCA) was set up in Vigo in 2006.

6.5.2 Marine Strategy Framework Directive

Besides the CFP, the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) also offers a framework to limit or avoid the impact of fisheries on the marine environment. A number of descriptors have been developed to define a good environmental status, some of them directly or indirectly related to fisheries (see also thematic chapter **Nature and environment**): descriptor 1 (biodiversity; Cochrane et al. 2010), descriptor 3 (populations of commercially exploited species; Piet et al. 2010), descriptor 4 (marine food chain; Rogers et al. 2010), descriptor 6 (integrity of the seabed; Rice et al. 2010), descriptor 9 (polluting substances in marine organisms for human consumption; Swartenbroux et al. 2010) and descriptor 10 (marine litter; Galgani et al. 2010).

The physical damage to the seabed due to fishing activities and the selective extraction of species, including the incidental catch of non-target species, has also been included in the indicative list of pressures and impacts. Furthermore, the need for a monitoring programme for the chemical pollution of commercial fish species has been highlighted. In the context of the MSFD related programme of measures for the Belgian marine waters (Belgian State 2016), there is also attention for marine recreational fisheries next to the commercial fisheries (measures 11, 24, 27 and 29D).

In 2018, a first version of the revision of the initial assessment of the Belgian marine waters (Belgian State 2018) was published in which the specific environmental targets for fisheries were evaluated. Despite the fact that

descriptor 3 was positively evaluated, fisheries in Belgian waters still have a high negative impact on the benthic habitat quality (descriptor 6) (IA2017 Condition of Benthic Habitat Communities: Subtidal Habitats of the Southern North Sea). As a result, the soft substrate was assessed as inadequate and the good environmental status (GES) was not achieved.

6.5.3 Data collection in Europe and Belgium

The collection of reliable and complete (both temporal and spatial) data is essential for fisheries management under the CFP, which is based on the best available scientific advice. The main instrument for data collection and management is Directive (EU) 2017/1004.

Within the context of the data collection framework, the EC draws up implementing acts to describe a multiannual Union programme for data collection. Those implementing acts lay down the detailed obligations of data collection for the member states:

- Implementing Decision (EU) 2019/909 lays down the list of mandatory surveys and thresholds for the implementation of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sector for the period 2020 to 2021.
- Commission Delegated Decision (EU) 2019/910 establishes the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors.

The financing of data collection has been covered by the EMF(A)F since 2014. The advice of the CFP based on the scientific information is provided through various bodies:

- ICES provides biological advice for EU fisheries management through international cooperation of fisheries biologists. The conclusions of the working groups within ICES that work on fish stock assessment are incorporated into the deliberations of the ICES Advisory Committee (ACOM);
- STECF is the regular advisory body to the EC on fisheries. This body was established in 1993 (Commission Decision 93/619/EC), renewed in 2005 (Commission Decision 2005/629/EC) and renewed at the beginning of 2016 under the new CFP (Commission Decision 2016/C 74/05). The STECF consists of a group of independent scientists from the different member states and advises the EC on all aspects of fisheries policy.

In Belgium, the research group Fisheries Biology of ILVO is responsible for the coordination and execution of the Belgian data collection of commercial fisheries, recreational fisheries (in cooperation with VLIZ), the fish processing industry and aquaculture. Based on the data collection, ILVO provides advice on the state and management of Belgian and European fish stocks. Furthermore, this research group supports research on the ecosystem approach, stock assessment methods, dynamics of marine ecosystems and the possible impact of fisheries management on the stocks and fisheries as such. In order to achieve these general objectives, research activities focus, among other things, on the collection and analysis of data relating to the size of fish stocks, the exploitation pattern of commercially important species and the marine ecosystem.

Inventories and studies on the economic and social data of the fisheries sector, the fish processing industry and aquaculture sector are also carried out by ILVO. This research results in both scientific and (socio-) economic advice to support the development and implementation of the CFP. Some of the key challenges are: the evolution from a single-species to a multi-species approach, ecosystem approach for fisheries, regionalisation, promoting cooperation between the fisheries sector and scientists through the Fisheries-Science Partnership (VWP), the Brexit (see SALV 2020), the socio-economic impact of policy changes, the evolution towards a full value chain policy, the expansion of end-users, the monitoring of protected and vulnerable species and the landing obligation.

The Implementing Decision (EU) 2019/910 also provides for an obligation to collect biological data from recreational fisheries. For the North Sea, data (catch and discards) should be collected within the recreational context for the following species: cod, sea bass, pollack, salmon, eel and elasmobranches. The monitoring programme for marine recreational fisheries (VLIZ, ILVO, FPS Environment, Province of West Flanders), provides for the collection of catch data (all species) and a first economic impact analysis in close cooperation with the marine recreational fisheries community (Verleye et al. 2019, Verleye et al. 2020a).

6.5.4 Sustainable fishing sector

The fishing industry has gone through several years of crisis in which the authorities have tried to respond appropriately with specific measures. The aim is to achieve more sustainability in the Flemish fishing industry, which is linked, among other things, to investments in increased profitability, energy-saving techniques in the broad sense (including engines, auxiliary engines, fishing gear, equipment, etc.), alternative, environmentally friendly or more selective fishing techniques, scrapping programmes to balance fleet capacity and quota, emphasis on other target species, changes in landing volumes, improvement of the quality of the fish, improved working conditions and safety of crews and the development of a sustainable aquaculture sector in Flanders (a.o. Roegiers et al. 2012). An overview of the current problems within the fisheries sector is provided in SALV (2016).

In order to be able to deal with the profitability problems of the fishing fleet, the Government of Flanders drew up an overal action and restructuring plan in 2006 (Fisheries Task Force 2006), aiming towards sustainable Flemish fisheries by means of structural measures. More specifically, the following restructuring measures were implemented:

- Adapted fleet policy: This plan is part of the European Regulation (EC) 744/2008, which provided public aid to vessel owners engaging in partial decommissioning and increased aid for modernisation for a certain period of time (until 31 December 2010 at the latest). In addition, the scrapping of vessels was temporarily supported by government intervention (MD of 2 June 2009). In addition, the maximum engine power was increased to 1,200 kW, creating more space for the pooling of engine power. A third fleet segment, the 'coastal fleet segment', was also established (see **6.3.2 Belgian fishing fleet**);
- Adjusted quota policy: The adjusted Flemish quota policy (in force since 1 February 2006) must contribute to an optimal and efficient quota use (more information: Adriansens 2009);
- Supporting policy: Alternative fishing techniques are being explored in order to convert the remaining vessels into a sustainable fleet.

In the pursuit towards a sustainable fishing sector, each member states is required to draw up an Operational Programme (OP) and an SEA of the national programme within the framework of the EMF(A)F (see RD of 18 May 2008). For the Belgian fishing sector, a SWOT analysis and a description of the strategy were made in relation to the four priorities of the EMFAF. The renewed Belgian OP is expected in 2022.

In 2012, the Government of Flanders already developed an Action plan selective fishing (2012) in order to react pro-actively on a few topics of the reformed CFP that came into effect in 2014. In this action plan, 10 priorities were proposed which must lead towards more sustainable fisheries. One of the actions points at the importance of the first societal covenant for sustainable fisheries (2011) that has been developed by the fishery sector and that lays down the guidelines for a transition to a sustainable fishery sector. As a result of this first covenant, these outlines were set out in the report '*Vistraject*' (De Snijder et al. 2015). This report must ensure that the sustainability objectives of the current CFP are achieved. *Vistraject* identifies seven main goals concerning the transition of the sector towards sustainable Flemish fisheries. These are based on three pillars: (1) profitability, (2) care for the environment and (3) the social aspect of fishing. In June 2015, the second social covenant implementing the objectives of the *Vistraject* project was signed (2015-2020). This new covenant was based on the ambitions within a renewed approach, both in terms of content and organisation, and with an increase in the number of partners involved. In this way, the Belgian fishery was able to evolve further towards sustainability based on responsible entrepreneurship and to provide the consumer with fresh fish that scores highly in terms of quality, and this with respect for the biological balances in the sea. As a result of the successful voluntary and positive involvement of the sector (bottom-up) in the policy process, a third covenant and accompanying action plan were published, which serve as a framework for the next period. With this third social covenant (2021-2025), the parties involved want to renew their commitment and want to support the Flemish fishery in the further pursuit of sustainability based on a multidisciplinary approach by all involved and interested parties.

ILVO is conducting research into more sustainable fishing techniques. For example, the design of the beam trawl is being adapted to increase selectivity and reduce seabed disturbance, drag and thus fuel consumption (Depestele et al. 2007, Stouten et al. 2007, Depestele et al. 2016, Depestele et al. 2019). Experimental modifications to fishing gear are also being tested in order to reduce discards of undersized fish and non-commercial organisms. It is expected that research on improved species and length selectivity will remain necessary in the future due to the discard ban (a.o. Depestele et al. 2011). Research is also being carried out into alternative fishing techniques such as, for example, handline fishing, gillnets, flyshooting and shrimp pulse trawls (Hovercran) (a.o. Van Craeynest 2009, Polet and Van Peteghem 2010, Verhaeghe et al. 2011, Verschueren et al. 2012, Depestele et al. 2012 (WAKO-II project (BELSPO)), Depestele et al. 2014 (WAKO-II project (BELSPO)), Soetaert et al. 2015, Depestele et al. 2016, Soetaert et al. 2018, Depestele et al. 2019, Soetaert et al. 2019, Verschueren et al. 2019, Boute et al. 2021).

Numerous research projects aim to make fisheries more sustainable. One of the most prominent projects with practical results is the VALDUVIS project (2012-2017). The VALDUVIS methodology determines the sustainability score at the level of each individual fish box landed on the basis of indicators relating to the three pillars of sustainability. The MaViTrans project (2017-2019) is a first application of the VALDUVIS tool on the market. The project aims to make the Belgian fishing fleet more sustainable by giving a market recognition to vessels that are formally committed to improve their sustainability score within a period of three years (started 11 June 2018). When the products meet a certain minimum score, they receive the sustainability mark '*Visserij verduurzaamt*', which is displayed on the auction clock. Recently, pilot projects are trying to make this sustainability score visible further down the commercialisation chain, right up to the consumer.

In addition, many other research projects aiming to provide further scientific support to the fishing sector can be cited:

- The VISTools project (2018-2020) aimed to automatically collect the data from various sensors on board a fishing vessel (scale, GPS, tensiometer, depth meter, fuel consumption) so that the yield, catch composition and fuel consumption can be determined at the level of each fishing activity. The real-time provision of information can support shipowners in making any adjustments to their operations;
- The Combituig project aimed to reduce the catch of choke species and other by-catches in beam trawling and improve their survival by innovative technical developments of the nets;
- The VALOREVIS project (2014-2015) in turn aimed, on the one hand, at mapping the residual flows in the fisheries sector that are the most interesting to valorise and, on the other hand, at facilitating and creating new industrial activities and cooperations in Flanders based on valorisation;
- The SPEKVIS project (2013-2014) aimed at identifying alternative materials for the polyethylene dolly ropes and thus bridge the gap with the textile sector. The introduction of plastics into the sea and their fragmentation into so-called microplastics can lead to the ingestion of these particles by marine organisms, and therefore constitute an important research field with a view to improving the quality of fish (De Witte et al. 2014, Van Cauwenberghe and Janssen 2014, Devriese et al. 2015, Vandermeersch et al. 2015, Devriese et al. 2017, Devriese and Janssen 2021). Additionally to this, a test project was started in the autumn of 2018 by the FPS Environment and VLIZ on the use of lead-free fishing weights in cooperation with the marine recreational fisheries sector (Verleye and Devriese 2019). This study was, together with the comprehensive follow-up study of Verleye and Dauwe (2021), taken into account by the European Chemicals Agency (ECHA) in the preparation process to develop a ban on the use and sale of lead for angling purposes;
- The Geovis project gathers the available information (both scientific data and sector information) about Belgian fishing grounds into an online platform, accessible to the sector and the policymakers. This initiative helps both the sector and the policymakers to take the necessary decisions in order to be able to carry out their activities, in a flexible way and with solid background information.

The legislative framework and the sustainability limits (economic, social and ecological) framing the development of the Belgian fisheries in the future, are determined by the CFP, as well as numerous other directives such as the Habitats Directive (Directive 92/43/EEC), the MSFD, the European Framework Directive for Maritime Spatial Planning (Directive 2014/89/EU), etc. Within these frameworks, the actors within the fisheries sector will be decisive for the future of the sector in Flanders. A prospective study has already been carried out by the SALV (2017).

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Decisions			
C/2016/1084	Commission Decision establishing a Scientific, Technical and Economic Committee for Fisheries	2016	1084
Implementing Decision (EU) 2019/909	Implementing Decision laying down the list of mandatory surveys and the thresholds for the application of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sector	2019	909
Delegated Decision (EU) 2019/910	Delegated Decision establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors	2019	910
Communications			
COM (2001) 264	Communication from the Commission: A sustainable Europe for a better world: A European Union strategy for sustainable development	2001	264
COM (2009) 163	Green Paper: Reform of the Common Fisheries Policy	2009	163
COM (2011) 417	Communication from the Commission: Reform of the common fisheries policy	2011	417
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2008/56/EC	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89
Directive (EU) 2017/1004	Regulation on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008	2017	1004
Directive (EU) 2019/883	Directive on port reception facilities for the delivery of waste from ships	2019	883
Regulations			
Regulation (EC) 744/2008	Regulation instituting a temporary specific action aiming to promote the restructuring of the European Community fishing fleets affected by the economic crisis	2008	744
Regulation (EC) 1005/2008	Regulation establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing, amending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999 (IUU Regulation)	2008	1005
Regulation (EC) 1224/2009	Regulation establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1049/2007 and (EC) No 1049/2007 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006 (Control Regulation)	2009	1224
Regulation (EU) 1380/2013	Regulation on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (Common Fisheries Policy)	2013	1380

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
Regulation (EU) 508/2014	Regulation on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006, (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council	2014	508
Regulation (EU) 1242/2019	Regulation on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006 and (EC) No 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/97, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulation (EC) No 1224/2009. 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council and repealing Council Regulations (EC) 894/97, (EC) 850/98, (EC) 2549/2000, (EC) 254/2002, (EC) 812/2004 and (EC) 2187/2005	2019	1241
Regulation (EU) 1139/2021	Regulation establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004	2021	1139

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 16 December 2005	Besluit van de Vlaamse Regering tot de instelling van een visvergunning en houdende tijdelijke maatregelen voor de uitvoering van de communautaire regeling inzake de instandhouding en de duurzame exploitatie van de visbestanden	2005-12-16/48
Decision of the Government of Flanders of 13 March 2015	Besluit van de Vlaamse Regering houdende een verbod op het gebruik van warrelnetten en kieuwnetten in de Vlaamse strandzone ter bescherming van zeezoogdieren	2015-03-13/02
Decision of the Government of Flanders of 5 February 2016	Besluit van de Vlaamse Regering houdende vaststelling van de werking en het beheer van het Financieringsinstrument voor de Vlaamse visserij- en aquacultuursector (FIVA) en de verrichtingen die voor steun in aanmerking komen	2016-02-05/24
Decision of the Government of Flanders of 9 September 2016	Besluit van de Vlaamse Regering tot vaststelling van aanvullende nationale maatregelen voor de instandhouding en het beheer van de visbestanden en voor controle op de visserijactiviteiten	2016-09-09/03
Decision of the Government of Flanders of 2 April 2021	Besluit van de Vlaamse Regering tot vaststelling van de regels voor de verplichte bijdrage van de reders van Belgische vissersvaartuigen aan het Fonds voor Scheepsjongeren	2021-04-02/32
Decrees		
Decree of 13 May 1997	Decreet houdende oprichting van een Financieringsinstrument voor de Vlaamse visserij- en aquacultuursector	1997-05-13/31
Decree of 28 June 2013	Decreet betreffende het landbouw- en visserijbeleid	2013-06-28/15
Royal Decrees		
RD of 4 August 1981	Koninklijk besluit houdende politie- en scheepvaartreglement voor de Belgische territoriale zee, de havens en de stranden van de Belgische kust	1981-08-04/31
RD of 21 December 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
RD of 18 May 2008	Koninklijk besluit tot vaststelling van het feit dat een beoordeling van de gevolgen op het milieu vereist is voor het nationaal operationeel programma voor de visserijsector en dat een beoordeling van de gevolgen op het milieu niet vereist is voor het nationaal strategisch plan voor de visserijsector	2008-05-18/32
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
RD of 28 June 2019	Koninklijk besluit betreffende de pleziervaart	2019-06-28/08
RD of 4 February 2020	Koninklijk besluit tot instelling van veiligheidszones in de zeegebieden onder Belgische rechtsbevoegdheid	2020-02-04/12

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
Ministerial Decrees		
MD of 2 June 2009	Ministerieel besluit tot toekenning van een beëindigingspremie voor de definitieve onttrekking van vissersvaartuigen aan de zeevisserijactiviteit in het kader van een vlootaanpassingsregeling	2009-06-02/01
MD of 16 March 2012	Ministerieel besluit tot uitvoering van het besluit van de Vlaamse Regering van 16 december 2005 tot de instelling van een visvergunning en houdende tijdelijke maatregelen voor de uitvoering van de communautaire regeling inzake de instandhouding en de duurzame exploitatie van de visbestanden, wat betreft het kustvisserssegment en de opdeling van bestaande visvergunningen	2012-03-16/10
MD of 19 May 2016	Ministerieel besluit tot uitvoering van het besluit van de Vlaamse Regering van 5 februari 2016 houdende vaststelling van de werking en het beheer van het FIVA en de verrichtingen die voor steun in aanmerking komen	2016-05-19/06
MD of 4 October 2016	Ministerieel besluit betreffende individuele maatregelen ter bescherming van het cultureel erfgoed onder water	2016-10-04/03
MD of 19 July 2019	Ministerieel besluit houdende het verbod op de pulsvisserij in de Belgische twaalfmijlszone	2019-07-19/06
MD of 24 December 2020	Ministerieel besluit houdende tijdelijke aanvullende maatregelen voor het jaar 2021 tot het behoud van de visbestanden in zee	2020-12-24/07
MD of 15 June 2021	Ministerieel besluit tot instelling van een veiligheidszone rond de zeeboerderij	2021-06-15/02
Laws		
Law of 19 August 1891	Wet betreffende de zeevisserij in de territoriale zee	1891-08-19/30
Law of 10 October 1978	Wet houdende vaststelling van een Belgische visserijzone	1978-10-10/30
Law of 22 April 1999	Wet betreffende de exclusieve zone van België in de Noordzee.	1999-04-22/47
Law of 5 July 2018	Wet betreffende de pleziervaart	2018-07-05/07

7 Marine aquaculture

Authors Daan Delbare[1], Nancy Nevejan[2], Margriet Drouillon[3], Peter Bossier[2], Thomas Verleye[4], Fien De Raedemaecker[4]

Lectors Karel Vanhulle[5], Lien Loosvelt[6], Senne Aertbeliën[7]

[1] Flanders Research Institute for Agriculture, Fisheries and Food (ILVO)
[2] University Ghent (UGent), Faculty of Bioscience Engineering, Department of Animal Sciences and Aquatic Ecology
[3] Ghent University (UGent), BLUEGent – Innovations in Aquaculture & Blue Life Sciences
[4] Flanders Marine Institute (VLIZ)
[5] Department of Agriculture and Fisheries, Fisheries service
[6] The Blue Cluster (DBC)
[7] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division

Delbare, D., Nevejan, N., Drouillon, M., Bossier, P., Verleye, T., De Raedemaecker, F. (2022). Marine aquaculture. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 123-138.

The term aquaculture covers the rearing or cultivation of aquatic organisms (in fresh, brackish or salt water) using techniques designed to increase the production of the organisms in question beyond the natural capacity of the environment, where the organisms remain the property of a natural or legal person throughout rearing and culture stage, up to and including harvesting (definition in Regulation (EU) 1380/2013). Mariculture, or marine aquaculture, is a specialised branch of aquaculture and includes the cultivation of organisms in a marine environment (FAO 2020). This definition comes from the Food and Agriculture Organisation of the United Nations (FAO) and is thus used in the FAO statistics (FAO Fisheries and Aquaculture Information and Statistics Service 2021). In addition, also aquaculture in areas adjacent to the sea (further referred to as aquaculture in the coastal zone) and land-based aquaculture of marine species are discussed within this thematic chapter.

In 2019, the worldwide aquatic production (through 'wild' fisheries and aquaculture, including macroalgae and other aquatic plants) amounted to 213.7 million tonnes. Aquaculture accounted for 56.2% (120.1 million tonnes) of the total production in 2019 (figure 1), compared to only 16.8% and 31.3% in 1990 and 2000, respectively. This makes aquaculture the fastest growing food production sector worldwide, with an average annual increase of 6.8% since 1990 (figure 1) (FAO Fisheries and Aquaculture Information and Statistics Service 2021).

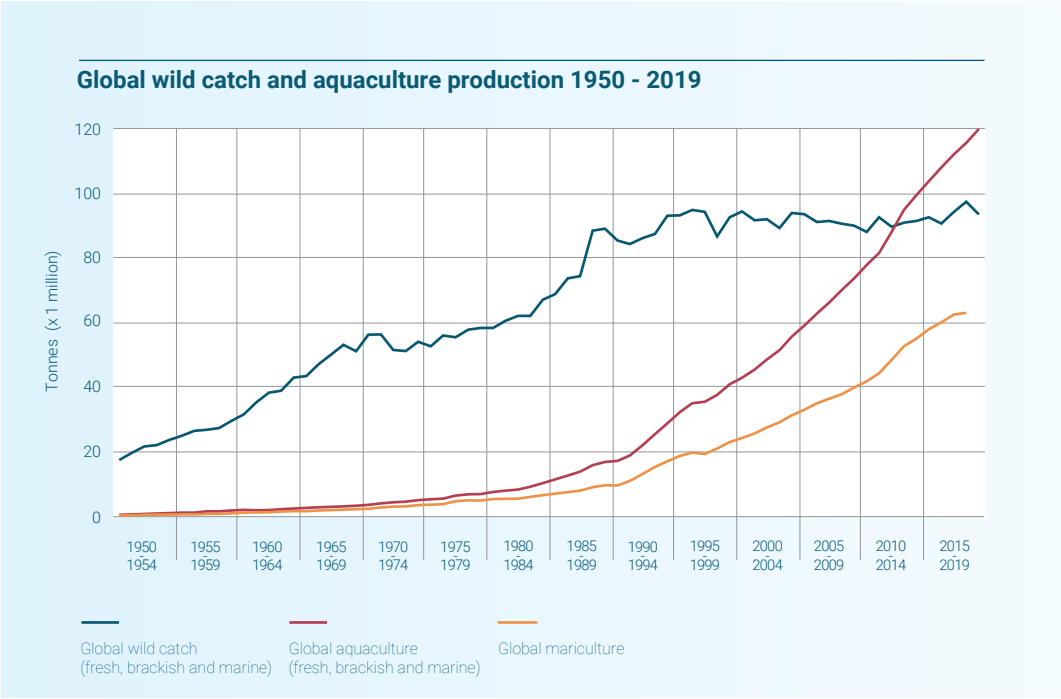


Figure 1. Global aquatic production (tonnes) through wild fisheries and aquaculture (fresh, brackish and marine) between 1950 and 2019 (Source: FAO Fisheries and Aquaculture Information and Statistics Service 2021).

Global mariculture production in 2019 amounted to 66.7 million tonnes, of which 34.6 million tonnes were macroalgae and other aquatic plants. This represents a total production value of 122 billion US dollars (FAO 2020). Europe produced a total of 2.7 million tonnes (4.1%) where the European Union (EU) accounted for only 0.9 million tonnes (1.3%). The main European mariculture producer is Norway (mainly salmon) with a total volume of 1.5 million tonnes, accounting for 53.6% of the European total. While the marine aquaculture production in the EU has stagnated over the past two decades (figure 2), Norway tripled its marine aquaculture production during the same period. The FAO did not record any commercial production of marine species in Belgium in 2019. The importance of freshwater aquaculture in Belgium was limited to a production volume of only 86 tonnes (figure 3) (FAO Fisheries and Aquaculture Information and Statistics Service 2021).

7.1 Policy context

At the European level, the policy concerning aquaculture (including mariculture) is conducted under the umbrella of the Common Fisheries Policy (CFP, Regulation (EU) 1380/2013). The European Commission, more specifically the Directorate-General for Maritime Affairs and Fisheries (DG MARE), coordinates policy and provides strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021-2030 (COM (2021) 236).

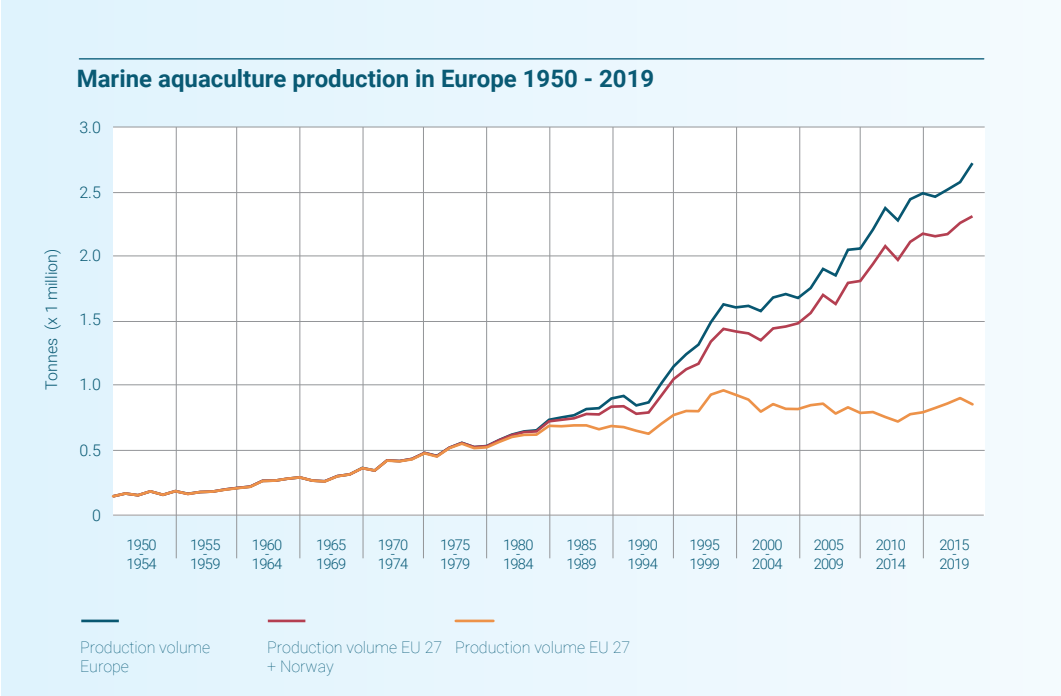


Figure 2. Marine aquaculture production (tonnes) in Europe and the European Union (EU) from 1950 to 2019 (Source: FAO Fisheries and Aquaculture Information and Statistics Service 2021).

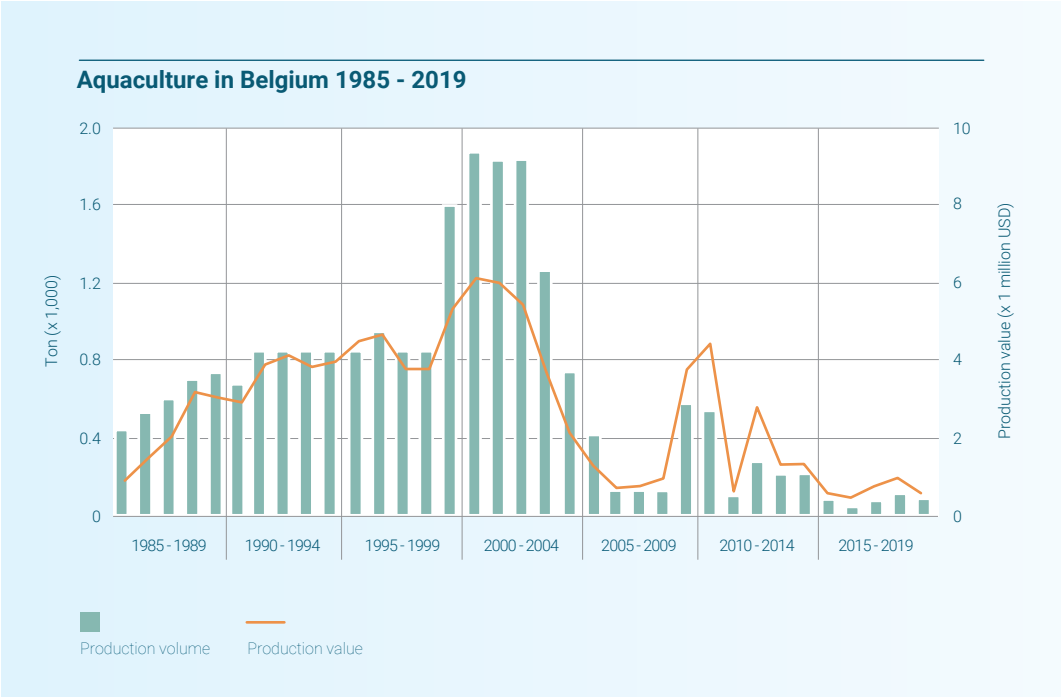


Figure 3. Annual aquaculture production (tonnes) and production value (USD) in Belgium between 1985 and 2019. The time series only include freshwater production as no commercial production of marine species has been recorded by FAO in the period under review (Source: FAO Fisheries and Aquaculture Information and Statistics Service 2021).

It focuses on the following objectives: (1) building resilience and competitiveness, (2) participating in the green transition, (3) ensuring social acceptance and consumer information and (4) increasing knowledge and innovation. An evaluation of the new strategic guidelines will be carried out by 2029, assessing their efficiency, effectiveness, coherence, relevance and EU added value. The farm-to-fork strategy COM (2020) 381 sets out a new approach to ensure that agriculture, fisheries, aquaculture and the entire food-value chain contribute appropriately to reducing

greenhouse gas emissions. Furthermore, sustainable aquaculture is one of the key objectives of the European Maritime and Fisheries Fund (EMFF, Regulation (EU) 508/2014) and the subsequent European Maritime, Fisheries and Aquaculture Fund (EMFAF, Regulation (EU) 2021/1139).

At the Belgian level, the granting of permits and the spatial planning of mariculture activities at sea (seaward side of the baseline) fall under the competence of the federal government (minister for the North Sea / FPS Public Health, Food Chain Safety and Environment). Aquaculture or mariculture infrastructures on Flemish territory (landward side of the baseline) are under the authority of the Government of Flanders. The Fisheries Service of the Policy Coordination and Environment Division (ABCO) of the Department of Agriculture and Fisheries is the managing authority of the Belgian Operational Programme for the implementation of the EMFF[1]. This Operational Programme for the Belgian Fisheries and Aquaculture Sector 2014-2020 includes measures to support aquaculture (summary brochure in Dutch only). These measures must be in line with the Belgian National Strategic Plan for Aquaculture (NSPA) (2014-2020). In order to better coordinate actions to promote aquaculture, EU member states are required to draw up a multi-annual strategic plan on the basis of the EU COM (2013) 229. In the mid-term revision of the plan in 2017, a significant extension was made to mariculture. A renewed Programme for the period 2021-2027 is expected in the course of 2022. Other regulations and competent authorities for mariculture and aquaculture infrastructures are presented on the website of the Flemish Aquaculture Platform.

7.2 Spatial use

7.2.1 Marine spatial planning and mariculture

The marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020) for the Belgian part of the North Sea (BNS) provides the possibility for sustainable mariculture under strict conditions in both the operational wind farms (e.g. Belwind and C-Power) and in the newly demarcated zone for renewable energy (Princess Elisabeth zone) (figure 4). The wind farm concession holders must agree to the installation of mariculture activities (no longer the case for the Princess Elisabeth zone). Furthermore, the mariculture activities must reduce the level of eutrophication within the concession zone and the concession or licensing authority must, where appropriate, safeguard a control zone within the demarcated zone as a reference for the situation without aquaculture activities.

In addition to these zones specifically delineated for marine aquaculture, the MSP 2020-2026 provides an additional five zones for commercial and industrial activities (CIA zones). In these zones, sustainable aquaculture can also be developed alongside other activities, such as renewable energy generation, energy storage, desalination, etc. As stated in the MSP, such activities can only take place if strict conditions are met regarding safety, impact on sea view, impact on naturalness, multiple use of space and impact on other activities. The strategic location of these areas - closer to the coast - may improve the economic feasibility of sustainable aquaculture. On the other hand, the size of these zones is rather limited and there might be competition with other space users.

For commercial aquaculture activities in the sea areas under the jurisdiction of Belgium, a procedure must be followed to obtain an authorisation and permit (RD of 7 September 2003) (see also website of the Royal Belgian Institute of Natural Sciences - Operational Directorate Natural Environment (RBINS-OD Nature)). A permit for use can be obtained from the Marine Environment Service, DG Environment of the Federal Public Service for Public Health, Food Chain Safety and the Environment (procedure in the RD of 22 July 2019 and in the RD of 7 September 2003). For the environmental permit, the application must be accompanied by an environmental impact assessment (EIA) in accordance with the RD of 9 September 2003 covering the regulations on environmental impact assessment in application of the Marine Environment Law of 20 January 1999 (MMM Law, see also thematic chapter **Nature and environment**). Appendix 3 of the MSP 2020-2026 also indicates that a fisheries impact report should be drawn up in the environmental permit procedure for activities within the six nautical mile (nm) radius from the baseline that require a permit. Such an impact report should be drawn up according to the guidelines of the Management Unit of the Mathematical Model of the North Sea (MUMM) of the RBINS. For activities located in Natura 2000 areas, in accordance with the RD of 27 October 2016, a draft of the appropriate assessment (*passende beoordeling*) must be included in the application in order to assess the impact on the conservation objectives set for these Natura 2000 areas. An advice on the environmental permit and Natura 2000 authorisation is formulated by the RBINS-MUMM and sent to the federal minister responsible for the North Sea.

[1] Pending the approval of the Belgian Programme EMFAF 2021 - 2027 (expected in the course of 2022) and the update of the NSPA on the basis of the new strategic guidelines, the current NSPA is still in force. Given the transition period of the EMFF Operational Programme of three years, the objectives of the current NSPA have been formulated until 2023. Some current projects that are still receiving financial support under the EMFF Operational Programme will contribute to the objectives of the current NSPA until 2023.

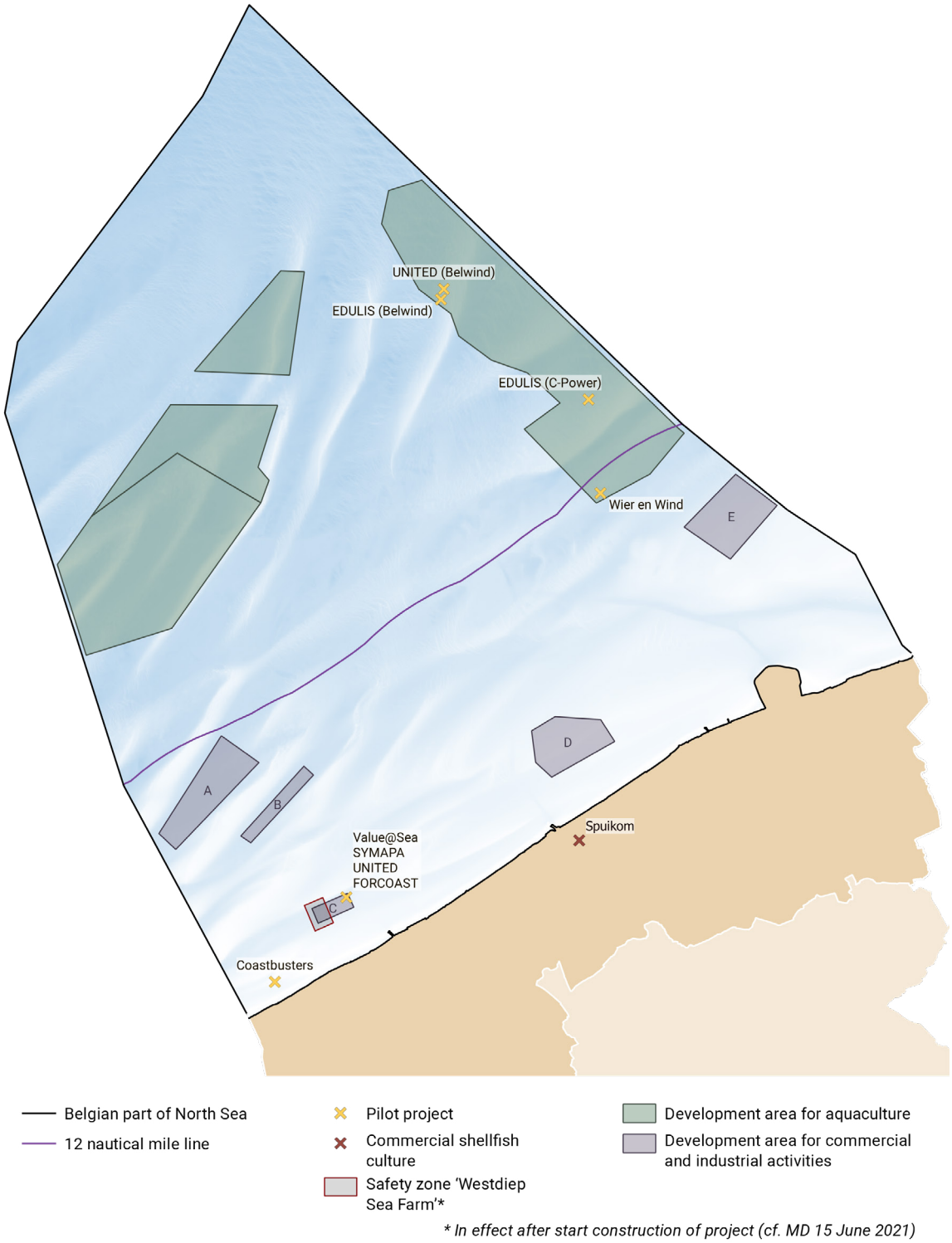


Figure 4. Sites reserved for aquaculture and for commercial and industrial activities in the BNS, including the location of pilot projects (Source: RBINS, MarineAtlas.be (based on the RD of 22 May 2019 (MSP 2020-2026)), Coastal Portal).

Aquaculture at sea involving the introduction of alien species, is subject to the additional procedure of the RD of 21 December 2001 on the protection of species in marine areas under Belgian jurisdiction. RBINS-MUMM is also the competent authority for the application of Regulation (EC) 708/2007 on the use of exotic and locally-absent species.

Shellfish culture must take place in designated production areas where the water quality, if necessary after an action programme, meets certain standards. For the North Sea, these standards have been set by the federal government, and for inland waters by the Government of Flanders. Zones for shellfish culture require special monitoring. The Sluice Dock of Ostend is the only inland waterbody recognised as a facility for shellfish production and therefore has the status of 'shellfish water' (Federal Agency for the safety of the Food Chain (FASFC)).

A coordinated spatial plan for mariculture is considered necessary at EU level (COM (2013) 229) to ensure the sustainable development and growth of aquaculture by reducing uncertainties, facilitating investments and addressing the lack of space. The compatibility of mariculture in the Belgian wind farms has already been investigated theoretically (see **7.5.3 Aquaculture research in Belgium**) and in practice (see **7.2.3 Pilot projects in the North Sea**). The added value of offshore mussel farming and the European market potential is also discussed in a report on the Blue Economy for Flanders (Bilsen et al. 2019).

7.2.2 Commercial aquaculture of marine species in Belgium

Commercial aquaculture in the Belgian coastal zone is currently limited to one commercial company, active in the Sluice Dock of Ostend. It involves the culture of both the flat oyster (*Ostrea edulis*) and the Pacific oyster (*Crassostrea gigas*) (see also Curé et al. 2000). The current aquaculture activities are distributed over two zones of respectively 3 and 4 ha (website Ostend Sluice Dock). The permits for the private use of public domain in the Sluice Dock for aquaculture are issued by the Coastal division of the Agency for Maritime Services and Coast (MDK). The environmental permit is granted by the Environment Department, who has an agreement with the FASFC concerning food chain safety. The Sluice Dock consultation platform coordinates the various Sluice Dock users by means of consensus and, based on this broadly supported consensus, formulates recommendations to the manager/owner, i.e. the Coastal division.

Late 2020, a commercial company acquired a user and environmental permit to develop a sea farm on a commercial scale in CIA zone C, better known as the *Westdiepzone*, at 5 km off the coast of Nieuwpoort and Koksijde (website sea farm)[2]. In total, this sea farm can cover an area of up to 4.5 km^2. A safety zone of 500 m around the first phase of the concession zone must be kept free from shipping from the day the construction phase will start (MB of 15 June 2021). In 2021, the company looked for partners for the installation and maintenance of the mussel lines, the cultivation and harvesting of Belgian mussels, and their processing and packaging. A first limited mussel harvest is expected by autumn 2022 followed by a full Belgian mussel season in 2023. At a later stage, the company also plans to cultivate oysters and seaweed.

Since July 2021, mussels from the *Bancs des Flanders*, harvested just across the French border through a partnership between a Belgian and a French company, have also been on the market (press release). Over the past two decades, a number of initiatives took place to cultivate mussels (*Mytilus edulis*) in the BNS, *inter alia* the 5b project *Vlaamse mosselkwekerij* (1998) and the PESCA project *Vlaamse mosselkweek* (2002). Between 2002 and 2006, offshore mussel cultivation experiments were carried out with private funding and scientifically supported by CLO-DVZ (now the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO)). Independently of this private initiative, a FIFG project (Financial Instrument for Fisheries Guidance) on the commercialisation of Belgian offshore suspended mussel culture was conducted between 2005 and 2008 by the former Foundation for Sustainable Fisheries Development (SDVO). In this project, the production of mussels by means of suspended cultivation in cages, spread over five different areas, was executed and evaluated (Milieu-effectenbeoordeling Mosselcultuur 2005, Delbare 2005, Van Nieuwenhove 2008, ICES 2011). The permit for these areas was granted by the MD of 7 October 2005 following the environmental impact assessment (EIA) (cf. the Law of 20 January 1999 and the RDs of 7 and 9 September 2003). The MD of 8 July 2005 (repealed by the MB of 14 January 2020) provided for a simplified procedure and model form for the determination of the EIA. The cultivated mussels were marketed under the name *Flanders Queen Mussels* and *Belgica mussels*. For the first one, the supply volumes remained very limited and the activity ended in 2010. The commercial production of the *Belgica mussels* started in 2006. The maximum supply was 300 tonnes (2010 and 2011), but production was stopped in 2011. In both projects, the used mussel cages were technically not resistant to the harsh weather conditions in the BNS.

Land-based production of Atlantic salmon (*Salmo salar*) is planned by a Norwegian company, which is pursuing a research collaboration with Ostend Science Park, UGent and Inagro. A production department of 13.5 ha is planned to be established in the port of Ostend starting in 2021, where salmon will be farmed from egg to adult salmon in land-based tanks. From 2023-2024 onwards, a production of 15,000-20,000 tonnes of salmon is expected.

[2] Some parties, including the town of Nieuwpoort, appealed against both permits, but by the end of 2021 no decision had yet been reached.

A final initiative concerns the commercial cultivation of whiteleg shrimp (*Penaeus vannamei*) in land-based closed systems using bio-logging technology. Given the start-up phase and the low production volume to date (400 à 500 kg in 2020), these volumes are not yet recorded in FAO statistics.

7.2.3 Pilot projects in the North Sea

Figure 4 (see **7.2.1 Marine spatial planning and mariculture**) shows the locations reserved for aquaculture and for commercial and industrial activities in the BNS. Scientific pilot projects can also be started outside these areas provided that the necessary permits are obtained.

Given the potential for shellfish and seaweed cultivation in the BNS, as demonstrated by several studies (*Alver et al. 2015*), the 'North Sea Aquaculture' project was conducted during the period 2016-2019 with private, FIVA (Financial Instrument for the Flemish Fisheries and Aquaculture Sector) and EMFF funding. The research project had a threefold objective, namely to innovate cultivation techniques for shellfish and seaweed, to organise efficient use of space in the BNS and to develop a market for new regional marine products. The 'North Sea Aquaculture' project comprised two separate projects/test sites. The (1) Value@Sea project (2017-2019) near the coast of Nieuwpoort, which sought to test the technological, biological and economic feasibility of integrated cultivation of extractive aquaculture species[3]: the flat oyster, scallop (*Pecten maximus*) and sugar kelp (*Saccharina latissima*). The (2) EDULIS project (2016-2018) took place in the Belgian wind farms C-Power and Belwind and investigated the technological, biological and economic feasibility of mussel (*Mytilus edulis*) farming in offshore wind farms. The forces acting on the mussel longline were recorded through integrated force meters to model the movement of the mussel culture system with input from the prevailing currents and wave conditions (Pribadi et al. 2019). This allowed the minimum requirements for a mussel culture system to be determined and the system design to be optimised. Both projects identified the factors that have the greatest impact on the profitability of offshore mussel farming and coastal shellfish and seaweed farming (see press release EDULIS project).

The pilot projects Coastbusters (2016-2019) and Coastbusters 2.0 (2020-2022) off the coast of De Panne explored the use of innovative biostabilisation methods as a coastal defence mechanism, with the aim of achieving natural sand accretion and strengthening the foreshore against coastal erosion (see also thematic chapter **Safety against flooding**). Three concepts were tested, each with the potential to form a natural biogenic reef, namely the use of tubeworms (*Lanice conchilega*), sugar kelp and mussels (Sterckx et al. 2019, Coastbusters 2020, De Corte 2020a, Goedefroo 2020, Sterckx et al. 2020). These projects do not strictly involve aquaculture but use aquaculture techniques as part of nature-based coastal protection.

The Wier en Wind project (2019-2022) aims to realise a large-scale and automated seaweed cultivation system, which can be deployed within the North Sea wind farms. The research focuses on the development of a seaweed cultivation system that is reliable at sea, the testing of different substrates for seaweed attachment and the automation of harvesting.

The SYMAPA project (2019-2022) investigate the possible synergies between mariculture of mussels, flat oysters and seaweed, and passive fishing. With this experimental design, the possibilities of multiple use of space are studied.

The FORCOAST project (2019-2022) aims to provide information services regarding the sectors active in fisheries, bivalve mariculture and oyster grounds restoration. These services include high-resolution data on water quality, meteorological variables in the coastal area and satellite data. One of the pilots takes place in *Westdiep*, where a service module is being developed to determine the optimal timing to deploy oyster spat collectors. Since this service module makes use of sea currents, water temperature and chlorophyll a data, it can also be used for the larval distribution of oyster larvae from various breeding areas.

The UNITED project (2020-2023) promotes the multiple use of offshore space through the installation of demonstration projects, examining technical, regulatory, economic, social and environmental requirements and impacts. One of the pilots is located in Belgium and aims at investigating the development of aquaculture of the native flat oyster and sugar kelp in the Belwind offshore wind farm. Suspended culture systems, which are commercially viable and adapted to harsh conditions, will be used. The pre-operational phase to test the system will be conducted in the *Westdiep*. In addition, the potential of the erosion protection layer of wind turbines to serve

[3] In extractive aquaculture, the cultivated species are not fed, but instead obtain their nutrition (e.g. single-celled microalgae, phytoplankton and other nutrients) from the sea itself. Harvesting the shellfish and seaweeds removes nitrogen and phosphate from the ecosystem and reduces the risk of eutrophication.

as a reef for flat oysters where young hatchlings can settle is being evaluated. In the short term, aquaculture can supply the adults and hatchlings to support the restoration efforts, and in the long term, the developed oyster reefs can supply the aquaculture industry with local seed stock. The restoration of flat oyster reefs has not only become a Belgian, but also a European focus (Native Oyster Restoration Alliance). Seaweed, on the other hand, is cultivated both offshore and nearshore (*Westdiep*) in order to be able to compare nutritional and growth characteristics, sowing techniques and origins of plant material.

Besides these Flemish and European pilot projects at sea, with participation of Flemish/Belgian partners, numerous other research efforts offer a broad view of various aspects of mariculture in the BNS (see **7.5 Sustainable use**).

7.3 Societal interest

For 2018, a total of 12,389 aquaculture enterprises were reported in the EU under the Data Collection Framework (DCF) and the EU Multi-Annual Programme (EU-MAP), accounting for a total employment of 74,634 people or 39,931 full-time equivalents (FTE) (STECF 20-12 The EU Aquaculture Sector - Economic Report 2020). In total, the aquaculture industry produced 1.2 million tonnes in the 27 EU member states, with a turnover of 4.1 billion euro. Marine teleost fishes generated the highest turnover of 1.8 billion euro (45%), followed by shellfish (1.3 billion euro) (31%) and freshwater teleost fishes (1.0 billion euro) (25%). In terms of production volumes, the crustacean sector was the most important (54%), followed by marine teleost fishes (24%) and freshwater teleost fishes (22%) (STECF 20-12 The EU Aquaculture Sector - Economic Report 2020).

In Belgium, the importance of aquaculture production for human consumption is limited, and only 86 tonnes of freshwater species were produced in 2019 with a value of around 1.0 million euro (figure 3) (FAO Fisheries and Aquaculture Information and Statistics Service 2021). Until now, the core of the Belgian aquaculture industry was located in Wallonia, where mainly trout is farmed (an aquaculture branch not covered in this thematic chapter). A public register of all aquaculture companies in Belgium is published by the FASFC. As of 2021, Flanders is estimated to produce (slightly) more than Wallonia. The Flemish Aquaculture Platform lists about 36 Flemish companies, but these are not only producers. The list also includes specialised feed companies, distributors of aquaculture products and consultancy firms. The most important freshwater aquaculture products are the so-called omegabaars (jade perch, *Scortum barcoo*), pikeperch (*Sander lucioperca*) and caviar (e.g. Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), beluga (*Huso huso*) and starlet (*Acipenser ruthenus*)) (Van Bogaert et al. 2021). The producers are active in land-based aquaculture and use closed RAS systems (Recirculating Aquaculture Systems). Marine aquaculture in Belgium is rather limited for the time being. Oyster farming in the Sluice Dock of Ostend is the only commercial shellfish culture that takes place in the Belgian coastal zone. The whiteleg shrimp farm in Ternat is the only land-based aquaculture of marine species.

Belgian production accounts for only 0.01% of EU production (EUMOFA 2021). No separate figures are available for Flanders. Employment in the primary Belgian aquaculture sector was estimated at 60 FTE in 2014, while the supplying sector accounted for an additional 78 FTE (Platteau et al. 2014). No more recent figures are available.

Historically, the cultivation of flat oysters along our coast was of considerable commercial importance (Pirlet 2012). Especially the Ostend Oyster (*l'Ostendaise or Royal Ostendaise*) enjoyed worldwide fame. Shortly before the First World War, oyster farming reached its peak with 26 oyster parks along the Belgian coast. Annually, 30-35 million oysters were imported from England and further cultivated in the Belgian oyster pits (Halewyck and Hostyn 1978, Polk 2002). The two world wars and the increasing pollution of the sea caused a strong decrease in the number of oyster farms and finally resulted in the almost complete disappearance of domestic oyster breeding today. An overview of these activities can be consulted on the website of the history of Belgian oyster farming (2016).

7.4 Impact

The increasing demand for food and the competition for space and clean water has led to more fundamental research on how the ocean can feed a growing world population. Several publications point to the need for a shift from land-based and coastal aquaculture production to sustainable offshore production systems (Lovatelli et al. 2013, Kapetsky et al. 2013, Costello et al. 2020, Costello et al. 2021). This also highlights the importance of integrated multitrophic mariculture (IMTA) (e.g. Bollengier 2016, Blue Bioeconomy report 2020, Knowler et al. 2020) as a mitigation approach against the excess generation of nutrients and organic matter by intensive mariculture activities (e.g. Soto 2009, Report of the Global Conference on Aquaculture 2010 (FAO 2012), Sorgeloos 2013, Buck et al. 2017). By breeding species from lower trophic levels and optimising food and nutrition strategies, the

impact on the ecosystem is minimised and long-term sustainability is pursued (JRC 2016). Non-fed mariculture, including seaweed production, is currently highly underdeveloped in contrast to its benefits and biological and economic potential (Stuchtey 2020, Seaweed revolution 2020). Other recommendations related to offshore aquaculture, fish feed and aquaculture technologies were formulated in the Bremerhaven Declarations of 2012 (Part I, Part II) and 2013 (Part I, Part II). Furthermore, the FAO's Blue Growth initiative emphasises the three pillars of sustainable development - economic, environmental and social - so that fisheries and aquaculture contribute to the Sustainable Development Goals (SDGs) of the United Nation's 2030 Agenda (Achieving Blue Growth (FAO 2018)). The Scientific Advisory Report (EC) Food from the Oceans (2017) also provides a framework on how more food (biomass) can be extracted from the ocean in a sustainable way and also formulates some policy recommendations to this end. The report pursues aquaculture with a focus on lower trophic levels and identifies mariculture as the sector with the greatest potential to meet the growing food demand.

Other voices are more critical with respect to the scientific debate and their expectations of mariculture within the 'Blue Growth' policy discourse, and advocate the sustainable cultivation of freshwater organisms to meet the growing food demand (Belton et al 2020, van der Meer 2020).

Mariculture can - provided the right approach and strategy - provide several positive effects for the ecosystem and its users (e.g. FAO 2020, HLPE 2014, European Commission 2018). In addition to contributing to global food security, aquaculture offers potential benefits for public welfare, the economy and the environment, such as:

- Sustainable and locally produced food (Stentiford et al. 2020);
- Healthy food;
- Infrastructure and employment (including fish processing companies) (WorldFish 2015, Slater 2017, FAO 2020);
- Mariculture of extractive species can reduce nutrient pollution in coastal waters (Chopin and Tacon 2020) and thereby create a remedial potential for the higher trophic species;
- Mariculture can contribute to the protection of the coastline and stabilise coastal vegetation and sediments (Zhu et al. 2020, Gentry et al. 2019);
- Lower environmental impact and lower CO_2 emissions if mariculture were to replace land-based animal protein production (Costello et al. 2021);
- Seaweed can be a bioresource of high quality components for human consumption (Pycke and Faasse 2015, Pycke et al. 2018);
- Seaweed can be used as raw material for the production of non-food: bio-based materials (Groenendaal et al. 2021), bio-active components for cosmetics or pharmaceuticals, feed for farmed fish or cattle and biofuels (Buck et al. 2017) (see also **7.5.3.3 New valorisation routes**);
- Non-fed mariculture, such as shellfish and seaweed, can support wild fish species by creating artificial habitats and refuges (Theuerkauf et al. 2021, Alleway et al. 2019, Gentry et al. 2019).

Mariculture at sea can also have a number of undesirable effects on the environment and on the users of the sea, depending on the technique used and the organisms cultivated. The potential negative effects of mariculture (fish and shellfish) are extensively addressed in international publications such as OSPAR 2010, FAO 2012, European Commission 2012, Brenner et al. 2014 and FAO 2018. At a national level, this aspect is addressed in the Milieu-effectenbeoordeling Mosselcultuur (2005), De Wachter and Volckaert (2005) (GAUFRE project BELSPO), Goffin et al. (2007), the Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische Visserijsector 2014-2020 and the Milieueffectenrapport van de zeeboerderij Westdiep (2020).

Some of the potentially negative effects are:

- Modifications to the natural nutrient flux by, *inter alia*, excretion of organic nitrogen compounds;
- Input of nutrients and organic enrichment;
- Influx of pollutants, litter and hazardous substances (Sandra et al. 2020);
- Disturbance of the seabed;
- Changes in hydrological conditions;
- Introduction of non-indigenous species and spread of non-indigenous species by acting as 'stepping stones' in the rearing facility (see also Verleye et al. 2020);
- Spread of diseases and parasites between farmed and wild stocks;
- Genetic contamination of wild populations;
- Impact on marine mammals and fish that may become entangled in the nets or other aquaculture infrastructures;
- Large-scale cultivation of seaweed can cause nutrient deficiencies with negative effects on the entire food web (van der Meer 2020);
- Impact on other users due to parts of the installation coming loose, litter, increased shipping, etc.

7.5 Sustainable use

7.5.1 International and European developments

The EU strategy for Blue Growth (COM (2012) 494) identified aquaculture as a sector with the potential to stimulate economic growth and generate employment throughout Europe. In order to unlock the potential of aquaculture in the EU and overcome the stagnation, the communication COM (2013) 229 identified four priority areas. These guidelines were the main pillar of the strategic coordination of EU aquaculture policy in the period 2014-2020:

- Simplify administrative procedures;
- Securing sustainable development and growth of aquaculture through coordinated spatial planning;
- Enhancing the competitiveness of EU aquaculture;
- Promoting a level playing field for EU operators by exploiting their competitive advantages (e.g. strict environmental regulation, food safety, consumer protection, social legislation).

Communication COM (2021) 236 reviews the aforementioned strategic guidelines for the sustainable development of EU aquaculture. These guidelines are the main pillar of the strategic coordination of EU aquaculture policy in the period 2014-2020. This new communication paves the way for EU aquaculture to become a resilient and competitive reference sector that will set a global standard in terms of sustainability and quality. In communication COM (2020) 381, the EC stipulates an action plan for the sustainable exploitation of marine resources. Europe is also establishing regulations for an aquaculture-friendly environment to ensure the health of aquatic animals and the safety and quality of aquaculture products.

The CFP also aims to promote the aquaculture sector. The competitiveness of the EU should be strengthened by improving the organisation of markets and by making full use of the EMF(A)F (see also thematic chapter **Fisheries**) to draw up and implement production and marketing plans and to strengthen the links between research and development (R&D) and the aquaculture sector. Within the EMFF 2014-2020, 'Union Priority 2' aims to promote environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture. The 'Aquaculture Advisory Council', established in 2016 and consisting of representatives of the aquaculture industry and other stakeholders, will further strengthen this cooperation (Regulation (EU) 2015/242 and Regulation (EU) 2017/1575).

Additionally, the EC provides support to member states to address barriers (due to procedures and regulations) in order to avoid obstacles in the development of the sector. For example, in 2016 a document was published on the application of the Water Framework Directive (WFD, Directive 2000/60/EG) and the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EG) in relation to aquaculture (European Commission 2016). Furthermore, Europe has produced guidance on the relationship between aquaculture and Natura 2000 sites (European Commission 2012). These guidelines should (1) provide a better understanding of conservation objectives, (2) promote good practice and (3) indicate how sustainable aquaculture and nature conservation can be compatible with each other.

Reducing marine litter is essential for the conservation and sustainable use of the oceans. On a global scale, little is known about the impact of aquaculture activities on the presence of marine and beach litter (FAO 2017, Huntington 2019, Sandra et al. 2020, Skirtun et al. 2021). On a European level, Directive 2019/904/EU requires member states to develop extended producer responsibility schemes for single-use plastic products for which no suitable and more sustainable alternatives are available. Besides, the European Parliament's (Chabaud 2021) advocates a systematic approach to tackle the impact of marine litter on the fisheries and aquaculture sector.

7.5.2 Federal and Flemish developments

At the Belgian level, mariculture activities have to comply with the Law of 22 April 1999 concerning the exclusive economic zone (EEZ) of Belgium in the North Sea and the Law of 20 January 1999 (MMM Law) relating to the protection of the marine environment and the organisation of marine spatial planning in the marine areas under Belgium's jurisdiction (see also thematic chapter **Nature and environment**). Several Implementing Decrees related to mariculture have been published under the MMM Law, such as the RD of 9 September 2003 on the environmental impact assessment, the RD of 7 September 2003 on the permit and authorisation procedure, the RD of 23 June 2010 on marine strategy and the RD of 23 June 2010 on achieving good surface water status. The RD of 18 May 2008 stipulates that an environmental impact assessment is required for the National Operational Plan regarding mariculture in marine areas under Belgian jurisdiction. A list of the Belgian/Flemish regulations to minimise the impact of aquaculture and mariculture facilities on the environment, is provided on the website of the Flemish Aquaculture Platform.

Like all EU member states, Belgium also has a national aquaculture strategy, in line with the non-binding strategic Union guidelines and as required by Art. 34 (2) of the CFP. This plan acts as the foundation for the realisation of Union priority 2 of the Operational Programme 2014-2020 (see also Department of Agriculture and Fisheries 2016). It aims to promote environmental sustainability, resource efficiency, innovation, competitiveness and knowledge-based aquaculture. The Operational Programme provides a SWOT analysis and an impetus to policy priorities for the Belgian aquaculture sector. With regard to this Union priority, Flanders wants to focus on the following objectives (Department of Agriculture and Fisheries 2016):

- Stimulate technological development, innovation and knowledge transfer;
- Promote competitiveness and viability of aquaculture companies, including the improvement of safety and working conditions;
- Protection and restoration of aquatic biodiversity and the promotion of aquaculture related ecosystems and resource efficient aquaculture;
- Promote aquaculture with a high level of environmental protection, animal welfare and health, public health and safety;
- Development of professional training and skills.

In preparation for the publication of the new European strategic guidelines for aquaculture (2021-2030) and the new EMFAF Regulation (2021-2027), the necessary preparations were made in Flanders and Wallonia in 2020 to update the National Strategic Plan for Aquaculture (NSPA 2017). The renewed NSPA for the period 2021-2030 will be published in the course of 2022, after approval of the included measures that are also reflected in the EMFAF programme (2021-2027). The NSPA describes, on the one hand, the common strands between the Flemish and Walloon regions and, on the other hand, discusses in more detail the regional points of interest.

The Coalition Agreement from the Flemish Government 2019-2024 and the Policy brief Agriculture and Fisheries 2019-2024 clearly state that aquaculture is a promising sector for Flanders and advocate active support to develop a strong, innovative and sustainable Flemish aquaculture sector. Furthermore, the Flemish Parliament developed a proposition for a resolution on the development of sustainable and integrated aquatic and mariculture in Flanders (2021) advocating for a continuation of policy embedding of this sector with concrete proposals in the area of:

- General and legislation-related matters;
- Knowledge, research, sharing of expertise and practice-oriented;
- Innovation, profitability and support for companies.

The Flemish Aquaculture Platform aims to stimulate and facilitate the development of the Flemish aquaculture sector, outlines the aquaculture landscape (trends and developments) in Flanders and acts as the information channel on aquaculture for entrepreneurs and researchers. In 2012, the Strategic Aquaculture Steering Group (SSAQ) was established under the framework of the Flemish Aquaculture Platform. This steering group brings together all levels of the aquaculture sector to further develop and adjust strategic choices where needed. Furthermore, it provides an aquaculture consultant to guide concrete projects and to promote networking. At the Flemish level, a bottleneck analysis and recommendations to facilitate sector development were published by the Court of Audit: Aquacultuur in Vlaanderen (2013). Through a participatory trajectory in 2021, coordinated by the Blue Cluster, the bottlenecks, needs and recommendations concerning the legislation and regulations on the Flemish and federal level were identified in order to realise a local, sustainable and innovative growth of mariculture (Blue Cluster 2021).

In cooperation with the Flemish aquaculture sector, the impact of aquaculture on marine litter is being mapped and possible remedial measures are being developed and applied. This is included in measure 13 of the Flanders Integrated Action Plan on Marine Litter (OVAM 2017).

7.5.3 Aquaculture research in Belgium

Several (scientific) institutions and companies conduct research on the sustainable development of aquaculture in Flanders and the BNS (see Flemish Aquaculture Platform). The research projects on marine aquaculture can be divided into four themes: (1) optimisation of the (local) supply chain, (2) innovation in production systems, (3) new valorisation routes and (4) land-based aquaculture. This division runs partly in parallel with the roadmap on sea food and marine biotechnology of the Blue Cluster (DBC). This spearhead cluster of the Government of Flanders focuses on a sustainable and innovative Blue Economy, and has developed this roadmap with the objective of increasing the consumption of locally produced marine food and fulfilling the potential of marine biorefinery.

7.5.3.1 Optimisation of the (local) supply chain

Research on the optimisation of the (local) supply chain is essential to guarantee local stocks of breeding and hatching material with a view to monitoring safety, quality and volumes. At present, there is no local hatchery material available in Flanders for the supply to aquaculture installations at sea. The projects in table 1 focus on research on the optimisation of the (local) supply chain.

Table 1. Past and current aquaculture projects, with participation of a Belgian partner, on the optimisation of the (local) supply chain.

Project and duration	Description
Aquavlan (2009-2014)	This project aimed at building the foundations for an economically, socially and ecologically sustainable aquaculture sector in the Flemish-Dutch border region. The project focused specifically on the sustainable farming of shellfish, fishes and the cultivation of saline vegetables.
Aquavlan2 (2016-2019)	This follow-up initiative supported companies in the aquaculture and greenhouse horticulture sectors with technical innovation.
BlueMarine³.com (2019-2022)	This project focuses on improving knowledge on hatchery technology for different species groups (seaweed, molluscs and crustaceans). Innovation is actively pursued for both biological and technological aspects, with a strong emphasis on the integrated multi-species approach, i.e. developing synergies and integration between species, infrastructure, breeding techniques and management.

7.5.3.2 Innovation in production systems

Innovation in production systems includes research on the multiple use of space, Aquaculture 4.0 and sustainable seeding and harvesting systems. The integration of aquaculture with other offshore activities is a research topic that received already quite some attention in the past. The use of innovative materials, technologies and data management in aquaculture is called Aquaculture 4.0. This technological revolution is necessary to improve efficiency and performance and increase sustainability in an environment subject to climate change (García-Poza et al. 2020). The implementation of methods or technologies for more sustainable and efficient harvesting of biomass is an area of research that is receiving increasing attention. The projects in table 2 focus on the above research themes.

Table 2. Past and current aquaculture projects, with participation of a Belgian partner, on the innovation in production systems.

Project and duration	Description
MARIPAS (2009-2010)	This project investigated the multi use of mariculture and offshore wind farms (Verhaeghe et al. 2011 and Alver et al. 2015).
AquaValue (2014-2015)	This project developed a roadmap for aquaculture in Flanders and investigated the integration of aquaculture with other offshore activities. Four pilot projects were launched providing a strong stimulus for the development of a sustainable, integrated aquaculture sector in Flanders. These projects formed the basis for a number of concrete follow-up projects that have been implemented at sea and on land (Value@Sea, EDULIS, Coastbusters and BlueMarine³.com).
PERSUADE (BELSPO) (2017-2021)	The focus of this project was on the functioning of the coastal ecosystem under the influence of the combination of both local and global stressors, including the operation of wind farms and mussel farming.
MPVAQUA (2019-2022)	The industrial research project focuses on innovative marine floating photovoltaic (MFPV) technologies for offshore electricity production in a harsh marine environment, possibly in synergy with aquaculture.
D4PV@Sea (2019-2020)	A toolbox was developed within this project for the assessment and integration of social and spatial risks of multifunctional marine infrastructure.
BIOGEARS (2019-2022)	Within this project, bio-based and biodegradable ropes are being developed in collaboration with a Belgian partner for European aquaculture. Besides the technical evaluation of the ropes for seaweed and mussel cultures, attention is also paid to sustainability and economic feasibility.
AlgaeDemo (2019-2021)	The project aims to demonstrate the sustainable, large-scale industrial cultivation of selected seaweed species in the open sea, equipped with automatic seeding, harvesting and monitoring systems.

Project and duration (continuation)	Description
AQUA-LIT (2019-2021)	The project has developed a toolbox of innovative ideas and methodologies at the European level (Vidal et al. 2020) to prevent litter from aquaculture activities. This project provides the necessary knowledge base on the identification of litter items that can be associated with aquaculture activities (Sandra et al. 2020) and stakeholder recommendations (De Raedemaecker et al. 2020) in order to design concrete policy measures (Devriese et al. 2019, Hipolito et al. 2020).
MARCOS (2020-2021)	This project investigated the potential of large-scale offshore aquaculture (LSOA) and its wave attenuation effect.

7.5.3.3 New valorisation routes

The research into new valorisation routes for marine species will also have an impact on mariculture developments in the longer term. A first step in this respect is the screening of marine species for valorisable components for high-value applications. The development of refining processes and production schemes and the marketing of marine products are also linked to this. Table 3 summarises the projects investigating these themes.

Table 3. Past and current aquaculture projects, with participation of a Belgian partner, on new valorisation routes.

Project and duration	Description
EnAlgae (2011-2015)	Within this project, a network of pilot installations for the cultivation of microalgae was built to investigate the valorisation potential as biomass for renewable fuel.
De Blauwe Keten (2015-2018)	The project focused on the development of a complete chain, from cultivation to market product, for the saltwater alga *Spirulina*.
SeaConomy (2016-2018)	The economic feasibility of local seaweed farming was studied in the desktop project of a multidisciplinary consortium of companies, sector organisations and government agencies (Pycke et al. 2018).
Blueshell (2017-2019)	The project investigated bioactive substances from shellfish for applications as food additives and growth promoters in strawberry cultivation. Residue streams from existing aquaculture productions may be valorised through this research scope.
Zeebes (2017-2019)	This project conducted research into the presence of interesting bioactive substances in shellfish for pharmaceutical and nutraceutical applications. In addition, the project also investigated a pilot process for the (re)production of tunicates as well as the technology and analyses for obtaining an economically feasible process of processing and drying these organisms for bulk applications in aquaculture feeds.
Study on growth conditions of European seaweeds (2018-2019)	This study on growth conditions of European seaweeds in the context of aquaculture created habitat suitability maps for a selection of European seaweed species based on ecological modelling (Westmeijer et al. 2019). Species-specific growth was quantified as a function of temperature, salinity, light and nutrients. In addition to identifying regions with favourable growth conditions for seaweed cultivation, climate scenarios were considered to assess how these regions will evolve in the future.
ValgOrize (2019-2021)	The project investigated the valorisation of seaweed and microalgae as food for the European market.
PROBIO (2019-2022)	The project focuses on bioprospecting and characterisation of bioactive substances originating from local North Sea species. Through a value chain approach, the project aims to simultaneously stimulate new applications and markets for aquaculture, biorefinery and biotechnology.
EffSep (2019-2024)	The project also focuses on the valorisation of by-products and aims to acquire knowledge on biomass stabilisation and extraction of macro-components (proteins, polysaccharides and lipids) from different types of biomass (including microalgae) while maintaining the functionality of these macro-components.

7.5.3.4 Land-based aquaculture

Land-based aquaculture of marine species is being investigated for the brown shrimp (*Crangon crangon*), as there is a niche market for live or large specimens of this species (Delbare et al. 2015). Research on other marine species on land has also gained interest in recent years (table 4).

Table 4. Past and current aquaculture projects, with participation of a Belgian partner, on land-based aquaculture.

Project and duration	Description
Shrimpbreed (2020-2022)	The project investigates the scaling-up of hatchery techniques and system development for farming to commercial product in so-called Shallow Raceway Systems, as well as the economic feasibility and marketing of live brown shrimp.
BioRAS kaviaar (2020-2023)	The project wants to develop, optimise and validate the integrated cultivation of the whiteleg shrimp (*P. vannamei*) and the macroalgae *Caulerpa lentillifera* (also called green caviar) in combination with a smart monitoring system. This will be examined both in a recirculation system (RAS) and an organic flocculation system.
SEACROPS (2021-2022)	This project aims to optimise the land-based large-scale cultivation of macroalgae.

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Communications			
COM (2007) 575	Communication from the Commission: An Integrated Maritime Policy for the European Union	2007	575
COM (2012) 494	Communication from the Commission: Blue Growth - opportunities for marine and maritime sustainable growth	2012	494
COM (2013) 229	Communication from the Commission: Strategic Guidelines for the sustainable development of EU aquaculture	2013	229
COM (2020) 380	Communication from the Commission: EU Biodiversity Strategy for 2030 - Bringing nature back into our lives	2020	380
COM (2020) 381	Communication from the Commission: A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system	2020	381
COM (2021) 236	Communication from the Commission: Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030	2021	236
Directives			
Directive 91/676/EEC	Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (Nitrate Directive)	1991	676
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild flora and fauna (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for community action in the field or water policy (Water Framework Directive)	2000	60
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive 2010/75/EU	Directive on industrial emissions (integrated pollution prevention and control)	2010	75
Directive (EU) 2019/904	Directive on the reduction of the impact of certain plastic products on the environment	2019	904
Regulations			
Regulation (EC) 708/2007	Regulation concerning use of alien and locally absent species in aquaculture	2007	708
Regulation (EC) 762/2008	Regulation on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96	2008	762
Regulation (EU) 1380/2013	Regulation on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC (Common Fisheries Policy)	2013	1380
Regulation (EU) 508/2014	Regulation on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (EMFF Regulation)	2014	508
Delegated Regulation (EU) 2015/242	Commission Delegated Regulation laying down detailed rules on the functioning of the Advisory Councils under the Common Fisheries Policy	2015	242
Regulation (EU) 2016/429	Regulation on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law')	2016	429

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
Regulation (EU) 2021/1060	Regulation laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy	2021	1060
Regulation (EU) 1139/2021	Regulation establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004	2021	1139

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Royal Decrees		
RD of 21 December 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
RD of 7 September 2003	Koninklijk besluit houdende de procedure tot vergunning en machtiging van bepaalde activiteiten in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-07/32
RD of 9 September 2003	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling in toepassing van de wet van 20 januari 1999 ter bescherming van het mariene-milieu in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-09/30
RD of 18 May 2008	Koninklijk besluit tot vaststelling van het feit dat een beoordeling van de gevolgen op het milieu vereist is voor het nationaal operationeel programma voor de visserijsector en dat een beoordeling van de gevolgen op het milieu niet vereist is voor het nationaal strategisch plan voor de visserijsector	2008-05-18/32
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
RD of 22 July 2019	Koninklijk besluit tot vaststelling van de procedure tot het bekomen van een gebruiksvergunning voor de zones voor commerciële en industriële activiteiten in de zeegebieden onder de rechtsbevoegdheid van België	2019-07-22/17
Ministerial Decrees		
MD of 7 October 2005	Ministerieel besluit houdende verlening aan de AG haven Oostende van een vergunning voor de productie van tweekleppige weekdieren door middel van hangstructuren in de zones Z1, Z2, Z3 en Z4 in de zeegebieden onder rechtsbevoegdheid van België	
MD of 14 January 2020	Ministerieel besluit tot opheffing van ministeriële besluiten betreffende de vereenvoudigde procedure voor opstellen van het milieu-effectenrapport	2020-01-14/02
MD of 15 June 2021	Ministerieel besluit tot instelling van een veiligheidszone rond de zeeboerderij	2021-06-15/02
Laws		
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 22 April 1999	Wet betreffende de exclusieve zone van België in de Noordzee	1999-04-22/47

8 Agriculture

Authors Tom Van Bogaert[1], Frank Stubbe[2], Sylvie Danckaert[1], Stijn Vanderheiden[3], Els Demuynck[1], Jonathan Platteau[1], Matthias Sandra[4], Steven Dauwe[4]

Lectors Lode Tanghe[5], Pieter De Graef[6]

[1] Department of Agriculture and Fisheries
[2] Flemish Land Agency (VLM)
[3] Department of Environment and Spatial Development
[4] Flanders Marine Institute (VLIZ)
[5] Province of West Flanders, Dienst Economie en Internationale Samenwerking
[6] Strategic Advisory Council for Agriculture and Fisheries (SALV)

Van Bogaert, T., Stubbe, F., Danckaert, S., Vanderheiden, S., Demuynck, E., Platteau, J., Sandra, M., Dauwe, S. (2022). Agriculture. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 139-151.

The Flemish agricultural sector is subject to strong economic, ecological and social changes (SALV 2017, LARA 2018, 2020, NARA 2020). Increasingly pronounced global warming, with more frequent and more intense heat waves and droughts, also contribute to this (IPCC 2019, Droogterapporten VMM). Coastal agriculture[1] is no exception and has experienced some noticeable changes in recent years (Regions datasets West Flanders Development Agency, provincies.incijfers.be, Department of Agriculture and Fisheries, Rede Gouverneur 2019). For example, there is a shift from traditional farm-based agriculture to large-scale, digital and sustainable agricultural practices, and cultivated land[2] is increasingly being used as a private garden or horse pasture. In addition, the sector is constantly seeking a balance with other user functions such as urbanisation, other economic developments and nature development. Nevertheless, as an inseparable part of the agro-food system, agriculture in the coastal zone still has an important economic value (Department of Agriculture and Fisheries). Many ecosystem services linked to agriculture also offer important societal advantages. Coastal agriculture forms a green oasis with various recreational assets, it is important in terms of water regulation and it offers a unique landscape with a typical biodiversity[3]. The large-scale historical land reclamations that resulted in today's typical landscape of waterways, dikes and agricultural landscapes with permanent grasslands have their origin in agriculture (Soens 2009).

However, agricultural activities also exert a significant impact on the marine environment. In particular, the nutrients (mainly nitrogen (N) and phosphorus (P)) coming from manure pose a problem. The situation is especially problematic in the southern part of the North Sea, the English Channel and close to shore (OSPAR Commission 2017) The most recent assessment of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) shows that about 30% of our North Sea contains an excess of nutrients (Desmit et al. 2018). The eutrophication problem however, is not entirely related to coastal agriculture. Nutrients from inland areas that reach the coast via waterways, also contribute to this problem. Conversely, marine influences can also put pressure on coastal agriculture, particularly through salinisation of the soil (TOPSOIL). However, there may be opportunities in the shape of halophile crops and smart water management (SALFAR, Rede Gouverneur 2019, Internet of Water).

8.1 Policy context

Within the framework of the European Green Deal (COM (2019) 640), the European Commission proposed a Farm-to-Fork Strategy (COM (2020) 381) for a fair, healthy and environmentally friendly European food system. This strategy includes both regulatory and non-regulatory initiatives, with the Common Agricultural and Fisheries Policy as the main instrument to support an equitable sustainable transition.

The Common Agricultural Policy (CAP) is the core of European agricultural policy and is determined by the Directorate-General for Agriculture and Rural Development (DG AGRI) of the EC, the European Council and the European Parliament (more information: De Europese Unie in het kort: landbouw 2017). A new CAP (2021-2027) will come into force in 2023, until then there is a transitional period. Unlike the CAP 2014-2020, Pillar I (income support and market measures) and II (rural development[4]) will be compiled in a single Strategic Plan (Flemish Rural Network, Department of Agriculture and Fisheries). The new CAP is based on nine objectives and aims at a vital and fully sustainable agricultural sector that can respond to major contemporary challenges such as climate change and biodiversity loss (IPCC, EEA 2020).

At the Flemish level, the agricultural policy is outlined by the Flemish minister of Agriculture (see also policy paper Agriculture and Fisheries 2019-2024), advised by the Strategic Advisory Council for Agriculture and Fisheries (SALV) and the Environment and Nature Council (Minaraad). The agricultural policy is oriented around eight strategic objectives that should guarantee a fair and viable income for the farmer towards a sustainable agricultural model. The policy also focuses on innovative business models, organic farming, agro-environmental/climate measures, agro-ecology, and wants to support and stimulate short-chain farming (more on the current Flemish (policy) initiatives concerning the greening of agriculture, see **8.5 Sustainable use**). The Department of Agriculture and Fisheries is responsible for preparing, implementing and evaluation of the policy. The policy is supported by the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), the Flanders Agricultural Marketing Board (VLAM) and the SALV.

[1] Unless stated otherwise, the coastal zone comprises the ten coastal municipalities (Blankenberge, Bruges, Knokke-Heist, Bredene, De Haan, Middelkerke, Ostend, De Panne, Koksijde and Nieuwpoort) and nine hinterland municipalities (Damme, Jabbeke, Zuienkerke, Diksmuide, Lo-Reninge, Gistel, Oudenburg, Alveringem and Veurne).
[2] Cultivated land includes the space occupied by the crop as well as the associated uncultivated areas: meadows, hedges, verges, passages, etc.
[3] Because of the marine focus, the ecosystem services mentioned will not be discussed further here. The issues concerning tourism and recreation, and nature in the coastal area are dealt with in the respective thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).
[4] Up to 2020, this was implemented through the Rural Development Program III (VLM, Department of Agriculture and Fisheries).

The provincial agricultural policy is governed by three bodies: the Provincial Executive for Agriculture, the Beleidskern Economie and Inagro (policy implementation, practice-oriented research and advisory services). The provinces play an important role mainly through practice-oriented research and information centres. Moreover, the Province of West Flanders also supports innovation and short-chain agriculture. The provincial authorities also have indirect responsibilities with regard to permit policy, spatial planning and the maintenance (carried out by the public polder authorities) of 2nd category unnavigable waterways (see also websites Province of West Flanders, Meerjarenplan 2020-2025, Inagro, Waterlopenbeheer West-Vlaanderen).

Additionally, agricultural policy is connected to other policy areas and bodies such as the Flemish environmental policy (inspiration note) and the Federal Agency for the Safety of the Food Chain (FASFC). More on the developments in international/European and Flemish agricultural policy can be found in LARA 2014, 2018, 2020 and Investeren in landbouw in België: 2014-2016 (2016). In the Codex Coastal Zone, theme Agriculture, you can find a comprehensive overview of the legal context related to agriculture.

8.2 Spatial use

The space reserved for agricultural activities in the coastal zone is under pressure due to strong urbanisation, other economic developments (e.g. port activities Zeebrugge) and increasing nature protection efforts. In Flanders, the areas reserved for agricultural purposes are registered in the Flemish Spatial Structure Plan (RSV) as 'agricultural structures'. The mandatory regulations of the RSV demand that the Flemish Region demarcates a specific area for agriculture (750,000 ha), as well as for nature and forest in the regional spatial structure plans or in the regional Spatial Implementation Plans (RSIPs, Geopunt Flanders). Regional plans were reaffirmed in case of a consensus between nature, forest and agriculture (AGNAS-strategy). In addition to the demarcation in the RSV and the reaffirmation of the agricultural area, it is possible to further refine this demarcation through the Spatial Implementation Plans (SIPs). The proposed timing of ten years to complete this demarcation (foreseen in 2007) was not achieved. This is due to the size of the assignment, the interference with other spatial processes and the area-specific consultation in drawing up the plans to implement the zoning changes (SIPs). Despite the fact that the deadlines have passed, the Flemish Department of Environment and Spatial Development (OMG) continues to work on this demarcation.

The process of the demarcation of the agricultural areas in the Coast-Polders-Westhoek region started in 2004. During this demarcation phase, a new integrated approach was used which took agriculture, nature and forest simultaneously into account. In consultation with the municipalities, provinces and stakeholders, a spatial vision was drafted in 2006 that indicated the most important structures: connected areas prohibited for agriculture, valleys for nature development, etc. The consultation process eventually resulted in 95,100 ha of reaffirmed agricultural area in the Coast-*Polders*-*Westhoek*[5] region (Danckaert 2013). The SIPs for agriculture, nature and forest in this region can be consulted on the website of RSV Flanders. Parallel to the further implementation of the RSV, the Government of Flanders is also preparing a new Beleidsplan Ruimte Vlaanderen. This plan is expected to contain the same demarcation objective as formulated in the RSV. The Strategic Vision document states that the aim is to work towards robust and resilient agricultural plots that, where possible, are kept free of buildings and given a multifunctional purpose. However, there's a trend towards turning agricultural land into private gardens or horse pastures[6], a phenomenon that also occurs in the polders (personal communication VMM, LARA 2020). Within the framework of the spatial development policy, OMG provides area-specific 'Territorial Development Programmes' with the aim of bringing together relevant stakeholders and realising short- and medium-term achievements based on common objectives. In this capacity, the Province of West Flanders has a cooperation agreement with OMG within the so-called T.OP. Kustzone (see thematic chapter **Social and economic environment**).

Areas of the agricultural structure are described in the Spatial Structure Plan of the Province of West Flanders (PRS W-VL). For coastal agriculture, the eastern and western polder areas are of particular importance.

A sound agricultural structure, as determined within the spatial planning processes (see above) can be realised, among others, through land exchange consolidation and land development projects. In Flanders, the Flemish Land

[5] Not all hinterland municipalities are fully included in this region, for example parts of Diksmuide and Bruges are not part of it, but rather belong to the region '*Veldgebied Brugge en Meetjesland*'.

[6] These phenomena are linked to the decline in the number of agricultural enterprises (see **8.3 Societal interest**) and the increased vacancy rate. A reconversion to today's environmental and energy standards appears in many cases too costly for new starters. The vacant farms are often sold with a number of hectares of agricultural land that are subsequently used, for example, as gardens or grazing land for domestic animals. The current urban development framework, with its basic rights for zone-restricted buildings, places few restrictions on this, and the new instrument 'contractual covenant approach' also allows for a non-agricultural reconversion. However, research shows that many non-agricultural uses cannot be legally permitted. There is also a lack of enforcement. These zone-restricted activities often also lead to challenges for the remaining agricultural activities (Verhoeve et al. 2018).

Agency (VLM) is responsible for the execution of land exchange consolidation projects and land development projects (VLM 2000, 2014). The aim of land exchange consolidation is to improve the economic exploitation of agricultural enterprises, on the one hand, and, on the other hand, to improve the use of land for nature and recreational purposes. An overview of all development projects (overall projects, rural projects, land development projects, land exchange consolidation projects and nature development projects) can be found in the VLM project database.

The cultivated land in the coastal zone has a total surface area of about 71,384 ha (2020) (figure 1). This corresponds to 11.4% of the utilised agricultural area in Flanders (Source: FPS Economy - Statbel). All parcels registered by the Department of Agriculture and Fisheries and their cultivation can be downloaded in GIS format from the Geopunt website and from the website of the Department of Agriculture and Fisheries.

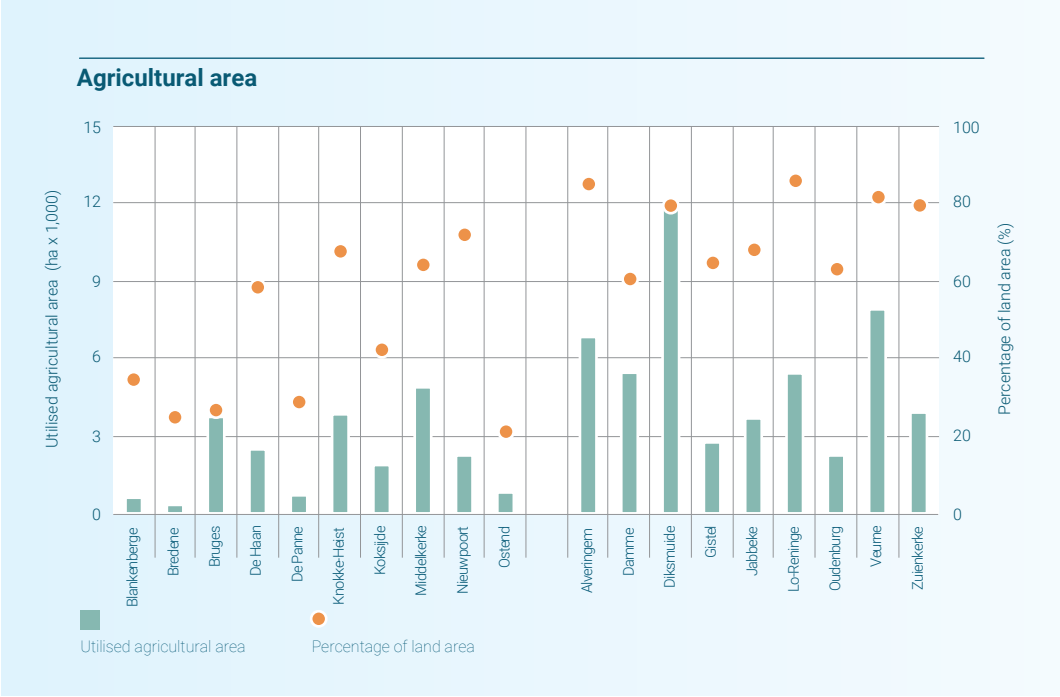


Figure 1. Agricultural area in ha in 2020 for the coastal and hinterland municipalities (Source: FPS Economy - Statbel, Coastal Portal)

8.3 Societal interest

In 2019, agricultural enterprises in the coastal zone (coastal municipalities + hinterland municipalities) generated a turnover[7] of 515.4 million euro, accounting for 24.8% of the total provincial sectoral turnover[8]. The largest revenue was realised by the various mixed farms which combine different sub-sectors of agriculture (125.7 million euro; 24.4%) followed by pig farms (118.2 million euro; 22.9%) and milk producing farms (94.8 million euro; 18.4%) (figure 2). These three industries generate more than 65% of the turnover of coastal agriculture on 56.1% of the cultivated land. Arable farming, practiced on almost 21.3% of the farmland, accounts for only 6.7% of the total turnover. When comparing the turnover of the coastal zone to that of the entire province, the relative importance of farms with other grazing animals (2.5 million euro; 48.2% of the provincial total), mixed cattle farms (33.9 million euro; 40.2%) and milk producing farms (94,8 million euro; 39.9%) is particularly distinctive.

In the coastal and hinterland municipalities, 2,053 agriculture and horticulture enterprises were active in 2019, with 4,104 employees corresponding to 8.8% of all agricultural enterprises in Flanders and 6.7% of all employees in agriculture. In the coastal zone, agriculture represents approximately 2.2% of the workforce (Dataset regions 2020, Landbouwgegevens 2019 FPS Economy - Statbel). The majority of both the enterprises and employees in the coastal zone are located in the hinterland municipalities (table 1), which are mainly focused on arable farming (table 2). The farms in the coastal zone in 2019 had a total of 133,397 cattle, 670,484 pigs and 3,962,370 poultry (Landbouwgegevens 2020 - Statbel).

[7] This is not the actual turnover generated, but rather a standard output (SO), a calculated value based on SO coefficients and the area of the different crops and the number of animals.
[8] For an estimate of the impact of the Brexit on Flemish agriculture, see LARA 2020.

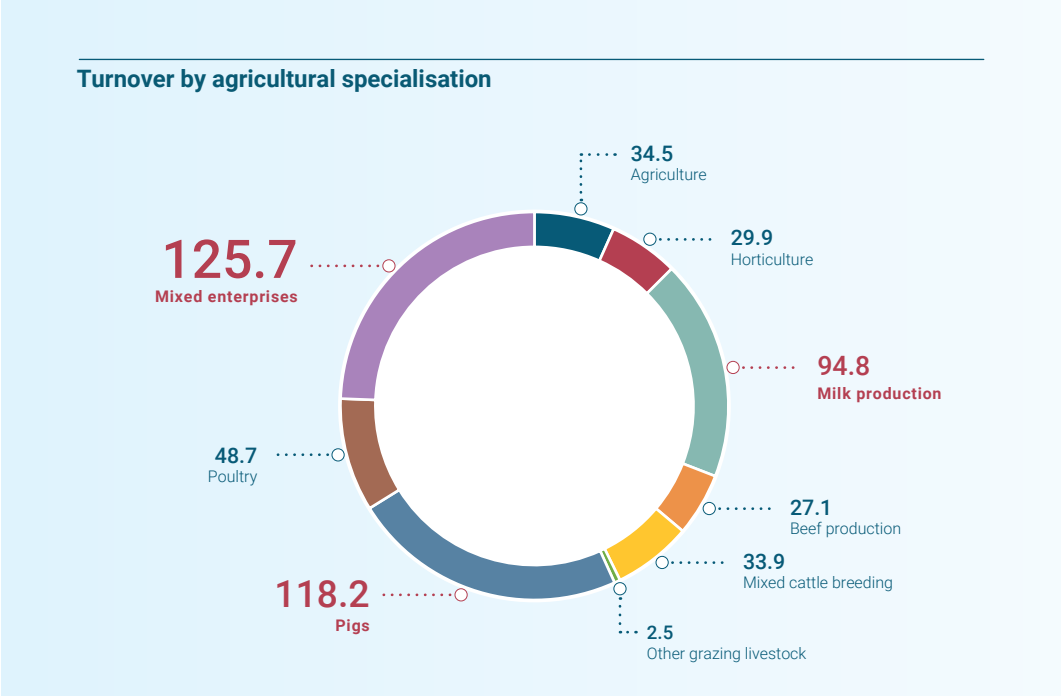


Figure 2. The total turnover (in euro) by specialisation (SO2013) for coastal agriculture in 2019 (Source: Department of Agriculture and Fisheries based on FPS Economy, SMEs, Self-employed and Energy - Statbel).

A small, yet strongly growing sector in Flanders and the coastal zone is that of organic farming (Flanders bioeconomy 2020, Timmermans and Van Bellegem 2020). In 2019, there were 34 organic farms in the coastal zone, 28 of which were located in the hinterland municipalities (Department of Agriculture and Fisheries). Organic farming takes place on 884 ha (including land in conversion), an expansion of 271% compared to 2012. When considered over the entire area of cultivated land (71,150 ha in 2019) in the coastal zone, this amounts to a modest 1.2% (figures requested from the Department of Agriculture and Fisheries and granted by TÜV Nord Integra and Quality Partner).

In addition to a direct economic value linked to food production, there is also a more indirect added value for society, such as activities linked to hinterland tourism (see thematic chapter **Tourism and recreation**) and the added value related to the various ecosystem services. However, these have not been quantified structurally to date[9].

For more figures on agriculture you can also visit the agricultural data website of the Department of Agriculture and Fisheries, the dienst Statistiek of the FPS Economy, SMEs, Self-employed and Energy, Statistiek Vlaanderen, Gemeentestatistieken VLM, West-Vlaanderen Ontcijferd of the West Flanders Development Agency and the website provincies.incijfers.be.

8.4 Impact

This section includes the (general) effects of agricultural activities on the ecosystem and the indirect effects of these activities on the marine environment (eutrophication). Additionally the effect of salinisation is discussed. Although salinisation is mainly the result of other human activities and climate processes, the phenomenon is of growing concern for agricultural activities in the coastal zone. It is also important to note that agriculture provides various beneficial ecosystem services with a producing, regulating and cultural function (vision note SALV 2020). For more information on agriculture and ecosystem services, see Van Gossum et al. 2016 and Dumez et al. 2017. A description of the ecosystem in the polder areas is included in the thematic chapter **Nature and environment**.

[9] More background on the socio-economic landscape, nature and the role of tourism in the coastal zone can be found in the dedicated thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

Table 1. Number of agricultural and horticultural enterprises and employees in the coastal and hinterland municipalities in 2019 (Source: Dataset regions 2020, Landbouwgegevens 2019 FPS Economy - Statbel).

Municipality	Employees	Enterprises
Blankenberge	49	19
Bruges	437	124
Bredene	33	7
De Haan	124	58
De Panne	44	17
Knokke-Heist	275	93
Koksijde	127	48
Middelkerke	216	150
Nieuwpoort	118	52
Ostend	152	25
Coastal municipalities	**1,575**	**593**
% Coastal municipalities	**38.4%**	**28.9%**
Alveringem	316	211
Damme	295	178
Diksmuide	604	351
Gistel	172	81
Jabbeke	264	118
Lo-Reninge	271	161
Oudenburg	125	73
Veurne	344	203
Zuienkerke	138	84
Hinterland municipalities	**2,529**	**1,460**
% Hinterland municipalities	**61.6%**	**71.1%**

Table 2. The number of enterprises in the coastal zone in 2019 by specialisation (Source: Department of Agriculture and Fisheries based on FPS Economy, SMEs, Self-employed and Energy - Statbel).

Specialisation	Number of enterprises in the coastal zone (2019)
Agriculture	588
Horticulture	80
Milk production	267
Beef production	234
Mixed catle breeding	144
Other grazing livestock (sheep, etc.)	84
Pigs and poultry	196
Mixed enterprises	53
Total enterprises	**2,053**

8.4.1 Effects on the ecosystem

In a.o. the *Vlaams Regionaal Indicatorenrapport* (VRIND 2017), the MIRA systeembalans (2017), the LARA (2018, 2020), Milieuverkenning (2018) and NARA 2020, various effects of agricultural activities on the environment in Flanders are listed (not exclusively for the coastal zone). For an overview of the main effects on the ecosystem, see table 3. More figures and studies on the interaction between agriculture and the environment can be found on the website of the Department of Agriculture and Fisheries and the VMM.

Table 3. Non-exhaustive overview of studies describing the main environmental impacts of agricultural activities.

Impact	Literature
Chemical products for crop protection	Van Esch et al. 2012, Lenders et al. 2013, Lenders and Deuninck 2016
Water use	Lenders et al. 2013, Lenders and Deuninck 2016, Danckaert and Lenders 2018, Antea 2018, more information see **8.4.3 Salinisation of the coastal zone**
Energy use	Lenders et al. 2013, Lenders and Deuninck 2016
Soil quality	e.g. densification resulting in salinisation and erosion susceptibility: Reubens et al. 2010, MIRA Themabeschrijving Bodemkwaliteit 2014, Erosie in Vlaanderen 2015, Swerts et al. 2020
Eutrophying emissions	Overloop et al. 2011, Overloop 2013, Voortgangsrapport Mestbank 2013, Lenders and Deuninck 2016, Mestrapport 2020, VMM more information see **8.4.2 Eutrophication of the coastal waters**
Acidifying emissions	VMM
Greenhous gas emissions	VMM
Emission of dust particles	VMM
Litter production	Statbel
Spatial use	VMM
Biodiversity	Honnay and Ceulemans 2016

8.4.2 Eutrophication of the coastal waters

The use of agricultural fertilisers, which are transported towards coastal waters via waterways, is an important contributor to the increase of nutrients (nitrogen (N), phosphorus (P)) in aquatic ecosystems (State of Europe's seas 2015, OSPAR). Excessive input of nutrients or 'eutrophication' reinforces the processes regulating phytoplankton production, potentially causing excessive phytoplankton growth, which can lead to changes in ecosystem structure and functioning, habitat destruction and an impoverishment of biodiversity (Zhang et al. 2010, federal environmental report, OSPAR IA 2017, Bushinsky et al. 2019). The eutrophication issue falls under descriptor 5 of the Marine Strategy Framework Directive (MSFD) and is described by Ferreira et al. (2010) in which the conditions for good environmental status are outlined (see **8.5.1 Measures against eutrophication**).

In the 1990s there was a clear downward trend in the amount of dissolved N and P in our coastal waters, which has levelled off in recent years (2006-2018) (OSPAR IA 2017, Desmit et al. 2018). A trend that is confirmed by land-based measurements (Fysisch-chemische kwaliteit oppervlaktewater 2018, Nutriënten in oppervlaktewater in landbouwgebied 2018-2019, Milieuverkenning 2018, LARA 2020, Mestrapport 2020, VMM). The VMM has a monitoring network for water quality, which has expanded with specific measuring points for agriculture since 1999 (the so-called MAP measuring points, see Geoloket waterkwaliteit). The most recent assessment of the MSFD shows that for approximately 30% of the Belgian part of the North Sea, the threshold value of a Good Environmental Status is exceeded (Belgian State 2018, Desmit et al. 2018). The Belgian coastal waters (up to 1 nautical mile (nm)) score poorly, while the situation in the territorial waters (up to 12 nm) is slowly improving. Further offshore, the concentration poses no problem (Desmit et al. 2018). Next to the transport of nutrients by rivers, atmospheric inputs are also of concern (OSPAR QSR 2010, OSPAR Commission 2017, Natura2000).

The various aspects of the eutrophication problem in coastal waters were previously extensively studied in the Belspo projects: AMORE, AMORE II, AMORE III-(phase 1 and phase 2) and the TIMOTHY project (more information: Lancelot and Rousseau 2004, Rousseau et al. 2006, Lancelot et al. 2007, Lancelot et al. 2009, Lancelot et al. 2011). A centralisation of knowledge and information on eutrophication in the southern part of the North Sea took place in 2014 within the framework of the ISECA project. The Belspo NewSTHEPS project carried out concentration measurements on chemical pollutants, including N and P, in the coastal zone in function of the MSFD. Finally, the Belspo SISCO project investigated, among other things, the problem of eutrophication for phytoplankton production in the Scheldt estuary (see thematic chapter **Scheldt estuary**).

8.4.3 Salinisation of the coastal zone

The phenomenon of soil salinisation has a significant impact on agriculture in the coastal zone. During hot, dry periods, the surface water in the fields can become saline, resulting in drinking water problems for animals. Additionally, brackish or saline groundwater can penetrate into the root zone of the soil (Zwaenepoel et al. 2016, De Bruyn 2020) with a detrimental effect on crops. Moreover, polder clay is very vulnerable to salt, which increases the risk of soil sealing (*verslemping*).

A natural division of fresh and salt/brackish groundwater occurs in the coastal zone. In the phreatic groundwater zone, a freshwater lens lies above a layer of salt/brackish water. This freshwater lens enables traditional agriculture in the polders. The lens acts as a buffer against seawater intrusion to the hinterland (Van den Eynde et al. 2011 (CLIMAR project phase 1 and phase 2) and the CLIWAT project), but has interruptions along the coast (TOPSOIL). This division between fresh and salt water is the result of a complex history in which human activities, such as water extraction for drinking water supply, agricultural purposes, large-scale infrastructure works (e.g. land reclamation, port expansion, tunnels, drainage systems, etc.) and interventions in water management (e.g. water level management, drainage systems, etc.) play an important role. Hydrological interventions in the coastal zone can therefore lead to short- or long-term changes in the distribution of fresh and salt water, possibly resulting in salinisation (Vandenbohede et al. 2009, Vandenbohede et al. 2010, Vandenbohede 2012, River basin management plan for the Scheldt 2016-2021). Additionally, the salinisation issue in the coastal zone is strongly linked to the drought issue. More frequent and more intense droughts linked to global warming are expected to increase the salt load on shallow ground and surface waters (Evaluatierapport droogte 2017). On the long term, a higher sea level can generate an additional salt load (Vandenbohede 2012, Zwaenepoel et al. 2016, De Bruyn 2020).

The salinity maps of the coastal zone underwent several updates in the past years. This happened in 2010 (CLIWAT project) for the middle coast (Nieuwpoort-Zeebrugge) (Vandenbohede et al. 2010), in the framework of the ScaldWIN project (Lebbe et al. 2012), and in 2014 for the eastern coastal zone (VMM 2016). These studies concluded that the fresh-saltwater balance is currently relatively stable. A detailed determination of the fresh-saltwater balance for the entire coastal and polder area was last carried out as part of the TOPSOIL project (2015-2021). These results also concluded that the degree of salinisation in the coastal zone is not increasing for the time being, although problems can occur locally in the event of extreme weather conditions (Delsman et al. 2019, salinisation map DOV Vlaanderen, Coastal Portal).

8.5 Sustainable use

Sustainability in European agricultural policy has gained importance in recent years (Lisbon Treaty, EU-2020 Strategy, EU Farm2Fork Strategy, CAP, etc.). With the previous CAP (2014-2020), measures were already taken towards a more sustainable agricultural sector, a strategy that will be continued and strengthened in the CAP (2021-2027). This ensures that the environmental and climate objectives in this new policy strategy are in line with the Sustainable Development Goals[10] of the UN (SDGs) (see also **8.1 Policy context**). The sustainable co-existence of agriculture with various user functions of the coastal zone (housing, tourism, recreation, industry, nature, etc.) is part of the European recommendation for Integrated Coastal Zone Management (ICZM, 2002/413/EG), although this policy has had little influence at European level in recent years. There are, however, European projects such as the COASTAL project which aim to explore and optimise synergies between the hinterland and the coastal zone. A key element to the project is the reinforcement of sustainable activities in the hinterland.

The Flemish agricultural policy is committed to innovative and environmentally friendly agriculture practices. The policy aims to strengthen the economic situation of its stakeholders, a sustainable food production, and

[10] Within the context of the SDGs, Flanders developed 'Vizier 2030', a 2030 goal-oriented framework towards a sustainable Flanders, built around 48 goals that are monitored by 87 indicators.

a contribution to an overarching circular economic model (policy paper Agriculture and Fisheries 2019-2024, Flemish circular food economy). Within this context, work is being done on a sustainable Flemish food strategy, which is based on four strategic objectives: (I) a resilient food economy; (II) food connecting farmers and citizens; (III) circular and sustainable entrepeneuring and (IV) healthy and sustainable food for all. At the Flemish level there is also the bio-economy policy plan in which, among other things, a closer cooperation between industry and agriculture must result in new, sustainable agricultural activities.

The yearly agriculture reports of the Department of Agriculture and Fisheries also cover a number of current Flemish policy themes that are connected to sustainable agriculture, such as water management, the manure action plan (*mestactieplan*), biodiversity, circularity, the bio-economy, etc. The Department also carries out studies for more sustainable agricultural activities and publishes specific recommendations in thematic 'praktijkgidsen' (for a selection see table 4). Furthermore, the Department of Agriculture and Fisheries also offers sector advice on themes such as rational water use and promotes sustainable practice centres. A service that is also provided at the provincial level by Inagro.

Table 4. Non-exhaustive overview of publications aimed at making agricultural activities more sustainable (Source: Department of Agriculture and Fisheries).

Theme	Publications
Crop protection	Demeyere and Nuyttens 2016
Water	Danckaert and Lenders 2018, Verhassel and Debussche 2018
Biodiversity	Zwaenepoel et al. 2016
Climate	Maertens et al. 2016
Agro-ecology	Bergen 2013
Food footprint	Cazaux et al. 2010, Bracquené et al. 2011, Danckaert et al. 2013
Agricultural challenges	Bergen et al. 2014, Van Buggenhout et al. 2016

Other projects in the region also aim at making agriculture more sustainable (project database Province of West Flanders, ILVO research). A number of reports and visions that propose recommendations on how to shift to a more sustainable agricultural model are also available. Some examples include: Mathijs et al. (2012), Dumez et al. 2014, the MIRA systeembalans 2017, the agriculture reports, Milieuverkenning 2018, Rede Gouverneur 2019, adviesnota's SALV. Studies like Gobin et al. (2008) and Maertens et al. (2016) also look at the adaptation opportunities and mitigation strategies of Flemish agriculture to climate change. Finally, there are quality systems that support the production of quality and sustainable agricultural products.

8.5.1 Measures against eutrophication

A further reduction in the use of nitrates and phosphates remains important for the achievement of a good environmental status in groundwater, surface waters and coastal waters (see thematic chapter **Nature and environment**) (Ferreira et al. 2010, Belgian State 2018, Nutriënten in oppervlaktewater in landbouwgebied 2019-2020, VMM MAP monitoring network, Mestrapport 2020). Within this context, OSPAR created a common procedure (2016) for estimating the eutrophication status of the North-East Atlantic (OSPAR Commission 2017). This unified monitoring and classification strategy is laid down in the eutrophication monitoring programme (see also OSPAR) and is in line with other European directives such as the MSFD and the Water Framework Directive (WFD, Directive 2000/60/EC) (see below). When the classification results in so-called problem areas, the OSPAR environmental strategy states that the contracting parties, individually or jointly, must take measures to reduce or eliminate the anthropogenic causes of eutrophication. The new OSPAR Strategy 2030 sets the objective of taking sufficient measures to avoid eutrophication in the OSPAR region by 2028. By 2030 nutrient concentrations should be sufficiently reduced to make sure that adverse eutrophication effects no longer occur (OSPAR 2021, OSPAR MAP 2021).

At the European level, the issue of eutrophication is addressed by various directives in the framework of the MSFD and WFD. The Nitrates Directive (Directive 91/676/EEC) is an integral part of the WFD[11], which *inter alia* imposes

[11] The Good Environmental Status (GES) is determined within 1 nautical mile (nm) seaward of the base line (ebb mark), while the Good Chemical

the obligation to achieve a good quality of surface and groundwater by 2015. This included substances that contribute to eutrophication, such as nitrogen and phosphorus, in its indicative list of main pollutants. The Nitrates Directive therefore aimed at reducing the runoff of nitrates from agriculture (Goffin et al. 2007). Other directives under the umbrella of the WFD also have a link with eutrophication, such as Directive 91/271/EC on urban waste water and Directive 2010/75/EU on industrial emissions. In the MSFD, eutrophication was included as descriptor 5 for the determination of the good environmental status (Ferreira et al. 2010).

The MSFD has been incorporated into Belgian law by the RD of 23 June 2010 on the marine strategy for the Belgian marine areas. The Marine Environment division (FPS Environment) is responsible for the coordination in terms of implementation. The cooperation between the federal level and the regions occurs within the CCIM Working Group on North Sea and Oceans that represents the international component of the marine environment for Belgium. In 2018, the criteria and methodological standards for determining good environmental status with regard to eutrophication were revised (Belgian State 2018, Desmit et al. 2018).

At the Flemish level, the WFD was translated into the Decree on Integrated Water Policy (Decree of 18 July 2003 and legal framework for integral water policy in Flanders, for implementing decisions and amendments see Coordination Committee on Integrated Water Policy) and partially converted at the federal level into the RD of 23 June 2010 on the establishment of a framework for achieving good surface water status (see also River basin management plan for Belgian coastal waters 2016-2021) (see thematic chapter **Nature and environment**). At the Flemish level, the Nitrates Directive was transposed into the Manure Decree that deals with the quality status of diffuse pollution of ground and surface water by agri- and horticulture. This decree was approved on 23 January 1991 and has been thoroughly amended several times since. The new Manure Decree (Decree of 22 December 2006) was enforced on 1 January 2007, with the sixth manure management plan (*Mestactieplan*) (MAP-VI) enforced during the period 2019-2022 (for implementation decrees and amendments see *Mestbank* VLM). This renewed manure management plan aims to break the levelled decline in water quality in order to bring the concentrations in line with the European targets (6e Actieprogramma ter uitvoering van de Nitraatrichtlijn 2019, Mestrapport 2020).

Nutrient limiting agricultural practices are also mentioned in the third Rural Development Programme (*Programma voor plattelandsontwikkeling,* PDPO III) in the framework of a sustainable CAP (see **8.3 Sustainable use**) and in MIRA systeembalans (2017). An up-to-date overview of the manure legislation can be found at the Mestbank website of the VLM.

Finally, efforts are being made to reduce atmospheric nitrogen deposition. On 23 April 2014, the Government of Flanders decided to set up a Programmatic Approach to address atmospheric nitrogen deposits (PAS). The PAS programme (2014-2031) aims to tackle the problem of the eutrophying and acidifying deposition of nitrogen in special protection areas (SPAs) as designated within the European Habitats Directive (Directive 92/43/EEC), of which about two thirds derive from agriculture. To this end, the focus is on source-based (on the emissions side) and effect-based measures. The first planning period runs from 2020-2025, a second planning period runs from 2025-2030. Monitoring is done by the VMM.

8.5.2 Measures against salinisation

The European Communication COM (2012) 46 provides an overview of the implementation of the Thematic Strategy for Soil Protection since its adoption in COM (2006) 231. Among other things, it discusses soil degradation through salinisation. Furthermore, intrusions of salt water have also been included in the WFD and the Groundwater Directive (Directive 2006/18/EC) as parameters for the quantitative and qualitative status of groundwater (see also VMM 2008).

In the River basin management plan for the Scheldt 2016-2021, a number of measures are included in a 'Coastal and Polder System Action Programme' consisting of three groups of measures[12] describing a collection of groundwater body-specific actions to combat salinisation. A detailed overview of all actions can be consulted at the website integraalwaterbeleid.be, a new River basin management plan 2022-2027 for the coastal waters is expected by the end of 2021. Additionally, the WFD is partially incorporated into Belgian legislation by the RD of 23 June 2010 on the establishment of a framework for achieving good surface water status. The management and monitoring (meetnet VMM) of groundwater and surface water quality is a core task of the VMM, Operational Water Management Department. See also Vandenbohede et al. (2010) and the legislation listed in the Codex Coastal Zone, themes Agriculture and Groundwater.

Status (GCC) reaches up to 12 nm seaward of the base line (see thematic chapter **Nature and environment**).
[12] The three measure groups: Protected and water-rich areas - groundwater section, Quantity ground water and Contamination of ground water.

In 'Climate change in the polders - Choosing fresh or salt?' (Zwaenepoel et al. 2016), an overview of solution strategies is provided, based on domestic and foreign research projects (with a focus on the Dutch context). It also discusses the challenges posed by a changing hydrology and the current knowledge gaps in this regard in the field of agriculture in the Flemish polder region. Furthermore, phase two of the TOPSOIL project (2015-2021) is attempting to develop local pilot projects with the help of stakeholder participation in order to improve the freshwater availability for farmers. Within the context of sustainable freshwater use to the benefit of farmers, there is also the Fresh4Cs project (2019-2022). This project, which zooms in on efficient water use in the coastal zone, investigates the possibility of storing freshwater above and belowground for the benefit of agricultural activities in the coastal polders. Additionally, the SalFar project (2014-2020) tested innovative agricultural methods for growing crops on saline soils using test sites in different regions. In Flanders, the research focused on the socio-economic barriers to saline agriculture and, through stakeholder participation, the researchers explored the salinisation issue and the potential of saline agriculture in the Flemish coastal zone.

Salinisation is also strongly linked to drought. Given the recent increase in the occurrence of droughts (Climate Portal), the Government of Flanders is increasing its efforts to combat this issue. The policy for tackling water scarcity and droughts is in line with the objectives of the WFD and focuses on limiting the economic and ecological damage. Concerning this topic, the Government of Flanders introduced the Blue Deal strategy to counter water scarcity and droughts[13]. A circular water policy will be central along with a strong emphasis on agriculture and nature as part of the solution. This plan contains a series of measures that are also included in the Actieplan Droogte en Wateroverlast (2019-2021). For example, 'Action 11: Development of an Integrated Water System Model for Drought Risk Management' looks at the *Westhoek* as a pilot region given its history of drought problems, the characteristics of polder management, the buffering by agriculture and water reuse by industry. Furthermore, the plan mentions the establishment of a West Flemish Centre of Expertise for Coastal Polders (*West-Vlaams Kenniscentrum Kustpolders*) that will focus on combining relevant water expertise. The Internet of Water project fits in this action plan. This project uses a sensor network to continuously monitor the water quality of the soil, ground and surface water so that targeted measures can be taken more quickly. In order to realise the Blue Deal objectives, 75 million euro in resources will initially be made available, including through the *Vlaams Landbouwinvesteringsfonds* (VLIF) and the expansion of the Water-Land-Schap 2.0 land development project. For the coastal zone specifically, the Government of Flanders also approved the *Oudlandpolder* land development project (LIP Oudlandpolder) in December 2020. This plan focuses on tackling the water problems in the area between Bruges, Ostend and Zeebrugge. Within the framework of this LIP, a water balance study is being carried out and additional sensors are being installed to map water availability. The water usage and supply in the coastal zone has already been mapped (Antea 2018).

Finally, within LABO RUIMTE (a partnership between *Team Vlaamse Bouwmeester* and the Department of Environment and Spatial Development), research has been initiated within the project De Droge Delta on spatial levers in the fight against water scarcity. Within the context of sustainable water management in the coastal zone, there were also Metropolitaan Kustlandschap 2100 (De Waegemaeker et al. 2012) and Stedelijk Systeem Kust.

8.5.3 Protection of agricultural nature and historical permanent grasslands (HPGs)

Agricultural areas in the coastal zone often contain valuable natural elements that are protected and managed in certain places (Coastal Portal, Natura 2000, Geopunt Vlaanderen, see also thematic chapter **Nature and environment**). An important landscape element are the so-called historical permanent grasslands (HPGs). HPGs are defined in the Nature Decree (Decree of 21 October 1997) as "a semi-natural vegetation consisting of grassland characterised by long term use as grazing pasture or hay meadows with either cultural/historic value or a species-rich vegetation of herbs and grasses where the environment is characterised by the presence of ditches, streams, pools, prominent micro relief, springs or seepages". The decree and the subsequent Implementation Decisions stipulate that HPGs are subject to a prohibition on, or require authorisation for, the modification of the vegetation and physical features (relief and small landscape elements, such as pools and streams) depending on their destination status in spatial planning. For more information on the protection status, see website of the Agency for Nature and Forest (ANB).

In order to achieve an effective protection of these grasslands, an inventory was made with the exact location of the HPGs (De Saeger et al. 2013). In 2015, the Government of Flanders reached a final agreement on the protection of 8,000 of the 12,000 ha HPGs, with some parts being protected through nature legislation and other parts through European agricultural policy (ANB, Investeren in landbouw in België 2014-2020 (2016)).

[13] A first reactive assessment framework for priority water use has already been developed (Government of Flanders 2021).

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Recommendations			
2002/413/EG	Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe	2002	413
Communications			
COM (2006) 231	Communication from the Commission: Thematic Strategy for Soil Protection	2006	231
COM (2010) 2020	Communication from the Commission: Europe 2020 - A strategy for smart, sustainable and inclusive growth	2010	2020
COM (2012) 46	Communication from the Commission: The implementation of the Soil Thematic Strategy and ongoing activities	2012	46
COM (2019) 640	Communication from the Commission: The European Green Deal	2019	640
COM (2020) 381	Communication from the Commission: A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system	2020	381
Directives			
Directive 91/271/EEC	Directive concerning urban waste water treatment	1991	271
Directive 91/676/EEC	Directive on the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive)	1991	676
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2006/118/EC	Directive on the protection of groundwater against pollution and deterioration (Groundwater Directive)	2006	118
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2010/75/EU	Directive on industrial emissions (integrated pollution prevention and control)	2010	75
Conventions			
2007/C 306/01	Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community	2007	306

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decrees		
Decree of 21 October 1997	Decreet betreffende het natuurbehoud en het natuurlijk milieu	1997-10-21/40
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Decree of 22 December 2006	Decreet houdende de bescherming van water tegen de verontreiniging door nitraten uit agrarische bronnen	2006-12-22/32

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
Royal Decrees		
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05

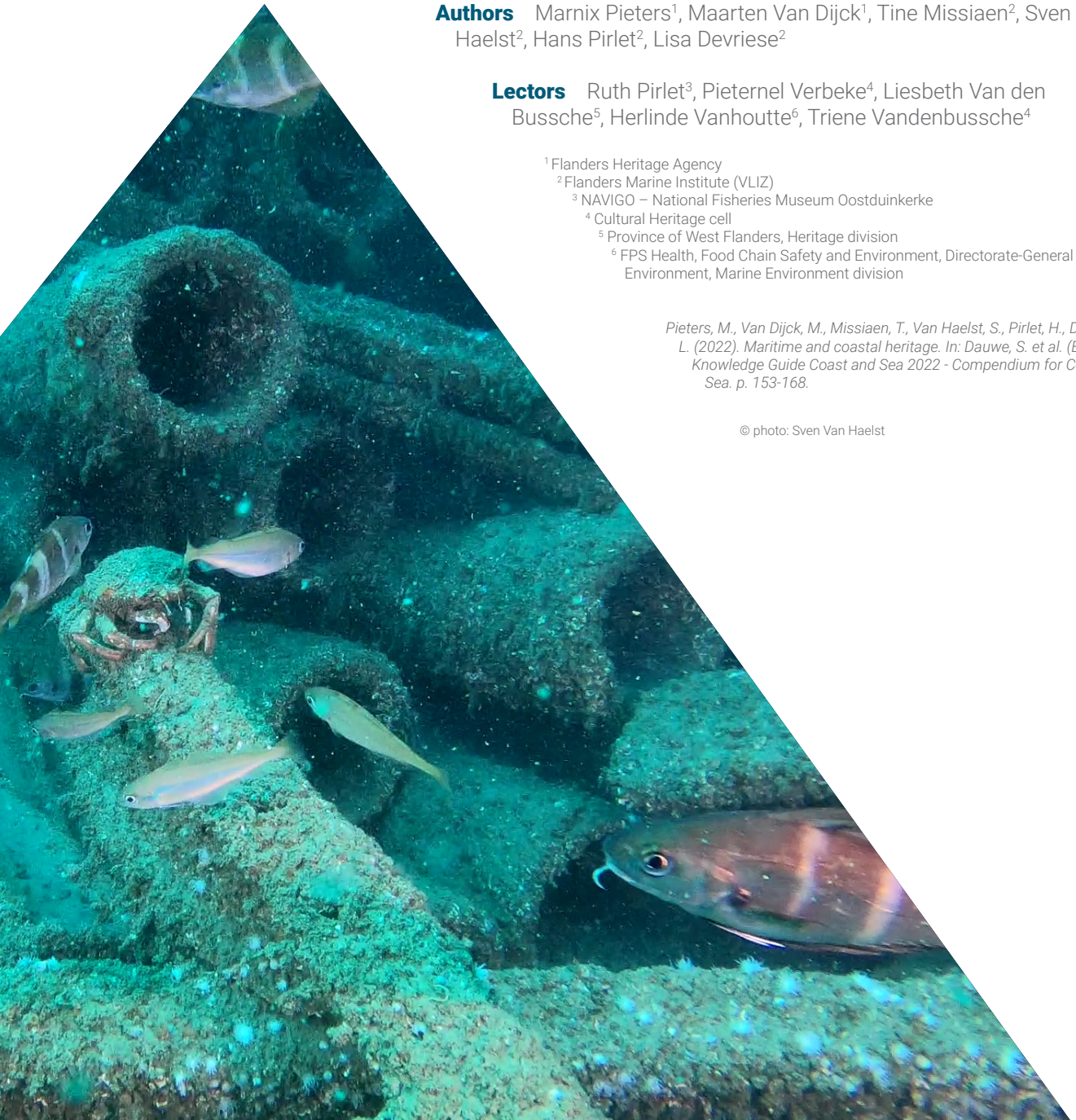
9 Maritime and coastal heritage

Authors Marnix Pieters[1], Maarten Van Dijck[1], Tine Missiaen[2], Sven Van Haelst[2], Hans Pirlet[2], Lisa Devriese[2]

Lectors Ruth Pirlet[3], Pieternel Verbeke[4], Liesbeth Van den Bussche[5], Herlinde Vanhoutte[6], Triene Vandenbussche[4]

[1] Flanders Heritage Agency
[2] Flanders Marine Institute (VLIZ)
[3] NAVIGO – National Fisheries Museum Oostduinkerke
[4] Cultural Heritage cell
[5] Province of West Flanders, Heritage division
[6] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division

Pieters, M., Van Dijck, M., Missiaen, T., Van Haelst, S., Pirlet, H., Devriese, L. (2022). Maritime and coastal heritage. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 153-168.



Maritime and coastal heritage encompasses a very wide range of themes. Comprehensive works that cover these maritime heritage themes for the Belgian part of the North Sea (BNS) and the adjacent coastal area do not exist. Addressing maritime and coastal heritage in an integrated way does, however, offer benefits in terms of understanding interrelationships and elucidating the wider context. Furthermore, the various types of boundaries have changed significantly over time. In the Roman period, for example, the coastline was located further seaward compared to the present situation, even though several tidal channels penetrated into the hinterland (see HisGISKust for the evolution of the coastline since the 16th century). As a result, archaeological heritage originally shaped on land in the former coastal area may now be submerged. Maritime and coastal heritage includes the following sub-aspects:

- Immovable heritage (immovable elements such as monuments, landscapes or archaeological sites)
  - > Maritime archaeological heritage on land;
  - > Cultural heritage under water;
  - > Architectural heritage typical of the coastal area;
  - > Coastal landscapes with heritage value;

- Movable heritage (easily movable objects, e.g. paintings, tapestries, archives, photographs)
  - > Moveable maritime and coastal heritage;

- Nautical heritage
  - > Immovable heritage: nautical heritage that could sail or float but is now connected to the shore, such as the Amandine in Ostend;
  - > Movable heritage: nautical heritage that can still sail or float and, hence, is not attached to the shore;

- Intangible heritage (non-physical heritage such as customs, habits, stories, songs, traditions, parades, dialects, etc.)
  - > Intangible maritime or coastal heritage.

9.1 Current situation

9.1.1 Maritime archaeological heritage

The concept of 'maritime archaeology[1]' includes the following aspects:

- Shipwrecks and other wrecks (e.g. airplanes) as well as parts thereof, regardless of the position they are found (in the sea, in rivers or former rivers or recycled anywhere on land). The extension to sites on land only applies to shipwrecks and parts thereof (Pieters et al. 2015);
- Settlements or traces of remains of human activity in seas, rivers or other bodies of water and their paleo-environmental context (Missiaen 2012, Missiaen et al. 2017, Missiaen et al. 2018). An important category of these can be linked to sea level rise after the cold phases of the ice ages;
- Land-based archaeological sites and traces and their paleo-environmental context which, in terms of their former function, were entirely focused on the sea or the water such as lighthouses, fishing villages, shipyards, seawalls, peat extraction, salt extraction, quays, drainage canals, etc. (Thoen 1978, Tys 2013, Tys 2017);
- Archaeological remains of marine fishes that are found far inland during archaeological research (Van Neer and Ervynck 2006, Van Neer and Ervynck 2016);
- Paleontological remains of terrestrial fauna found at sea (for the BNS and adjacent beaches, see Vermeersch et al. 2015, Pieters et al. 2020).

There is no restriction with regard to the age of the investigated archaeological heritage. For instance, a shipwreck from WWII is given a different archaeological treatment than a shipwreck from the Bronze Age (e.g. Moies 2020).

Since 2003, systematic research on maritime archaeological heritage has been carried out by Flanders Heritage Agency and its precursors (Institute for the Archaeological Heritage (IAP), Flemish Institute for Immovable Heritage (VIOE)). Since 2017, focus has mainly been put on inland waterways (rivers, docks, the *Zwin*, etc.) and the intertidal area adjacent to the territorial sea. The Flanders Heritage Agency Inventory offers an overview of the valuable archaeological, architectural, landscape and nautical heritage in Flanders. In 2020, the former Central Archaeological Inventory (CAI) was fully integrated in the aforementioned Flanders Heritage Agency Inventory through the modules 'observations' and 'events'.

[1] Maritime archaeology, nautical archaeology, marine archaeology, and underwater archaeology are all related concepts. In the heritage sector, the term 'maritime archaeology' is increasingly used as an umbrella term for all four concepts.

9.1.1.1 Databases

For the entire spectrum of maritime archaeological heritage, as outlined above, a number of central databases are available for Flanders and the BNS:

- The database of the Flanders Heritage Agency aims at structurally documenting and disclosing relevant information concerning maritime archaeological heritage in Flanders and in the BNS. On this website, more information can be found about shipwrecks (and their contents) that are present in the North Sea and in Flanders, artefacts from the sea, and maritime sites such as fishing villages and lighthouses.

In addition, two more databases offer valuable structured information about parts of the above described heritage i.e. shipwrecks, without having an archaeological perspective:

- The wreck database of the Flemish Hydrography was developed from a perspective of safe shipping. The information in this database formed the basis for a book on shipwrecks in the North Sea which provides an inventory discussing 227 different wreck sites (Termote and Termote 2009);
- The online database wreck site (a private initiative), which has become an internationally respected and consulted database on shipwrecks and their positions (see also the Coastal Portal).

9.1.1.2 Key publications

In addition to the three databases mentioned above, a number of overview publications are available covering part of the maritime archaeological spectrum.

Since 2021, the web page Onderzoeksbalans archeologie in Vlaanderen replaces the Research Balance website of the Flemish Heritage Agency, and makes a range of research reports in chronological and thematic chapters available. For maritime archaeology we refer to Lentacker and Pieters (2021), which includes two synthesis documents:

- An overview of the archaeological research in the BNS seawards of the highwater line (including the beach) (published in adapted format by Pieters et al. 2010);
- An overview of shipwrecks and components found in rivers and on land in Flanders. The medieval shipwrecks from Flanders have also been included in an overview article on medieval ships (Van de Moortel 2011).

For the study of the maritime archaeological heritage of WWI, the overview article: War Under Water (Termote 2014) provides a structured insight into the activities of the Unterseeboot Flottille Flandern during the period 1915-1918. In 2018, the exhibition '1914-18 - The Battle for the North Sea' on the underexposed story of the war at sea took place at the Provincial Court in Bruges (Termote 2018). Recently, the inventory of 100-year-old shipwrecks was created by VLIZ on behalf of FPS Mobility (Demerre et al. 2020; the research reports of each wreck can be consulted via the website of FPS Public Health).

For the study of shipwrecks found on land, research on the medieval shipwrecks in the village of Doel is of importance from an international perspective (see logbook immovable heritage, Haneca and Daly 2014, Vermeersch and Haneca 2015, Vermeersch et al. 2015). In recent decades, extensive research has been carried out in Flanders on the archaeological heritage of late medieval and early modern fishermen, particularly on the medieval fishermen's community of Walraversijde. A first substantial part of the research data from the archaeological survey at Raversijde was published in Pieters et al. (2013). A number of studies have been carried out by the *Vrije Universiteit Brussel* with regard to the maritime landscapes in the Belgian coastal plains (e.g. Tys 2004, Tys 2013, Tys 2017). Recently, the University of Ghent (UGent), in close cooperation with the Flanders Marine Institute (VLIZ), took the first steps in structured research on drowned (pre)historic landscapes off the Belgian coast (Missiaen et al. 2017b, De Clercq 2018, Pieters et al. 2020). The available evidence for these drowned prehistoric landscapes is steadily growing. Research in the fairway the 'Scheur' discovered an area with exceptionally large numbers of bones from the Late Pleistocene and Palaeogene (Pieters et al. 2020).

9.1.1.3 Archaeological evaluation and reconstruction

- The IWT project *Archaeological research in the North Sea: development of an efficient assessment methodology and proposals for sustainable management in Belgium* (SeArch) (2013-2016) provided

methodologies and created a growing awareness for the knowledge gaps that exist concerning buried shipwrecks and prehistoric relics in the North Sea (Van Haelst et al. 2016a, 2016b, 2016c, Missiaen et al. 2016). In addition, guidelines are provided for the users of the North Sea, including a legal framework concerning maritime archaeological heritage. This legal framework must ensure the proper management of valuable heritage, taking into consideration the appropriate economic exploitation of the North Sea (Missiaen et al. 2016, Missiaen et al. 2017);
- The systematic stripping of Belgian beaches of unexploded ordnance regularly reveals archaeologically relevant data, such as the discovery of a cast iron cannon on Wenduine beach (Van Haelst et al. 2020);
- The project Verdwenen Zwinhavens examines the role of Bruges as a late medieval port and the maritime-cultural landscape that stretched along the Zwin tidal channel. The stories about the vanished Zwinhavens were presented virtually as a time travel in the expo space of the Zwin Nature Park (2021);
- Commissioned by the Department of Mobility and Public Works (MOW - Maritime Access division), a palaeo-landscape reconstruction of the Zeebrugge coastal area was carried out in the period 2016 - 2020. This involved a unique geological, palaeo-landscape and archaeological study of the Zeebrugge region (offshore) and was part of the Coastal Vision project (formerly known as the *Vlaamse Baaien* project or *Complex Project Kustvisie*).

The other categories of maritime archaeological heritage on land, such as seawalls, port structures, lighthouses, lime kilns, salt extractions, etc. remain largely unexposed in the archaeological research in Flanders. Water Heritage Flanders is the Flemish umbrella organisation for wet and dry water heritage aimed at stimulating new touristic initiatives and activities (e.g. Schoeters 2017). The dry water heritage on the coast includes the NAVIGO museum in Oostduinkerke and the lighthouses of Ostend and Nieuwpoort. The sailing vessel Mercator and the museum ship Amandine in Ostend (Van Dijck 2012) and the Cog of Doel, on the other hand, are part of the wet water heritage.

9.1.2 Nautical heritage

The nautical heritage policy was established relatively recently as a result of two parallel developments. Firstly, since the 1980s, there has been a focus on the types of vessels that are in danger of disappearing or have already disappeared. This led to attempts to preserve, restore or build replicas of ships that had already disappeared. The organisation of the Ostend at Anchor event belongs to this social development. Secondly, since the beginning of the 1990s, attention for the nautical heritage (historical fleet) arose from the Industrial Heritage cell within the former Department of Monuments and Sites (now Flanders Heritage Agency). The link between nautical and industrial heritage seems obvious, as the ships were built with materials that were also used in other economic sectors. The inventory of nautical heritage is kept by the Flanders Heritage Agency and has since been integrated into the aforementioned inventory of immovable heritage: inventaris.onroerenderfgoed.be. It was adopted on 16 June 2017, which means that the authorities or other parties such as ports can link certain legal effects and benefits to the nautical heritage inventory. The Flanders Heritage Agency published a comprehensive brochure containing information on the inventory, its establishment and the protection of nautical heritage (see also Varend erfgoed in Vlaanderen 2016). An overview of the corresponding literature can be consulted via the website of the Onderzoeksbalans Bouwkundig Erfgoed. Also the Flemish-Dutch magazine Erfgoed van Industrie en Techniek published a theme issue on nautical heritage in 2016-2017.

Specifically for the coast, two types of vessels are of great importance: fishing vessels and sailing yachts. An overview of the fishing vessels since 1929 can be found in the database of the Belgian fishing fleet of the VLIZ (see also thematic chapter **Fisheries**). The Panesi project examined the construction of fishing vessels on the coast using the archives and plans of the Panesi shipyard preserved by the NAVIGO museum (Van Dijck and Daems 2015). The study outlines the history of shipbuilding on the coast and describes the development of the fishing vessels built between 1870 and 1970.

The sailing vessel Mercator, is considered a case out of category, which was protected as a monument in 1996 and marked as nautical heritage in 2017. The steel barquentine of 78 m was built in 1932 according to the plans of Adrien de Gerlache (see also VLIZ Wetenschatten 2012 – Adrien de Gerlache, VLIZ Wetenschatten 2015a). The Mercator was used to train merchant marine officers. It opened to the public as a museum ship in 1961 (Vanden Bosch 2001). Lastly, the West-Hinder Light Ships (1950, Belliard yard, Ostend, Janssens 1997, De Graaf 2012, VLIZ Wetenschatten 2015b) were used as floating lighthouses warning ships for shallow sandbanks and were eventually replaced by unmanned light platforms in 1993.

9.1.3 Architectural heritage along the coast

The interest in the preservation of architectural heritage in Belgium dates back to the 19th century. The architectural heritage along the coast includes many components that are specifically maritime-related: hotels and other residential accommodation, tourist and recreational facilities and infrastructure (see also thematic chapter **Tourism and recreation**), coastal defence (civil and military) (see also thematic chapters **Safety against flooding** and **Military use**), lighthouses, sluices, all kinds of maritime business infrastructure, etc. The first two groups of coastal architectural heritage mentioned above are closely linked to the rise of tourism in Flanders during the last 200 years. This coastal tourism especially took off in the last quarter of the 19th century (Constandt 1986). The Belle Epoque Centre in Blankenberge exhibits architectural accomplishments that originated along the coast between 1870 and 1914.

The Flanders Heritage Agency made an inventory of architectural heritage in Flanders, municipality by municipality, from 1970 to 2012 (Bouwen door de eeuwen heen; geographic inventory). The results of the inventory are publicly available and can be consulted online at: inventaris.onroerenderfgoed.be. An up-to-date overview of the spatial distribution of the protected architectural heritage along the coast and additional information can be consulted on the Geoportal from the Flanders Heritage Agency (geo.onroerenderfgoed.be). Specifically for West Flanders, there is the survey work *Monumentaal West-Vlaanderen* offers in three volumes an illustrated overview of all the protected monuments and landscapes in the province, on 1 January 2001. The coastal area is discussed in volume III, published in 2005 (Cornilly 2005).

Thematic overview publications, albeit not exhaustive, also exist for certain groups of architectural heritage such as lighthouses (Warzée 1999), military heritage from WWI along the coast (Deseyne 2007, Vernier 2012), the Atlantic Wall (Philippart et al. 2004, Philippart 2014), tourism-related heritage (Cornilly 2006), and modern architecture (Cornilly 2007).

The industrial archaeological heritage is also increasingly being addressed in the context of heritage conservation. This industrial heritage includes a number of typically maritime components such as shipyards, port infrastructure, docks and dry-docks and fish processing companies (Onderzoeksbalans bouwkundig erfgoed, Onderzoeksbalans industrieel erfgoed). In Ostend, for example, the 'new trading docks' (Houtdok, Zwaaidok and Vlotdok) are included as established architectural heritage (inventory). Because of its maritime location, Flanders could boast a fairly large number of shipyards until well into the 20th century, building both wooden and metal vessels for inland, coastal and maritime navigation. Research on the industrial heritage of shipbuilding in Flanders, however, is limited to a few case studies, such as the Van Praet and Van Damme shipyards in Baasrode (Segers 1994), and a first important overview of fisheries-related shipyards by Desnerck and Desnerck (1974) and Desnerck and Desnerck (1976). Pioneering work on the port of Antwerp was conducted by Albert Himler (Himler and Moorthamers 1982, Asaert et al. 1993, Himler 1993). The harbour cranes of Antwerp also received the necessary attention (Vrelust et al. 2014, Moermans, Van Dijck and Vrelust 2015, Van Schoors 2018). The other Flemish ports were studied to a much lesser extent or in a much less nuanced way. The industrial heritage linked to sea fisheries (fish processing companies) has been little explored nor mapped up till now. Information on the history of fish smoking and drying companies in West Flanders during the period 1850-1950 is available (e.g. De Clerck 2006, De Clerck 2007). An overview of the history of Belgian oyster farming is provided by Halewyck and Hostyn (1978), Polk (2002), Pirlet (2012), Steevens and Van Moerbeke (2015) and Pirlet (2016), as well as on the following website (see also thematic chapter **Marine aquaculture**).

9.1.4 Landscapes with heritage value[2]

The coastal landscape, bordered by the Pleistocene sand region, has been largely shaped by humans. Without embankments and drainage, this area would look completely different. There has been a significant human impact, although some areas such as *De Grote Keignaard* in Zandvoorde have a rather natural appearance (Cornilly 2005). The protected landscapes in the coastal area include very diverse areas ranging from creek areas (Lapscheure, *De Grote Keignaard* in Zandvoorde), backlands (Lampernisse), dune regions (*Westhoek* dunes, *Houtsaeger* dunes in De Panne, *Cabour* in Adinkerke), tidal areas (the *Zwin* and Yser Estuary), heathlands (Westende), transitional areas (*Zwinbosjes*, *Duinenweg/Duinenstraat* in Raversijde) to specific and completely human-made areas such as the *Moeren* region (located between Veurne and Dunkirk on the French-Belgian border).

An overview of the spatial distribution of the known landscape heritage can be found in the scientific inventory landscape atlas, and can be searched on the inventory website and is offered on map in the geoportal Immovable

[2] Research on the genesis and significance of the maritime landscape (drowned paleo-landscapes) is included in maritime archaeology.

Heritage. An overview of the protected landscapes in West Flanders on 1 January 2001 can be found in 'Monumental West Flanders' (Cornilly 2005). The situation after the 1 January 2001 is recorded in the landscape atlas, the geoportal Immovable Heritage and via the website of Monumentenwacht Vlaanderen.

9.1.5 Movable and intangible heritage[3]

9.1.5.1 Movable heritage

The term 'movable heritage' covers historically valuable objects that can usually be found in museum collections, archives or heritage libraries. Museums generally focus their collection policy on a particular theme. Certain museums focus on the historical story of a city, region or country, whereas others focus on collecting art, technology or everyday objects.

- An overview of the museums along the coast can be found on the website of Uit in Vlaanderen. There are about twenty museums located in the coastal area[4], some of which focus specifically on the coast (see www.erfgoedinzicht.be for the digital disclosure to the collection of these museums);
- Several libraries are located along the coast. Some of them have publications with historical value in their collection. An overview of these collections is provided on the website collectiewijzer of the Flemish heritage library. The VLIZ library exclusively collects publications on the sea and coast. The library and documentation centre of the NAVIGO[5] museum focuses on the history of fisheries in the broadest sense.

Furthermore, the archives of the various government levels are important sources of movable heritage.

- The Archiefbank contains overviews of private archives that are of importance to maritime heritage (e.g. of the Free Fishing Schools);
- The State Archives of Belgium also preserve many records relating to coastal municipalities, which can be consulted via the searchable database;
- The provincial archives have their own database, Probat, where besides the archives of the province of West-Flanders, several municipal archives can be consulted (e.g. De Haan, Koksijde, Middelkerke, Blankenberge). The city archive of Ostend has its own website. In addition, the various image databases should be mentioned for their role in providing access to historical photographic material. The provincial image database contains pictures of quite a few coastal municipalities. The municipalities De Panne, Koksijde and Nieuwpoort are connected to the image database Westhoek verbeeldt. The image database Kusterfgoed primarily collects heritage collections from and on the municipalities of Middelkerke, Ostend, Bredene, De Haan and Blankenberge, and also focuses on the collections held by local heritage players and private individuals.

The initiative 'A century of sea fishery in Belgium' of VLIZ collects historical data on e.g. landings, income and legislation of the Belgian fisheries (see also thematic chapter **Fisheries**; Lescrauwaet 2013). In 2018, a reference work has been published on the core aspects of the wider fishing business during 500 years of Flemish sea fishing (Lescrauwaet et al. 2018). This work is based on archive, data and literature research, and the information is offered via the central online platform History of Belgian sea fisheries. In cooperation with national and international partners, VLIZ has also initiated the project Southern Netherlandish Prize Papers Research, in which documents of ships seized by the British Admiralty from the late 17th to early 19th century are valorised in a Flemish context (Pannier and De Winter 2020). These documents focus on the War of the Spanish Succession (1702-1714) and the socio-cultural context of the privateering communities of Ostend and Dunkirk. In 2020, the book 'Gekaapte brieven' was published, a private initiative about the letters that Ostend seamen and corsairs wrote home in 1664, but never reached their destination. Finally, the local historical societies also preserve a lot of interesting material. Until recently, an overview of all local historical societies along the coast was available via *Heemkunde Vlaanderen*. Since 2019, *Heemkunde Vlaanderen* is included in Histories, a Flemish heritage organisation subsidised by the Government of Flanders. Currently, as an extension to the Bibliography of the History of Ostend, a Bibliography of the History of the Central Coast is being compiled by Ghent University (UGent), *Kusterfgoed* and VLIZ. The bibliography will be available for digital consultation and will include works on the history of Middelkerke, Ostend, Bredene, De Haan and Blankenberge.

[3] Research on prehistoric heritage is included in maritime archaeology.
[4] It should be noted that certain actors (museums, libraries, archives, etc.) that are not located in the coastal area also have interesting collections on maritime and coastal heritage.
[5] Due to museum closure and renovations to the NAVIGO museum, this website page will not be available again until 2023.

9.1.5.2 Intangible cultural heritage

Intangible cultural heritage represents traditions, customs, knowledge and practices inherited or historically developed by a group of people, so in short for living traditions that are still continued. Dialects, processions or crafts are just some examples of intangible heritage. In this context, the Government of Flanders launched a platform for intangible heritage in Flanders. Individuals or organisations must apply to be included in the inventory. The inclusion in the inventory of Flanders is a prerequisite to apply for UNESCO recognition. Some examples of intangible heritage at the coast are the horseback shrimp fishermen in Oostduinkerke (recognised by UNESCO as intangible heritage in 2013) and the carnival of Blankenberge.

The typical coastal intangible heritage is currently threatened due to several factors. The fisheries heritage as well as the fisheries sector are under pressure. Rising fuel prices, expanding regulations and decreasing catch rates lead to the professional reorientation of many fishermen. As a result, the movable and intangible heritage related to fisheries is becoming less and less important. A museum such as NAVIGO collects everything related to fisheries and its history, but there are also other initiatives such as oral history projects (Rappé 2008, Strubbe 2011), which are committed to the preservation of this heritage. Also see Sincfala, the museum of the *Zwin* region, which does not only cover 2,000 years of folk history in the *Zwin* region but also offers a fisheries collection about the local fishermen and their families. Lastly, the Coastal Heritage Unit has a story archive in the context of coastal themes (such as go-carts, beach flowers made from crepe paper, agriculture, beach food, camping life, etc.).

9.2 Policy context

On an international level, the policies related to cultural heritage are primarily defined by the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Important legal instruments are the Convention concerning the Protection of the World Cultural and Natural Heritage (1972), and specifically for maritime and coastal heritage, the Convention on the Protection of the Underwater Cultural Heritage (2001) and the Convention for the Safeguarding of the Intangible Cultural Heritage (2003) (see website UNESCO for full list of legal instruments). A database updated by UNESCO also contains many national laws of the member states related to cultural and natural heritage. The International Council on Monuments and Sites (ICOMOS) is an international non-governmental organisation dedicated to the preservation of monuments and sites throughout the world, working closely with UNESCO and also acting as an advisory body. ICOMOS consists of an international committee, national committees and scientific committees. For underwater heritage, there is an active international scientific committee, namely the International Committee on the Underwater Cultural Heritage (ICUCH) that promotes the Convention of 2001. Furthermore, Belgium is also involved as member of the Advisory Council in the organisation European Maritime Heritage.

The main legal framework for activities at sea is the United Nations Convention on the law of the sea (UNCLOS 1982). In this almost globally ratified treaty, two clauses concerning heritage have been added. The UNESCO Convention on the Protection of Underwater Heritage has the intention to further complement and specify UNCLOS regarding the underwater cultural heritage.

At European level, the policy on cultural heritage is developed by the Directorate General for Education and Culture (DG EAC) of the European Commission, which recognised immovable heritage (landscapes, architectural heritage and archaeological heritage) as part of the cultural heritage. The Commission proposed a European cultural agenda in order to respond to challenges of globalisation and to intensify the cooperation inside the EU (COM (2007) 242, COM (2010) 390). By endorsing the Agenda of Rome (25 March 2017), the European Union (EU) promised to work towards a social Europe, a union which preserves our cultural heritage (COM (2017) 206). At the initiative of the European Commission, 2018 was designated European Year of Cultural Heritage, involving intensive cooperation with major European heritage organisations such as Europa Nostra and Nemo. Additionally, the Council of Europe (culture, heritage and diversity) plays a very important part in heritage conventions, such as the Convention of Granada (Convention for the Protection of the Architectural Heritage of Europe; 1985), Convention of Valletta (Convention for the Protection of the Archaeological Heritage of Europe – revised; 1992), Convention of Firenze (European Landscape Convention; 2000) and the Convention of Faro (Convention on the Value of Cultural Heritage for Society; 2005) (see website Culture and Cultural Heritage for an overview of the European cultural heritage legislation). The European Heritage Network (HEREIN) is a permanent information system that assembles public authorities of the member states responsible for cultural heritage (focusing on the architectural and archaeological heritage) under the umbrella of the Council of Europe. The HEREIN network also provides an overview of the heritage policies in the member states.

In Belgium, immovable cultural heritage is a competence of the Regions, whereas the movable and intangible cultural heritage is covered by the communities. Archaeological heritage in the North Sea under Belgian supervision is a federal competence. In this context, the Law of 4 April 2014 on the protection of underwater cultural heritage (the so-called 'OCE[6] Law') and the accompanying RD were repealed by the new Law of 23 April 2021.

- This law largely implements the provisions of the UNESCO Convention for the Protection of Underwater Cultural Heritage. According to the OCE Law, all findings at sea had to be reported to the Governor of West Flanders. The governor acted as 'recipient of underwater cultural heritage' and was not only responsible for the registration and notification of findings, but also provided advice to the competent (former secretary of state) minister for the North Sea regarding the possible heritage status of a finding. Under the new Law of 23 April 2021, a cooperation agreement will be drawn up concerning the findings;
- On 21 September 2016, a RD was adopted imposing measures regarding in situ protected underwater heritage followed by several MDs for the protection of underwater cultural heritage, including individual measures for the protection of 9 of the 11 already recognised wreck sites in the Belgian North Sea (see implementing measures of the Law of 4 April 2014, see **9.3.1 Maritime archaeological heritage**). For the shipwreck sites HMS Wakeful and UB-29, these measures were not necessary because of their location in a fairway. Consequently, these sites are indirectly protected. The Law of 23 April 2021 further defines the scope of application for underwater cultural heritage (e.g. including the paleontological context) (Van Quickenborne 2020). Wrecks which have been underwater for more than one hundred years will therefore automatically be considered as underwater heritage, and on the basis of a research report, the minister for the North Sea can determine whether specific wrecks are also eligible for this and the possible protection in situ. When the law was approved, this implied that, according to an initial inventory, 54 wrecks were granted the status of underwater cultural heritage, a selection of which can then be protected (Demerre et al. 2020).

The international and European regulations on underwater cultural heritage and the current legal situation in Belgium regarding this subject have been examined in the context of the SeArch project on the archaeological heritage in the North Sea (Maes and Derudder 2014, Derudder and Maes 2014, Missiaen et al. 2016, Missiaen et al. 2017). Additionally, a 'best practice' brochure was developed with recommendations on how to optimally include the underwater heritage in the planning and execution of works at sea, as well as various protocols for reporting archaeologic discoveries (downloadable via www.sea-arch.be/resultaten).

The policy notes on immovable heritage (2019 – 2024) and culture (2019 – 2024) contain the strategic lines of the heritage and cultural policy in Flanders, which are concretised and prioritised in annual policy letters. In Flanders, the competences with regard to immovable, movable and intangible heritage are covered by different bodies:

- Flanders Heritage Agency, part of the Department of Environment and Spatial Development (OMG), is responsible for the policy preparation and evaluation as well as for the policy implementation (policy-oriented, scientific research, realisation of inventories, protection, management support and communication) with regard to immovable heritage (see also Brochure Onroerend Erfgoed – Samen de zorg voor onroerend erfgoed vanzelfsprekend maken 2017). The agency has carried out these tasks in an integrated way since 1 January 2013. The OMG inspection division is responsible for the supervision and enforcement;
- The Department of Culture, Youth, Sports and Media (CJSM) is responsible for the policy concerning movable and intangible heritage. The policy regarding this heritage has its own website within the Department. The official Inventaris Vlaanderen – Immaterieel Erfgoed is managed by the Government of Flanders in cooperation with *Werkplaats Immaterieel Erfgoed* (WIE) with the aim of highlighting intangible heritage in Flanders. The Flemish Institute for Cultural Heritage (FARO) plays an intermediary role between the cultural heritage field (movable and intangible heritage) and the government. It supports cultural heritage organisations, local and provincial governments and managers of cultural heritage, and promotes the development of the cultural heritage field. Additionally, the organisation Herita vzw supports and unites all actors involved in heritage. Herita vzw also manages several heritage sites and organises activities related to heritage (e.g. Heritage Day).

At the Flemish level, there are some important legislative documents and concept notes on heritage and cultural policy:

- Since January 1st, 2015, a decree on immovable heritage has been in place (see brochure Onroerend Erfgoed: de regelgeving 2014, brochure Onroerend erfgoed: een toelichting 2014) that replaced three preceding decrees (Monument Decree of 1976, Archaeology Decree of 1993 and Landscape Decree of

[6] OCE – NL: *Onderwater Cultureel Erfgoed* (underwater cultural heritage)

1996) and a law on the preservation of monuments and landscapes (1931). All maritime immovable heritage present in the coastal area, including the beach down to the average low water mark at springtide, is included in this decree. On 14 July 2017, the Government of Flanders approved the concept note 'aanpassing Onroerenderfgoeddecreet', after which the Amending Decree was approved on 4 July 2018. The amendments include the adaptation of the protection procedure and the new relocation procedure. The enactment of this decree is gradually taking place from 1 January 2019 to 1 January 2022;

- Other important legal documents at the Flemish level are the *Topstukkendecreet* (Decree of 24 January 2003, protection of cultural heritage because of its special value in Flanders), the Decree of 29 March 2002 with regard to the protection of the historical fleet (Province of West Flanders 2008) and the Cultural Heritage Decree of 6 July 2012 with regard to cultural heritage (and the revision of 24 February 2017, concerning Flemish cultural heritage policy). The Cultural Heritage Decree of 27 February 2017 is linked to the Implementing Decree of 31 March 2017 and contains a Strategic Vision note to recognise and support cultural heritage organisations;
- A revision of the Historical Fleet Decree was ratified by the Government of Flanders on 9 May 2014. The revised decree entered into force with the Implementing Decree of 27 of November 2015 (see also brochure Onroerend erfgoed: Varend erfgoed in Vlaanderen). In the Decree of the Government of Flanders of 14 December 2018, some changes were made to the Historical Fleet Decree.

The Government of Flanders already put the depot policy on the agenda in 2008 by assigning the regional depot policy to the five provinces and the Flemish Community Committee. Since 1 of January 2018, the Government of Flanders, and no longer the provinces, are setting the direction for the regional depot policy (see also **9.5.5 Movable and intangible heritage**; website FARO erfgoedwijzer).

In 2015, the Coastal Heritage cell (kusterfgoed.be) was established in which five coastal municipalities (Middelkerke, Ostend, Bredene, De Haan and Blankenberge) work together on movable and intangible heritage along the coast.

9.3 Spatial use

9.3.1 Maritime archaeological heritage

The geographical position of the maritime heritage in marine areas is included in a number of databases. These also play an important role in policy and management decision making. Flemish partners have been involved in two European projects: the Archaeological Atlas of the 2 Seas project (in which the maritime archaeological heritage in France, England and Belgium has been mapped) and the MACHU project (Managing Cultural Heritage Underwater) in which a Geographical Information System (GIS) with the position of underwater cultural heritage in European seas was developed. The North Sea wrecks project strengthens cooperation and knowledge base on the location of wrecks, munitions and lost materials and waste, mapping maritime heritage sites in the North Sea area. As far as the BNS concerns, there are three databases that offer structured information: www.maritieme-archeologie.be, wrecks database (and digital map), and www.wrecksite.eu.

As far as maritime heritage in the North Sea is concerned, it is not evident to claim specific marine space for this purpose as heritage may potentially be present anywhere. It seems more appropriate to take advantage of the existing protective measures for *inter alia* nature to also conserve and protect a representative sample of the underwater heritage in situ. The aim of this policy is that, when underwater heritage has to disappear for compelling reasons, it gets the appropriate care and does not disappear without control. The locations of underwater heritage sites in the BNS that are recognised as cultural heritage underwater by the Law of 23 April 2021 are listed in a register (www.vondsteninzee.be).

Since 2014, underwater cultural heritage has been given a spatial translation by the recognition and protection of eight ship wreck sites (the lightship West-Hinder, de HMS Wakeful, a 19th century wooden sailing ship that perished near the coast of Ostend, the VOC ship 't Vliegend Hart, the SS Kilmore, the WWI submarine U-11, the HMS Brilliant and the wreck site on the Buiten Ratel Zandbank). The MD of 6 April 2018 recognised and protected three more shipwreck sites (the French destroyer Torpilleur Branlebas, the wooden gunboat H.M. Motor Launch 561, and the German submarine UB-29) (figure 1, table 1). The Law of 23 April 2021 heritage ensures that 54 wrecks that have been underwater for at least 100 years will automatically be given the status of underwater cultural heritage, and can therefore be protected in situ in future (FPS Public Health, Demerre et al. 2020).

In annex to the RD of 20 March 2014, established for the marine spatial plan (MSP 2014-2020), the cultural and ecological importance of the more than 215 (ship)wrecks that lay in the BNS is acknowledged (Maes and Seys

2014). In the new marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020), respect of underwater cultural heritage in the BNS is again an important objective, whereby:

- The most valuable cultural heritage under water is protected in situ according to a legal procedure;
- The areas with protection measures for the recognised shipwreck sites are included;
- Appropriate mitigating measures are adopted if cultural heritage would be threatened by human activities;
- Wrecks are enabled in the context of nature preservation.

Table 1. Individual protective measures for the 11 recognised ship wreck sites .

Wreck site	Individual protective measures	Wreck site	Individual protective measures
West-Hinder	Line fishing, anchoring, dredging and fishing with trawling nets prohibited	HMS Brilliant	Line fishing, anchoring and dredging prohibited
HMS Wakeful	Indirect (no individual measures)	Buiten Ratel Zandbank	Anchoring and dredging prohibited
zeilschip (kust van Oostende)	Anchoring and dredging prohibited	Torpilleur Branlebas	Fishing with trawling nets prohibited
't Vliegend Hart	Anchoring and dredging prohibited	H.M. Motor Launch 561	Fishing with trawling nets prohibited
SS Kilmore	Line fishing, anchoring and dredging prohibited	UB-29	Indirect (no individual measures)
U-11	Line fishing, anchoring, dredging and fishing with trawling nets prohibited		

9.3.2 Architectural heritage at the coast

The geoportal of Flanders Heritage Agency (geo.onroerenderfgoed.be) provides an overview of the geographical locations of the architectural heritage in the coastal area. Additional information about the heritage elements can be obtained via click-through functions. Coastal municipalities such as Ostend can also dispose of an Action Plan Architectural Heritage to protect, preserve, manage and evaluate future developments.

9.3.3 Landscapes with heritage value

The geoportal of Flanders Heritage Agency provides an overview of the geographical location of landscapes with heritage value in the coastal area (see also the inventory landscapes with heritage value and the Wetenschappelijke inventaris landschappelijk erfgoed).

9.4 Societal interest

Despite the fact that the importance of heritage is generally recognised, the economic significance, benefits and societal return on investment are often unknown. The study by De Baerdemaeker et al. (2011) deals with the socio-economic impact of the immovable heritage (policy) in Flanders. The direct economic impact of immovable heritage in Flanders was investigated by Vanhoutte (2019). Flanders is mostly associated with heritage, art and artists, beer, good food and beverages, according to a Reputation study (2017) by Tourism Flanders. Furthermore, the report of the Cultural Heritage Counts project for Europe discusses the value of cultural heritage and its impact on Europe's economy, culture, society and environment. In general, marine and maritime cultural heritage are underappreciated (Pieters 2017).

With regard to the coastal zone, mainly the economic benefits related to coastal tourism are known (see also thematic chapter **Tourism and recreation**). According to De Baerdemaeker et al. (2011), 189.229 (or 10%) of the overnight stays in hotels along the coast in 2009 were related to the presence of immovable heritage. Along with day trippers and recreationists, heritage tourism expenditure amounts to more than 2 million visitors annually, whereas the total heritage-related tourism expenditure amounts to almost 60 million euro. Numbers on the cultural attractions are available in the Trendrapport Kust (2018-2019) (see also thematic chapter **Tourism and recreation**). According to Maes et al. (2005) (GAUFRE project BELSPO), many shipwrecks in the BNS create a tourism revenue.

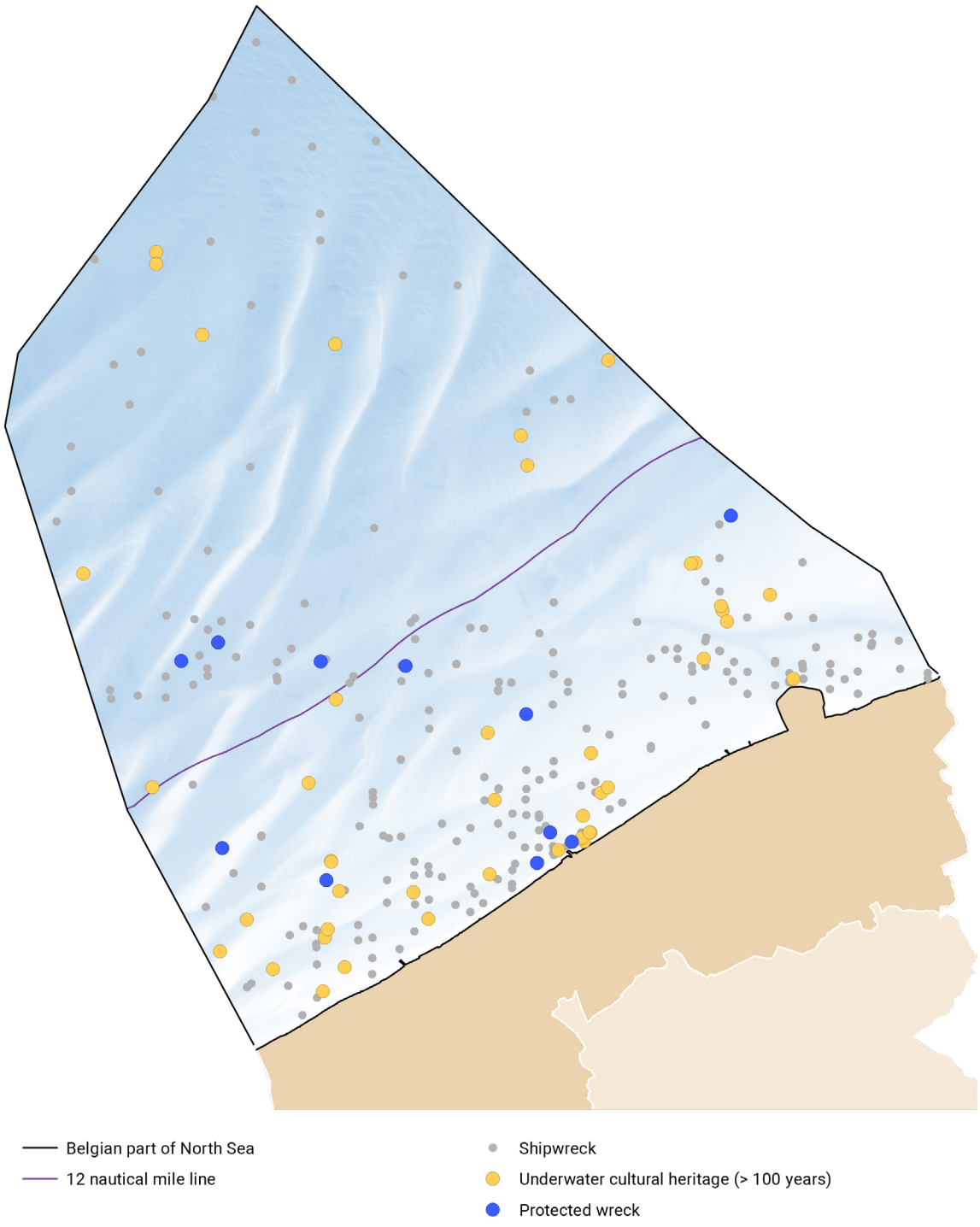


Figure 1. Ship wreck sites in the BNS (Source: Flanders Heritage Agency, MD of 6 April 2018, FPS Mobility, Coastal Portal)

Other aspects of the social importance of cultural heritage in the coastal area are less known and only fragmented figures and information exist:

- According to Maelfait et al. (2012), more than 4 million euro of grants were allocated between 2008 and 2010 by the Government of Flanders for the restauration and maintenance of cultural heritage in the coastal zone;
- The proximity of immovable heritage creates a better living environment which affects the value of housing. In De Panne, where 44% of the municipal surface is protected (in this variable, the landscape heritage in

particular weighs in on the architectural heritage), a house would gain around 21.000 euro added value. In Knokke-Heist, this figure is 17% and a house will gain approximately 8.300 euro in added value (De Baerdemaeker et al. 2011);
- Social employment projects are developed in a number of historic shipyards;
- Museums are also associated with education. However, there are no data available regarding their impact. Local historical societies, heritage organisations or private individuals occasionally work together with schools;
- The social importance of heritage and the social aspect of volunteering are expressed through the many volunteers who are active in various community groups, heritage organisations, museums and other subsidised organisations (such as Kusterfgoed).

9.5 Sustainable use and management

9.5.1 Maritime archaeological heritage

Until recently, underwater heritage was barely considered, mainly because of the ignorance about it. In 2014, however, a law on the protection of underwater cultural heritage in the BNS entered into force (Law of 4 April 2014). This law introduced an obligation to report findings in the BNS of which the finder may suspect that they are cultural heritage. Discoveries in the territorial sea, the exclusive economic zone or the continental shelf have to be reported to the Governor of West Flanders on the website www.vondsteninzee.be, where they are subsequently entered in a register (see also the SeArch project established protocols: Van Haelst et al. 2016a, 2016c). Archaeological findings on the beach should be reported to the Flanders Heritage Agency (see also Van Haelst et al. 2016b, De Blauwe 2017). Under the new Law of 23 April 2021, a cooperation agreement will be drawn up regarding the discoveries. At the end of 2016, five new shipwrecks in the North Sea were recognised as cultural heritage on the basis of the Law of 4 April 2014. With the MD of 6 April 2018 another three wrecks were recognised, which ensures that a total of 11 wrecks are recognised (e.g. the sailing ship on the Buiten Ratel, the HMS Briljant, the light ship West-Hinder and the Torpilleur Branlebas). In the meantime, also protective measures are in place for these 11 heritage sites (whether or not indirectly for e.g. HMS Wakeful and the UB-29). The shipwreck Westhinder was completely cleaned up by order of the federal government (2018-2019) (Devriese and Janssen 2021), amounting up to 2 tonnes of iron, 1 ton of fishing lead and 1.5 tonnes of fishing nets and plastic waste. The Law of 23 April 2021 implies that wrecks that have been underwater for more than a hundred years are automatically considered as underwater heritage, of which a selection can then be protected (Demerre et al. 2020).

The amendment of the law on the marine environment in view of marine spatial planning (Law of 20 January 1999) is important as well. Underwater heritage is also mentioned in annex 1 of this maritime spatial plan (Verhalle and Van de Velde 2020). This annex does not have the intention to claim specific areas for heritage purposes in the North Sea (as is the case for the other user functions). Instead, it is examined how existing protective measures can be used to achieve multiple uses of certain marine areas. Some field examples are listed below:

- The Nemo Link project (see thematic chapter **Energy (including cables and pipes)**), which aims at connecting transmission networks between Great Britain and Belgium, strives towards maximal evasion of known or newly detected heritage sites to reduce the effect on the maritime cultural heritage. Knowledge about these heritage sites and their position along the cable route is crucial for this purpose;
- A preliminary geophysical study (within the framework of the Sustainable Management Plan) also found locations with possible archaeological remains in the bed of the Upper Sea Scheldt, as a result of which an archaeological investigation was started (Van Haelst et al. 2019);
- For the development of the new Princess Elisabeth zone for offshore wind energy, the federal government is proactively carrying out an archaeological (desktop) study;
- The paleolandscape reconstruction of the coastal area near Zeebrugge is a good example of how an economically driven project (Coastal Vision project) can be done in synergy with the research on drowned landscapes and underwater heritage. The extensive media attention for the recent discoveries of fossil bone material in the *Scheur* near Zeebrugge is a proof of the great social relevance (Van Haelst and Pieters 2018).

9.5.2 Nautical heritage

Since 29 March 2002, there has been a decree that regulates the protection of nautical heritage (Van Dijck 2017). This Nautical Heritage Decree was modified on 9 May 2014 and has, together with the accompanying Decision on Nautical Heritage of 27 November 2015, the purpose of supporting owners and users of heritage vessels in

keeping their vessels in service. They can develop a management plan for their vessel, in which for the period of several years of maintenance, the restorations, a budget and the opening of the vessel are worked out (see also Brochure Onroerend Erfgoed: Varend erfgoed in Vlaanderen 2016). Based on this plan, a grant can be claimed (maintenance and/or management grant). The nautical heritage policy is implemented by the Flanders Heritage Agency. A separate, fourth department of the Royal Commission for Monuments and Sites was established to advise the minister on nautical heritage and the historic fleet. On 1 January 2015, this commission was transformed to the Flemish Commission for Nautical Heritage (VCVE). In order to achieve a responsible conservation policy, an inventory of nautical heritage and the historical fleet was developed.

Early 2021, 32 vessels had already been inventoried as nautical heritage in the coastal area[7] (see inventory). Seven vessels were listed as protected nautical heritage and two vessels (the school ship Mercator and the fishing vessel OD1 Martha) as protected monument. Of course, not all protected and inventoried vessels are coast-related. Other sectors such as inland shipping can be covered by the protections.

9.5.3 Architectural heritage at the coast

Due to the ever-growing scarcity of open space at the coast, the remaining heritage is under increasing pressure both in the coastal and hinterland municipalities (Maelfait et al. 2012). The protection of immovable heritage is regulated by the Decree on immovable heritage (see Brochure Onroerend Erfgoed - de regelgeving 2014, Brochure Onroerend erfgoed - een toelichting 2014), which entered into force in 2015. Since 2009, the architectural heritage has been recorded in the inventory, which has certain legal consequences: demolition becomes less evident (with a few exceptions), whereas a change of function is made easier as long as it benefits the preservation of the cultural heritage value (Maelfait et al. 2012). The protection decisions regarding immovable heritage can be consulted on the following website: https://www.onroerenderfgoed.be/de-gevolgen-van-een-bescherming.

9.5.4 Landscapes with heritage value

The scarcity of open spaces along the coast also applies to landscapes with heritage value. Besides the protected landscapes which, in addition to their heritage value, usually have an important ecological value, the immovable heritage sector is currently focusing on the instrument of the so-called anchorage areas. These areas are designated by the Flemish minister for Heritage, and constitute the contribution from the sector to the AGNAS consultation (defining the natural and agricultural structure in the Flemish Spatial Structure Plan (*Ruimtelijk Structuurplan Vlaanderen*)). An anchorage area is a valuable landscape with a series of heritage elements (landscape, architectural, archaeological or maritime).

In the past, these anchor areas could be given legal status at the time of 'designation'. From then on, the local government was obliged to take it into account when developing a Spatial Implementation Plan (SIP) (Landschappen: een kennismaking 2013). The Decree on immovable heritage no longer allows such 'designation'. However, in order to preserve the immovable heritage, items from the landscape atlas can be established. Until recently, anchor points could be found in the protection database, but from now on they are searchable on the inventory website. An established item can be used by the municipality, province or Flemish Region in a SIP as a basis for the demarcation of a heritage landscape. Anchor sites that were 'designated' under the old regulation have been equated with an item from the inventory website and with a real estate heritage development plan.

9.5.5 Movable and intangible heritage

The list of objects and collections with an exceptional value (topstukkenlijst) contains several hundred pieces or (sub)collections. Some of these are linked to the coast. It mainly concerns paintings from Ensor, Permeke and Spillaert from the collection of Mu.Zee Ostend, the Royal Museum of Fine Arts Antwerp (KMSKA), and the Museum of Fine Arts (MSK) Ghent. In order to be incorporated in this list, an object has to meet strict selection criteria. It should be both rare and essential. Grants can be requested for the restoration of these valuable pieces (Decree of 24 January 2003).

As from 1 January 2018, the Government of Flanders itself determines this regional depot policy (De Langhe 2018). Currently, the allocation of the depot policy to the provinces has not yet been withdrawn, which does not

[7] Four vessels of importance for the coastal area but located elsewhere in Flanders were also included (O.205 François Musin and the West-Hinder three in Antwerp, the West-Hinder one in Kruibeke, and the BOU8 Isabelle in Boekhoute (Assenede).

explicitly prohibit the provinces from pursuing their own depot policy. In West Flanders, it was decided in 2017 to no longer conduct a depot policy, but to support the three depot dossiers Ypres (*Potyze*), Kortrijk (*Trezoor*) and Bruges (*Erfgoedfabriek*). Since 2008, this policy focuses on two trajectories including the registration of movable heritage possessed by museums, local historical societies and other heritage managers, as well as the conservation and management of these pieces. In order to assist museums and heritage associations in registering their collections, the heritage database www.erfgoedinzicht.be was developed.

The official inventory of intangible heritage currently contains 64 elements, four of which are specific to the coast: the carnival of Blankenberge, the Godelieve procession in Gistel, horseback shrimp fishing in Oostduinkerke, and since 2021 also selling beach flowers on the beach. The inventory is established according to the bottom-up principle. Organisations or individuals must apply to have an element of intangible cultural heritage included in the inventory. Elements included in the inventory must receive an annual progress report (via the applicant) with information about the activities concerning the protection of the element. For now, inclusion in the inventory only increases the visibility of the element. Being in the inventory is a prerequisite to be included in the UNESCO list of intangible heritage.

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
WHC	World Heritage Convention	1972	1996
UNCLOS	United Nations Convention on the law of the sea	1982	1994
UCH	Convention on the protection of the underwater cultural heritage	2001	2009
ICH	Convention for the safeguarding of the intangible cultural heritage	2003	2006

European legislation and policy context			
Acronyms	**Title**	**Year A**	**Year EIF**
Conventions			
Granada Convention	Convention for the protection of the architectural heritage of Europe	1985	1987
Valletta Convention	Convention for the protection of the archaeological heritage of Europe (revised)	1992	1995
Firenze Convention	European Landscape Convention	2000	2004
Faro Convention	Convention on the value of cultural heritage for society	2005	2011

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decrees		
Decree of 3 March 1976	Decreet tot bescherming van monumenten en stads- en dorpsgezichten	1976-03-03/30
Decree of 30 June 1993	Decreet houdende bescherming van het archeologisch patrimonium	1993-06-30/33
Decree of 16 April 1996	Decreet betreffende de landschapszorg	1996-04-16/34
Decree of 29 March 2002	Decreet tot bescherming van varend erfgoed	2002-03-29/37
Decree of 24 January 2003	Decreet houdende bescherming van het roerend cultureel erfgoed van uitzonderlijk belang (Topstukkendecreet)	2003-01-24/40
Decree of 16 July 2010	Decreet houdende instemming met het verdrag ter bescherming van het cultureel erfgoed onder water, aangenomen in Parijs op 2 november 2001	2010-07-16/10
Decree of 6 July 2012	Decreet houdende het Vlaams cultureel-erfgoedbeleid (Erfgoeddecreet)	2012-07-06/31
Decree of 12 July 2013	Decreet betreffende het onroerend erfgoed (Onroerenderfgoeddecreet)	2013-07-12/44
Decree of 24 February 2017	Decreet houdende de ondersteuning van cultureelerfgoedwerking in Vlaanderen (Cultureelerfgoeddecreet)	2017-02-24/17
Royal Decrees		
RD of 21 September 2016	Koninklijk besluit betreffende de reglementaire maatregelen ter bescherming van het cultureel erfgoed onder water	2016-09-21/12
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
RD of 30 July 2021	Koninklijk besluit tot uitvoering van de wet van 23 april 2021 tot implementatie van het UNESCO verdrag van 2 november 2001 ter bescherming van het cultureel erfgoed onder water en de bescherming van waardevolle wrakken	2021-07-30/17
Ministerial Decrees		
MD of 6 April 2018	Ministerieel besluit betreffende de erkenning van 3 scheepswrakken als cultureel erfgoed onder water	2018-04-06/01
MD of 14 May 2020	Ministerieel besluit tot opheffing van het ministerieel besluit van 4 oktober 2016 betreffende individuele maatregelen ter bescherming van het cultureel erfgoed onder water	2020-05-14/18
Laws		
Law of 7 August 1931	Wet op het behoud van monumenten en landschappen	1931-08-07/30
Law of 20 January 1999	Wet ter bescherming van het mariene milieu [en ter organisatie van de mariene ruimtelijke planning] in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 23 April 2021	Wet tot implementatie van het UNESCO-verdrag van 2 november 2001 ter bescherming van het cultureel erfgoed onder water en de bescherming van waardevolle wrakken	2021-04-23/10

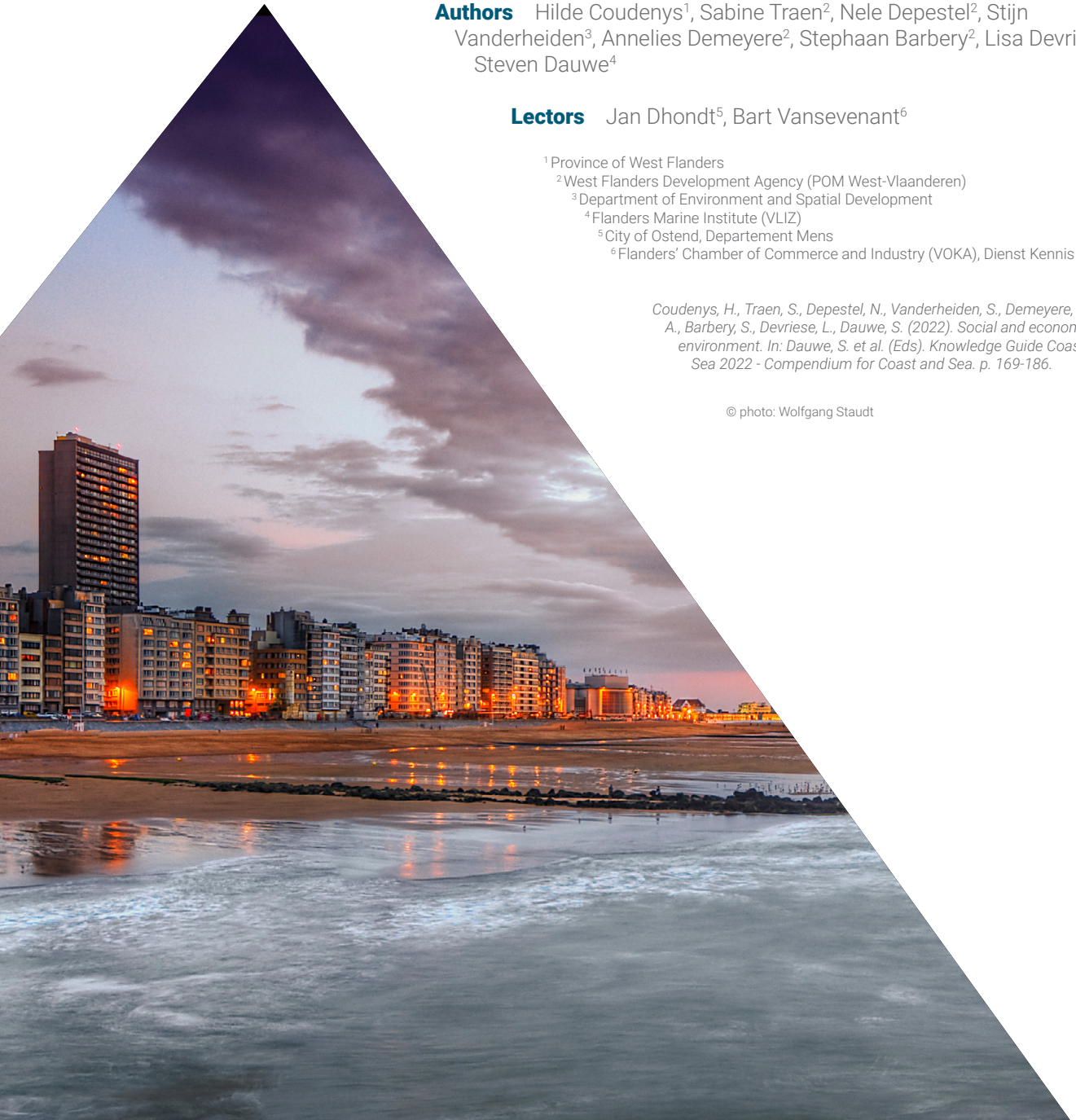
10 Social and economic environment

Authors Hilde Coudenys[1], Sabine Traen[2], Nele Depestel[2], Stijn Vanderheiden[3], Annelies Demeyere[2], Stephaan Barbery[2], Lisa Devriese[4], Steven Dauwe[4]

Lectors Jan Dhondt[5], Bart Vansevenant[6]

[1] Province of West Flanders
[2] West Flanders Development Agency (POM West-Vlaanderen)
[3] Department of Environment and Spatial Development
[4] Flanders Marine Institute (VLIZ)
[5] City of Ostend, Departement Mens
[6] Flanders' Chamber of Commerce and Industry (VOKA), Dienst Kennis & Advies

Coudenys, H., Traen, S., Depestel, N., Vanderheiden, S., Demeyere, A., Barbery, S., Devriese, L., Dauwe, S. (2022). Social and economic environment. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 169-186.



Coastal zones are often areas with their own identity and specific challenges. These heterogeneous regions show, certainly in socio-economic terms, clear differences between their coastal municipalities and its hinterland (The changing faces of Europe's coastal zones, EEA 2006, Balancing the future of Europe's coasts, EEA 2013). This is also the case along the Belgian coast, where the neighbourhoods located by the sea are clearly distinguished from those located further inland. In many cases, the seafront neighbourhoods exhibit more metropolitan characteristics such as high population densities, an increased risk of deprivation, loneliness, limited facilities for less mobile people, pressure on the housing market, more people living alone, etc.

The Belgian coast is characterised by an atypical social environment with a relatively old population and a high number of second-residences (Westtoer 2016, Stedelijk systeem kust 2017, Dauwe et al. 2019). The Belgian coast is also very distinctive from an economic perspective, with on the one hand, the presence of large economic gateways (two seaports, an international airport) and a diverse network of economic activities linked to coastal tourism and the Blue Economy. On the other hand, there's also increased unemployment, more seasonal employment and few quality jobs for the higher-educated (Breyne et al. 2007, Maelfait et al. 2012, Dauwe et al. 2019, West-Vlaanderen Ontcijferd 2020).

In this thematic chapter, the Belgian coastal zone[1] is primarily compared to the province of West Flanders. However, it is possible to benchmark these figures within larger geographical areas (e.g. the Flemish Region) when consulting the publications or websites cited within this thematic chapter.

10.1 Policy context

In Belgium, policy on the socio-economic environment involves both federal and Flemish actors. At the federal level, there are the federal public services: FPS Employment, Labour and Social Dialogue, FPS Economy, SMEs, Self-employed and Energy and the federal public planning service for social integration (PPS SI). At the Flemish level, there are the policy areas Work and Social Economy and Economy, Science and Innovation (see also the Flemish policy papers Work and Social Economy 2019-2024 and Economy, Science policy and Innovation 2019-2024).

Housing policy and spatial planning are governed by the Flemish Department of Environment and Spatial Development (OMG) (see the Flemish policy papers Environment 2019-2024 and Living 2019-2024). OMG runs, in cooperation with the Province of West Flanders, a territorial development program (*territoriaal ontwikkelingsprogramma*) for the coastal zone (T.OP Coastal Zone) (*T.OP Kustzone*). The program works by an action-oriented programme for the spatial development of this area in the short and medium term and is centered around themes such as the 'urbanised coastal zone', 'polder space' and 'land-sea interactions'. The T.OP Coastal Zone programme is based on the revised Provincial Spatial Structure Plan (PRS W-VL), local partner consultations and studies such as CcASPAR, MKL2100, Codex Coastal Zone, STADSMonitor, etc. (see also in more detail in **10.4.3 Urban vision development on the coast**). Other Flemish policy areas such as Welfare, Public Health and Family (WVG), Education and Training (OV), Culture, Youth, Sport and Media (CJSM), and Mobility and Public Works (MOW) also play an important role in the social and/or economic environment of the coastal zone.

The Province of West Flanders (e.g. Streekhuis Kust) and the municipalities are important in the implementation of economic and housing policy and spatial planning (see below and thematic chapter **Tourism and recreation**). The legal framework for spatial planning can be found in the Codex Coastal Zone, theme Spatial planning. The local legislation for coastal residents is also listed in the Codex Coastal Zone, within the theme Local legislation.

10.2 Spatial use

The total area of the coastal zone amounts to 1,183 km². The coastal municipalities constitute 42% of this area, the hinterland municipalities take up 58% (Land use according to the *Kadasterregister* - Statbel).

The current spatial use is determined by the regional plans drafted by the federal government in the 70s and 80s. A regional spatial plan (*gewestplan*) corresponded roughly to one or more districts, in which space was arranged into areas where housing and facilities could further expand, where business activities could be accommodated, where camping sites were provided in recreational areas, where natural areas were protected and where there's

[1]The coastal zone comprises the ten coastal municipalities (Blankenberge, Bruges, Knokke-Heist, Bredene, De Haan, Middelkerke, Ostend, De Panne, Koksijde and Nieuwpoort) and the nine hinterland municipalities (Damme, Jabbeke, Zuienkerke, Diksmuide, Lo-Reninge, Gistel, Oudenburg, Alveringem and Veurne).

room for agriculture. An area on a regional spatial plan could be further refined by the municipality in special urban plans (BPAs). This was especially the case for buildable areas. As a result, differences remain between the coastal municipalities in terms of, for example, height and density of appartments.

The spatial planning system changed with the new Flemish Decree on the organisation of spatial planning (Decree of 18 May 1999). The destinations in a regional spatial plan remained valid until they are replaced by a new destination through a spatial implementation plan (SIP). Such SIPs can be drafted by municipalities, provinces or the Flemish Region. The establishment of a SIP corresponds with the implementation of a spatial vision, described in a spatial structure plan. There are three spatial structure plans: the Flemish Spatial Structure Plan (RSV), the West Flanders Spatial Structure Plan (PRS W-VL) and the municipal structural plans. These spatial visions determine the future spatial use. The Regional Plans, SIPs and BPAs can be consulted on the following website.

The RSV identifies the coast as both an urban- and a tourist-recreational network. This means that a coherent urban policy for the coast should be pursued, with opportunities for further development of tourist-recreational activities (both for day tourism and residential tourism) and qualitative residential environments. This grants the regional urban area of Ostend (comprising parts of Middelkerke, Ostend, Bredene and Oudenburg) the role of accommodating emerging needs for housing and business activities. Additionally, Ostend and Zeebrugge are designated as economic gateways, providing the two seaports, as well as the International Airport Ostend-Bruges, with further opportunities for development. The development of these gateways is defined in regional spatial implementation plans (RSIPs). The Flemish Region also anchors large continuous nature areas such as the *Zwin*, the beaches between seaside neighbourhoods on the west coast, etc. within these RSIPs. Parallel to the further implementation of the RSV, the Government of Flanders approved the White Paper 'Beleidsplan Ruimte Vlaanderen' 2017' on 30 November 2016. In this White Paper, the Government of Flanders formulates objectives, spatial development principles and activities that will act as a basis for the transformation of Flanders' space. Subsequently, on 20 July 2018, the Government of Flanders approved the Strategische visie Beleidsplan Ruimte Vlaanderen 2018, in which strategic objectives are outlined for the coming Flanders' Spatial Policy Plan (*Beleidsplan Ruimte Vlaanderen* (BRV). A draft BRV is currently being prepared which, after approval, will be subjected to a public consultation. The intention is for provinces and municipalities to also come up with a new spatial policy plan to replace the current structure plans (a preliminary draft for the province of West Flanders is expected in early 2022). Specifically, for the coast and the *Westhoek*, a supra-local strategic vision has already been developed in which the spatial development of the region is optimally attuned to mobility and public transport (Vandekerckhove et al. 2019). A Territorial Development Programme (T.OP Kustzone) was also developed within this renewed spatial development policy for the coastal zone (see **10.1 Policy context** and **10.4.3 Urban vision development on the coast**).

The PRS W-VL refines the coastal planning space, giving each coastal municipality opportunities for further development. This is further detailed in municipal structural plans and converted into municipal spatial implementation plans. The province determines the possibilities regarding constructions on the beach or dyke by means of provincial spatial implementation plans (PSIPs). The PRS W-VL and the PSIPs are available at www.west-vlaanderen.be/ruimtelijke-planning.

10.3 Current state

10.3.1 Social environment

10.3.1.1 The coast and its inhabitants

On 1 January 2020, the coastal zone counted 426,075 inhabitants (coastal municipalities: 339,501; 79.7%; hinterland municipalities: 86,574; 20.3%). This is 35.4% of the total population of West Flanders (Rijksregister, processed by the Data and Analysis service of the West Flanders Development Agency (D&A) | provincies.incijfers.be). About 14.4% of the population in the coastal zone has foreign roots. In the coastal municipalities this is 16.1% against 7.5% of the inhabitants of the hinterland municipalities (Rijksregister, processed by D&A | provincies.incijfers.be).

Between 2010-2020 the population of the coastal zone has increased with 2.7% (figure 1), and at a similar rate in the coastal and hinterland municipalities. The increase in the coastal zone is slightly below the population increase in the province of West Flanders (+3.5%). Projections by Statistiek Vlaanderen suggest that the population in the coastal zone will increase by more than 5% by 2035. The expected population growth in the coastal zone (and by extension for the whole of West Flanders) is less than the expected population growth in Flanders in general (+7.6%).

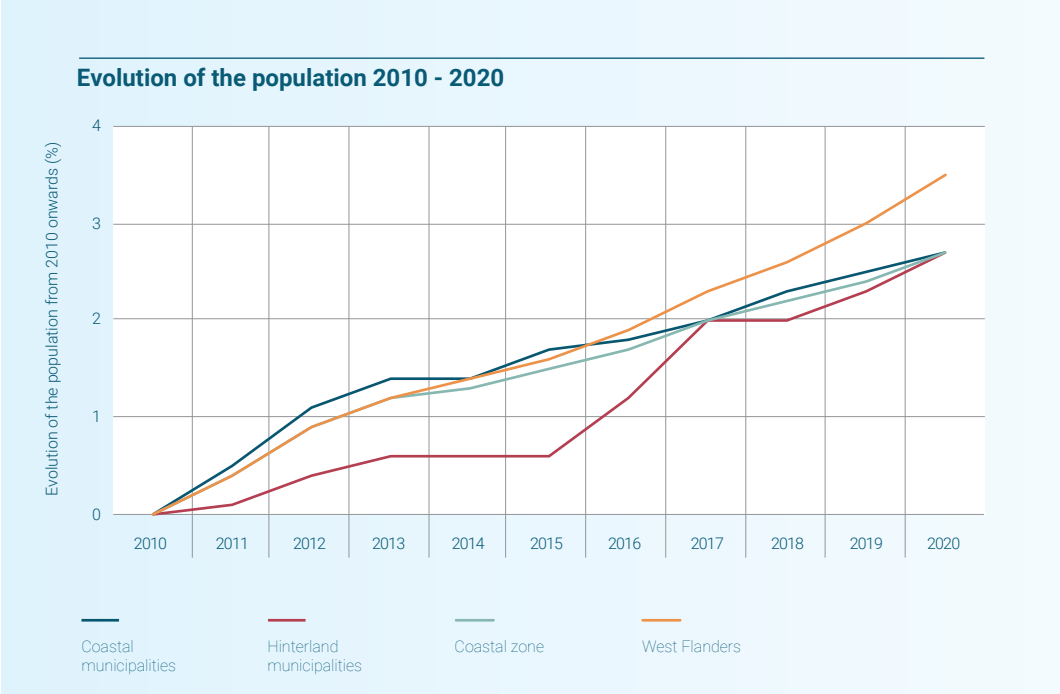


Figure 1. The relative evolution of the population in the coastal zone and the province of West Flanders between 2010-2020 (Source: Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be).

The Belgian coast, combined with the Dutch and parts of the northern French coast, constitutes one of the coastal regions along the North Sea with the highest population density. Regions with over 1,000 inhabitants per km² are recorded in the coastal zone of the Netherlands and Belgium (North Sea Region Climate Change Assessment 2016). The average population density in the Flemish coastal zone is 374 inhabitants per km², although this is strongly demarcated geographically. The average population in coastal municipalities is 708 inhabitants per km², whereas on average 131 inhabitants per km² live in hinterland municipalities. The population density can be even higher, regularly exceeding 1,000 inhabitants per km², when closer to the coast (figure 2) (Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be, Coastal Portal). These strong regional differences exert an impact on major social and economic domains, including employment, housing, mobility, etc. (Dauwe et al. 2019).

The Belgian coastal zone is also characterised by an unbalanced population structure and demographic dynamics. Phenomena such as dejuvenation and ageing manifest themselves more strongly along the Belgian coast than in the rest of Flanders, most notably in the coastal municipalities (De Klerck 2011, Dauwe et al. 2019). For instance, the population aged 0-17 decreased in the entire coastal zone (-6.0%) (2010-2020), while the population aged 65 and over increased strongly within the same period (+23.0%) (figure 3). The age class 65+ represented 27.8% of the total population in the coastal zone in 2020, accounting for 118,455 people (ageing effect or "*vergrijzing*"). In contrast, only 15.3% of the coastal inhabitants are younger than 18 (65,366 people). Of the people older than 65, 30% is older than 80 (internal ageing effect or "*interne vergrijzing*"). Between 2010-2020, the age class 80+ in the coastal zone increased by 35%. Eight coastal municipalities appear on the list of the 20 Belgian municipalities with the oldest population (Rijksregister, 1 January 2021). Only the municipalities of Bruges and Bredene did not appear on this list.

Demographic structure coefficients also tell us something about the composition and evolution of the population (table 1). In general, the coastal zone can be divided into two realities, with the hinterland municipalities resembling the provincial trend, while the coastal municipalities follow a separate trajectory. In West Flanders in 2020, there were 153 60+ inhabitants for every 100 0-19 year-olds. For the coastal municipalities, this ageing rate (*verouderingsgraad*) increases up to 227. The grey pressure (*grijze druk*) (ratio of 65+ population to the 20-64 population) amounts to 54 in the coastal municipalities (per 100 persons of working age, there are 54 people over 60). The internal ageing effect (*interne vergrijzing*) (share of 80+ within the group 65+) amounts to 30 in the coastal municipalities. Meaning, the coastal municipalities score slightly lower in comparison with the hinterland municipalities and West Flanders in general (both 32).

On 1 January 2020, 203,726 households resided in the coastal zone (Rijksregister, processed by D&A | provincies.incijfers.be). Between 2010 and 2020, the number of households increased by 7%. This growth exceeded that of the number of inhabitants (+2.7%). Over the past 10 years, the coastal zone has therefore been characterised by a "thinning" of households, with smaller average households. The average family size in the coastal zone is 2.06 persons. The municipalities in the hinterland have an average family size of 2.32; in the coastal municipalities the average family size is 2.00 persons (Rijksregister, processed by D&A | provincies.incijfers.be).

Table 1. A selection of demographic structural coefficients for the coastal zone (coastal municipalities + hinterland municipalities) and the province of West Flanders (Source: Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be).

Indicator	Structural coefficients			
	Coastal municipalities	Hinterland municipalities	Coastal zone	West Flanders
Ageing rate (60+/0-19 year*100)	227	142	207	152
Grey pressure (65/ 20-64 year*100)	54	38	51	42
Internal ageing (80+/65+*100)	30	32	30	32

** More coefficients describing the demographic context of the coastal zone can be consulted and compared at provincies.incijfers.be, theme Bevolking.*

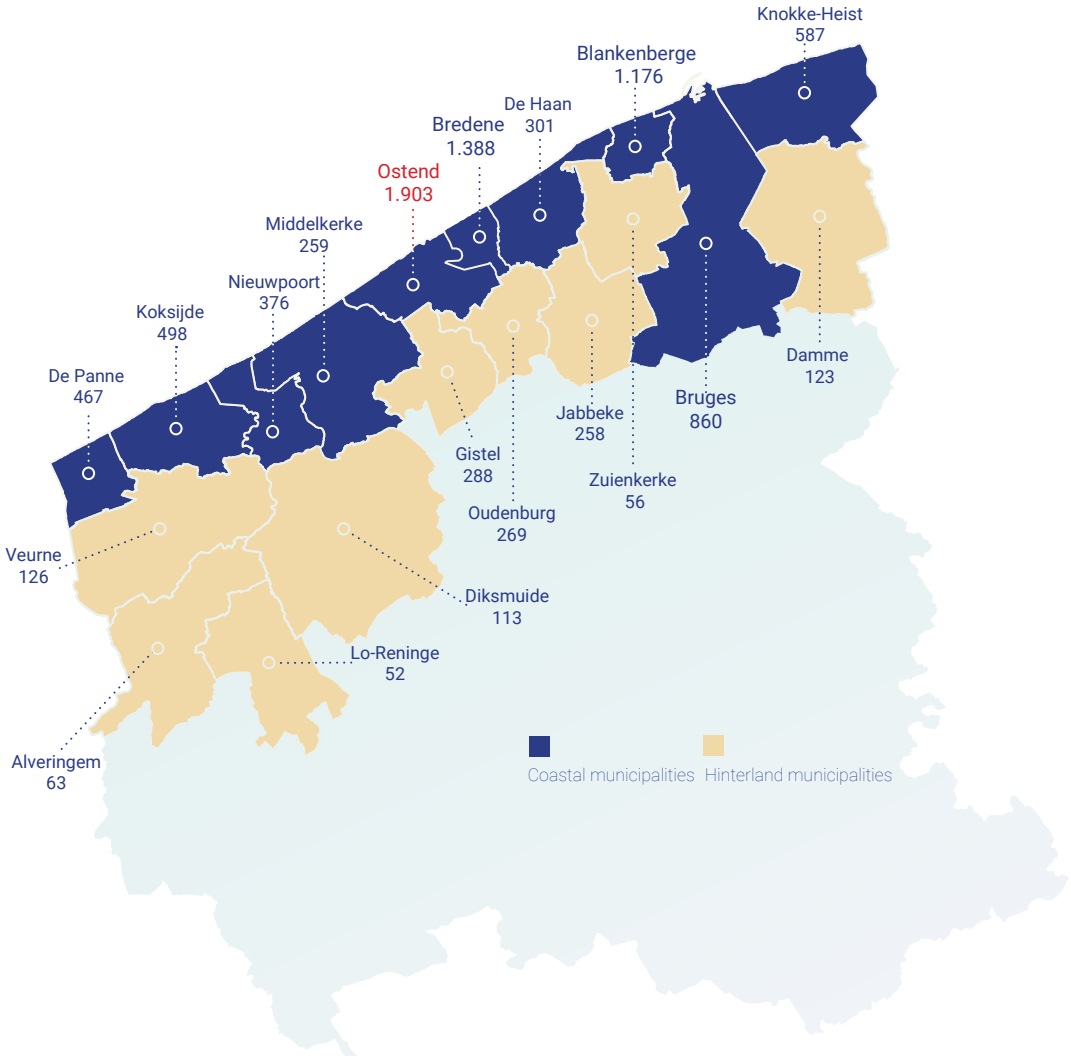


Figure 2. Population density (inhabitants/km²) in the coastal zone (Source: Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be, Coastal Portal).

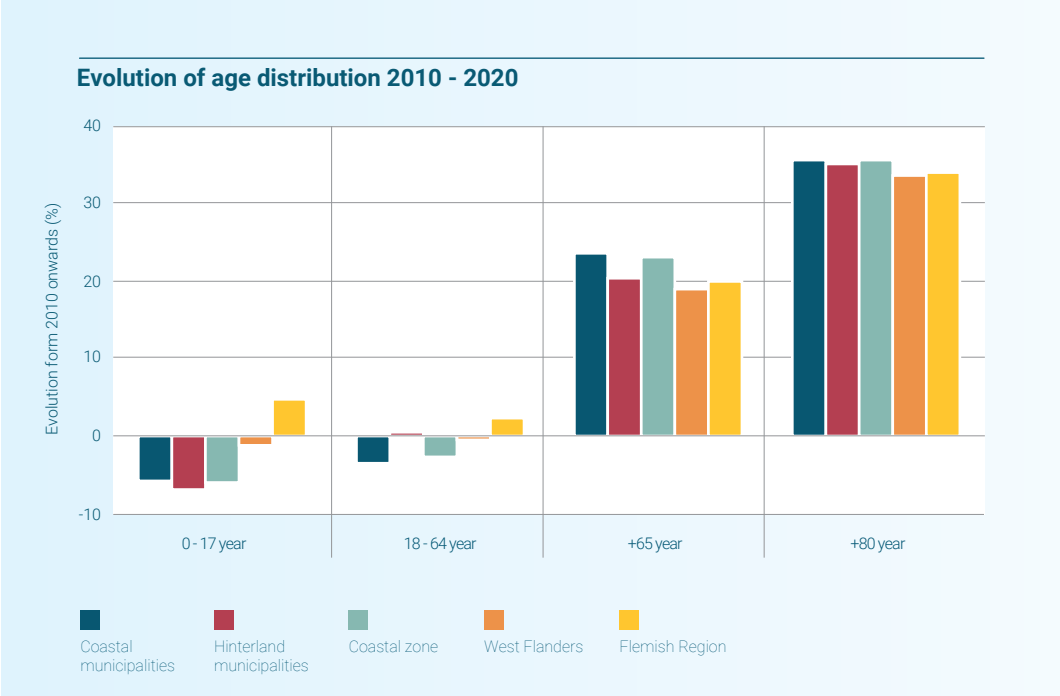


Figure 3. Evolution (%) of the age distribution (0-17 years, 18-64 years, 65+ years, 80+ years) of the coastal population and the province of West Flanders for the period 2010-2020 (Source: Rijksregister, 1 January 2020, processed by D&A | provincies incijfers.be).

Based on the characteristics of households, a household typology can be put together. A household can consist of a person living alone, several adults living together without under-aged children (household without child under the age of 20) or one or more adults living together with one or more under-aged children (household with children) (figure 4). The latter category also includes single-parent households. Of all households in the coastal zone, 38.7% are people living alone, 43.2% are households without children and 18.1% are household with children.

Coastal municipalities are characterised by the low proportion of households with children and the high proportion of single households (40.9%). The high degree of singles is distinctive for coastal municipalities (figure 4), something that can predominantly be explained by the ageing population and the 'terminus effect' (people who want to start a new life at the coast, often pension migrants). The share of households consisting of singles increased strongly (+16%) between 2010-2020 (figure 5). The increase in the number of singles was more pronounced in the hinterland municipalities (+26%) (Rijksregister, 1 January 2020 processed by D&A | provincies.incijfers.be).

Taking a closer look at the population characteristics, the indicators above point to a more urban character of the coastal municipalities: an older population, many people living alone, a high population density and many people with a foreign background. This urban profile is also reflected in the deprivation atlases (*Kansarmoedeatlas West Vlaanderen* 2011, 2014, 2017 and 2021), which contain an analysis at neighbourhood level. The neighbourhoods located along the coastal strip display a relatively more vulnerable profile in comparison to the neighbourhoods located behind this coastal strip. In order to determine the urban profile of the coastal strip and the associated problems, an analysis at neighbourhood or area level is necessary. The Kansarmoedeatlas 2021 shows that 25% of all families in the coastal zone live in a deprived neighbourhood, which is higher than the average for West Flanders (16%). In the coastal municipalities, an average of 29% of the families live in a deprived neighbourhood. For the hinterland municipalities, this is 7% of the households (Kansarmoedeatlas 2021, see also the Gemeentelijke steekkaarten - kansarmoede). The highest number of deprived neighbourhoods in West Flanders is located in Ostend (28) (figure 6). The two household types that are of particular concern are singles and single-parents.

In order to accomodate less prosperous families, the municipalities of the coastal zone provide social housing opportunities. There are 12,624 social housing units spread over the entire coastal zone. Ostend takes up a majority with 3,246 social rental houses (2020), representing a share of 8.9 social rental houses per 100 private households (figure 7). Other municipalities with a high share of social rental housing are Veurne (10.8) and Nieuwpoort (8.1). In comparison, the average share of social rental houses per 100 private households in the coastal zone is 6.2. In the province of West Flanders this share, at 6.4, is slightly higher.

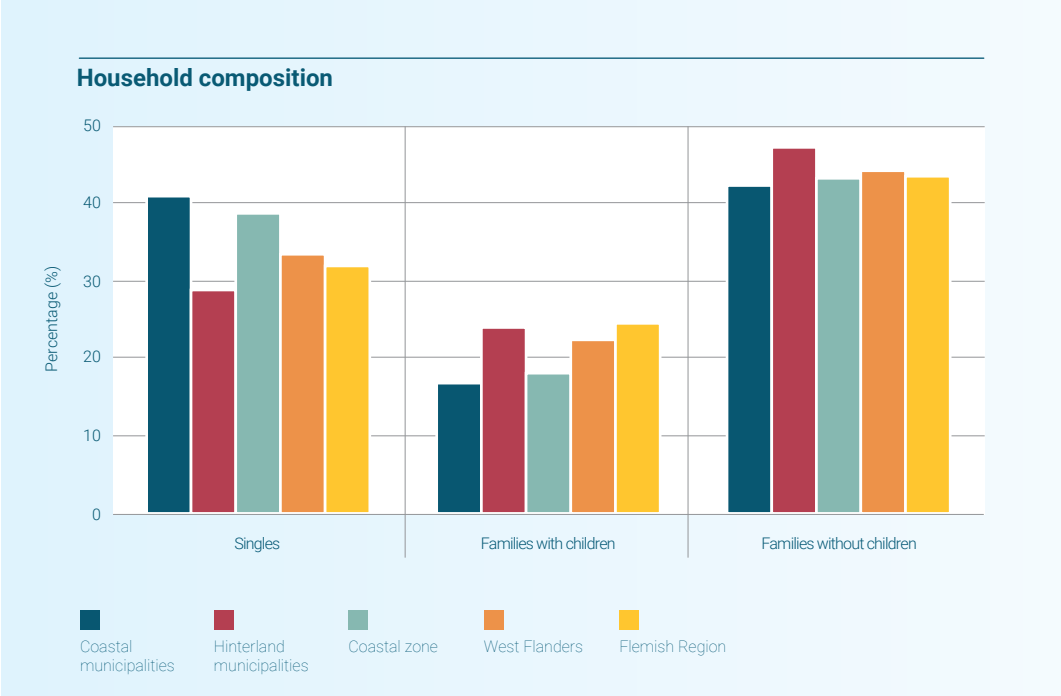


Figure 4. Proportion of households without children, with children and singles to the total number of households in the coastal zone and the province of West Flanders (Source: Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be).

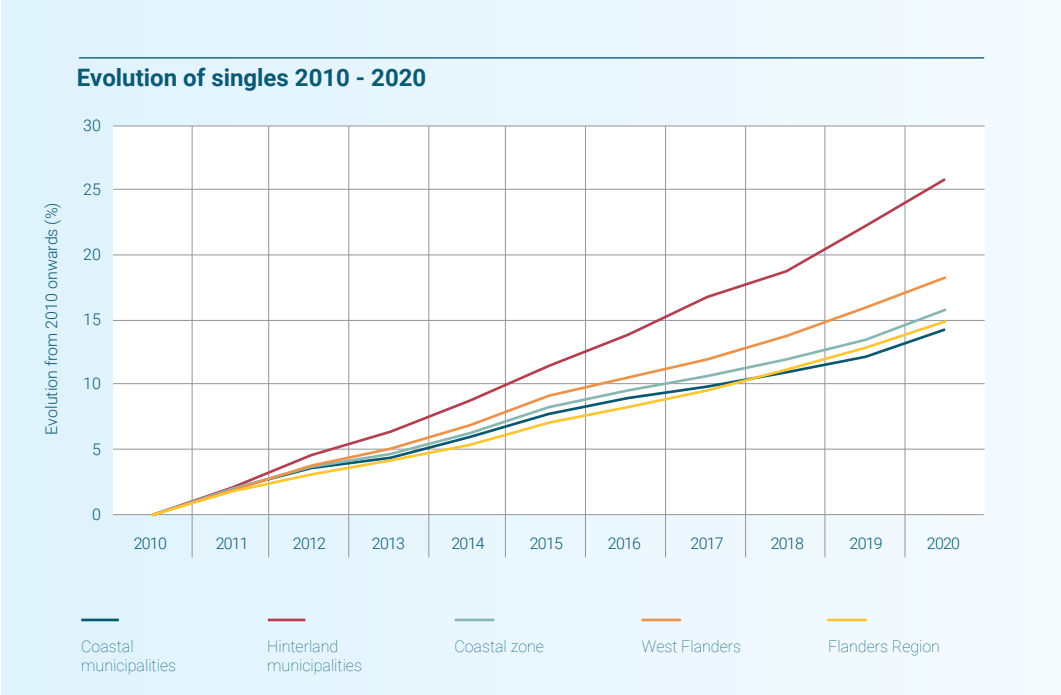


Figure 5. The relative evolution of the number of single households in the coastal zone and the province of West Flanders between 2010 and 2020 (Source: Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be).

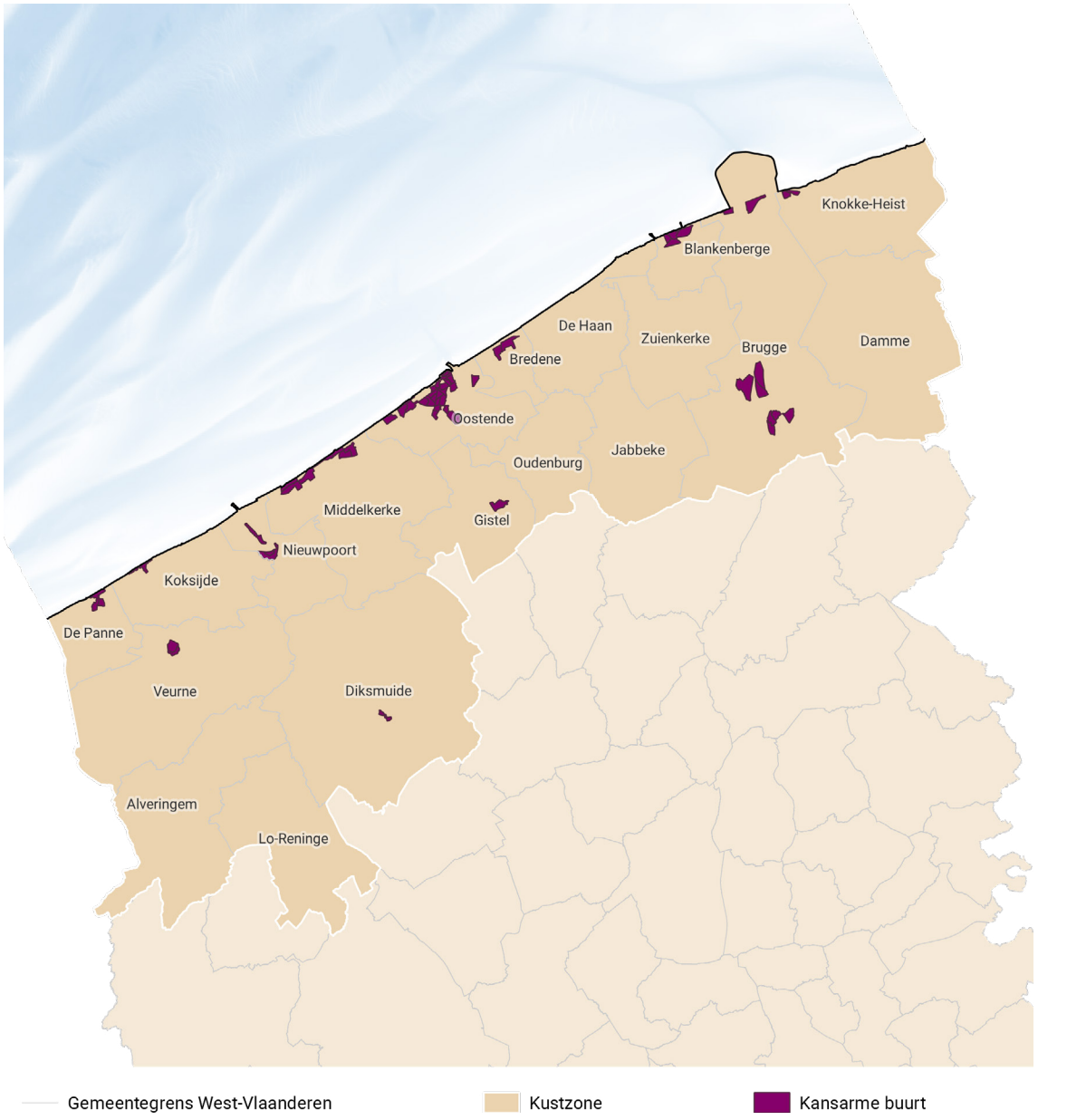


Figure 6. Location of the deprived neighbourhoods in the coastal zone (bordeaux) (Source: Kansarmoedeatlas 2021, Coastal Portal).

10.3.1.2 The coast and its inhabitation

On 1 January 2020, the coastal zone counted 352,232 housing units (table 2). In terms of housing type, a distinction is made between single-households and a multi-family household. At the Flemish and provincial level, two out of three housing facilities are single-household units; one in three facilities are situated in multi-household units. This ratio is slightly different in the coastal zone: 57% of the housing facilities are situated in multi-household units. The difference between the coastal municipalities and the hinterland municipalities is noteworthy. In the coastal municipalities, 63% of the facilities are situated in multi-household units. In the hinterland municipalities, this is only 15%.

The total number of housing units in the coastal municipalities is considerably higher than the number required to house its inhabitants. On average, 35% of housing units in the coastal zone are not used as a permanent home (= housing unit where a household is domiciled). Figure 8 shows the housing surplus, which we define here as non-domestic housing, as being primarily a coastal phenomenon. The hinterland municipalities have on average only 9% of housing facilities that are used for purposes other than permanent residence. Houses in coastal municipalities thus often serve other functions, like second-homes, business activities or even remain tenantless (Dauwe et al. 2019).

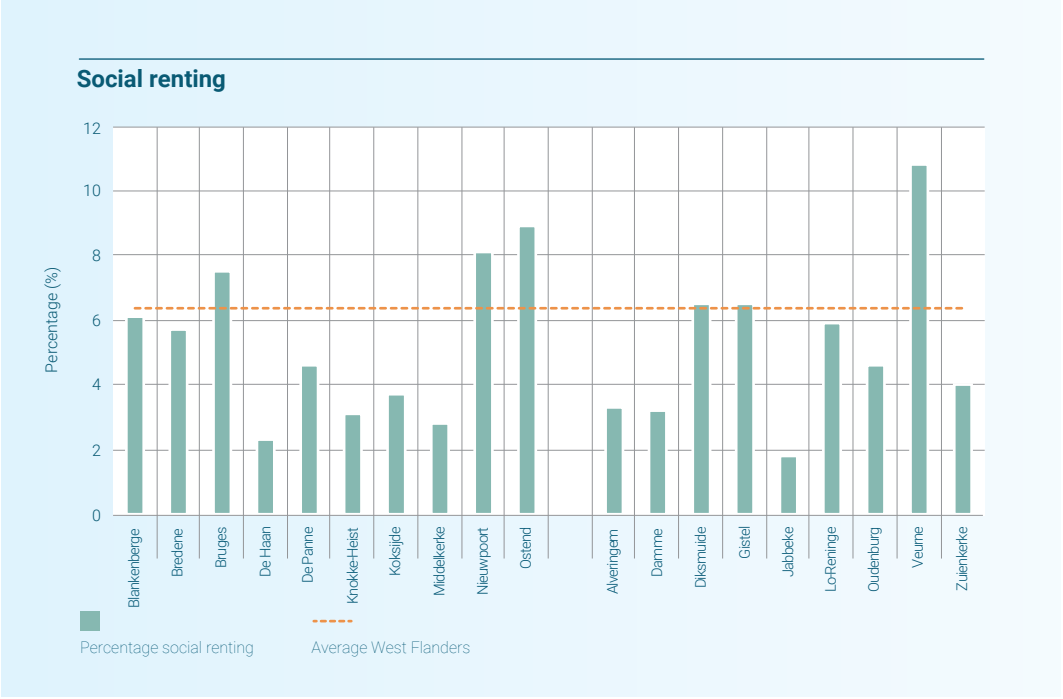


Figure 7. Municipal share of social rental housing (rented through social housing companies and social rental agencies) by the number of private households (Source: Vlaamse Maatschappij voor Sociaal Wonen, 1 January 2020, processed by department D&A | provincies.incijfers.be).

Table 2. Number of housing units by type of housing (Source: Kadaster and Rijksregister, 1 January 2020, processed by D&A | provincies.incijfers.be)

Region	Housing units	Single household units		Multi-household units	
	Amount	Amount	Percentage	Amount	Percentage
Coastal municipalities	284,144	105,386	37.1%	178,758	62.9%
Hinterland municipalities	41,088	34,789	84.7%	6,299	15.3%
Coastal zone	325,232	140,175	43.1%	185,057	56.9%
West Flanders	690,361	443,377	64.2%	246,984	35.8%
Flemish Region	3,274,393	2,185,031	66.7%	1,089,362	33.3%

10.3.2 Economic environment[2]

The coastal zone is characterised by a diverse economic landscape with some of the country's largest economic gateways and sectors (two international seaports, an international airport, a commercial fishing industry, offshore energy production, tourism, etc.). The societal relevance of the Blue Economy and the importance of coastal agriculture is presented in separate thematic chapters within the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022) and approached in a more integrated way in the thematic chapter **Blue Economy and Innovation**. A numerical sectoral overview of the economic environment of the coastal zone can be found on the website of the West Flanders Development Agency.

[2] On 13 March 2020, a set of urgent measures aimed at containing the spread of the SARS-CoV2 virus (virus causing COVID-19) entered into force by MD. In addition, restrictive conditions for visiting the coastal region were imposed from 18 March onwards (MD of 18 March 2020). In the following weeks and months, these advices were adapted according to the health situation based on the guidelines of the National Safety Council (overview of current regulations, corona website FPS Public Health, Food Chain Safety and Environment). At the time of writing, restrictive conditions were still in place and no information was available yet on the social and economic impact of these measures on the region.

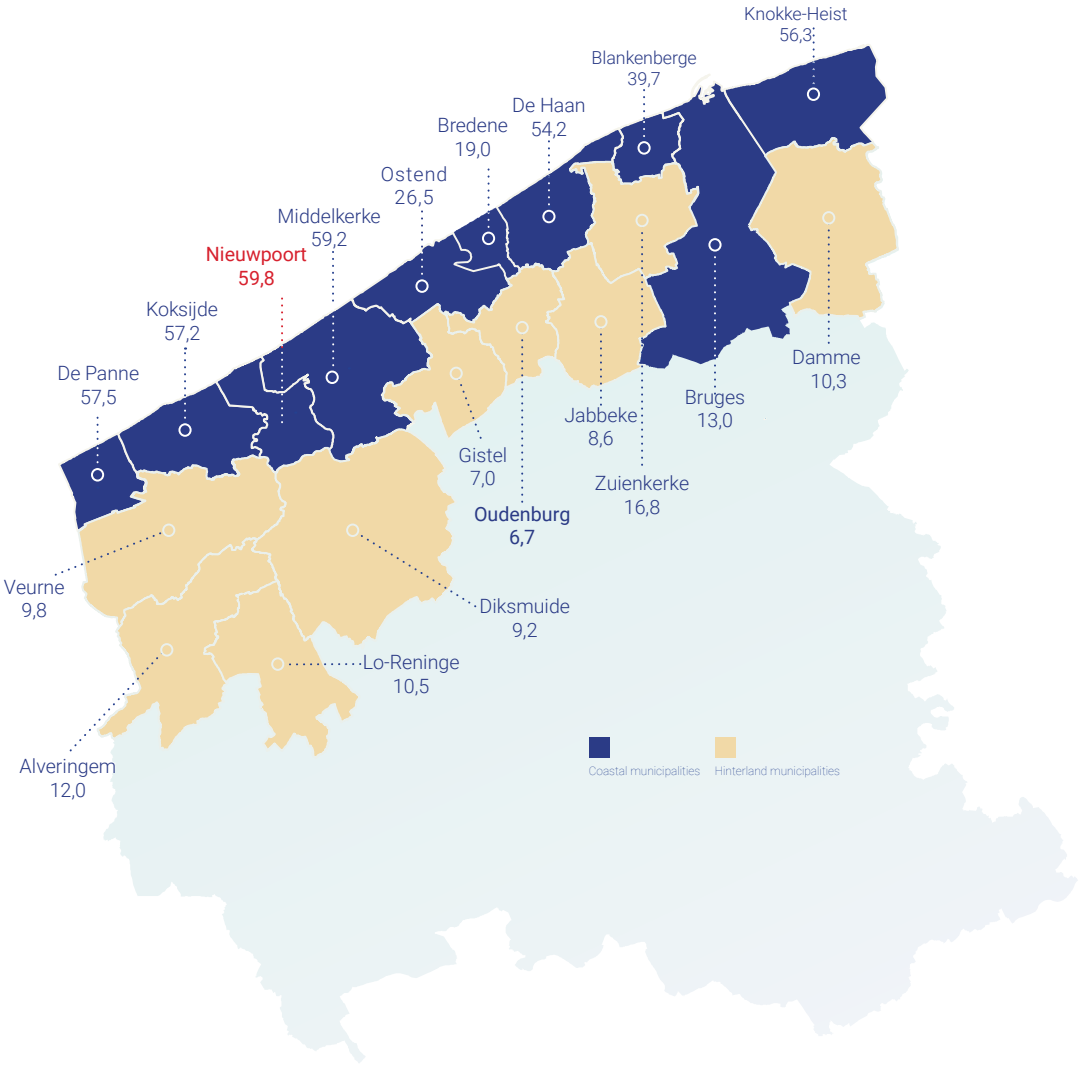


Figure 8. Share of housing units without domicile in the coastal zone (Source: FPS Finance, General administration of Patrimonial Documentation, 1 January 2020, processed by D&A | Province of West Flanders, Coastal Portal).

10.3.2.1 The coast and its labour market

On 31 December 2018, there were 186,534 professionally employed people (employees, self-employed (excluding secondary profession) and helpers) in the coastal zone. This is an increase of 4.9% compared to 31 December 2008. The coastal zone provides job opportunities for 34.3% of the total number of professionally employed people in West Flanders. At the end of 2018, the coastal and hinterland municipalities counted 125,358 and 21,972 employees, respectively 34.0% of the total in West Flanders. An additional 29,188 self-employed and helpers (excluding self-employed people in secondary profession) were active in the coastal municipalities and 10,016 in the hinterland municipalities. In this way, the coastal zone hosts 35.4% of the West Flemish total of self-employed people (RSV and NISSE, processed by the West Flanders Development Agency) (figure 9).

The coastal zone is characterised by a weak industrial base. At the end of 2018, the share of employees in the secondary sector[3] (construction + industry) was 13.7% in the coastal zone, compared to 26.0% in West Flanders. Moreover, no less than 88.2% (86.0% in the entire coastal zone) of the employees in coastal municipalities, are working in trade and services, of which tourism, catering, but also health care constitute an important part (see also Dauwe et al. 2019, West-Vlaanderen Ontcijferd 2020). However, in the tourism and catering sector, a large part of the jobs are seasonal. In comparison, 73.3% of all employees in West Flanders are active in trade and services (RSZ, processed by the West Flanders Development Agency) (figure 10).

[3] Primary sector: the economic sector that generates income from the production of food and raw materials;
Secondary sector: the economic sector that generates income from processing food and raw materials;
Tertiary sector: the economic sector in which companies seek to make a profit by selling their goods or services;
Quaternary sector: the non-commercial provision of services, e.g. government services and government-subsidised services.

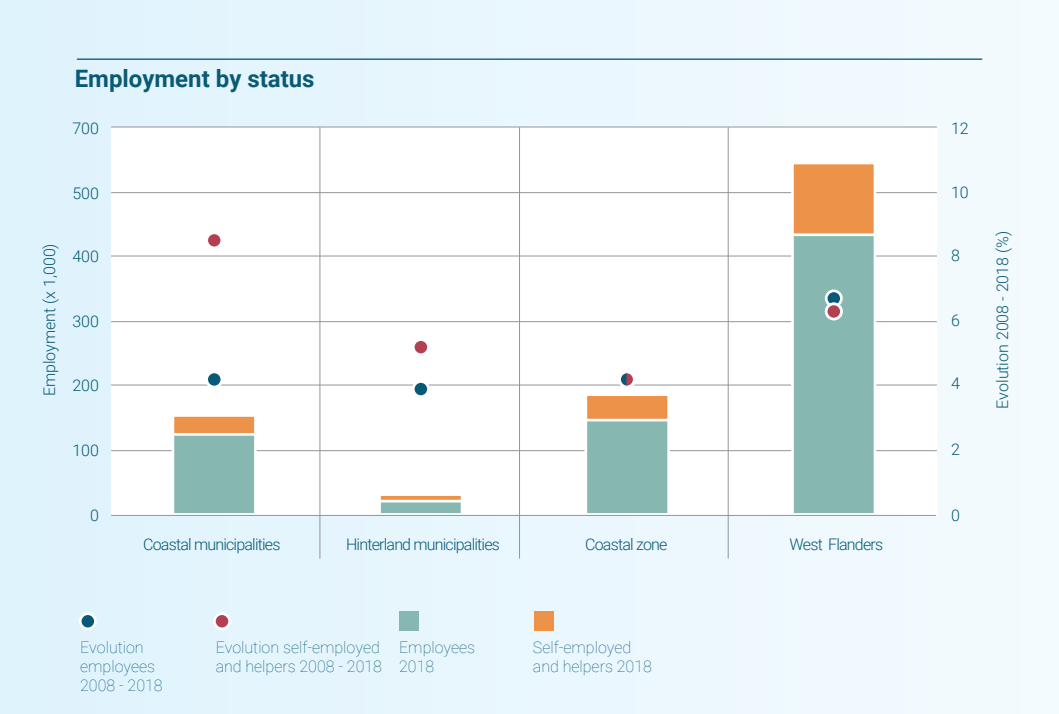


Figure 9. The number of employed people in the coastal zone, split into employees, self-employed and helpers on 31 December 2018, extended with the evolution in employed people compared to 2008 (Source: RSZ and NISSE, processed by the West Flanders Development Agency).

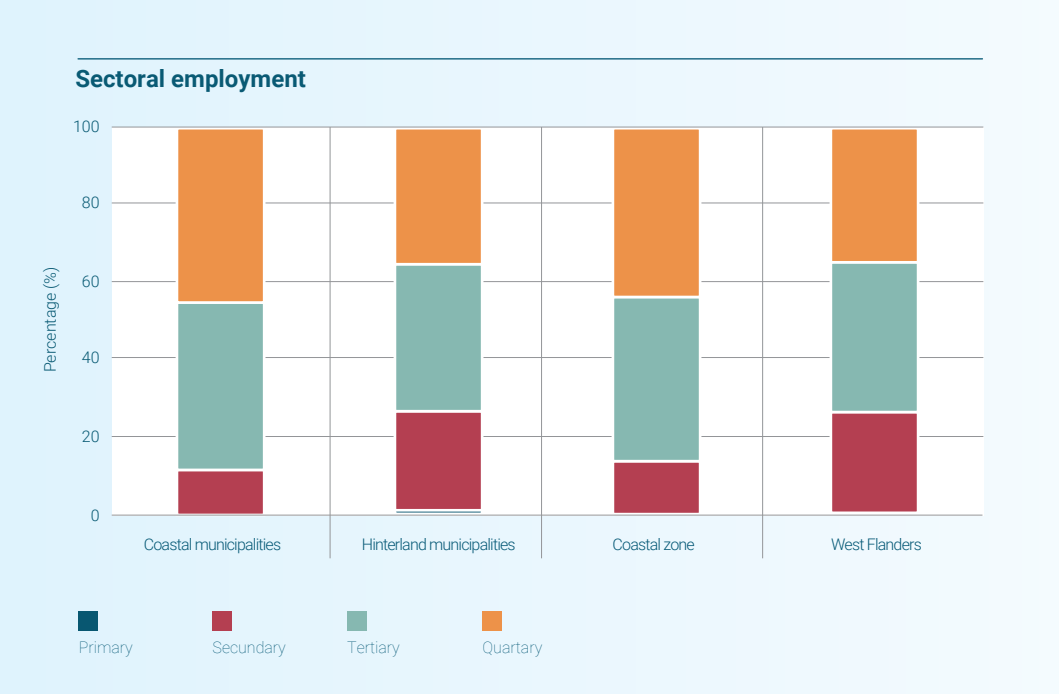


Figure 10. Share of sectoral employment for employees on 31 December 2018 (Source: RSZ, processed by the West Flanders Development Agency).

In 2018, 142,573 inhabitants in the coastal municipalities and 40,834 inhabitants in the hinterland municipalities belonged to the professionally active population (employed and unemployed jobseekers) aged between 18 and 64 or 33.4% of the total figure for West Flanders. In 2018, the activity rate - the ratio of the professionally active population to the total population aged between 18 and 64 - was 75.4% in the coastal zone. The coastal zone scores slightly below the provincial average (77.9%), but the differences are strongly region-specific. The employment rate - the ratio of the number of working people to the total population aged 18-64 - too, was somewhat lower in the coastal zone (70.6%) as compared to West Flanders in general (74.1%) (figure 11). With an unemployment rate - the number of non-working jobseekers in relation to the professionally active population aged between 18 and 64 - of 6.3%, the coastal zone performed worse than average in West Flanders (4.9%). However, this can mainly be attributed to the coastal municipalities (7.1%); in the hinterland municipalities the unemployment rate (3.6%) was noticeably lower (Vlaamse Arbeidsrekening, processed by the West Flanders Development Agency). In 2019, the coastal zone counted 11,251 non-working jobseekers or 42.4% of the total of West-Flanders (VDAB, NEO, FPS Economy (Statbel) processed by the West Flanders Development Agency). Additionally, the coastal zone counted 421 older unemployed people[4]; or 46.2% of the provincial total. The unemployment pressure - the ratio of the number of non-working jobseekers and older unemployed relative to the current professionally active population (18-64 years) - is clearly higher in the coastal municipalities (5.4%) than in the hinterland municipalities (2.8%) and West Flanders (3.9%) (figure 12) (VDAB, NEO, FPS Economy (Statbel) processed by the West Flanders Development Agency). An important link can be made with the level of education. To illustrate, in Ostend, with an unemployment rate of over 10%, 36.2% of the children attending primary school have a lower-educated mother. Of those children, 48.1% receive an education allowance and 31.6% speak a language other than Dutch at home. In addition, 51.4% lives in a neighbourhood with an increased educational delay (Departement Onderwijs en Vorming, processed by provincies.incijfers.be). In Ostend, 53.6% of the pupils in ordinary primary education are indicator pupils[5].

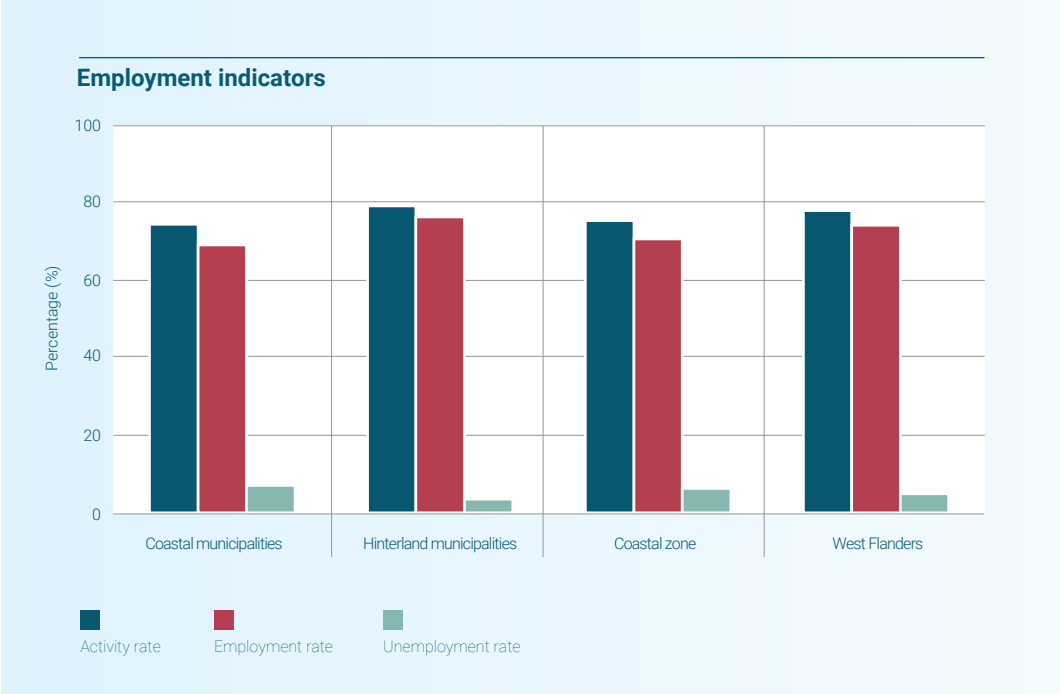


Figure 11. The activity rate, employment rate and unemployment rate in the coastal zone in 2018 (Vlaamse Arbeidsrekening, processed by the West Flanders Development Agency).

Of all coastal municipalities, only four (Bruges, Knokke-Heist, Ostend and Nieuwpoort) had a positive commuting balance among employees in 2017. In these municipalities the number of employees who came to work in the municipality, but lived elsewhere, exceeded the number of inhabitants working outside the municipality (Vlaamse Arbeidsrekening, processed by the West Flanders Development Agency). In West Vlaanderen Ontcijferd 2020, provincies.incijfers.be and the Regions Dataset, labour market statistics are provided at municipal, district and provincial level.

[4] As of 2019, an older unemployed person must be 64 years old or older and have a professional background of 44 years.
[5] An indicator pupil is a pupil to whom at least one of the following criteria applies: the family has received an education allowance during the previous school year, the family has a limited income or the mother does not have a secondary education diploma or certificate of passing the sixth year in secondary education.

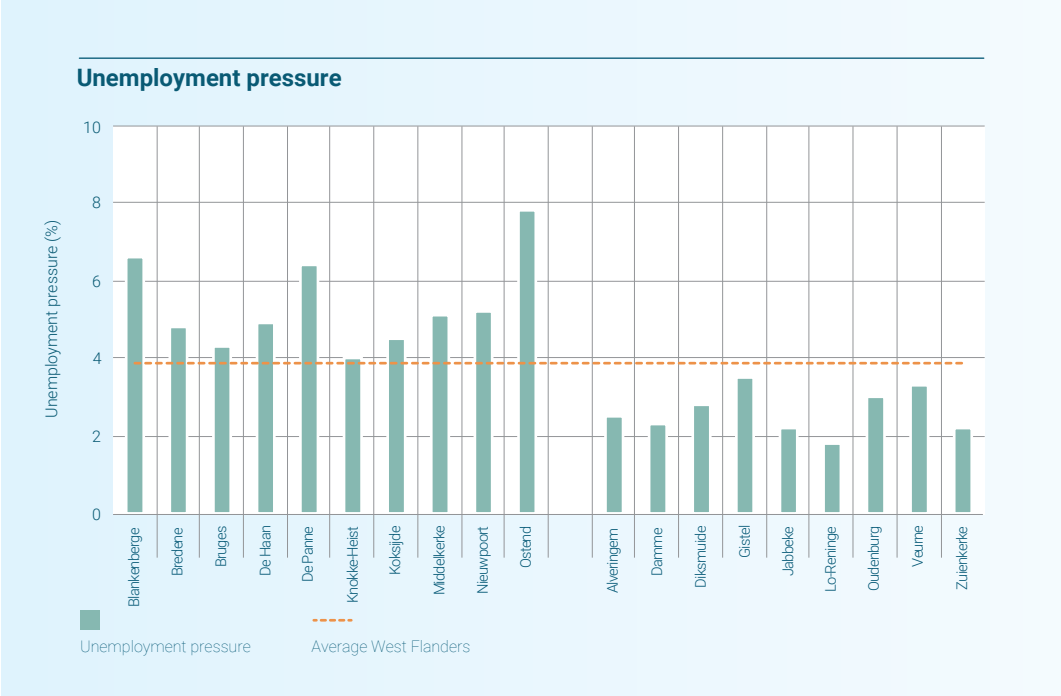


Figure 12. Unemployment pressure within the coastal zone in 2019 (Source: VDAB, RVA, FPS Economy (Statbel) processed by the West Flanders Development Agency).

10.3.2.2 Wealth and entrepeneurship

In 2018, the produced wealth measured by Gross Domestic Product (GDP)[6] per capita, was lower in West Flanders (39,312 euro) than in the Flemish Region in general (41,072 euro). Bruges (40,308 euro) is the only coastal district with a GDP per capita higher than the average of West Flanders (Institute for National Accounts (INR), processed by the West Flanders Development Agency). Between 2009-2018, the GDP per capita rose by an average of 2.9% per year in West Flanders, with the strongest increase in the district of Ypres (+3.6%) and the weakest in the district of Roeselare (+2.4%). Because GDP per capita in West Flanders grew more strongly, compared to Belgium, West Flanders was able to narrow the wealth gap on a national level; the gap with Flanders remained similar. Compared to the 2009 tax year, West Flanders made up ground in 2018 (+2.5%, compared to the Flemish Region +2.2%). This evolution is also apparent in the wealth index[7] (*welvaartsindex*) (West Flanders 104.7; Flemish Region 107.1) and has been noticeable for a number of years (FPS Economy (Statbel), Fiscal Statistics, processed by the West Flanders Development Agency).

In terms of the gross value added (GVA[8]), the district of Bruges, with a share of 24.2%, is in second place after Kortrijk in 2018. The coastal districts of Ostend and Veurne accounted for 10.5% and 5.0% of the total GVA, respectively. In 2018, the GVA per employee in West Flanders amounted to 96,131 euro, meaning West Flanders remains well below the Flemish average (102,986 euro) (West-Vlaanderen Ontcijferd 2020) with the exception of Veurne (108,930) and Ostend (103,733) (NBB, processed by the West Flanders Development Agency).

In 2019, enterprises registered in West Flanders generated a combined turnover of 104.3 billion euro representing 16.1% of the Flemish total (West-Vlaanderen Ontcijferd 2020). In the same year, there were 42,650 active enterprises in the coastal zone, representing 33.6% of the total for West Flanders. 32,022 of these active enterprises were located in the coastal municipalities, 10,628 in the hinterland. Of all active enterprises in the coastal zone, 68.4% are active in the tertiary sector, 16.7% in the secondary sector, 9.0% in the quaternary sector and 5.9% in the primary sector. At provincial level, the share in these sectors looks slightly different: 63.2% in the tertiary sector, 21.6% in the secondary sector, 7.7% in the primary sector and 7.5% in the quaternary sector. The economic dynamic of

[6] A measure of the economic wealth produced or generated in a country or region, used as an indicator to measure its level of prosperity. GDP is compiled by adding to gross value added to basic prices, taxes on products related to production and imports, and subtracting subsidies on products related to production and imports.
[7] This index compares the average income per inhabitant of a certain region (e.g. municipality) to the average income per inhabitant in the whole of Belgium. For Belgium, this index is set at 100.
[8] The difference between the market value of goods and services produced in one year and the market value of goods and services consumed in the production process (Statistiek Vlaanderen).

the coastal enterprises is higher too, compared to West-Flanders This is made evident by a number of indicators that describe this dynamic (table 3). These findings can be fully attributed to the urban character of most coastal municipalities as urban centres tend to record more start-ups and closures over time. The higher turbulence rate along the coast can also be partly explained by the nature of the activities. Among the frontrunners of the start-ups and closures is the hotel and catering industry, which is much more strongly represented in the coastal zone than on average in West Flanders. For instance in 2019, there were 4,301 active enterprises in the hotel and catering industry in the coastal zone (coastal municipalities: 3,648 active enterprises, hinterland municipalities: 653 active enterprises), accounting for 50.4% of the province of West Flanders. The coastal municipalities alone accounted for 42.8% of the number of hotel and catering businesses in West Flanders. The proportion of active enterprises in the hotel and catering industry compared with the total number of active enterprises is: 11.4% in the coastal municipalities, 6.1% in the hinterland municipalities, 10.1% in the coastal zone, and 6.7% in West Flanders. Additionally, 4,485 enterprises were active in retail in the coastal zone in 2019 (coastal municipalities: 3,607 active enterprises; hinterland municipalities: 878 active enterprises), accounting for 39.2% of the province of West Flanders. The coastal municipalities alone account for 31.5% of the number of retail enterprises in West Flanders (FPS Economy (Statbel) processed by the West Flanders Development Agency).

Table 3. Economic dynamics of enterprises in the coastal zone in 2019 (Source: FPS Economy (Statbel) processed by the West Flanders Development Agency).

Region	Founding ratio* (%)	Exit ratio** (%)	Turbulence rate*** (%)
Coastal municipalities	9.8	7.0	16.8
Hinterland municipalities	8.1	5.8	13.9
Coastal zone	9.3	6.7	16.0
West Flanders	9.0	6.0	15.0

**Founding ratio: the ratio of the number of founded enterprises to the number of active enterprises.*
***Exit ratio: the ratio of closures and bankruptcies to the number of active enterprises.*
****Turbulence rate: the sum of the founding- and exit ratio.*

In terms of the number of enterprises, the coastal zone has an average of 29.2 commercial enterprises per 1,000 inhabitants (compared to 23.9 in West Flanders) (2020). In the coastal municipalities this amounts to 31.5 commercial enterprises per 1,000 inhabitants, in the hinterland municipalities 20.2. The highest number of commercial properties in the coastal zone (excluding unoccupied properties per 1,000 inhabitants) is recorded for Knokke-Heist (44.4), Nieuwpoort (43.3) and De Panne (37.3). The highest vacancy rate (vacant commercial properties compared with all commercial premises) is recorded for De Panne (20.2%), Koksijde (13.5%) and Blankenberge (12.4%) (2020) (Locatus, Statbel, processed by the West Flanders Development Agency).

The coastal zone covers 36.8% of the total surface area of West Flanders. In terms of surface area used for business activities, the coastal zone accounted for 23.5% of the total area of West Flanders on 1 January 2019. In West Flanders, 17.5% of the built-up area is used for business activities. The proportion of this area used for business activities is higher in the coastal municipalities than in the hinterland municipalities (16.9% compared to 10.4%) (FPS Economy (Statbel) processed by the West Flanders Development Agency).

In 2017, the spatial productivity[9] equalled 42.4% in the coastal zone, 52.8% in the coastal municipalities, 21.8% in the hinterland municipalities, and 31.7% in West Flanders in general (Vlaamse Arbeidsrekening and FPS Economy (Statbel) processed by the West Flanders Development Agency). This means that 42.4 people were working in the coastal zone per hectare of economically occupied land. These differences are caused by the different morphology and economic structure of these regions. On the one hand, relatively less industry and fewer users of large spaces, and on the other hand, more trade and services with offices and high-rise buildings, as well as more employees per unit of land. Until 2008, spatial productivity in West Flanders remained relatively stable, after which the indicator showed a declining trend until 2016. In the coastal zone, land productivity has been following a declining trend since 2007. These declines are the effect of a growing spatial separation of living and working. Commercial sub-urbanisation or migration from the city towards the surrounding countryside, following residential sub-urbanisation, has increased significantly in recent years. The Flemish Spatial Structure Plan (RSV) has not yet been able to curb this trend.

[9] Spatial productivity is the ratio of gross domestic product (GDP) to the use of space, expressed in hectares (ha) of built-up area (Department of Environment and Spatial Development).

Statistics on the socio-economic situation on municipal, district and provincial level are also provided in West-Vlaanderen Ontcijferd 2020, provincies.incijfers.be and the Regions Dataset. Figures, tables, graphs and maps with respect to the socio-economic situation of the coastal zone can be compiled per selected zone via the data portal of provincies.incijfers.be.

10.4 Sustainable use

A physical environment with sufficient public space and qualitative living conditions are essential for a sustainable living environment and the wellbeing of inhabitants. The coast holds some advantages in this respect, given the beneficial effect of sea air on health (Hooyberg et al. 2020). However, the (metropolitan) urban profile and the high level of deprivation indicate that there are also many challenges at the coast (Maelfait et al. 2012, Dauwe et al. 2019, West Flanders Development Agency, provincies.incijfers.be). The main concerns relate to the lack of a balanced and healthy social environment. For example, the rapid ageing of the population, the increasing internal ageing (80+ years of age), the amount of people living alone, the various relocations and the pressure from tourists and second-home inhabitants create a skewed social and demographic mix which (especially in the seaside neighbourhoods) results in an atypical model of society and pressure on the housing market (Meire and Bracke 2005, Rijksregister, Maelfait et al. 2012, Province of West Flanders 2015, Dauwe et al. 2019 (see also the regional policy plans, **10.1 Policy context** and **10.3.1 Social environment**).

10.4.1 Sustainable living at the coast – the ageing effect and second-homes

Proportionally, significantly more elderly people live on the coast than in the rest of Flanders, resulting in a different societal model. Moreover, according to recent projections, the (internal) ageing of the population in the coastal zone will continue to rise until at least 2030, just like in other Flemish towns and cities (Province of West Flanders 2015, Government of Flanders (2016), provincies.incijfers.be) (see also **10.3.1 Social environment**). This phenomenon of a strongly ageing population composition is further reinforced by the second-home residents. Research has shown that in 80% of cases (>120,000 people), owners of second-homes on the coast are older than 50 and generally do not have children under 18 living at home (WES 2008, *tweede verblijven aan de kust*, part 1 and part 2; Westtoer 2016). On the basis of the provincial tax on second-homes, it is estimated that 30% of the housing units in the coastal zone are used as second-homes, representing approximately 97,000 housing units (situation 2017, calculated by D&A Province of West Flanders). However, on average they are only 49 nights a year are occupied by its owner (Impact tweede verblijvers voor het Kusttoerisme, Westtoer 2016). The use of the housing stock for purposes other than residential purposes can have negative consequences for society, such as an increased sense of insecurity and a lack of social cohesion. On the other hand, a large stock of second-homes at the coast is one of the preconditions for the tourist industry as second-home tourism generates a turnover of approximately 1.5 billion euro (Impact tweede verblijvers voor het Kusttoerisme, Westtoer 2016) (see thematic chapter **Tourism and recreation**).

The Province of West Flanders is actively pursuing the coastal ageing program (*Vergrijzing aan de kust*) where the coast can be regarded as a laboratory for the future ageing of the population of Flanders. For example, the reports Vergrijzing aan de kust: lust of last? (2012) and Onderzoek naar verhuisbewegingen van senioren aan de kust en de impact op de woonmarkt en zorgsector outline the situation of the ageing population at the coast, while formulating a number of bottlenecks and challenges. The Ruimte voor ouderen (2017) inspiration guide provides an overview of the various types of housing for elderly people and tries to respond to the housing needs of coastal residents in West Flanders. Vandekerckhove et al. (2015) analysed the relocation movements of people aged 80+ at the coast, including the consequences for the housing market and the health care sector in the coastal zone. The study reveals a number of trends: the retired migrant is insufficiently prepared for the consequences of ageing, a social network is important, and the housing options along the coast appear unsuitable. A number of challenges and recommendations are also formulated: e.g. consider ageing as an asset (e.g. opportunities for voluntary work, economic opportunities, etc.) and focus on adapted and self-reliant housing and awareness-raising (see also De Klerck 2011, website West Flanders Development Agency). The liveability study for the coast (Meire and Bracke 2005) also shows that the mutual involvement of residents is poor, especially in the seaside neighbourhoods. For many single-living (senior) residents at the coast, who left their social environment behind, there is a genuine chance of social isolation. The study therefore emphasises the importance of restoring and strengthening personal social networks.

10.4.2 Economic development at the coast

The guideline for the socio-economic development of the province of West Flanders, and hence the coastal zone, is described in the recent Master Plan Economy 2020-2025 of the West Flanders Development Agency. This plan forms the framework for the structural valorisation of earlier efforts within the West Deal strategy (2013-2018) and must respond to new challenges such as the consequences of the corona crisis and Brexit.

In the former West Deal strategy, a number of guidelines that specifically applied to the coastal zone were elaborated upon, such as the possibilities of Ostend becoming a hub for Blue Energy, the development of the port of Zeebrugge, touristic opportunities for the Ostend-Bruges International Airport, etc. Another concrete application of West Deal is Factories for the Future (FvT) (*Fabrieken voor de Toekomst*). These factories[10] reflect the key economic areas of the province and aim to reinforce enterprises and provide them access to innovation, knowledge and expertise. In the maritime context, there's the FvT Blue Energy, based at Ostend, which focuses on the development of wind, wave and tidal energy.

West-Vlaanderen Groeit - Ambitie 2030 (2015) investigated the state of affairs of the West Flemish economy and its future prospects. Five future visions and five specific work areas were formulated, in which the economy in the coastal zone (blue energy, ports, care economy, etc.) was also addressed. Additionally, in the framework of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC), a first socio-economic analysis of the use of Belgian marine waters and the costs related to the degradation of the marine environment was conducted in 2012 (Belgian State 2012, Börger et al. 2016), of which an update was published in 2018 (Volckaert and Rommens 2018). These studies partially address the socio-economic developments along the coast, including the accommodation of tourists and their expenditure (see also thematic chapters **Tourism and recreation** and **Nature and environment**).

10.4.3 Urban vision development at the coast

The Territorial Development Program for the Coastal Zone (T.OP Kustzone) was launched in November 2015 under the stewardship of the Department of Environment and Spatial Development (OMG) with the aim of tackling large-scale spatial challenges in the coastal zone in cooperation with the Province of West Flanders and the municipal authorities (see also **10.1 Policy context** and thematic chapter **Tourism and recreation**). Urban development issues are compiled into a supported vision or master plan by a group of experts. Such a plan can subsequently be put into practice by the municipalities by means of a spatial implementation plan or by issuing permits. Projects applicable to the coastal zone are being designed in three areas: the 'urbanised coastal zone' (*verstedelijkte kustzone*), the 'polder space' (*polderruimte*) and the 'land-sea interaction zone' (*land-zee interactie*) (including the dunes). Each of these areas has a central theme and focuses on specific projects or on knowledge building and sharing. Within the 'urbanised coastal zone', the general focus is put on densification, accessible locations and on providing a wide range of housing options (e.g. for families, the elderly, etc.). This also involves looking at how the built-up area can contribute to robust coastal protection (see also thematic chapter **Safety against flooding**). The 'land-sea interaction' area (including the dunes) focuses on the potential optimisation of the connectivity between the various dune areas (primarily the western coastal zone). The 'polder space' area mainly focuses on the role and place of water in the environment and in all possible forms of use. An overview of the realised and planned projects can be consulted at www.topkustzone.be.

In the past, research was conducted under the platform LABO RUIMTE, a partnership between the Team *Vlaamse Bouwmeester* and OMG, on how to come up with sustainable solutions to complex spatial issues in the coastal zone. For example, Stedelijk Systeem Kust examined a robust reconversion of the urban system (Stedelijk Systeem Kust 2017). Additionally, there was the design study Metropolitaan Kustlandschap 2100 on the development potential of the coast up to 2100. In the context of a changing climate and within the socio-economic context, the coastal zone was considered one functionally coherent area, one urban metabolism (Geldof and De Bock 2014). Within the Integrated Territorial Development Plan for West Flanders (based on the West Deal strategic plan), the Health Care Accelerator project was implemented. In this plan, local authorities, health care institutions, companies and knowledge institutions collaborated to provide a sustainable answer to the needs of the growing group of elderly citizens.

[10] There are currently five Factories for the Future: New Materials, Food, Blue Energy, Mechanical Engineering and Mechatronics, and Health Care Economics.

Finally, there are also vision or planning processes with a socio-economic dimension that focus partly or entirely on the seaside, such as the Coastal Vision project (formerly *Complex Project Kustvisie*) which focuses on the development of sustainable measures for long-term coastal protection, the marine spatial plan (MSP 2020-2026, RD of 22 May 2019) for the Belgian part of the North Sea (see also thematic chapters **Safety against flooding**, **Nature and environment** and **Integrated maritime policy**) and the Think Tank North Sea (think tank where representatives from policy, science, industry and society at large develop thematic visions towards a sustainable North Sea with a 2050 time horizon).

Legislation reference list

Overview of the relevant legislation on federal and Flemish level. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decrees		
Decree of 18 May 1999	Decreet houdende de organisatie van ruimtelijke ordening	1999-05-18/33
Royal Decrees		
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
Ministerial Decrees		
MD of 13 March 2020	Ministerieel besluit houdende dringende maatregelen om de verspreiding van het coronavirus COVID-19 te beperken	2020-03-13/02
MD of 18 March 2020	Ministerieel besluit houdende dringende maatregelen om de verspreiding van het coronavirus COVID-19 te beperken	2020-03-18/01

11 Tourism and recreation

Authors Darline Vandaele[1], Liesbet Billiet[1], Jonas Lescroart[2], Steven Dauwe[2]

Lectors Jan van der Borg[3], Dries Debruyne[4], Hannelore Maelfait[5], Bart Neuts[3]

[1] Westtoer
[2] Flanders Marine Institute (VLIZ)
[3] Katholieke Universiteit Leuven (KU Leuven), Geography and Tourism
[4] The Blue Cluster (DBC)
[5] Province of West Flanders

Vandaele, D., Billiet, L., Lescroart, J., Dauwe, S. (2022). Tourism and recreation. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 187-196.

Europe is the most visited tourist region in the world (COM (2010) 0352) and, in addition to the preservation of natural, historical or cultural heritage, the sector ensures the development, innovation and diversification of various products and services. Blue tourism (including the cruise industry) is the main driver of the European Blue Economy in terms of added value and employment (The EU Blue Economy Report 2020). About half of all overnight stays by tourists take place in coastal areas (Eurostat Regional Yearbook 2020 and COM (2014) 86).

The Belgian coast is the most popular holiday destination in the country. In 2019, the year before the corona crisis, the region recorded over five million arrivals and almost 28 million overnight stays in residential tourism. The coast also welcomed nearly 18 million day-trippers (Westtoer, Trendrapport Kust 2019-2020).

Not only the coastal municipalities are attractive for tourists, the hinterland of the coastal zone has touristic assets as well. For instance, the tourist regions *Brugse Ommeland* and *Westhoek* together registered almost 600,000 arrivals and 1.3 million overnight stays in 2019 (Westtoer, Trendrapport Brugse Ommeland 2018-2019, Westtoer, Trendrapport Westhoek 2018-2019). Moreover, because of its war history, the *Westhoek* also welcomes a large number of commemorative tourists. During the commemoration period (2014-2018) of the Great War (1914-1918), 2.8 million tourists visited the region (Westtoer, WOI-herdenkingstoerisme in de Westhoek 2019). However, it should be mentioned that the borders of these tourist regions extend beyond the hinterland municipalities of the coastal zone.

11.1 Policy context

11.1.1 Coastal tourism policy

The European tourism policy is stipulated by the Directorate-General Internal Market, Industry, Entrepeneurship and SMEs (DG GROW) of the European Commission (see also Overview of EU Tourism Policy). Within the context of the renewed Blue Growth strategy (COM (2021) 240), a new European strategy for sustainable coastal and marine tourism will be drawn up (DG MARE).

In Flanders, the Travel To Tomorrow policy (*Reizen naar Morgen*) of Tourism Flanders (which is under the supervision of the Flemish minister for Tourism (policy paper Tourism 2019-2024)), elborates a new vision on tourism which was adopted since April 2021 (not exclusively for the coastal zone). This new vision continues on the path towards sustainable and qualitative tourism where the entire experience is key and where the interests of the various stakeholders are taken into account. This shift to quality instead of quantity was already one of the objectives of the Strategic policy plan for coastal tourism and recreation 2015-2020, drawn up by Tourism Flanders and *Westtoer*. This plan stipulates the thematic and regional strategic and operational objectives for a sustainable development of coastal tourism (see also **11.5 Sustainable use**).

The policy for the *Brugse Ommeland* and the *Westhoek* regions is outlined at the provincial level by *Westtoer* in the strategic policy plans for tourism and recreation of *Brugse Ommeland* (Brugse Ommeland 2013-2018) and the *Westhoek* (Westhoek 2018-2024).

In the past, coastal projects were financed by the Government of Flanders via the *Kustactieplannen* (I-III; 1997-2009) and the Impulsprogramma Vlaamse Kust (2010-2014). Since 2015, the realisation of the above mentioned strategic objectives has focused on tourism leverage projects (*toeristische hefboomprojecten*) within the tourism impulse programmes of the Government of Flanders and cycling and walking network projects that apply to the whole of Flanders. Since 2020, four thematic funding calls have been launched under the banner 'Everyone deserves a holiday' (*Iedereen verdient vakantie*).

Additionally, a permanent measuring and monitoring system has been developed that provides figures on the characteristics of coastal tourism. The results are compiled in an annual trend report (Westtoer, Trendrapport Kust 2019-2020), a key figures overview and a six-monthly monitoring report. These reports also include figures on expenditure and employment (Kenniscentrum Westtoer).

11.1.2 (Water)recreation policy

The provincial policies on outdoor recreation in the coastal zone are drawn up by Westtoer in strategic policy plans. Recreation is also included in the strategic policy plan for the province's tourist regions.

Concerning water recreation along the coast, the RD of 4 August 1981 on the Police and Shipping Regulations for the Belgian territorial sea, coastal harbors and beaches is of interest (Federal Public Service (FPS) Mobility and Transport, oplijsting vaarregels). Additionally, the marine environment Law of 20 January 1999 and its implementing decrees impose a number of restrictions on recreation in marine protected areas (see also thematic chapter **Nature and environment**). The regulation with regard to boating and water recreation on the waterways has been developed by the DG Shipping (FPS Mobility and Transport). Within the framework of the Law establishing the Belgian Shipping Code (Scheepvaartwetboek) (Law of 8 May 2019), a revised legislation on recreational boating was enforced on 4 July 2019 (RD of 28 June 2019). An overview of the most important changes can be consulted on FPS Mobility and Transport, wijzigingen pleziervaart. The Federal Consultation Platform Pleziervaart spans the gap between the sector and the federal government to optimise consultation.

At the European level, the (bathing) water quality in the coastal zone (within the 1 nautical mile (nm) zone) is addressed under the umbrella of the Water Framework Directive (WFD) (Directive 2000/60/EC) umbrella by, among others, Directive 91/271/EC on urban waste water and Directive 2006/7/EC concerning the management of bathing water quality. The latter directive sets out the standards for bathing water quality (VMM 2006, see also the website kwaliteit zwemwater). These European measures are implemented at federal level by the RD of 23 June 2010 concerning the establishment of a framework for achieving good surface water status. At the Flemish level, the Decree of 18 July 2003 (Integrated Water Policy) (more information: Coordination Committee on Integrated Water Policy (CIW)) and the Decision of the Government of Flanders of 8 December 1998 on bathing water quality are of importance. The Flemish Agency for Care and Health (*Vlaams Agentschap Zorg en Gezondheid*) is responsible for the health aspect of bathing water quality.

More information on the sectoral legislation and the legal framework on tourism and recreation at the coast can be found on the website of Tourism Flanders and in the Codex Coastal Zone (themes Tourism and recreation, Coastal zone management and Local legislation).

11.2 Spatial use

11.2.1 Spatial planning for coastal tourism

In the Belgian part of the North Sea (BNS), tourist and recreational activities are not zone-specific, provided that the safety and sustainability of the activity can be guaranteed (annex 1, MSP 2020-2026, RD of 22 May 2019). In this context, compatibility with other uses is an important point of attention. For example, tourist activities may be subject to both temporal (e.g. in case of military exercises, construction works, etc.) and permanent (e.g. near wind farm concession zones) restrictions. However, it should be mentioned that an increasing number of guided visits to wind farms are being organised for tourists.

The areas for tourism and recreation are primarily demarcated by spatial planning (see thematic chapter **Social and economic environment**). Instruments such as the spatial structure plans, spatial implementation plans (SIPs) and regulations at the Flemish, provincial and municipal levels, indicate the potential for future tourist/recreational developments within certain areas. In the Flemish Spatial Structure Plan (RSV), the coast is identified as an urban network, which is a defining structure on the Flemish level. Because of its tourist-recreational facilities, the coast is also recognised as a tourist-recreational network which requires a policy on a Flemish level. This policy is developed within the framework of initiatives and studies such as *Metropolitaan Kustlandschap 2100* (MKL 2100) (phase 1 (including an outline of the historic context of coastal tourism)/ phase 2 / phase 3 part 1, 2 and 3), the Master Plan for Coastal Safety (2011), the ecosystem vision for the Flemish coast (Vanderbiest et al. 2017a, Vanderbiest et al. 2017b) and the Coastal Vision project (see thematic chapter **Safety against flooding**). The designation of Ostend and Bruges as regional urban areas (*regionaal stedelijke gebieden*), and Blankenberge and Knokke-Heist as small urban areas (*kleinstedelijke gebieden*) in the RSV is also important for the tourism sector as this designation entails consequences for the potential 'highly dynamic functions' that may be developed in the coastal region. Subsidies have already been granted for revaluation projects in Ostend (2009 and 2013) and Koksijde (2019) (10 jaar Strategische projecten 2018) through the Strategic Projects (*Strategische projecten*) tool in the context of the RSV. In addition to the RSV, the regional spatial implementation plans (RSIPs) can be consulted at Omgeving Vlaanderen.

Parallel to the further implementation of the RSV, the Government of Flanders is working on a new spatial policy plan (Beleidsplan Ruimte Vlaanderen). A strategic vision has been prepared in the autumn of 2021 that sets out the policy for a renewed approach to mobility and land use. The vision builds on previous initiatives such as the Groenboek. Vlaanderen in 2050: mensenmaat in een metropool Beleidsplan ruimte Vlaanderen (2012) and Witboek Beleidsplan Ruimte Vlaanderen. For the coast and the *Westhoek*, a supra-local strategic vision

has already been developed wherein the spatial development of the region is optimally attuned to mobility and public transport (Vandekerckhove et al. 2019). In the context of this spatial development policy for the coastal zone, a Territorial Development Programme (T.OP Kustzone) has been developed. In this active instrument, the Department of Environment and Spatial Development (OMG) collaborates with the Province of West Flanders and local authorities on short- and medium-term spatial development projects. The *T.OP Kustzone* builds on the revised Provincial Spatial Structure Plan W-VL (PRS-WVL) local partner consultations and studies such as CcASPAR, MKL2100, Codex Coastal Zone, STADSMonitor, etc. (see thematic chapter **Social and economic environment**).

The Province of West Flanders is also working on a new spatial policy plan (concept report expected early 2022). Important supra-regional policies for the coast are formulated in the current PRS W-VL. Within this plan, several coastal municipalities were selected as residential areas with opportunities for touristic-recreational development under specific conditions. The PRS W-VL also defines outdoor recreational green areas, amusement parks and tourism-recreational linear elements (watercourses, railway beds, dykes and road infrastructure). Additionally, a number of strategic project areas were selected where tourism and recreation should be given an important place (PRS W-VL, Strategic policy plan for coastal tourism and recreation 2015-2020). These include the Yser estuary in Nieuwpoort, the area to the east of Blankenberge, the area to the south of Knokke's railway station, the military base of Koksijde and the east bank of Ostend. The provincial spatial implementation plans (PSIPs) (in particular the PSIPs for beach and dike) are of significant importance for organising the tourist-recreational functioning of each coastal zone area. A zoning is defined that outlines a number of preconditions for future developments. The coastal zone already has a well-developed cycling and walking network and development zones have been designated for the construction of 'cycling highways' between seaside municipalities.

At municipal level, processes are under development to create new opportunities for tourism and recreation within the municipal structural plans. This should enable the spatial planning of tourism and recreation at a local level to be written down in more detail in the implementation plans. In this regard, a guideline is provided by the research of Gruijthuijsen (2015) on the needs and requests of tourists in Belgian and Dutch seaside resorts, in which, among other things, the demand for a modernisation of public spaces was recorded.

11.2.2 Management of touristic space

The Government of Flanders owns almost all beaches[1] along the Belgian coast, with the exception of the military base at Lombardsijde (Belgian Defence) and some strips in De Panne and Koksijde (municipal authorities). The Coastal division (FPS Mobility and Public Works (MOW), Agency for Maritime Services and Coast (MDK)) grants concessions for the development, maintenance and exploitation of the marinas for water recreation and sports (sailing schools, recreational boats, recreational sea fishing, hikers, etc.) along the Flemish coast (Coastal division). In this context, an annual budget of over 20 million euro is foreseen. Additionally, the Coastal Division is responsible for providing safe coastal protection measures (see also thematic chapter **Safety against flooding**) in which the added value for tourism is often taken into account during the development of innovative coastal protection measures (e.g. grass dikes) (Coastal division). The Coastal Division is also in a position to grant beach and seawall concessions for tourist and recreational use in consultation with municipal authorities, other public authorities, utility companies, contractors, private persons, etc. (Coastal division).

11.3 Societal interest

11.3.1 Coastal tourism[2]

The tourist-recreational sector is crucial for the coastal economy. In 2019, 5,543,368 arrivals at the coast in the residential tourism sector could be registered, representing a total of 27,723,420 overnight stays (figure 1). Commercial accommodation constitutes roughly 42% of these stays, and second-home tourism 58% (Westtoer, Trendrapport Kust 2018-2019, more information: study Vakantieganger in commercieel logies Kust 2017, Impact tweedeverblijvers voor het Kusttoerisme, Westtoer 2016). An additional 17,241,000 day-trippers arrived at the coast in 2019 (Westtoer, Trendrapport Kust 2018-2019). In 2020, however, both residential and day tourism experienced a steep decline due to the corona crisis and related leisure restrictions. In 2020, coastal tourism registered 4.0 million arrivals (-27.5% compared to 2019) and 23.2 million overnight stays (-16.3% compared to 2019). Whereas the number of day-trippers before the corona crisis varied between 16 and 19 million tourists

[1] The total beach area on the Belgian coast amounts to 25.3 km², of which 20.2 km² is low beach and 5.1 km² is high beach (for the beach area per municipality, with a division into high and low beach: Biologische waarderingskaart en Natura 2000 Habitatkaart - Toestand 2018).
[2] Here we follow the statistical definition of 'tourism', which includes business visits in addition to private visits.

(Toerisme in cijfers XL 2017, Dauwe et al. 2019, Westtoer Trendrapport Kust 2018-2019, Westtoer 2021), this had dropped to 10.0 million tourists in 2020 (-42.2% compared to 2019) (Toerisme in cijfers XL 2017, Dauwe et al. 2019, Westtoer Trendrapport Kust 2018-2019, Westtoer, Trendrapport Kust 2019-2020, Westtoer 2021).

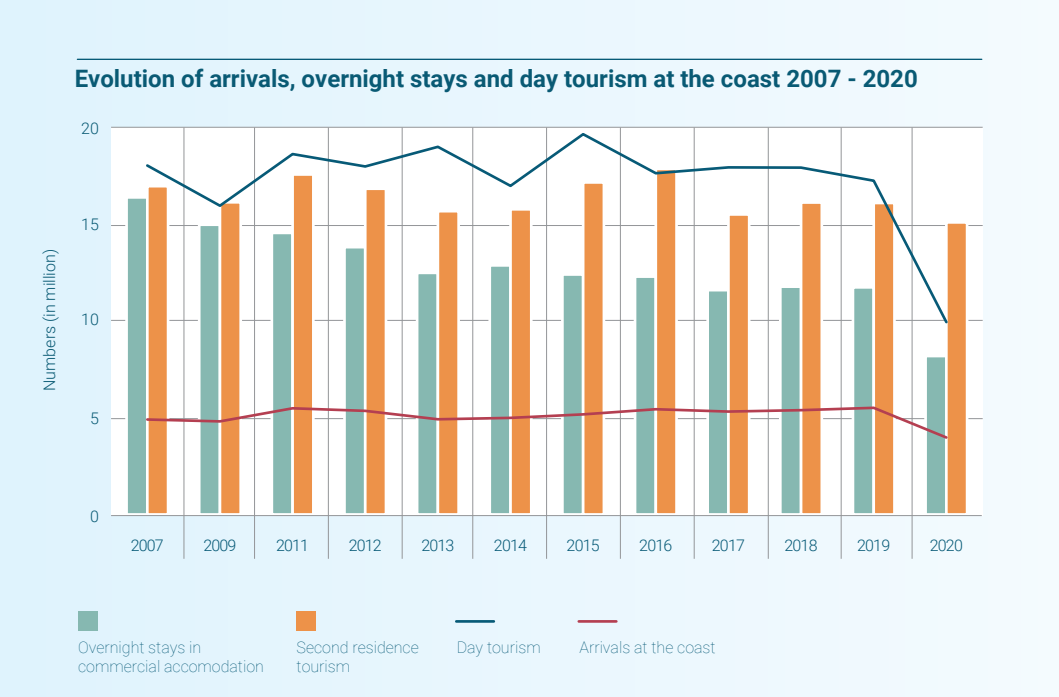


Figure 1. Evolution of the number of day-trippers, overnight stays in commercial accommodations, second-home tourists and arrivals along the coast (Westtoer, Trendrapport Kust 2012-2013, Westtoer, Trendrapport Kust 2015-2016, Westtoer, Trendrapport Kust 2017-2018, Westtoer, Trendrapport Kust 2018-2019, Westtoer, Trendrapport Kust 2019-2020).

The decline in the number of tourists also had economic consequences, with a reduction in turnover from approximately 3 billion euro (2019) to 2.2 billion euro (-26.7%) (2020) (Westtoer, Trendrapport Kust 2018-2019, Westtoer, Trendrapport Kust 2019-2020). The largest losses were registered in day tourism (-67.0% compared to 2019) (Westtoer, Trendrapport Kust 2019-2020). In 2019, residential tourism accounted for 2.2 billion euro of direct expenditure and day tourism for 793 million euro (table 2) (Westtoer, Trendrapport Kust 2018-2019, more information: Vakantieganger in commercieel logies 2017). When visiting the coast, the average day-tripper spends about 45 euro per day, a resident in commercial accommodation 68 euro per night and a second-home owner in a holiday house 42 euro per night (Impact tweedeverblijvers voor het Kusttoerisme, Westtoer 2016, Vakantieganger in commercieel logies 2017, Dagtoeristen aan de kust 2018). A study of the meeting industry on the coast shows that this sector accounts for a turnover of 60 million euro (2013) (Westtoer, onderzoek Meeting aan Zee 2015, Westtoer, Trendrapport Kust 2018-2019).

Table 2. The direct expenditure of coastal tourism per type of tourism in 2019* (Westtoer, Trendrapport Kust 2018-2019).

Type of tourism	Direct expenditure of tourists in million euro	Percentage
Commercial accomodation	804.7	26.9
Second-home tourism	1,308.5	43.8
Mooring in marinas	22.1	0.7
Day tourism	793.4	26.5
Meeting industry	60.0	2.0
Total	**2,988.7**	**100**

** The figures in the most recent trend report, Trendrapport Kust 2019-2020 don't allow a complete actualisation of this table.*

The activities of Belgians during day trips (including those to the coast) were examined in more detail in pilootonderzoek naar daguitstappen van de Belg (2010-2011) and more recently in Dagtoeristen aan de kust (2018). These show that the weather conditions are the major decisive factor for a visit to the coast and that strolling on the dike (73%), visiting cafes, tearooms, terraces (51%) and restaurants (47%) are the most popular activities. About 80% of the tourists come to the sea by car (Westtoer 2021). The presence of the International Airport Ostend-Bruges and the seaports of Ostend and Zeebrugge play an important role in the influx of foreign tourists to the Belgian coastal zone. The traffic figures for the International Airport Ostend - Bruges are available on its website. On the website of the *Mobiliteitsraad Vlaanderen* (MORA) figures are available about the number of passengers in the above-mentioned ports.

Along the Belgian coast 26 water sports clubs were active in 2019, accounting for approximately 9,720 members (Dauwe et al. 2019, Coastal Portal). Additionally, 12 yacht clubs were active, spread over the four coastal marinas (Zeebrugge, Blankenberge, Ostend, Nieuwpoort) with a total capacity of 3,553 berths (Westtoer, Trendrapport Kust 2018-2019). A survey in April 2019 showed that the Flemish coastal marinas have approximately 9,540 members, the majority of which are affiliated to the yacht club of Nieuwpoort (5,640 members) (Dauwe et al. 2019, Maelfait 2020). As part of the Seaconomics project (2010-2014), the economic significance of the marinas was investigated (Westtoer, onderzoek gebruikers kustjachthavens 2013). Based on this study, the average turnover generated by all users of the Flemish coastal marinas was estimated at 25.3 million euro per year. More recent figures by *Westtoer* estimate this to be rather 22.1 million euro (Westtoer, Trendrapport Kust 2018-2019).

Direct employment based on coastal tourism turnover in 2019, is estimated at 21,518 full-time equivalents (FTE), with a total employment (direct and indirect) of 31,679 FTE, assuming that 1 million euro represents 7.2 FTE of direct employment and 3.4 FTE of indirect employment (Westtoer, Trendrapport Kust 2018-2019). In 2020, total employment was estimated at 22,900 FTE. This is probably an underestimate which can be attributed to systems of temporary unemployment that were put in place as a result of the corona crisis (Westtoer, Trendrapport Kust 2019-2020).

The relationship between coastal tourism and the social and economic aspects of the coast is also partly addressed in the thematic chapter **Social and economic environment**.

Finally, it is worth mentioning that, in addition to an obvious economic added value, there is increasing scientific evidence that 'blue spaces', particularly coastal areas, have a positive influence on the general sense of wellbeing of humans that should not be underestimated (SOPHIE project, Hooyberg et al. 2020, Severin et al. 2021).

11.3.2 Hinterland tourism

In addition to coastal tourism, hinterland tourism also accounts for a significant number of arrivals and overnight stays. The tourist-recreational regions of *Brugse Ommeland* and *Westhoek* recorded almost 600,000 arrivals and 1.3 million overnight stays in 2019, before the corona crisis (Westtoer, Trendrapport Brugse Ommeland 2018-2019, Westtoer, Trendrapport Westhoek 2018-2019). In 2020, however, these regions also noted a sharp decline in the number of overnight stays (601,600; -114.6% compared to 2019) and arrivals (239,800; -144.4% compared to 2019) (Westtoer, Trendrapport Brugse Ommeland 2019-2020; Westtoer, Trendrapport Westhoek 2019-2020). In Bruges, there were approximately 1.3 million arrivals and 2.2 million overnight stays in 2019. These are arrivals and overnight stays in commercial accommodation (excluding second-home tourism) (Kenniscentrum Westtoer). In 2020, this dropped to 0.4 million arrivals and 0.7 million overnight stays (Westtoer, Kerncijfers West-Vlaanderen 2020).

11.4 Impact

As mentioned above, coastal tourism has a significant economic and societal value and is directly linked to a number of facilities such as the coast tram and marinas. However, tourism in the coastal area also creates certain challenges for the social and ecological environment. On the social level, the amount of little-occupied second-homes has an impact on the quality of life along the coast, resulting in higher real estate prices and a weakened social cohesion. Moreover, the region also suffers from mobility problems and (seasonal) unemployment (Meire and Bracke 2005, Goffin et al. 2007, Maelfait et al. 2012, Dauwe et al. 2019, Kansarmoedeatlas West-Vlaanderen 2021 (see thematic chapter **Social and economic environment**)).

The large amount of second-homes also affects the cultural heritage along the coast (IDEA consult 2009), although clear synergies between tourism and the coastal heritage exist, such as the touristic function of cultural-

historical buildings along the coast (De Baerdemaeker et al. 2011, Kusterfgoed) (see thematic chapter **Maritime and coastal heritage**).

From an ecological point of view, the emergence of mass tourism at the coast from the 1930s onwards, with the massive implantation of tourist-recreational accommodation (holiday homes, campsites, weekend accommodation parks, second-homes, etc.) has played a major role in the urbanisation of the coastal zone, the fragmentation of valuable open space and the disappearance of biotopes (PRS W-VL, Goffin et al. 2007, Maelfait et al. 2012, Henkens et al. 2012, Coastal Portal). Especially the dune area has experienced a strong fragmentation, partly caused by spatial planning (Welkom in de duinen 2008, Provoost et al. 2014, Vanderbiest et al. 2017a) (see thematic chapter **Nature and environment**). Furthermore, the high concentration of tourists and residents in the coastal zone during the peak season can cause several direct and indirect ecological effects (table 3). The number of tourist at the coast can be monitored with the Kustbarometer.

Table 3. An overview of the main direct and indirect ecological effects caused by the high concentration of tourists and residents in the coastal zone.

Impact	Literature
Energy and water use	Vanlerberghe and Vanhoutte 2001, Goffin et al. 2007 (see thematic chapter **Agriculture**), Lenders et al. 2013, Antea 2018
Litter on the beach and in the water	Lescrauwaet et al. 2006, Goffin et al. 2007, Maelfait 2008, Doomen et al. 2009, Claessens et al. 2013, Actieplan Marien Zwerfvuil 2017, Devriese and Janssen 2017, Belgian State 2018, Seys et al. 2019, Devriese and Janssen 2021 (more on the impact of marine litter, see thematic chapters **Maritime transport, shipping and ports** and **Nature and environment**)
Mechanical beach cleaning	Belpaeme 2003, Dominguez 2006, Goffin et al. 2007, Doomen et al. 2009, Vanhooren et al. 2011, De Bruyn et al. 2020
Eutrophication of the coastal waters	Maes et al. 2004 (MARE-DASM project BELSPO), OSPAR 2017, Desmit et al. 2018, VMM (see thematic chapter **Agriculture**)
Traffic intensity	Goffin et al. 2007, Dauwe et al. 2019
Trampling and disruption of the beach and dune ecosystem	Vincx et al. 2001, Maes et al. 2004 (MARE-DASM project BELSPO), Provoost et al. 2004, Derous 2005 (GAUFRE project BELSPO), Goffin et al. 2007, Krijgsveld et al. 2008, Welkom in de duinen 2008, Provoost et al. 2014 (see thematic chapter **Nature and environment**), Seys et al. 2019, De Bruyn et al. 2020
Pollution by recreational boating	Maes et al. 2004 (MARE-DASM project BELSPO), De Wachter and Volckaert 2005 (GAUFRE project BELSPO), Lescrauwaet et al. 2006, Goffin et al. 2007
Pollution by recreational fisheries	Verleye and Devriese 2019, Verleye and Dauwe 2021 (see thematic chapter **Fisheries**)

11.5 Sustainable use

In recent years, there has been a trend towards putting responsible tourism within a more comprehensive framework than only the protection of the environment. The United Nations Sustainability Goals for example, have become an important framework in the development of tourism activities (United Nations Sustainability Goals, Travel to Tomorrow, Roadmap Blauw Toerisme, DBC).

The shift to an integrative form of added-value tourism within a sustainable framework is reflected at the European level in the renewed vision of a sustainable blue economy (COM (2021) 240) (see **11.1 Policy context**). Europe identifies the protection and creation of nature as a precondition for the development of sustainable and resilient tourism. The importance of heritage (see thematic chapter **Maritime and coastal heritage**) and "slow" tourist activities (local activities, reduced frequency of travel, etc.) is also underlined. These two elements are also reflected in the plans of *Interreg VI Vlaanderen-Nederland* (Interreg Vlaanderen-Nederland: concept programma 2021-2027).

At the Flemish level, this new integrative and sustainable vision on tourism is translated into the Flemish government's Travel to Tomorrow policy vision (see **11.1 Policy context**). In this context, a new, quality-oriented framework is being used for evaluation purposes. Today, sustainability in tourism or recreation is recognised and promoted through various quality labels such as the Blue Flag for sustainable tourism, the Q-label for tourism entrepreneurs, the Green Key, the accessibility label of the non-profit association Inter, etc. (more information: Tourism Flanders). Inspired by the Travel to Tomorrow policy vision, the Flemish spearhead cluster The Blue Cluster (*De Blauwe Cluster*, DBC) has developed a vision towards a sustainable, innovative but authentic tourist

experience (Roadmap Blauw Toerisme, DBC). By initiating and participating in various projects (see also table 4), this vision is further elaborated.

In addition to making tourist and recreational activities more sustainable, nature also occupies an important place in the tourist experience. Ecotourism generates increasingly more income, which in turn results in ecologically valuable landscape programmes and projects: e.g., the Belgian Coast, Ztar, Life+ project FLANDRE, Vedette project (table 4). Moreover, the natural areas in the coastal zone maintain a whole range of ecosystem processes that are crucial for maintaining tourism and recreation as an ecosystem service (Van der Biest et al. 2020).

In order to ensure the protection of nature, including against the environmental impact of tourism activities, Europe has established the Natura 2000 network of protected areas under the Habitats Directive (Directive 92/43/EC) and the Birds Directive (Directive 2009/147/EC) (see thematic chapter **Nature and Environment**). For the protection of nature in the coastal zone, the Dunes Decree (14 July 1993 and following) and the Flemish Ecological Network (*Vlaams Ecologisch Netwerk* (VEN)) are also important (see in more detail in the thematic chapter **Nature and Environment**). In this context, Vanden Eede et al. (2014) developed biological valuation maps for the Belgian coastal zone, which can be used as a tool to support decision-making by local policymakers for orienting spatial projects and allowing tourism activities. In addition, *the Milieurapport Vlaanderen, Achtergronddocument 2006: Kust en Zee* (Goffin et al. 2007), the *Kustkompas: indicatoren voor een duurzaam kustbeheer* (Maelfait et al. 2012) and the Strategic policy plan for coastal tourism and recreation 2015-2020, elaborate on the balance between nature conservation on the one hand and the needs of recreational users and tourists on the other hand. Finally, the combination of recreation and nature is discussed in publications such as De Uitkerkse polder, een recreatieve meerwaarde voor de Vlaamse kust (2007), Welkom in de duinen (2008), Henkens et al. (2012), Cosyns et al. (2014) and Provoost et al. (2014).

Table 4. Non-exhaustive list of studies, projects and visions that address sustainable coastal tourism.

Study - project - vision	Description
Kindvriendelijkheid aan de Vlaamse kust	Study on how to make the Flemish coast more attractive for families with children.
Klimaatverandering als motor voor een vernieuwd kusttoerisme? (De Waegemaeker 2012)	Study examining the impact of a compartmentalised coast (CcASPAR) on coastal tourism.
Aligning biodiversity conservation and ecosystem services in spatial planning: Focus on ecosystem processes (Van der Biest 2020)	Overview of the impact of various ecological and anthropogenic processes along the Belgian coast on tourism and recreation as an ecosystem service.
COASTAL	Project that draws up an integrated picture of the coast and the hinterland, looking for sustainable and socially relevant business and policy opportunities, including links with tourism.
FLANDRE	LIFE project with the aim of improving nature and the nature experience on the French-Belgian border.
Ztar	The Ztar project, successor to the ZENO project, aimed to restore the mudflats and salt marshes of the Zwin natural reserve.
120 km Kustkwaliteit	Project to develop sustainable beach and coastal management. See e.g. studies by van Meenen 2009, Pijpers 2009, kansen aan de kust 2009.
VEDETTE	Project that focuses on sustainable and eco-tourist development within the cross-border dune area between Dunkirk and Westende.
EUROCYCLO	Project to promote bike tourism in the region.
TENDANCES	Project encouraging the development of specific products and services that can contribute to the promotion of the heritage and characteristics of the French-Belgian coast and the Luxembourg province.
PROFIT	Project aimed at making the tourism sector more profitable and sustainable by boosting innovation.
FACET	Project investigating how circular solutions can reduce the pressure on resources and waste production of coastal tourism.
Think Tank North Sea	Cross-sectoral vision platform (similar to The North Sea Vision 2050) where representatives from the quadruple helix (policy, private, scientific and society at large) develop visions for the sustainable development of the North Sea by 2050.
Coastal memorandum Natuurpunt *(Kustmemorandum Natuurpunt)*	Vision that addresses the benefits of manual beach cleaning and advocates for integrated coastal zone management.

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Communications			
COM (2010) 352	Communication from the Commission: Europe, the world's No 1 tourist destination – a new political framework for tourism in Europe	2010	352
COM (2012) 494	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
COM (2014) 86	Communication from the Commission: A European strategy for more growth and jobs in coastal and maritime tourism	2014	86
COM (2021) 240	Communication from the Commission: On a new approach for a sustainable blue economy in the EU. Transforming the EU's Blue Economy for a Sustainable Future	2021	240
Directives			
Directive 91/271/EEC	Directive concerning urban waste-water treatment	1991	271
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2006/7/EC	Directive concerning the management of bathing water quality and repealing Directive 76/160/EEC (Bathing Water Directive)	2006	7

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 8 December 1998	Besluit van de Vlaamse regering tot aanduiding van de oppervlaktewateren bestemd voor de productie van drinkwater categorieën A1, A2 en A3, zwemwater, viswater en schelpdierwater, ter omzetting van Richtlijn 2006/7/EG van het Europees Parlement en de Raad van 15 februari 2006 betreffende het beheer van de zwemwaterkwaliteit en tot intrekking van Richtlijn 76/160/EEG	1998-12-08/51
Decrees		
Decree of 14 July 1993	Decreet houdende maatregelen tot bescherming van kustduinen	1993-07-14/31
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Royal Decrees		
RD of 4 August 1981	Koninklijk besluit houdende politie- en scheepvaartreglement voor de Belgische territoriale zee, de havens en de stranden van de Belgische kust	1981-08-04/31
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 28 June 2019	Koninklijk besluit betreffende de pleziervaart	2019-06-28/08

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
Laws		
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 8 May 2019	Wet tot invoering van het Belgisch Scheepvaartwetboek	2019-05-08/15

12 Safety against flooding

Authors Toon Verwaest[1], Daphné Thoon[2], Jaak Monbaliu[3], Frank Mostaert[1], Peter Van Besien[2], Chantal Martens[4], Ine Moulaert[4], Tina Mertens[4]

Lectors Steven Vandenborre[5], Eline Damman[6], Kristien Veys[7], Philippe De Maeyer[8], Bob Peeters[9]

[1] Department of Mobility and Public Works (MOW), Flanders Hydraulics Research
[2] Agency for Maritime and Coastal Services – Coastal division
[3] Katholieke Universiteit Leuven (KU Leuven), Department of Civil Engineering
[4] Flanders Marine Institute (VLIZ)
[5] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[6] Department of Mobility and Public Works (MOW), Policy division
[7] The Blue Cluster (DBC)
[8] Ghent University (UGent), Department of Geography
[9] Flanders Environment Agency (VMM)

Verwaest, T., Thoon, D., Monbaliu, J., Mostaert, F., Van Besien, P., Martens, C., Moulaert, I., Mertens, T. (2022). Safety against flooding. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 197-211.

Flooding along the coast can be driven by storm surges and sea level rise. In Europe, the coastal regions with the highest flooding risk are the North Sea coasts of Belgium, the Netherlands and Germany, as well as the Mediterranean coastal area of northern Italy (EEA Report 2017). The North Sea coast of Belgium, characterised by coastal dunes, sandy beaches and a naturally soft foreshore, may be vulnerable for violent storm surges (Quante and Colijn 2016). To date, no increased erosion could be demonstrated for the Belgian coast because the coastline is maintained by beach nourishments and in certain zones natural sediment accretion occurs (see also the CREST project).

Flooding of low-lying polders due to heavy rainfall may occur in the coastal region as well, but is not unique for this zone. It is important to also take into account a possible flooding of the hinterland, especially since the changes in precipitation by 2100 may be 10% higher along the coast than inland (Van Steertegem 2009). Due to the strong increase in extreme, short-period rainfall events, sewage and other drainage systems will face additional stress in the future (Brouwers et al. 2015). An additional challenge in the coastal zone concerns the integration of flood risks from inland waters (such as the Yser river) on the one hand and from the sea on the other (e.g. Willems 2013). As such, the decrease of the time window for discharges of excess water from the hinterland to the sea as a result of sea level rise requires additional attention. However, in this thematic chapter, flooding of the hinterland will not be further considered.

Climate influences: rising sea levels and storm surges

The Flemish Environment Agency (VMM), in collaboration with the Coastal Division among others, has developed the Climate Portal Flanders, which maps the climate situation with maps, key figures and graphs. In this portal, the current climate situation (temperature, precipitation, etc.), the effects (flooding, heat, drought, etc.) and the impact (casualties, costs, etc.) of climate change can be consulted. Furthermore, climate scenarios up to 2100 can be visualised.

Global long-term climate scenarios are published by the Intergovernmental Panel on Climate Change (IPCC). Brouwers et al. (2015) further provides an overview of the available scenarios with respect to sea level rise and storm surges for the Belgian coast. Within the context of the Coastal Vision project and the CREST project, climate projections were made for the IPCC climate scenarios RCP2.6[1], RCP4.5, RCP8.5 and one extreme scenario, with time horizon 2100 (CREST project and Flemish government 2018). Such assessments are important to provide sound underpinning of flood safety policies.

Between 1902 and 2015, the average sea level on earth increased by 0.16 m. The average annual increase has not remained the same during this period, but has accelerated. Today, the global average (calculated over 2006-2015) is 3.6 mm per year, corresponding to about 2.5 times the rate of the average increase of 1.4 mm per year between 1901 and 1990 (IPCC 2019). This exceeds the sustainability goal of maximum 2 cm rise per decade (Brouwers et al. 2015). Human activities are the main cause of sea level rise since 1970 (Slangen et al. 2016, IPCC 2019). The magnitude of sea level rise may vary locally. This can be explained in part by the non-uniform distribution of changing water density, a different impact of changes in ocean circulation, and local vertical (both upward and downward) movements of the earth's crust (website Milieurapport). The statistical analysis of the data is not easy because sea level is not only affected by climate change, but also by natural fluctuations. Nevertheless, it can be deduced from the series of measurements of the Belgian coast that the annual mean sea level[2] in 2019 is significantly higher than at the beginning of the measurements. In Ostend this is an increase of 134 mm between 1951 and 2019 (figure 1). In previous decades, significant increases in the annual average sea level were also recorded for Zeebrugge and Nieuwpoort (website Milieurapport). In addition to sea level, high and low tides can be analysed. In Ostend an approximate linear trend increase of high waters of 2 cm per decade is observed (Willems 2015). Since 2013, the annual mean high water heights are systematically higher than the trend line. Further research should reveal whether this is effectively an accelerated upward trend, or due to long-term oscillations (Willems 2019). From a data analysis of the extreme high waters at Ostend, the storm surge[3] shows a small additional increasing trend of 0.2 mm/year in addition to the yearly average increase of the astronomical component of 1.8 mm/year. However, this trend is not statistically significant taking into account the natural fluctuations in the occurrence of storms (Willems 2019).

[1] RCP (Representative Concentration Pathway) scenarios are scenarios that describe the evolution of greenhouse gases up to 2300 and are used in the fifth report of the Intergovernmental Panel on Climate Change (IPCC). The RCP8.5 scenario is the most extreme, pessimistic scenario and implies that nothing is done to combat climate warming. This is the so-called business-as-usual-scenario (Source: Royal Meteorological Institute of Belgium (RMI)).

[2] The sea level in Figure 1 is expressed in m RLR (Revised Local Reference). This means that the data of a local reference (for the Belgian coast this is the TAW or *Tweede Algemene Waterpassing*) to the international reference level.

[3] The storm surge heights can be calculated in two ways: the so-called straight surge or the skewed surge. For the skewed surge, the total flood elevation is reduced by the astronomical flood elevation during the same time cycle, with both often not occurring at the same time. For the straight surge, the total flood elevation is reduced by the astronomical water elevation at the same time (Willems 2019).

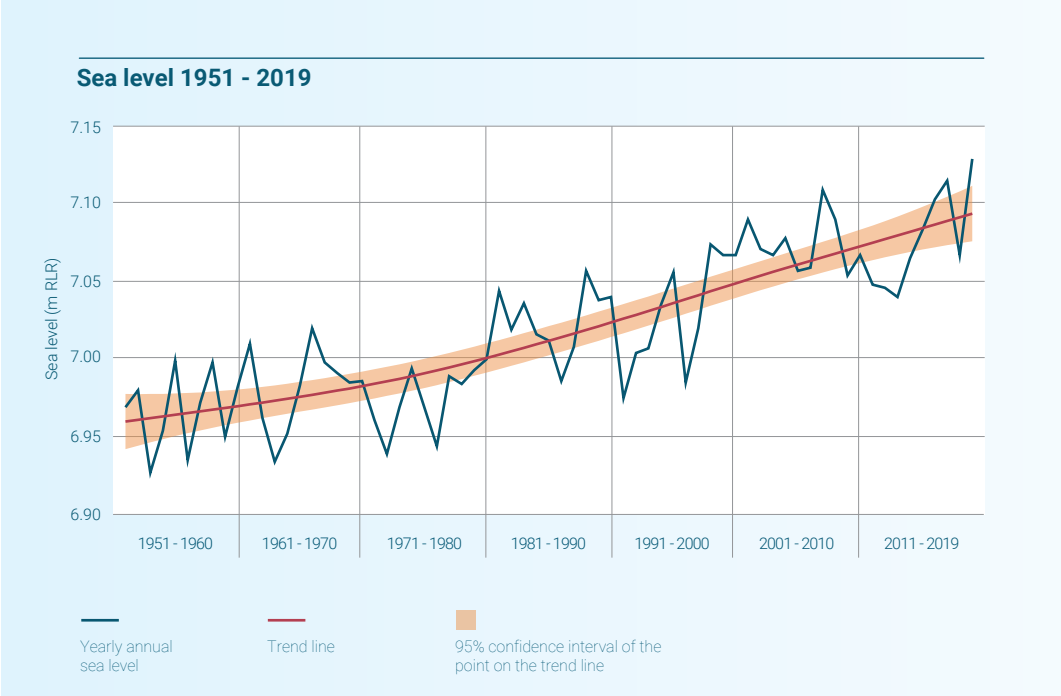


Figure 1. Evolution of the sea level on the Belgian coast (Ostend, 1951-2019) (Source: Milieurapport).

Events such as storms and floods are classified according to their return period. This return period represents the recurrence period of an event. A return period of 100 years means that a certain event occurs on average every 100 years, and thus there is 1 chance out of 100 that a particular event will occur in the next year. It is interesting to note here that with an (additional) sea level rise of about 50 cm, the current return period of a storm with a level of + 7.0 m TAW (Second General Water Supply) will shift from 1 chance out of 1,000 to 1 chance out of 100 per year (table 1). An increased storm frequency could not be demonstrated for the Belgian part of the North Sea (BNS) (Van den Eynde et al. 2011, CLIMAR project BELSPO, Hossen and Akhter 2015). Based on predictions with climate models, assuming an RCP8.5 scenario for the last thirty years of the 21st century, no significant increase in storm surge is expected, however an increase in extreme wind speeds is predicted (Van den Eynde et al. 2019).

Table 1. An overview of the flood risks in the Belgian coastal area in 2015 for different storm surge levels and return periods, including the associated casualties and the direct economic damage (Vanneste et al. 2018). (These numbers also include flood risks in the outskirts of Zeebrugge, albeit with simplified assumptions.

Flood risks in the Belgian coastal zone			
Storm surge level	**Return period**	**Casualties**	**Direct economic damage**
+ 6.5 m TAW	~100 year	40	1.061 billion euro
+ 7.0 m TAW	~1,000 year	215	3.884 billion euro
+ 7.5 m TAW	~4,000 year	570	6.873 billion euro
+ 8.0 m TAW	~17,000 year	2147	10.491 billion euro

12.1 Policy context

At European level, the Floods Directive (Directive 2007/60/EC) was adopted in 2007 out of concern for the harmful effects of any flood on people, nature, heritage, economy etc. and the possible increase in the number of floods in the context of climate change. The directive applies to all European coastal and inland waters. Within the framework of this directive, the member states will analyse the river basins and associated coastal areas prone to flooding. In implementation of the aforementioned directive, flood hazard maps (physical properties of a flood such as the extent and depth of a flood) and flood risk maps (potential negative impacts on humans, the environment, heritage, etc.) must be drawn up by the member states. For Flanders, these maps can be consulted via the Waterinfo maps catalogue.

In Flanders, these flood risk management plans were integrated with the river basin management plans drawn up within the context of the European Water Framework Directive (WFD, Directive 2000/60/EC) (see thematic chapter **Nature and environment**). Since 1980, the water management policy has been the responsibility of the regions (special Law of 8 August 1980). The most important legislative instrument within this policy is the Decree Integral Water Policy of 18 July 2003 (coordinated on 15 June 2018 in the Water Code), which since 2010 provides for the Flemish implementation of the European Flood Directive. The flood risk management plans of the Flemish coastal area are included in the river basin management plan for the Scheldt (Programme of Measures for River Basin Management Plans for Scheldt and Meuse 2016-2021, River Basin Management Plans for Scheldt and Meuse 2016-2021)[4], and a river basin management plan for the Belgian coastal waters (Basin Management Plan for Belgian Coastal Waters 2016-2021) (see also thematic chapters **Nature and environment** and **Scheldt estuary**). The Coordination Committee for Integrated Water Policy organises consultation at the Flemish level between the various policy areas and administrative levels involved in water policy.

Building on the European adaptation strategy (COM (2013) 216) (website Climate-ADAPT), which was launched in 2013, the European Green Deal (COM (2019) 640) included an update to this adaptation strategy (COM (2021) 82). Within the framework of the Green Deal, a European Climate Law (Regulation (EU) 2021/1119) has been in force since 29 July 2021, that, among other things, legally anchors the European goal of climate neutrality by 2050.

In Belgium, coastal policy is mainly a Flemish competence. Although the federal government is competent for the area seaward from the baseline (i.e. low water line), the Flemish government also has some competences with impact beyond the baseline, mainly the coastal protection infrastructure (coastal safety) and the maintenance of navigation channels to the four Flemish seaports. Specifically, for floods from the sea, the Coastal division (part of the Agency for Maritime Services and Coast (MDK), which falls under the Flemish Mobility and Public Works (MOW) policy area) is responsible for protecting the Flemish coast against flooding.

An assessment of the Flemish coastal protection in 2007 and 2008 showed that at that time, about one third of the straight coast[5] and the coastal ports needed additional protection against the impact of heavy storm surges. The Masterplan for Coastal Safety (2011) describes the measures that need to be taken for an adequate protection of the coastline and the adjacent low-lying polders against a storm surge with a return period of 1,000 years, with 2050 set as the time horizon. The masterplan took into account a sea level rise of 30 cm[6]. The plan has been implemented in stages since its approval by the Flemish Government on 10 June 2011 and is now in an advanced phase. An update of the assessment in 2017 revealed that at the locations where measures have already been implemented as part of this Masterplan for Coastal Safety (2011), the level of protection has clearly increased. However, at some locations additional measures are needed to reach the proposed safety level. The intention is to use 'soft' measures (beach nourishment, dune nourishment, etc.) as much as possible complemented by 'hard' measures (storm walls, wave attenuating construction of the seawall, etc.) where necessary. An overview of the measures, including their status, is given in table 2. In addition to the measures within the framework of the Masterplan for Coastal Safety, beach nourishments are also carried out for maintenance purposes, or, as in the case of Nieuwpoort (2017), as nature compensation for the construction of the OW plan Ostend (Gysens 2009).

In parallel with the Masterplan for Coastal Safety (2011), and building on initiatives that have been taken since 2009 both from private initiatives (THV Noordzee Kust 2009) as from the government (Masterplan Vlaamse Baaien 2014), the starting decision of the Coastal Vision project was taken in 2017. This project aims to develop a long-term approach for the protection of the Flemish coast, assuming a sea level rise up to 3 m. The project was initiated within the Complex Projects framework. On June 25 2021, the Flemish Government decided to discontinue this procedure and to continue the development of the Coastal Vision project with a tailored approach.

In addition, the Sigmaplan of the Flemish government should also be mentioned. This plan elaborates the protection against flooding from the Scheldt and its tributaries, and runs until 2030, but wil not be further discussed in detail here (see also thematic chapter **Scheldt estuary**, ScheldeMonitor and the website of the Flemish-Dutch Scheldt Commission (VNSC)).

[4] The new River Basin Management Plans for Scheldt and Meuse 2022-2027 will take effect on 1 January 2022. See thematic chapter **Nature and environment**.
[5] Straight coast: the whole of the beaches, foreshores, dunes and sea dikes.
[6] The water level at sea during a 1,000-year storm is currently around +7 m TAW. Sea level rise will cause the water level to rise. The Masterplan for Coastal Safety (2011) uses the following assumptions regarding sea level rise: +30 cm by 2050, +80 cm by 2100 (compared to the year 2000); a constant acceleration of 0.08 mm/year, which is in line with the acceleration of global sea level rise as monitored by satellite since the 1990s (IPCC 2019).

Table 2. An overview of the protection measures and the status of implementation per focus area anno spring 2021. The planned quantities of sand for the nourishments were derived from the Masterplan for Coastal Safety (2011). The section numbers refer to the individual sections of coastline (with an average length of 250 m) which are used to devide the Belgian coast. The numbering runs from 2 (on the French border) to 255 (on the border with the Netherlands).

Zone of interest	Selected measures, incl. the planned nourishment quantities	State of implementation (anno 2021)
De Panne - section 8	• Dune nourishment; • Planned: 22,000 m³ sand.	• A detailed safety assessment shows that the standards for flood risk are not exceeded, making dune nourishment unnecessary.
De Panne-centrum (section 13 to 18)	• Beach nourishment with an elevated beach; • Planned: 85,000 m³ sand.	• 2011: beach nourishment; • 2017: maintenance; • 2020: maintenance.
St. Idesbald - Koksijde-centrum (section 21 to 31)	• Beach nourishment with an elevated beach; • Planned: 248,000 m³ sand.	• 2011: beach nourishment; • 2017: maintenance.
Koksijde - section 39	• Raising the road by the nourishment of the dune passage in combination with the reconstruction of the road; • Planned: 1,800 m³ sand.	• 2013: dune passage raised and rebuilt.
Haven Nieuwpoort	• Construction of a storm surge barrier.	• 2018: start of construction of the storm surge barrier; the construction works will take more than three years; • Completion of the abutment on the right bank is scheduled for 2022.
Middelkerke - Westende (section 74 to 88)	• Beach nourishment with a low-lying beach in combination with wave-absorbing expansions and a storm wall seawards of the casino; • Planned: 1,700,000 m³ sand.	• 2013-2015: phased nourishment for a beach lower than the seawall level; • 2017: maintenance; • 2021: start phased reconstruction of the seawall with wave-absorbing expansion grass dyke.
Raversijde - Ostend Wellington (section 97 to 108)	• Beach nourishment with a low-lying beach in combination with a high storm wall or adapted seawall ramp and wave-absorbing expansion or widening of the seawall at Raversijde; • Planned: 1,500,000 m³ sand.	• 2013-2014: widening and raising of the beaches; • 2014: beach nourishment; • 2018: maintenance; • 2020-2021: Construction of a storm wall of 40 cm on the dyke of Mariakerke; • 2021: Construction of a dune in front of the dyke as measure for the windblown sand on the N34 and the tram rails and the restoration of the dyke in Raversijde; • 2021: Maintenance beach nourishment.
Ostend centre (section 109 to 117) + Port of Ostend + Ostend-East (section 118 to 120)	• OW-Plan Ostend (storm walls in the port, beach nourishment and wave-absorbing expansion seawall, mobile storm walls on seawall Ostend centre)	• 2012: dyke Albert I promenade along the entire length, strengthened and equipped with a fully removable mobile storm wall; *Zeeheldenplein* near *Klein Strand* completely renovated and strengthened; • 2013: construction of nourishment; • 2018: maintenance; • Since 2014: construction of a storm wall on the quays in the *Vismijnlaan*, *Wandelaarskaai* and *Slijkense Steenweg*; • 2020-2021: construction of a mobile storm wall between *Zeeheldenplein* and *Visserskaai*; • 2021: The preferred alternative for the protection of the inner port of Ostend is being developed.
Ostend-East (section 121)	• Beach nourishment in line with OW-plan, subsection on integrated coastal zone management Oosteroever (sections 199 and 120); • Planned: 85,000 m³ sand.	• 2014: beach nourishment; • 2021: development of natural dunes in front of the Spinoladyke, planting of marram gras.
De Haan - Wenduine (section 172 to 176)	• Beach nourishment with low beach in combination storm walls on roundabout and seawall/widening seawall; • Planned: 700,000 m³ of sand.	• 2012: construction of a nourishment from west to east at the level of the entire seawall; • 2014, 2016, 2017, 2018, 2020: maintenance; • 2015: renovated widened seawall, equipped with water barriers and storm walls; • 2021-2023 [in addition to the Masterplan for Coastal Safety] phased construction of an optimised groyne field to combat erosion.

Zone of particular attention (continuation)	Selected measures, incl. the planned nourishment quantities	State of implementation (anno 2021)
Port of Blankenberge	• Construction of a storm wall on + 8 m TAW in combination with an erosion protection embankment around the harbour	• 2016-2018: construction of a storm wall (phase 1); • 2020: construction of new quay walls, mobile barriers and a pilot with a self-closing mobile barrier; • 2021 [in addition to the Masterplan for Coastal Safety] construction of a new breakwater for the harbour channel.
Blankenberge (section 185 to 195)	• Beach nourishment low beach; • Planned: 384,000 m³ sand.	• 2014-2015: phased nourishment; use of dredged sand from the port channel.
Port of Zeebrugge	• Construction of a storm wall at + 8.0 m TAW around Prince Albert I dock and connected to the locks in combination with an erosion barrier around the port.	• 2018: Construction of the storm walls in design phase; • 2020-2021: construction of storm walls between New Yorklaan and Visart Lock and between Zweedse Kaai and Vandamme Lock.
Knokke-Heist (section 225 to 243)	• Beach nourishment (profile between steep and low beach); • Planned: 3,620,000 m³ sand.	• 2012, 2013, 2014, 2015, 2017: planned nourishments; • phased nourishment of 2,000,000 m³ in total: started in 2020 with a foreshore nourishment, end expected in 2023-2024; • 2021: nourishment on the beach of Duinbergen.
Zwin (section 250 to 255)	• Zwin project.	• 2016-2019 construction of 4 km long Zwindijk, in combination with measures against salinisation.
Rehabilitation of locks and weirs	• Ports of Blankenberge, Ostend and Zeebrugge.	• These projects are carried out in several phases.

Belgium and Flanders are, each within the limits of their competences, committed to both mitigation of and adaptation to climate change. At the federal level, there is the National Climate Adaptation Strategy (National Climate Commission 2010). At the Flemish level, the Flemish Adaptation Plan 2013-2020 (Department of LNE 2013) ensures the structural integration of adaptation in the policy and in the operation of the various policy areas. From 2021 onwards, the Flemish Energy and Climate Plan (2019) and the Flemish Climate Strategy (Flemish Government, 2019) will apply as transversal policy plans.

In order to implement all of the coastal protection measures, environmental legislation must also be respected by the development of environmental impact reports. Furthermore, for the construction of hard structures, environmental permits must be granted.. This implies a close collaboration with, in particular, the Marine Environment division of FPS Public Health, the Royal Belgian Institute for Natural Sciences (RBINS), the Agency for Nature and Forest (ANB) (which falls under the Flemish policy domain Environment) and the Flemish Department of Environment and Spatial Development (OMG) with regard to the granting of environmental permits.

100% safety can never be guaranteed, which is why emergency plans remain necessary. All coastal municipalities are required to draw up a municipal emergency plan against flooding from the sea (special emergency and intervention plan for flooding, BNIP flooding). If the (expected) impact of a storm surge exceeds the municipal level, emergency planning is scaled up to provincial level (with a coordinating role for the provincial governor), or even to the national level if provincial emergency planning prove insufficient. The Province of West Flanders is responsible for the preparation and coordination of the provincial 'BNIP Flooding'. The Crisis Centre of the FPS Home Affairs can take over the coordination by the implementation of the National Emergency Plan for Floods and High Water.

12.2 Spatial use

The Masterplan for Coastal Safety (2011) describes the location of the zones of interest along the Flemish coast, as well as the measures to be taken for each of these zones (see table 2 for an overview of the measures). The status of the works in each zone can be followed on the Coastal division website. The spatial distribution of the flood hazard (the physical properties of a flood such as extent and depth) and the flood risks (potential negative consequences for people, the environment, heritage, etc.) can be consulted for Flanders via the map catalogue of waterinfo.be. For the Coastal Vision project the use of space is further elaborated in the integrated research project.

Coastal protection is also addressed in the marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020). With regard to coastal safety, sufficient space has been foreseen by the long-term vision (FPS Public Health, Food Chain Safety and Environment 2020) to realise the objectives of the Masterplan for Coastal Safety (2011). In the MSP 2020-2026, a zone for the testing of new methods of coastal protection is included near the Broersbank (off the coast of De Panne) (see also **12.5.1 Nature-based solutions**). Furthermore, the MSP 2020-2026 assumes the most sustainable extraction of sand and gravel, *inter alia* in function of the protection of the coast against flooding. In principle, coastal protection measures are possible everywhere in the BNS. This is important since new forms of coastal protection are developing, some of which can be situated more offshore. For the construction of a test island, specific conditions have been formulated in the actions for the implementation of the MSP.

12.2.1 Types of coastal protection

Depending on the type of coastal protection deployed, the required space will vary. The publication of De Bruyn et al. (2020) gives an overview of the three different types of coastal profiles that occur along the Flemish coastline: dune landscape, touristic areas and ports, each with their own requirements and potential for coastal protection. Depending on the protection needs and the local preconditions, including the available space, the appropriate type of coastal protection will be applied. Traditionally, a distinction has been made between soft coastal protection (beach, foreshore or dune replenishment, etc.) and hard coastal protection (storm walls, dike elevations, dune foot reinforcements, etc.). Hybrid solutions are often chosen, e.g. a combination of beach nourishment and dike reinforcement. In recent years, there has been an increasing focus on so-called Nature Based Solutions. These are discussed further in **12.5 Sustainable use**.

12.3 Societal interest

12.3.1 Damage and casualties caused by floods

More than 85% of the Belgian and Dutch coastal zone (zone up to 10 km inland for floods from the sea) lies below +5.0 m TAW and thus below the level of an annual storm (+5.5 m TAW) (EEA 2006, Euroion project, EEA 2013, EEA 2017). Approximately 15% of the surface area in Flanders lies below 5.0 m above mean sea level. Moreover, the Belgian coastline is the most built-up coastal region in Europe. In 2000, more than 30% of the coastal zone (zone up to 10 km inland) was built up and so was almost 50% of the area up to 1 km from the coastline. In the province of West Flanders, 33% of the population lives in low-lying polder areas that are susceptible to flooding by the sea (Brouwers et al. 2015). In addition to habitation, the coastal zones of the Netherlands and Belgium are home to important economic activities, partly because of the presence of seaports. Hence, in case of a flood, the loss of human life and material damage may be very high (Publications office of the European Union 2010, Kellens 2011, Boelaert 2017, EEA 2017, Coppens et al. 2018). Without mitigation and adaptation measures, the annual damage from coastal flooding in the EU could increase to nearly 814 billion euro in 2100, with at least 3 million EU citizens affected by coastal flooding (European Commission 2020). In Belgium, the annual damage in 2100, assuming further development on fossil fuels and RCP8.5, can be estimated at 20 billion euro, with 31,700 people affected by floods (Vousdoukas et al. 2020).

The study carried out to determine the protection measures of the Masterplan for Coastal Safety (2011) includes flood risk calculations in addition to the safety assessment of the sea barrier. To this end, the Flanders Hydraulics Research (the Department of Mobility and Public Works of the Flemish government) in cooperation with the Coastal Division have drawn up flood maps with corresponding estimates of casualties and storm surge damage for the coastal area (see also: the Waterinfo map catalogue, where the information on potential economic damage and economic risks in the event of flooding can also be found). For the calculation of flood risks (in terms of casualties and damage), Flanders Hydraulics Research and the Ghent University developed the so-called LATIS software. LATIS version 4 will allow the mapping of the ecological, social and cultural impact of floods for Flanders (Beullens et al. 2017). These flood risk calculations are updated on a regular basis. The most up-to-date results are determined for the situation in 2015 (Ruiz Parrado et al. 2017, Vanneste et al. 2018).

Table 1 summarises the calculation results for a range of extreme storm surge levels. It is noteworthy that the direct economic damage in absolute value is higher than the figures from the previous calculation in 2006 (Meire et al. 2011). This is on the one hand the result of improvements in the LATIS software and on the other hand the result of an update of the monetary value of the buildings and infrastructure on the seawall and in the coastal zone. After all, the ongoing spatial developments in the coastal region mean that the economic and human losses are potentially increasing. Hence, in general it can be stated that the damage that a storm with a certain probability

of occurrence can cause is usually increasing (Plan-MER voor het Geïntegreerd Kustveiligheidsplan: kennisgeving 2009, Kellens 2011). Compared to the previous calculation in 2006, a decrease in damage and number of casualties is observed for the state in 2015, when for both times the same (monetary) values are used as input for the calculations. This is due to the already implemented measures of the Masterplan for Coastal Safety (2011).

Furthermore, within the framework of the Masterplan for Coastal Safety (2011), a map was developed with the distribution of a flood in case of a 1,000-year storm surge, most recently under the conditions of the year 2020 (figure 2). The greatest material risks are located in the vicinity of the four harbours, which are also among the weakest points in terms of coastal safety. Prior to the implementation of the Masterplan for Coastal Safety (2011), the coastal towns that scored the lowest were: Oostende-Centre, Oostende-Raversijde Oostende-Mariakerke, Oostende-Wellington and De Haan-Wenduine. Also, in Middelkerke-Westende, the risk of damage and the risk of casualties was relatively high. In the meantime, these risk have been reduced by implementing the planned interventions of the Masterplan for Coastal Safety (2011) in the coastal municipalities.

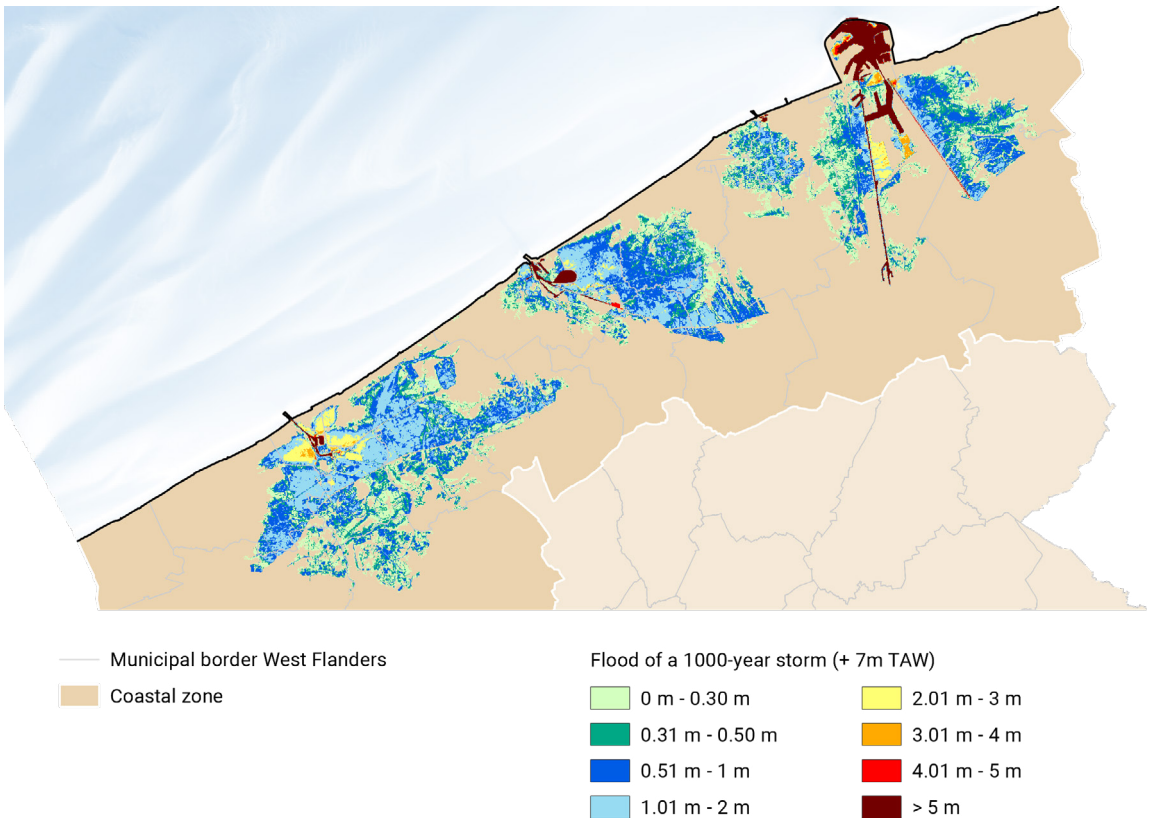


Figure 2. Simulation of the spread of flooding during a 1.000-year storm surge (+7,0 m TAW storm) under 2020 conditions (Masterplan Kustveiligheid 2011, Vanneste et al. 2021).

12.3.2 Investments in coastal protection

For the period 1998-2015, it is estimated that the total cost for coastal protection and climate adaptation (protecting coasts from flooding and erosion) for the EU amounted to 15.8 billion euro (DG Maritime Affairs and Fisheries 2009). In the ClimateCost project (2009-2011), these costs were also calculated for different future scenarios (Brown et al. 2011). Other European projects that have addressed this issue are COASTANCE (2007-2013), ANCORIM (2009-2012), Theseus (2009-2013), CoastAdapt (2009-2011), CLAMER (2010-2011), SCAPE (2016-2020) and LISCOAST (2018).

A recent report commissioned by the Blue Cluster (Bilsen et al. 2019) on the economic and societal relevance of the Blue Economy in Flanders, also addresses the economic and societal importance of coastal protection. The report states that in Belgium around 18 million euro are spent annually on coastal protection. This expenditure is made, among other things, in the context of the regular maintenance of the beaches and the implementation of the Masterplan for Coastal Safety (2011).

The total cost of the Masterplan for Coastal Safety (2011) was estimated at the time of conception at more than 300 million euro. An important cost included in this estimate concerns the renovation and reinforcement of locks, dams and drainage structures in the ports. In addition, it was estimated that an average of 600,000 to 700,000 m³ of sand per year would be required for the periodic maintenance of the new beaches. Prior to the start of the Masterplan for Coastal Safety (2011), an annual average of 550,000 m³ of sand was added to the Flemish beaches (pumped up with pressure pipes or brought in by trucks) (Maelfait and Belpaeme 2007, Vandewalle et al. 2008, Masterplan for Coastal Safety 2011). Figure 3 shows the annual volumes of sand for beach and foreshore nourishment. An important reason for the large volumes in 2014 and 2017 are the emergency nourishments after major storms (e.g. *Sinterklaas* storm in December 2013, *Dieter* storm in January 2017) (see also thematic chapter **Sand and gravel extraction**).

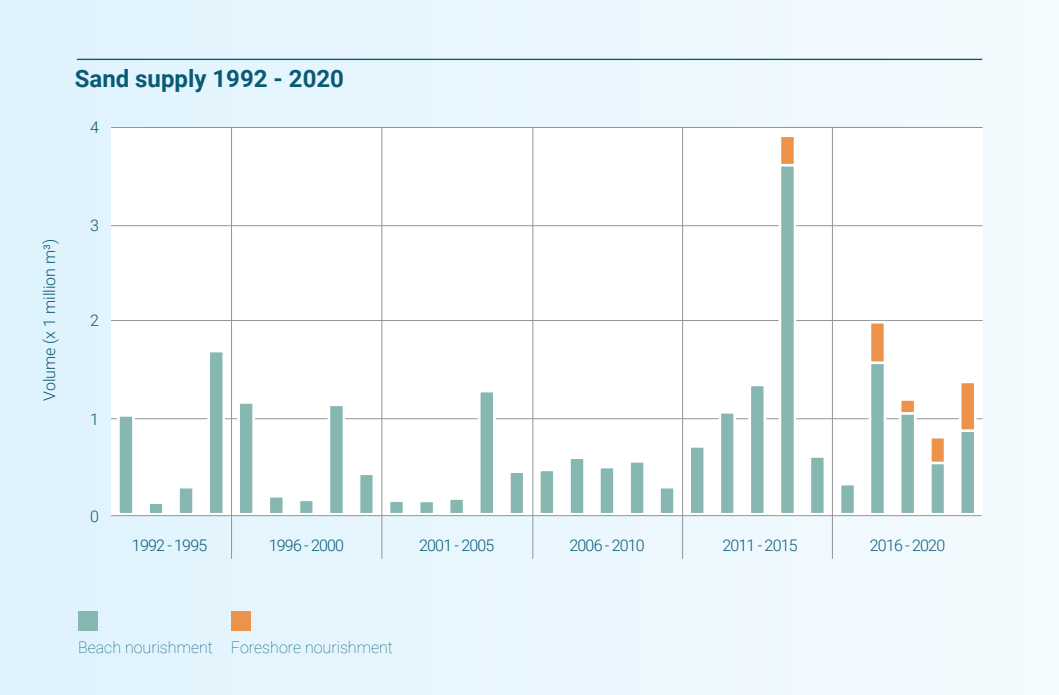


Figure 3. Evolution of the annual volumes of sand for beach and foreshore nourishment (Source: Coastal division). In the case of a beach nourishment, sea sand is applied via dredgers above the low-water line. For forshore nourishment, the sand is applied below the low-water line.

In addition, the Flemish government invests in research on how to integrate coastal safety sustainably and cost-effectively into the spatial development of the coastal zone. This happened, amongst others in the CREST project. The Living Lab Raversijde, which grew out of the CREST project, *inter alia* provides for a test dike that has been custom-built for research purposes. This research infrastructure should lead to more insight into the processes of wave overtopping and wave force on structures, and will result in long-term, detailed hydrographic monitoring of the soft coastal protection at Raversijde to facilitate research and innovation (incl. pilot tests).

12.4 Impact

Depending on the technique used, the protection works and infrastructure on the Flemish coast have an impact on a number of environmental aspects. Both the hard and soft coastal protection measures are therefore subject to the European EIA Directive (Directive 2014/52/EU), as a result of which an environmental impact assessment (EIA) must be carried out before the environmental permits are granted.

In general, the EIA studies in the context of the Masterplan for Coastal Safety (2011) estimated the environmental impact that may occur during and after construction and as a result of maintenance works. The effects must therefore be considered potential effects that are project-dependent. The effects stemming from the exploitation of the required resources (e.g. sand extraction at sea) were included in separate EIA reports. Table 3 provides an overview of the potential impacts to be considered in the assessment of coastal protection measures and the related literature that elaborates on these topics. For a more detailed description, reference is made to the

following publications: Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009), Plan-MER - Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007).

In addition to a general plan-EIA which describes the environmental impact of the protection measures of the Masterplan for Coastal Safety (2011) in its entirety, a project-EIA is also drawn up (when necessary) to assess the local effects of individual projects. In 2016, for example, the project-EIA for the storm surge barrier in Nieuwpoort was approved (OMG, Nature and Energy 2016) and in 2021 the notification was made for the project-EIA for the measures against the sedimentation in the marina in Blankenberge (Darras 2021). In most cases, however, an exemption from a project-EIA can be requested.

Table 3. An overview of the potential effects that should be considered when evaluating coastal protection measures, accompanied by the relevant literature.

Discipline	Potential effects	Literature
Water	• Turbidity of the water column; • Changes in the flow pattern and currents of the sea water; • Hydrological effects – changing groundwater levels in the dunes and adjacent areas; • Changes in groundwater quality (depending on the quality of the supplied sand).	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009), Lebbe 2011
Seabed	• Impact on the seabed, beach, dune and polder soils (degree of soil disturbance) and the effect on soil morphology.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009), Houthuys 2012, Van den Eynde et al. 2012, Janssens et al. 2013, Houthuys et al. 2014, Colson et al. 2016, INDI67 project BELSPO
Air	• Emissions into the air and their impact on human health.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)
Noise and vibrations	• Noise impact on humans and animals and the effects on human health.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)
Landscape, archaeology and architectural heritage	• Functional fragmentation of the spatial use; • Visual-spatial effects of adding or changing landscape elements; • Disappearance and disturbance of historical geographical elements and structures; • Effects on architectural heritage and archaeology.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)
Fauna and flora	• Effects on habitat, vegetation, benthos and avifauna; • Creation of habitats due to the expansion of dry beaches and dunes; • Barrier function for benthos.	Engledow et al. 2001, Speybroeck et al. 2004, Volckaert et al. 2004, Speybroeck et al. 2006a, Speybroeck et al. 2006b, Speybroeck et al. 2007, Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Van Ginderdeuren et al. 2007, Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009), Janssen and Rozemeijer 2009, Braarup Cuykens et al. 2010, Vanden Eede and Vincx 2011, Vanden Eede 2013, Van Tomme 2013, Van Tomme et al. 2013, Vanden Eede et al. 2014, Colson et al. 2016, Staudt et al. 2021
Mobility	• Modifications in accessibility.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)
Spatial use (human-space)	• Modifications in access possibilities; • Modifications of recreational area; • Functional changes; • Nuisance.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)
Human, health and safety aspects	• Potential health effects, due to the exposure to polluted air, noise emissions and vibrations; • Changes in the safety of recreationists or inhabitants, due to changing sea currents, or due to the placement or removal of obstacles, or general modification of coastal safety.	Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende (2007), Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting (2009)

Within the context of the ecosystem vision for the Flemish Coast, an impact assessment framework was developed that allows to provide scientifically founded information on the impact of an intervention on the ecosystem and to inform policy makers about the possible consequences of a decision (Van der Biest et al. 2017a, Van der Biest et al. 2017b, Van der Biest et al. 2020). The practical application of the ecosystem services concept to a number of marine infrastructure projects was elaborated in Boerema et al. (2016) and Boerema et al. (2021).

12.5 Sustainable use

A resilient coast can withstand influences or fluctuations in the environment and will not change significantly as a result of natural processes and sustainable use. A resilient coastal protection was defined as a key element for a sustainable Flemish coastal ecosystem in the ecosystem vision for the Flemish Coast (2017). This study provides a vision for the development of the coastal protection on the long-term, linked to an ecological assessment framework developed to assess the (long-term) impact of future developments in the context of coastal safety with respect to the feasibility of this vision (Van der Biest et al. 2017a, Van der Biest et al. 2017b).

In view of the many users which are active in the coastal zone, Europe formulated in 2002 a recommendation for an integrated coastal zone management (ICZM, 2002/413/EC). Within the framework of the Masterplan for Coastal Safety (2011) the principles of integrated coastal zone management were followed in the execution of the social cost-benefit analysis. The Coastal Vision project launched in 2017 focuses primarily on coastal safety but also looks at possible benefits on an economic, social and natural level (see also note Rondelez and Pirlet 2018 with focus area on the eastern part of the Flemish Coast).

Within this context, the quadruple helix approach (in which government, research, industry and the public are jointly involved) is gaining importance. An example of this is the Think Tank North Sea, a neutral and unbiased entity in which stakeholders from the quadruple helix discuss on themes such as: 'Living with Climate Change' (Mertens et al. 2020) or 'Working with Nature' (Degraer et al. 2020). The mutual cooperation between governments, knowledge institutions, companies and citizens plays an important role in the elaboration of innovative concepts, which are gaining interest in the field of coastal safety. The Blue Cluster, the Flemish maritime innovation cluster, supports companies in setting up partnerships with other companies, knowledge centres and government institutions for the development and promotion of economic activities at sea. A number of initiatives, demonstration and innovation projects for integrated coastal protection are included in table 4.

12.5.1 Nature-based Solutions

Although themes such as Low Impact Development or Best Management Practices have been in use since the 1970s, it is mainly since 2007 that the term Nature-based Solutions (NbS) has appeared in literature (Ruangpan et al. 2020). There are several definitions of NbS (a.o. Cohen-Schaham et al. 2016), each emphasising the need to balance social, economic, and environmental objectives, and the importance of its sustainability in the long term (Martin et al. 2020).

In 2020, the European Commission defined nature-based solutions as: '*Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions*'. At the same time, NbS is not the only term to describe natural solutions to climate challenges. Other terms that are used include Building with Nature (De Vriend et al. 2015), Ecological Engineering (Borsje et al. 2011), Nature-based infrastructure (Sutton-Grier et al. 2018), Natural and Nature-based features (Bridges et al. 2021), Ecosystem-based Coastal Defence (Temmerman et al. 2013), Working with Nature (Degraer et al. 2020), Ecosystem Approach (Adriana Gracia et al. 2018), where the emphasis may either more on problem solving or more on management approaches. NbS can therefore be seen as an umbrella term, encompassing a wide range of conservation and sustainability measures (Eggermont et al. 2015, Nesshöver et al. 2017, Gómez Martin et al. 2020, Vojinovic 2020). NbS are especially a subject where innovation from government, research and industry come together. Natural or nature-based protection measures include shallow sandbanks, foreshores and replenishments; underwater reefs; mudflats, salt marshes and intertidal sandflats and dunes (Van der Biest et al. 2017a, Van der Biest et al. 2017b, Bonte et al. 2021). Examples of NbS along the Flemish coast are the construction of an additional dike at Raversijde in 2021 (SARCC project), the construction of biogenic reefs with the purpose of (future) coastal protection, such as the pilot project near De Panne (Coastbusters 2.0 project), the facilitation of beach nourishment through sand transport over coastal sandbanks (Verwaest et al. 2020) or the development of dunes near Ostend Oosteroever (Strypsteen and Rauwoens 2021). An overview of the potential of NbS on our sandy coast is given in Boerema et al. (2021).

Table 4. An overview of studies, projects and initiatives in the context of coastal protection.

Studies, projects and initiatives	Timeframe	Short description
CLIMAR project (BELSPO) (Van der Biest et al. 2009, Van den Eynde et al. 2009, Van den Eynde et al. 2011)	2006-2011	This project developed a framework in which adaptation measures, to control the impacts of climate change, can be evaluated for the ecological as well as the social and economic aspects of the North Sea environment.
QUEST4D project (fase 1 and fase 2 BELSPO) (Van Lancker et al. 2012)	2007-2011	This project quantified erosion/ sedimentation patterns and distinguished the natural from anthropogenic induced sediment dynamics.
CcASPAR (Allaert et al. 2012)	2009-2012	This project conducts research on the spatial impact of climate change with the aim to develop spatial adaptation strategies and sustainable policies for Flanders on various spatial levels. The developed strategies have been tested for the coast and the Yser Valley.
Kappa-plan (Kustwerkgroep Natuurpunt 2010)	2010	Natuurpunt and the West Flanders Environmental Federation (WMF) advocate for an integrated climate adaptation plan for a sustainable coastal protection. In this Kappa plan, coastal protection is designed with natural climate buffers against climate change and flooding.
Coastal communities 2150 (Stratton 2012)	2011-2014	This project aims to inform stakeholders in coastal areas about climate change and its effects on the coast (erosion, floods, etc.).
Metropolitaan Kustlandschap 2100 (verkennende en methodologische analyse van de Belgische kust, ontwerpopgaven en exploratief ontwerpend onderzoek deel 1, 2 en 3) (Geldof and De Bock 2014)	2012-2014	This initiative from *LABO Ruimte (Ruimte Vlaanderen and Team Vlaamse Bouwmeester)* – in association with the Department of Mobility and Public Works (MOW) and the Agency for Maritime and Coastal services – explores various possible future scenarios for the Flemish coast from a metropolitan perspective.
4shore project (Colson et al. 2016)	2013-2016	Over a period of three years, this project has mapped ecological changes in foreshore and beach nourishments on a temporal and spatial scale for the beach and the shallow coastal zone (Mariakerke and Bredene). Within the 4shoreBis project, the macrobenthos and the physio-chemical characteristics of the bottom sediments were evaluated for the beach of Middelkerke after a beach nourishment.
Meetnet Vlaamse Kust – project Broersbank (Thoon 2016)	2013-2016	This study project has built up a unique data set and set of numerical models that will contribute to further research into a safe, robust coastline. In order to investigate the impact of sandbanks on the reduction of wave energy in detail, a monitoring network was started, consisting of seven buoys off the coast.
TILES project (BELSPO) (Van Lancker et al. 2019)	2013-2017	The TILES project (Transnational and Integrated Long-term marine Exploitation Strategies) is focused on forecasting and adaptive long-term management strategy for the exploitation of geological resources in the North Sea.
ARGONAUTS (Montreuil et al 2017)	2013-2018	*ARGus and in-situ mONitoring of beAch and shoreface NoUrishmenT for Sustainable coastal safety*. The aim of the project is to evaluate a foreshore nourishment in Ostend (Mariakerke) as an alternative measure to maintain extended/ nourished beaches.
Provoost et al. 2014	2014	In this ecosystem service report of the *Natuurrapport 2014*, the protection against floods from the sea by means of natural coastal protection elements is elaborated.
CORDEX.be project (BELSPO) (Termonia et al. 2018)	2014-2017	The aim of the CORDEX.be project is to combine the existing and new research activities of nine Belgian partners in the field of climate modelling in order to create a consistent scientific basis for climate services in Belgium. The valorisation of the CORDEX project is discussed in Van Schaeybroeck et al. (2021).
INDI67 project (BELSPO) (Fettweis et al. 2020)	2014-2019	Development of methods to improve the monitoring of MSFD indicators 6 (sea floor integrity) and 7 (hydrographical conditions).

Studies, projects and initiatives (continuation)	Timeframe	Short description
CREST project (Monbaliu et al. 2020)	2015-2019	The CREST-consortium (Climate Resilient Coast) studied the robustness of the Flemish coast under a changing climate regime. In particular, effects on coastal dynamics and impact for future safety strategies were investigated. This innovation project enabled a better insight into near coastal and inland physical processes, but also into the flood risks along the coast and the impact of the wave transfer. Furthermore, the project determined the resilience of the natural coastal system in relation to storms and wind; and developed climate scenarios for the Belgian coast. The CREST project is divided into three core activities: (1) integrated modelling of waves, currents and sediments on a multi-scale, (2) advanced modelling of wave overtopping risks in coastal municipalities and (3) improved knowledge of coastal processes.
Building With Nature	2015-2020	This project demonstrated 'Building With Nature' projects, which increase coastal safety solutions using natural processes to manage flood risks and coastal erosion while improving ecosystem services. To this end, 'Nature Based Solutions' were applied at 7 coastal locations in BE, NL, D, DK, SE (sand nourishments on the North Sea coast and Wadden Sea barrier islands) and at 6 locations in river basins in BE, NL, SE, SCO (e.g. river restoration). In Flanders, a beach nourishment in Ostend was investigated.
SCAPE project	2016-2020	The aim of this project was to protect coastal areas against the consequences of climate change, such as floods and extreme rainfall, on the basis of a landscape guided design. Water managers, planners and architects developed a joint approach deploying the landscape against the water-related consequences of climate change.
Territoriaal Ontwikkelingsprogramma (T.OP) Kustzone	2016-running	T.OP Coastal Zone was inititated by the Department of Environment and Spatial Development (OMG) in cooperation with the province of West Flanders to draw up an action-oriented programme for the spatial development of the coastal zone in the short and medium term.
Coastbusters (Coastbusters 2020)	2017-2020	In the innovation project Coastbusters the possibility to use biogenic reefs as coastal protection measure was investigated. The species tested to act as natural coastal protection were seaweed or sea grass, mussels and sand mason worms. Mussels seemed the most optimal species to act as a reefbuilder and therefore to serve as coastal protection measure.
RS4Mody project (BELSPO)	2017-2021	This project aimed to investigate the morphodynamics of a tidal beach from short (storm event) to long term (> 25 years). This allowed for a better understanding of the morphodynamics of the beach and the implications thereof for coastal management.
ENDURE	2018-2020	This project focused on dune management to make the 2 Seas area resilient to climate change. In order to visualise the advantages of different dune management approaches (hard engineering versus ecosystem-based approach), a call for tenders was launched for the development of new cartographic solutions. With a clear visualisation, coastal managers should be able to better understand how their measures are changing the coastal zone.
DataBeach	2019-2021	The DataBeach project developed groundbreaking new measurement technology, machine learning models and probabilistic calculation methods for disruptive advances in the design of soft coastal protection measures. The Coastsnap station in Ostend was also installed within the Databeach project.
SARCC	2019-2023	The project seeks solutions to sustainably protect coastal cities from the effects of rising sea levels. The focus of the project is on the use of Nature-based Solutions (NbS) within coastal defenses, both in policy and in the concrete construction of coastal protection projects. An important part of the project is the building up of knowledge about NbS, and the dissemination of knowledge to authorities and society.

Studies, projects and initiatives (continuation)	Timeframe	Short description
Coastbusters 2.0	2020-2022	Building on the research conducted in Coastbusters, Coastbusters 2.0 conducts further research into a sustainable design for the development of a self-sustaining mussel reef as coastal protection measure. Research will focus on sustainable and biodegradable materials, the design of a modular biogenic reef concept, innovative monitoring solutions and the ecosystem preconditions and services of coastal reefs.
Coastsnap Belgium	Running since 2020	CoastSnap is a global Citizen Science project that aims to engage citizens to participate in scientific research on the accretion and erosion of different beaches. The project provides specially designed holders at fixed "CoastSnap locations" where people can place their smartphone in order to take a standardised picture of the beach. These photos form a dataset on which scientific research is carried out. In Belgium, Coastsnap stations are currently installed in Ostend (Oosteroever, as part of the Databeach project) and Koksijde (as part of the RS4 Mody project).
Bankbusters	2021-2024	Bankbusters aims to strengthen the knowledge of ecosystem processes, associated boundary conditions and concepts for the reuse of dredged material in order to facilitate the restoration of eroded tidal flats and wetlands and improve local ecosystem services.

Legislation reference list

Overview of the relevant legislation on European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Recommendations			
2002/413/EG	Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe	2002	413
Communications			
COM (2013) 216	Communication from the Commission: An EU Strategy on adaptation to climate change	2013	216
COM (2019) 640	Communication from the Commission: The European Green Deal	2019	640
COM (2021) 82	Communication from the Commission: Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change	2021	82
Directives			
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2007/60/EC	Directive on the assessment and management of flood risks (Floods Directive)	2007	60
Directive 2014/52/EU	Directive to amend Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment	2014	52
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89
Regulations			
Regulation (EU) 2021/1119	Regulation to establish the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')	2021	1119

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decrees		
Decree of 14 July 1993	Besluit van de Vlaamse regering betreffende de definitieve aanwijzing van de beschermde duingebieden en van de voor het duingebied belangrijke landbouwgebieden.	1994-11-16/33
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Decree of 25 April 2014	Decreet betreffende de complexe projecten	2014-04-25/I8
Royal Decrees		
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode 2020 tot 2026 in de Belgische Zeegebieden	2019-05-22/23
Law		
Special Law of 8 August 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02

13 Military use

Authors Griet Scheerlinck[1], Pascal Depoorter[1], Hans Pirlet[2], Steven Dauwe[2]

Lectors Tine Missiaen[2], Eric Stienen[3], Steven Degraer[4], Jens Warrie[5], Filip Clauwaert[1]

[1] Ministry of Defence
[2] Flanders Marine Institute (VLIZ)
[3] Research Institute for Nature and Forest (INBO)
[4] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature)
[5] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division

Scheerlinck, G., Depoorter, P., Pirlet, H., Dauwe, S. (2022). Military use. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 213-223.

Military exercises regularly take place in the Belgian part of the North Sea (BNS) and in the coastal area. These include target practice from land towards the sea, target practice at sea towards floating targets, detonation of found war materials, exercises in laying, searching for and sweeping mines with several NATO member states, etc. Amphibian, rescue and flight exercises are carried out as well, and Belgian Defence is also involved in search and rescue operations, law enforcement, pollution control, etc. in the BNS (Maes et al. 2005, GAUFRE project BELSPO, Notices to Mariners (NtM) 2021 No. 1, Belgian Defence). For this purpose, specific zones are reserved in the marine spatial plan (MSP) (MSP 2020-2026, annex 1) (RD of 22 May 2019) (figure 1).

In addition to the current use of the North Sea for military purposes, the BNS still contains traces of past wars. For example, there is an extensive World War I dump site of war munitions located on a sandbank near Knokke-Heist, the so-called *Paardenmarkt*, and the seabed is littered with the wrecks of military ships (Wrakkendatabank) (see thematic chapter **Maritime and cultural heritage**).

Within the framework of NATO, Belgian Defence is also providing a contribution to the organisation of an information hub for commercial shipping, and to proactively contact ships in high-risk zones (Naval Cooperation and Guidance for Shipping (NCAGS), see NtM 2021 No. 1 notice 1/7).

The naval component of the Belgian Ministry of Defence is also developing activities outside the BNS. In cooperation with FPS Mobility and Transport, Belgian Defence provides support for vessels navigating the Belgian flag. Belgian Maritime Threat Awareness and Reporting (BEMTAR) provides information on the maritime safety situation, identifies threats and monitors ships worldwide.

In the remainder of this text, however, the focus will be mainly on the activities within the BNS.

13.1 Policy context

The policy relating to military activities is a federal matter attributed to the Ministry of Defence (Belgian Defence). An overview of the legislation with regard to the military activities (at sea) is provided in the Codex Coastal Zone, theme Military Activities and NtM 2021 No. 1.

13.2 Spatial use

The marine spatial plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020) indicates a number of zones reserved for military activities (figure 1, Coastal Portal). Attention is paid to compatibility with other (potential) users, such as shipping traffic, renewable energy zones, nature functions (marine mammals, breeding season of birds) and other new developments (alignment with zones for commercial and industrial activity (CIA), art. 23 MSP 2020-2026). The coordinates of these areas, and situational restrictions, are communicated via Notices to Mariners (*Berichten aan Zeevarenden*) and visualised in nautical charts (NtM 2021 No. 1, Flemish Hydrography, MSP 2020-2026, annex 1).

13.2.1 The role of Belgian Defence in the coastal zone and the BNS

Military activities and exercises regularly [1]take place in demarcated areas in the BNS and the coastal zone (Flemish Hydrography, Coastal Portal, NtM 2021 No. 1, Belgian Defence). These include:

- Target practices from land towards the sea (carried out by the land forces). These practices take place among others from the military base (beach) in Lombardsijde. Appropriate signs and announcements are provided (see also the Belgian Defence) The practice area is divided into three sectors (K-small, M-medium and G-large), depending on the weapons used (NtM 2021 No. 1, see notice 1/67 and 1/68) (figure 1):
  - > The K-sector: the dangerous zone is located within a sector with a radius of 2.5 miles around the Nieuwpoort lighthouse, bounded by mark 114° from the Nieuwpoort lighthouse and 191° from the former water tower of Westende (position 51° 10', 14 N - 2° 46', 62 E);
  - > The M-sector: the dangerous zone is located within a sector with a radius of 7.5 miles around position 51° 08', 62 N - 2° 46', 15 E, bounded by the same marks as the small sector;
  - > The G-sector: the dangerous zone is located within a sector with a radius of 12 miles around position 51° 08', 62 N - 2° 46', 15 E, bounded by the same marks as the previous sectors.

[1] Every year, the Lombardsijde military base is available for various military activities during more than 60 days. In function of the operational needs of the Belgian Defence, the number of days can change. In principle, shooting exercises towards the sea are never organised on Saturday and Sunday, public holidays or in July and August.

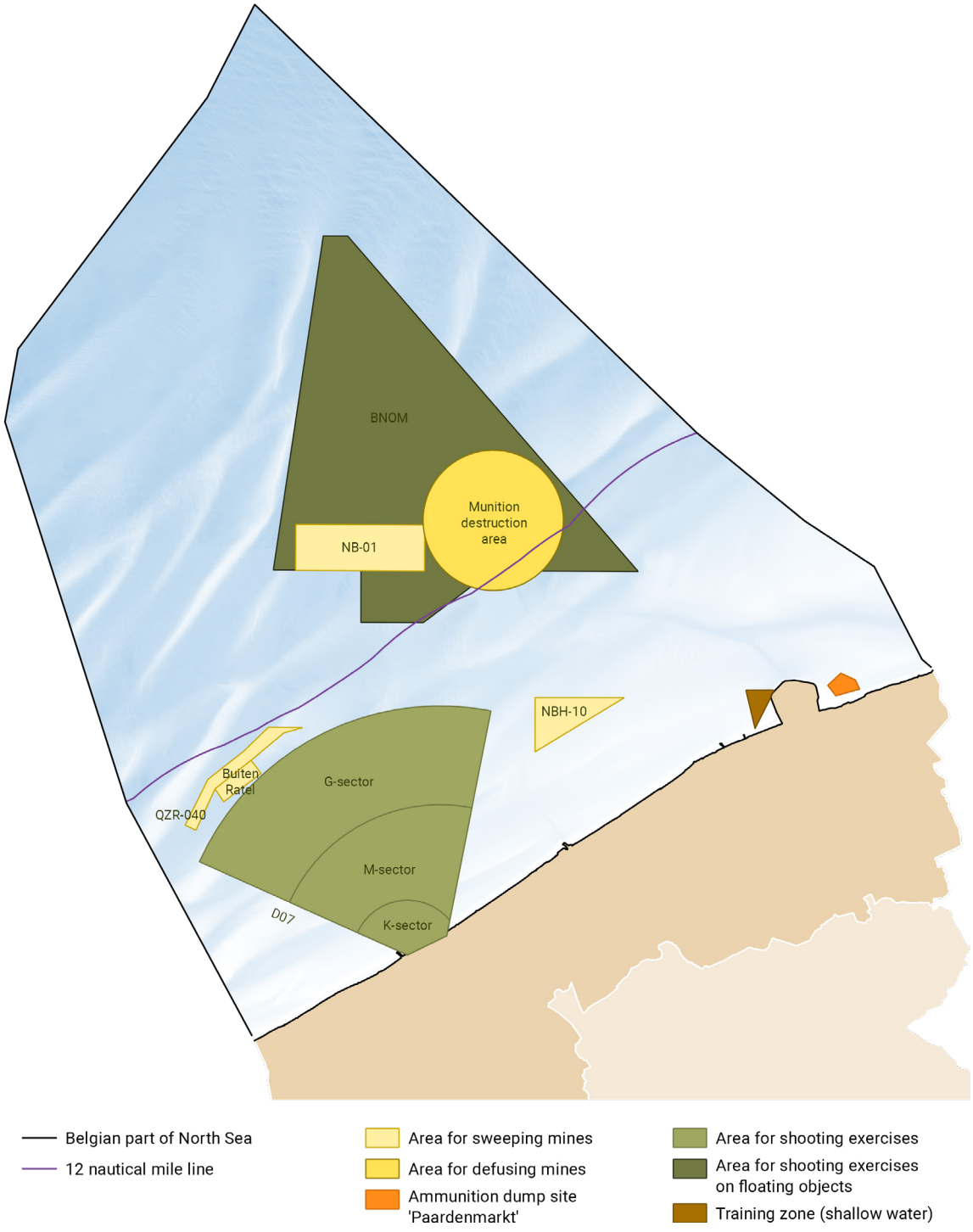


Figure 1. The demarcation of the military training zones in the BNS (Source: RBINS, MarineAtlas.be (based on RD of 22 May 2019) (MSP 2020-2026), Coastal Portal, Flemish Hydrography).

- Exercises on laying and sweeping mines. These international exercises take place in two smaller areas, NB-01 (between Goote Bank and Westhinder, for exercises in deep water) and NBH-10 (between Wenduine and Ostend Bank, for exercises in shallow water). For certain manoeuvres, or due to weather conditions, it may be necessary to navigate outside of these areas. If necessary, the training zones can be extended to a circular detonation zone and towards the port of Ostend;
- Detonation exercises with practice mines. These exercises take place in the circular area (see also figure 1;

'munition destruction area') in the south-eastern part of the Belgian national training area for naval vessels (BNOM zone, zone Thornton Bank-Gutter Bank). After the exercises, the practice mines are removed;
- Detonation of historical (war) mines. On a regular basis, real war mines are found by ships, fishermen or dredgers (see also **13.4.2 Impact on other users**). The management of mines and explosives (Unexploded Ordnance, UXOs) fished up at sea must be carried out in accordance with NtM 2021 No. 1, see notice 1/14. Such mines are also detonated in the circular area, except in case of an emergency when the mine appears to be immovable (NtM 2021 No. 1, see message 1/69);
- The QZR 040 zone and the zone *Buiten Ratel* are practice areas used by the International Naval Mine Warfare school EGUERMIN in Ostend for Naval Mine Counter Measures (NMCM) training (NtM 2021 No. 1, see notice 1/70);
- Amphibian, rescue and flight exercises. Amphibian- and rescue exercises take place in a new training zone in shallow water west of the port of Zeebrugge (Coastal Portal, MSP 2020-2026);
- Extensive exercises by several NATO member states. Such international large-scale exercises are held in the BNS every two years. NATO determines the location of the exercises, although the large BNOM zone and the NBH-10 zone are the most likely training zones.

In addition to the different training activities, the naval vessels and resources of the Belgian Defence are used for military operations, including the Maritime Situational Awareness (MSA) for escorting and monitoring foreign vessels as well as for a wide range of specific military security interventions (e.g. Maritime Security Operations – MSO).

In the event that non-Belgian military vessels wish to navigate in territorial waters, this must be reported in advance and, if necessary, political approval must be obtained (RD 30 December 1923). There is an existing procedure for this in which the country's embassy requests prior approval from the FPS Foreign Affairs (dipclear-procedure). Submarines are required to sail on the surface when passing through the territorial sea. In case of submarine accidents, a specific Distressed Submarine procedure is activated (DISSUB, see NtM 2021 No. 1, notice 1/13).

13.2.2 Military bases[2]

The following bases are located in the coastal area:

- Quarter Lombardsijde (Nieuwpoort/Middelkerke);
- Quarter Adjudant Vlieger F. Allaeys (Koksijde[3]) (from 2023 onwards operational from Ostend-Bruges international airport);
- Naval barracks Bootsman Jonsen (Ostend), including the Naval Mine Warfare school EGUERMIN;
- Naval base Zeebrugge (Zeebrugge);
- Quarter LTZ V. Billet Damage Control center (Brugge Sint-Kruis);
- Damage Control Center (Brugge).

There are aslo a number of military domains in the coastal zone that have a management protocol with the Flemish Region (in general the Agency for Nature and Forest (ANB), see also **13.5.4 The management of military domains**):

- Camp Lombardsijde in Nieuwpoort/Middelkerke (54 ha);
- Camp *'t Pompje*/ military domain Schorreweide in Oudenburg (62 ha).

13.2.3 Historical dump site of military munition

According to OSPAR, over 150 dump sites have been identified throughout the north-east Atlantic Ocean (OSPAR 2010). After WWI, the Belgian military dumped German war munition on a large scale a few kilometres off the

[2] In this thematic chapter, frequent reference is made to quarters, bases, domains, camps. On the basis of personal communication with Belgian Defence, the following demarcation is proposed (these are not official guidelines):
- Quarters/Barracks: refers more to the land-based aspect and specifically to the infrastructure including the buildings, meeting rooms, dormitories, etc.;
- Base: relates mainly to air and naval forces and refers to the domain where, in addition to infrastructure such as buildings and roads, aircraft or ships are also present. For example, Kleine Brogel air base, Zeebrugge naval base, etc;
- Domain: one refers to a military domain when it concerns the spatial aspect and the delimitation of a certain zone as being not accessible to the public. For example, the military training area of Ryckevelde;
- Camp: refers to a larger military domein including practice areas, quarters, barracks (military buildings). E.g. quarter Lombardsijde.

[3] Proposals on how the reconversion of the military base of Koksijde can be shaped, are outlined in a scoping note.

coast of Knokke-Heist on a shallow sandbank called *De Paardenmarkt*. At least 35,000 tonnes of munitions are estimated to be buried under 2-6 m sediment (Monjoie et al. 2005) of which about one third is assumed to consist of poison gas shells. However, there are indications suggesting that this proportion may be significantly higher (Missiaen 2013). The zone is a pentagon of about 3 km^2 (Missiaen et al. 2002). The official coordinates of the pentagon are included in the marine spatial plan (RD of 22 May 2019, MSP 2020-2026). In this pentagon, all bottom-disturbing activities are prohibited (RD of 20 March 2014). Exception can be made for scientific research and management activities, provided that a risk analysis is drawn up according to an as yet to be published procedure (RD of 22 May 2019, MSP 2020-2026, Art. 18).

13.3 Societal interest

The Belgian Navy performs a wide range of tasks both on a national and international level. The core tasks of the Navy include: securing maritime trade routes, destroying explosives at sea, taking part in operations in NATO, UN, and EU context, controlling the territorial and exclusive economic zone, humanitarian operations, rescue operations at sea, tracing wrecked ships, and supporting diplomacy, trade and other departments (Belgian Defence). Below, a number of sea-related tasks and roles performed by the Belgian Defence, in addition to the defence of the Belgian territorial sea, are elaborated upon.

- In case of emergency or an ecological disaster in the Belgian marine areas, the Channel or the North Sea, the Belgian Defence offers support and assistance, and provides helicopters, a 'ready duty ship' and divers (General Emergency and Intervention Plan (ANIP) North Sea). The deployment of additional staff and military resources can be requested through the Provincial Commander of West Flanders (Belgian Defence, Guidelines for Homeland Operations);
- Through the Maritime Security Centre Belgium (MIK) in Zeebrugge and the Maritime Rescue and Coordination Centre (MRCC), the Belgian Defence constitutes a part of the operational branch of the Coast Guard Centre (de Kustwacht 2011) (see thematic chapter **Maritime transport, shipping and ports**). MIK is comprised of four Coast Guard partners (Belgian Defence, Maritime and River police, Customs and FPS Mobility and Transport) that work closely together based in the naval base in Zeebrugge. The organisation and responsibilities of MIK are stipulated in the RD of 6 February 2009. The MRCC coordinates SAR operations and, in addition to distress, emergency and safety traffic, provides notifications to shipping vessels through the Ostend Radio, both inland and at sea (Belgian Coastal Station, Ostend Radio, NtM 2021 No. 1, see notice 1/4). The Belgian Defence also intervenes in case of pollution on the North Sea, SAR operations and in case of the detonation of explosives at sea;
- The Belgian Navy is responsible for the detection of violations in the Belgian territorial waters (Law of 13 June 1969, Law of 20 January 1999, Law of 22 April 1999). The Belgian Navy collaborates with the Management Unit of the Mathematical Model of the North Sea (MUMM) of the Royal Belgian Institute of Natural Sciences (RBINS-MUMM) to detect and tackle pollution at sea. The Regent Decree of 30 March 1946 grants other specific competences to the Belgian Navy regarding marine and coastal mine sweeping and the surveillance of fisheries. In this context, the Belgian Navy does on-board inspections of fishing vessels in cooperation with the Fisheries division of the Department of Agriculture and Fisheries;
- The Belgian Navy is also responsible for the operation of the marine research vessel Belgica and the Coast Guard surveillance aircraft (the *Britten-Norman Islander*), aimed at combating air pollution at sea. Both are managed by the MUMM (RBINS-MUMM). Belgica was replaced by a new research vessel, Belgica II, in the autumn of 2021;
- To carry out its tasks at sea, the Belgian Navy relies on 14 warships and four support ships, including a sailing ship, two tugboats and a research vessel (Belgica II). This fleet is being systematically modernised. In 2019, new contracts were signed with the Dutch Navy for the renewal of the frigates and mine counter measures (mcm) vessels (first delivery expected in 2024). This large-scale investment is accompanied by the necessary spillovers towards the Belgian economy, including a new drone factory to be built in Ostend, along with new centres of expertice, etc. (Belgium Naval and Robotics, ECA Group);
- The Belgian Navy is also responsible for the training of foreign naval officers. The Belgium-Holland Naval Mine Warfare school EGUERMIN in Ostend trains students of NATO-countries in mine counter measures (MCM) at sea. The Naval Mine Warfare Centre of Excellence (NMWCE) in Ostend advises NATO on all aspects of MCM at sea. The Mission Support Centre has an extensive database of seabed data collected during annual campaigns funded by Navy resources. In this context, it also collaborates with universities;
- Additionally, the law regulating the protection of the underwater cultural heritage (Law of 23 April 2021) introduced a notification requirement for found items which the discoverer may suspect to be cultural heritage. Following this law, the Navy Commando asks ship commanders to report discoveries in the territorial sea, the exclusive economic zone or on the continental shelf to the Governor of West Flanders who takes on the role of receiver of the underwater cultural heritage (see also the website of vondsteninzee.be and the thematic chapter **Maritime and coastal heritage**).

13.3.1 Employment

With several bases and quarters along the coast, the Belgian Defence provides important direct and indirect employment. In 2020, direct employment in the coastal region amounted to 2,161 employees (table 1). Indirect employment stems from various maintenance companies which employ their staff at the bases (e.g. vessels maintenance), as well as companies that perform occasional assignments for the Navy, either at the naval base or at their own shipyards. Furthermore, the suppliers responsible for supplying the quarters and ships should also be taken into account (Belgian Defence).

Table 1. The direct employment numbers at the army quarters and bases in the coastal zone in 2020 (Belgian Defence).

Base	Employment (2020)
Zeebrugge (naval base, including crew)	1,050
Ostend (Naval Mine Warfare school)	115
Lombardsijde (practice area + medical detachment)	284
St-Kruis (training navy, including Dutch colleagues in the context of binational activities)	437
Koksijde (airbase)	275
Total	**2,161**

13.4 Impact

13.4.1 Impact on the environment

13.4.1.1 Military activities on the BNS and seaward target practice

The potential impact of military activities on the BNS and seaward target practice on the marine environment is discussed in detail by Degraer et al. (2011). Exercises on the detection of mines and submarines, using sonars (zones NB-01 and NHB-10) may have a negative effect on marine mammals and fish (Degraer et al. 2011, De Cauwer and Van Gaever 2019). Exercises with explosives/target practices can also disrupt marine animals and birds (Degraer et al. 2011). The mitigating measures taken by the Ministry of Defence in this context, in accordance with the marine environment Law of 20 January 1999 and marine spatial planning (MSP 2020-2026, RD of 22 May 2019), are discussed in section **13.5 Sustainable use**.

Munition that ends up on the seabed during exercises is not cleared, except for practice mines. This may have a local negative impact on the ecosystem, due to the risk of leakage of copper and lead from munition, although the effect of this leaching may be smaller than the leaching due to other activities (Derous 2005 (GAUFRE project BELSPO), Maes et al. 2005, Degraer et al. 2011).

The target practices from land towards sea take place near the *De IJzermonding* nature reserve (Yser Estuary, including the recently established Nieuwpoort beach reserve) and near the Habitats Directive area of the 'Flemish Banks'. Additionally, two marine Birds Directive areas (special protection area 1 and 2) and the Ramsar area 'Western Coastal Banks' (designated for seaducks and grebes living there) are located in the vicinity of the target practice sector. The negative impact on fauna can be partially reduced by proper timing, taking account of the presence of marine mammals and large concentrations of disturbance-sensitive seabirds and the breeding season (Degraer et al. 2011, MSP 2020-2026 annex 1).

13.4.1.2 Historical dump site of war munition

The release of chemicals from munition found at the *Paardenmarkt* site, such as mustard gas, Clark components and TNT (e.g. see Francken and Ruddick 2003, Francken et al. 2006, Francken and Ruddick 2007, Francken and Hafez 2009, Missiaen 2013), may lead to the pollution of sediment, the water column, and can disturb the food chain (e.g. OSPAR QSR 2010, Law et al. 2010, De Cauwer and Van Gaever 2019). An overview of the scientific research conducted on the impact of the ammunition storage at the Paardenmarkt site up to 2009 can be found in Missiaen and Henriet (2010).

The monitoring campaign of 2018 demonstrated for the first time traces of explosive residues and combat gases, centrally located in the site, which was confirmed by a second campaign in 2019. The measured values are well below the maximum permitted concentrations for these substances and do not pose a danger to public health (see **13.5.3 Measures for historical dump site of war munition**) (FPS Public Health).

13.4.2 Impact on other users

The military activities on the BNS are organised in such a way that conflicts with other users are avoided as much as possible. Non-military shipping is only prohibited within the various military training zones in the event of a military activity.

Unexploded war materials (unexploded ordnances, UXOs) constitute a potential danger for different users of the sea, such as fishermen, dredgers, offshore energy developers. Localised or retrieved explosives will be marked and reported to the Coast Guard. A mine action team then disarms the explosive. The procedure to be followed in Belgium when mines or explosives are encountered can be found in NtM 2021 No. 1, see notice 1/14 and the Explosives Chart. In order to keep the sea, coastal waters and harbour channels free of mines, the Belgian Navy has entered into an international cooperation with the Dutch Navy: BENEFICIAL COOPERATION. In the first instance, the problem of the remaining explosives from the First and Second World Wars will be addressed.

13.5 Sustainable use

13.5.1 Measures for seaward target practice

The target practices that occur in the coastal area of Nieuwpoort-Lombardsijde are subject to restrictions in order to reduce social and ecological nuisance. No target practices take place on Saturdays, Sundays, and on public and school holidays, and these exercises only take place during the day (see **13.2.1 The role of Belgian Defence in the coastal zone and the BNS**). The periods when the target practices are suspended, are provided in the NtMs (NtM 2021 No.1, see notice 1/67A) and on the website of Belgian Defence. Infringements and complaints relating to the target practice regulations can be submitted to the Federal Police.

The target practices take place near the *De IJzermonding* nature reserve and in the marine areas of the western coastal zone, which are protected by the EU Birds Directive (Directive 2009/147/EC) and Habitats Directives (Directive 92/43/EEC) (see also **13.4.1 Impact on the marine environment**). The effects of these target practices on the environment can be reduced by a proper timing (for example, no target practices during the breeding season or by taking account of the presence of marine mammals) (Maes et al. 2005, GAUFRE project BELSPO, Degraer et al. 2011).

13.5.2 Measures for military activities at sea

On an international level, naval ships need to respect the regulations stipulated in the United Nations Convention on the law of the sea (UNCLOS 1982). The current trend for naval vessels is to be exemplary in ecological terms. Within NATO there is a special working group responsible for this (Nato Naval Armaments Group (NNAG) AC/141 - SWG12). The purpose of this working group is to promote the exchange of information and the development of solutions between the NATO navies in order to comply with national and international regulations for the protection of the marine environment and to jointly launch initiatives to build up an environmentally friendly fleet. In order to set an example, NATO has adopted the principles of the MARPOL and London Conventions and has adapted them to the specific requirements of naval vessels. Technically, the treaties are not applicable to military vessels, but military vessels do make the necessary efforts to respect these regulations. This has resulted in a series of publications such as the Allied Maritime Environmental Protection Publication (AMEPP). Each of these publications treat a specific aspect of maritime environmental protection. The purpose of these documents is to provide a clear, general guideline for naval architects and designers of naval systems, in accordance with the treaties mentioned above. On the basis of the AMEPP publications, the environmental legislation is incorporated in the design of new ships with minimal impact on the operational capacity, readiness, safety, survival and comfort of the crew.

The impact of military activities on the marine environment is in principle not covered by environmental policies and treaties, such as the international ASCOBANS Agreement. The impact of military activities (noise) on small cetaceans is being studied in the framework of this agreement and calls upon the introduction of mitigating

measures in cooperation with military authorities, e.g. see Bräger et al. (2010) and the European Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) (e.g. descriptor 11 Energy, incl. Underwater Noise). Within the MSFD, it is proposed to take into account the effects of military activities on the environment in the framework of the Natura 2000 sites protected by the European Birds and Habitats. Habitats Directive Article 6 (paragraphs 3 and 4) provides a balanced framework to deal with potential conflicts between military activities and nature conservation at sea (Guidelines for the establishment of the Natura 2000 network in the marine environment 2007, Natura 2000 EC). In the revision of the initial assessment for the Belgian marine waters (under MSFD obligations) it is reported that no measurements of underwater noise were collected in the BNS during the detonation of ammunition dumped at sea. This noise is most likely about of the same magnitude as pile driving for offshore wind turbines (Belgian State 2018). Research has shown that the destructive effect of such shock waves can be large and far-reaching, e.g. several tens of km for a 250 kg bomb (von Benda-Beckmann et al. 2015).

The national measures aimed at protecting the marine environment (see thematic chapter **Nature and environment**) do not cover military activities (marine environment Law of 20 January 1999). The military activities can only be subjected to a permission or authorisation as a result of a common recommendation by the minister whose authority includes the protection of the marine environment and by the minister of Defence. In such a case, the permission or authorisation is granted by both ministers. The marine environment Law states that the military authorities, in consultation with the minister responsible for the protection of the marine environment, must make every effort to prevent damage and environmental disturbance, without jeopardising the deployment of the armed forces. Degraer et al. (2011) proposed a number of measures to mitigate the impact of military shipping, the detonation of ammunition at sea, the use of sonars, chemical pollution, etc. In this context, Belgian Defence has purchased 'pingers' to chase off marine mammals during mine sweeping exercises or during the detonation of underwater ammunition.

The testing of nuclear weapons in the BNS has been prohibited by law since 1966 (5 August 1963 – Convention for the banning of experiments with nuclear weapons). The abandonment of nuclear weapons or weapons of mass destruction outside territorial waters has been prohibited since 1973, and from 1999 onwards, this ban applies to the entire BNS based on the Law of 18 August 1972 (GAUFRE project BELSPO). In 2017, the fourth periodic evaluation was concluded regarding the objectives set in the OSPAR strategy for radioactive substances (OSPAR IA 2017). The results suggest that the member states involved are making good progress in preventing radioactive pollution in the marine environment.

Finally, the Royal Military Academy is conducting research on the optimisation and sustainability of military activities at sea (Mees et al. 2018).

13.5.3 Measures for historical dump sites of war munition

On an international level, the London Convention (1972) and the OSPAR Convention (1992) prohibit the dumping of waste or other matter, including chemical waste. The dumping of chemical weapons at sea was eventually prohibited with the ratification of the Chemical Weapons Convention (CWC) in 1997. OSPAR also published a recommendation for reporting conventional and chemical ammunitions in the OSPAR area (OSPAR Recommendation 2010/20).

On the European level, the MSFD constitutes an important framework for measures against pollution from ammunition in offshore dump sites. Two of the descriptors in the MSFD to determine a Good Environmental Status (GES) are related to the concentration of pollutants: descriptor 8 (concentrations of contaminants) (Law et al. 2010) and descriptor 9 (contamination in fish and seafood) (Swartenbroux et al. 2010). The revision of the initial assessment for Belgian marine waters (in the context of MSFD obligations) did not include the leakage of ammunition and monitoring of these chemicals (Belgian State 2018). Given the fact that the dumping site at the *Paardenmarkt* sandbank is situated within territorial waters (12 nautical miles (nm) seaward) and partly within coastal waters (3 nm), the European Water Framework Directive (WFD, Directive 2000/60/EC) offers a relevant legislative framework in case of pollution. The WFD and the MSFD have been incorporated in Belgian legislation by the RD of 23 June 2010 (surface water status) and the RD of 23 June 2010 (marine strategy) (see also thematic chapter **Nature and environment**).

Due to its short distance from the coast and the shallow location, and given the fact that the dumping area is partly situated inside the Birds Directive area, Special Protection Area (SPA) 3, it is crucial to monitor the *Paardenmarkt* ammunition dump site on a regular basis (e.g. Missiaen et al. 2002, Missiaen 2013). DG Environment along with OD Nature (RBINS) and Belgian Defence (divers) coordinates regular sampling at the *Paardenmarkt* in order to timely detect any leaks of pollutants from the ammunition (OD Nature). To this end, the technique of passive

samplers has been used for some time now (e.g. see Monteyne et al. 2013, ICES WGMS Report 2015). Up to now, it has always been recommended to leave the munition dump site untouched for the time being and to monitor it thoroughly (e.g. Missiaen and Henriet 2010, Degraer et al. 2011). However, in response to the recent detection of chemical pollutants in the water (see **13.4.1 Impact on the marine environment**), monitoring efforts have increased in order to get a better picture of the situation and several additional studies are planned for the coming years to develop a sustainable management strategy for the site (FPS Public Health). For example, the SBO project DISARM (2020-2023) will conduct further research on the *Paardenmarkt* to substantiate the various management options for the site. This multidisciplinary project aims to evaluate the risk of explosion and to draft a chemical risk profile for people and the environment. This will allow different management options to be substantiated worldwide, with the *Paardenmarkt* munitions dump as a challenging case study. Additionally, recently within the Programme for Innovation Procurement (PIP) of the Government of Flanders, on the initiative of the Department of Mobility and Public Works (MOW) and the Maritime Access division, a project ran concerning a test removal of dumped war ammunition at the *Paardenmarkt*. After an extensive market consultation in 2020, it was decided not to continue with the PIP project. Finally, the Policy Statement by the minister for the North Sea indicated that further research to support the management of the Paardenmarkt munitions dump would be continued over the coming years (Van Quickenborne 2020, summary market consultation report Maritime Access division).

In addition to buried ammunition dumps at sea, ammunition can also be found in wrecks on the seabed. In this context, the North Sea Wrecks project (2018-2022) provides spatial planners, competent authorities, economic actors and other stakeholders with the necessary tools to evaluate and propose risk reduction solutions for wrecks and munition in the North Sea. Finally, within the BASTA project research is being carried out into how more detailed mapping of the seabed can contribute to improved detection of underwater ammunition.

13.5.4 The management of military domains

International (military) organisations (UN, NATO, EU member states) as well as federal, regional and local authorities issue environmental laws and regulations to limit the impact of human activities on people and our surrounding environment. The Belgian Defence applies these laws and regulations in accordance with the general policy of the Ministry of Defence and taking account of the military specificity (Policy Form Environmental policy).

Two military domains in the coastal area (owned by the Ministry of Defence) are managed by the Agency for Nature and Forest (ANB) through a cooperation protocol: camp Lombardsijde and camp *'t Pompje*. The military function prevails and sets certain preconditions, but the often unique ecological as well as recreational/economic values are recognised and managed accordingly (Dumortier et al. 2009, RESTORE project). The environmental technical management plan concerning the dunes of the military domain Camp Lombardsijde was drafted by Degezelle and Hoffmann (2002). The military base in Koksijde will be redeveloped in the near future. Ideas about the possible future destination have been drawn up in a master plan. In addition to a further expansion of recreational aviation, the plan also looks at possibilities for businesses, new bicycle connections, additional sports and youth facilities and nature development.

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
Test Ban Treaty	Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water	1963	1966
Seabed Arms Control Treaty	Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and the ocean floor and in the subsoil thereof	1971	1972
RAMSAR	Convention on wetlands of international importance, especially as waterfowl habitat	1971	1975
London Convention	Convention on the prevention of marine pollution by dumping of wastes and other matter	1972	1975
MARPOL	International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978	1973	1978
UNCLOS	United Nations Convention on the law of the sea	1982	1994
ASCOBANS	Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998
CWC	Convention on the prohibition of the development, production, stockpiling and use of chemical weapons and on their destruction	1993	1997
Scheldt Treaty	Scheldt Treaty	2002	2005

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Regent's Decree of 30 March 1946	Besluit betreffende oprichting en organisatie van de Marine	
Royal Decrees		
RD of 30 December 1923	Koninklijk besluit inzake toelating van vreemde oorlogsschepen in de wateren en havens van het Koninkrijk	1923-12-30/01
RD of 6 February 2009	Koninklijk besluit tot oprichting en organisatie van het maritiem informatiekruispunt	2009-02-06/39
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
Laws		
Law of 13 June 1969	Wet inzake de exploratie en de exploitatie van niet -levende rijkdommen van de territoriale zee en het continentaal plat	1969-06-13/30
Law of 18 August 1972	Wet houdende goedkeuring van het Verdrag tot verbod van de plaatsing van kernwapens en andere wapens voor massale vernietiging op de zeebedding en de oceaanbodem en in de ondergrond daarvan, opgemaakt te Londen, Moskou en Washington	1972-08-18/32
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 22 April 1999	Wet betreffende de exclusieve zone van België in de Noordzee.	1999-04-22/47
Law of 4 April 2014	Wet betreffende bescherming van het cultureel erfgoed onder water	2014-04-04/07

14 Scheldt estuary

Authors Yves Plancke[1], Tom Maris[2], Thomas Verleye[3], Matthias Sandra[3]

Lectors Frederik Roose[4], Dries Vervoort[5], Jurgen Suffis[4]

[1] Department of Mobility and Public Works (MOW), Flanders Hydraulics Research
[2] University of Antwerp, Ecosystem Management (ECOBE)
[3] Flanders Marine Institute (VLIZ)
[4] Department of Mobility and Public Works (MOW), Maritime Access division
[5] Department of Mobility and Public Works (MOW), Policy division

Plancke, Y., Maris, T., Verleye, T., Sandra, M. (2022). Scheldt estuary. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 225-236.

The North Sea region is home to a number of important estuaries. These include the estuaries of the Seine (France), the Elbe (Germany), the Weser (Germany), the Humber (United Kingdom), the Ems-Dollard (Germany and the Netherlands), the Thames-Essex (United Kingdom) and the Scheldt (the Netherlands and Belgium) (Debergh et al. 2009, TIDE-toolbox). These estuaries have a great ecological value and parts of them are designated as Natura 2000 areas (see also thematic chapter **Nature and environment**). On the other hand, these estuaries provide space for important economic activities such as harbour developments and tourism. Furthermore, these estuaries face common challenges such as increasing flood risks, upscaling of shipping, issues regarding sediment management and the preservation of ecosystem functions. Considering the common challenges of these areas, European collaboration projects concerning estuarine research and management have been conducted. Depending on the project and the project partners, these projects focus on one or several of these challenges (e.g. TIDE, SEDNET, SCALDWIN, EMOVE, HARBASINS, SMARTSEDIMENT, INTERTIDE, etc., see also list of projects in ScheldeMonitor).

The Scheldt estuary consists of the Sea Scheldt and its tidal tributaries (Durme, Rupel, Zenne, Dijle and Netes), the Western Scheldt and the mouth of the Scheldt with the *Vlakte van de Raan*. The preservation of the tidal regime along the entire salt - freshwater gradient, with the associated tidal habitats and communities, is a unique feature in North-West Europe (Directorate Zeeland and AWZ 2001). The strong interaction between the Scheldt estuary and the North Sea results in the exchange of water masses, dissolved matter, sediments, fauna and flora, etc.

Although that the Scheldt estuary is a Flemish-Dutch matter, this thematic chapter mainly focuses on the Flemish context. For the Dutch efforts in the Western Scheldt in the context of nature, safety and accessibility, reference is made to the website of Rijkswaterstaat and the Natuurpakket Westerschelde.

14.1 Policy context

14.1.1 Common policy and management

The policy and management of the Scheldt estuary is a cross-border affair that involves both Flanders and the Netherlands. Between both countries, several treaties and memoranda of understanding (MoU) on the Scheldt estuary have been concluded (Vlaams-Nederlandse Scheldecommissie (VNSC)). Furthermore, ministerial declarations and treaties have been adopted in the context of integrated water management in the Scheldt Basin, which not only involve Flanders and the Netherlands, but also the Walloon Region, the Brussels-Capital Region and France (International Scheldt Commission). An overview of historical treaties and agreements is available in van Langenhuysen and van Langenhuysen (1919) and Baekelandt (2002).

To ensure the alignment between the Flemish and Dutch authorities, a number of specific cross-border organisations for the Scheldt estuary have been created. In 1948, on the occasion of the foundation of the Benelux Customs Union, the Technical Scheldt Commission (TSC) was established. This commission consisted of Dutch and Belgian/Flemish officials and was responsible for studies on the Scheldt (e.g. the Delta Plan, the Scheldt-Rhine connection, the Long-term vision on the Scheldt estuary and the Development sketch 2010 Scheldt estuary). In 2008, the TSC was succeeded by the Flemish-Dutch Scheldt Commission (VNSC) as stated in the Treaty on Common policy and management of the Scheldt estuary (2005). The VNSC consists of a political college, an official college and an executive secretariat. This body promotes the cooperation between Flanders and the Netherlands at the policy and management level in the pursuit of a safe, accessible and natural Scheldt estuary. In order to create a strong support base for further development of the Scheldt estuary, the Scheldt Council was established in 2014. This official advisory board contributes to the future policy of the VNSC. In response to specific policy and management questions, the official college may set up working groups to carry out specific tasks. Seven working groups were established under the VNSC: 'Development sketch 2010', 'Long-term perspective on nature', 'Long-term perspective on accessibility', 'Research and monitoring (R&M)', 'Flexible dumping', 'Monitoring New Lock Terneuzen (NST)' and 'Decision supporting system NST'.

In 2013, the VNSC published a first evaluation report (Evaluation of the Treaty on policy and management of the Scheldt estuary) of the Flemish-Dutch cooperation based on the Scheldt Treaty on Common policy and management. In a second report, recommendations are made for the evaluation period 2019-2023 (Evaluation of the Treaty on policy and management of the Scheldt estuary 2014-2018). This report also identifies a number of priority themes towards a robust and sustainable Agenda for the Future of the Scheldt estuary. This agenda started in 2014 with a comprehensive policy and management support research programme. Meanwhile, the first research programme of the 'Agenda for the Future, 2014-2018' has been completed and, in collaboration with stakeholders (e.g. through the establishment of the Scheldt Council), initiatives have been launched to develop long-term perspectives for nature and accessibility. The first research programme resulted in substantive conclusions

relevant to the management as well as recommendations for new and additional research opportunities, which led to the Roadmap to Agenda for the Future 2019-2023 and the Research Programme 2020-2023. In addition to this research programme, the cooperation between Flanders and the Netherlands also consists of an integrated monitoring programme aimed at the functioning of the estuary (MONEOS), which is monitored by the permanent VNSC Working Group Research and monitoring (R&M).

In addition to the system monitoring included in the MONEOS programme, specific monitoring programmes are carried out with the aim of making the effects of certain interventions visible. The MONEOS-T implementation programme monitors the effects of the construction and maintenance strategy of the widening of the waterway based on the protocol for flexible dumping, and there are numerous monitoring efforts that make it possible to map the nature development projects in Zeeland. Using research and monitoring programmes such as OMES (*Onderzoeksprogramma Milieu Effecten Sigmaplan*), most of which is included in the cross-border monitoring programme MONEOS, Flemish water authorities and scientists can monitor the autonomous developments of the hydro-morpho-ecological system and the environmental impact of human activities on the Scheldt estuary (Maris et al. 2020a, Maris et al. 2020b).

The ScheldeMonitor was set up in 2003 on behalf of the VNSC with the aim of acting as a central information system on research and monitoring in the Scheldt estuary. Since 2010, in addition to providing access to information (expertise, literature, projects, etc.), the ScheldeMonitor also focuses on data (datasets, measurements, etc.) and data products (maps, graphs, indicators, etc.) related to the Scheldt estuary, with a focus on accessing and archiving data series from the MONEOS programme.

14.1.2 Joint nautical management

There is also cooperation between Flanders and the Netherlands on a sector level. Through the Joint Nautical Management (GNB), both countries ensure the organisation of smooth and safe shipping traffic to and from the Scheldt ports. The Permanent Commission for the Supervision of Scheldt Navigation, established by article 9 of the Convention of 19 April 1839 regulating the separation between the Netherlands and Belgium, is the highest body in the organisation of the GNB and is responsible for the safe and smooth handling of shipping traffic. The Joint Nautical Authority (GNA) is responsible for the daily nautical control of the traffic flow. Realtime monitoring of shipping traffic on the Scheldt is carried out by the Scheldt Radar Network (SRK), a shipping guidance system that is jointly managed by the Flemish and Dutch governments. The operational, functional and technical management of the systems of the SRK is carried out by the Management and Operation Team (BET-SRK).

14.1.3 International Scheldt Commission

The International Scheldt Commission (ISC) was initially established by the Treaty of Charleville-Mézières (1994) under the name 'International Commission for the Protection of the Scheldt' (ICBS). The commission is operating under its current name since 2002, following the coming into force of the Scheldt Convention. The aim of this entity is to strengthen cooperation between the riparian states (France, Belgium and the Netherlands) and Regions (Flanders, Brussels and Wallonia) of the international Scheldt river basin, for the benefit of sustainable and integrated water management. Since 2000, the commission has been responsible for making a single management plan for the international river basin district of the Scheldt and for coordinating the national programmes of measures (first elaboration in 2009) in the implementation of the Water Framework Directive (WFD, Directive 2000/60/EC). The current management plan (Scheldt, coast) and programme of measures apply for the period 2016-2021.

14.1.4 European guidelines

The management and policy of the Scheldt estuary are to a large extent guided by international and European legislations such as the Birds- (Directive 2009/147/EC) and Habitats Directives (Directive 92/43/EEC) (Natura 2000), the Waterframework Directive (WFD) (Directive 2000/60/EC) and the Floods Directive (Directive 2007/60/EC). This is done by setting specific targets for good ecological and chemical status (WFD) and conservation objectives (COs – N2000). The national and regional policy instruments then provide for the local implementation of these directives (see also thematic chapter **Nature and environment**). An overview of the policy framework for the Scheldt estuary is available in Debergh et al. (2009).

14.1.5 Long-term vision on the Scheldt estuary

The Long-term vision on the Scheldt estuary (LTV, Directorate of Zeeland and AWZ 2001) has been the starting point for a common integrated, cross-border policy. This vision was jointly adopted by the Netherlands and Flanders in 2001 and approved by the governments and parliaments of both countries. The objective of the LTV was to develop a healthy and multifunctional estuarine water system that is used sustainably for human needs. The vision mainly focused on the themes 'safety', 'accessibility' and 'nature', while keeping the development of the morphology of the estuary as a central focus. The LTV was made up of three components:

- Short-term situation sketch: starting situation (2005) based on the expected short-term effects as a result of the already planned measures and the established policy;
- Target 2030: description of the long-term situation to be pursued (2030);
- Development sketches 2010: description of alternative medium-term policy strategies to move from the short-term situation sketch to the long-term target.

The Development sketch 2010 Scheldt estuary (ProSes 2004) included project proposals (measures and policy efforts) that had to be started mainly in the period 2004-2010 in order to achieve the target set for 2030. Most of the projects have now been completed. A number of projects, such as the Natuurpakket Westerschelde (with the depoldering of the *Hedwige-Prosperpolder*) and the realisation of the Sigmaplan, are still in progress.

In Flanders, the LTV themes 'safety' and 'nature' are jointly implemented in the updated Sigmaplan (2005) approved by the Government of Flanders. The measures laid down therein serve both safety and nature, with a robust estuary at stake. The objectives for nature in the Sea Scheldt were refined and concretised as a result of the updated Sigmaplan (Adriaensen et al. 2005). A series of measures were proposed to achieve these objectives. Three types of measures can be distinguished:

- The development of mudflats and salt marshes by allowing controlled reduced tides (RT) in a flood control area (FCA);
- The renewal of dikes or depoldering;
- The development of wetlands in the valley, potentially as a FCA.

14.2 Spatial demarcation

By definition, an estuary contains the part of a river that is subject to tidal influences (Fairbridge 1980) and where salt seawater is mixed with fresh surface water. In the case of the Scheldt estuary, this is the area from the mouth of the river to the locks in Ghent (Merelbeke), including the Durme, Rupel, Zenne, Dijle and Netes up to where tidal influence can be recorded. The exact spatial boundary of the estuary is formed by the dikes (figure 1).

The Long-term vision of VNSC (Directorate Zeeland and AWZ 2001) applies to a specific geographic area. However, a trans-border perspective is used when this is required for certain aspects. The upstream border was set at the locks in Ghent (Merelbeke) and the upstream border of the tidal influence of the tributaries. The downstream border of the estuary contains the Scheldt and its river mouth, including *Vlakte van de Raan* and other shallow water areas. The channels are taken into account up to the limit of the nautical management (indicative border: the piloting intersections west of *het Scheur*). The Port of Zeebrugge and its fairway *Pas van het Zand* are not included in the area demarcated for the LTV. The LTV also covers the banks up to the main weirs.

The evaluation method (Maris et al. 2014a) uses the most detailed classification based on the OMES (research on the environmental effects of the Sigmaplan) compartments and a classification into macro/mesocells specific to the Western Scheldt. The OMES classification is initially based on variations in salt content. In the freshwater zones, residence times are also taken into account (figure 2). This scale level is aggregated into a chain of macrocells and mesocells. The macrocells are formed by the large curved ebb channels and straight flood channels, which are intertwined by shortcut channels (Depreiter et al. 2014). Depending on the desired spatial detail, the zones are taken together or the focus is put on a smaller spatial scale within a zone. For example, different scale levels can be distinguished (Maris et al. 2014a, Barneveld et al. 2018):

- Level 1: Estuary;
- Level 2: Western Scheldt – Sea Scheldt – Tributaries;
- Level 3: Strong polyhaline zone – Weak polyhaline zone – Mesohaline zone – Zone with strong salinity gradient – Oligohaline zone – Freshwater zone with long residence time – Freshwater zone with short residence time – Tributaries;
- Level 4: Scheldt-compartment (compromise between macro-/mesocells in the Western Scheldt and the OMES compartments in the Sea Scheldt).

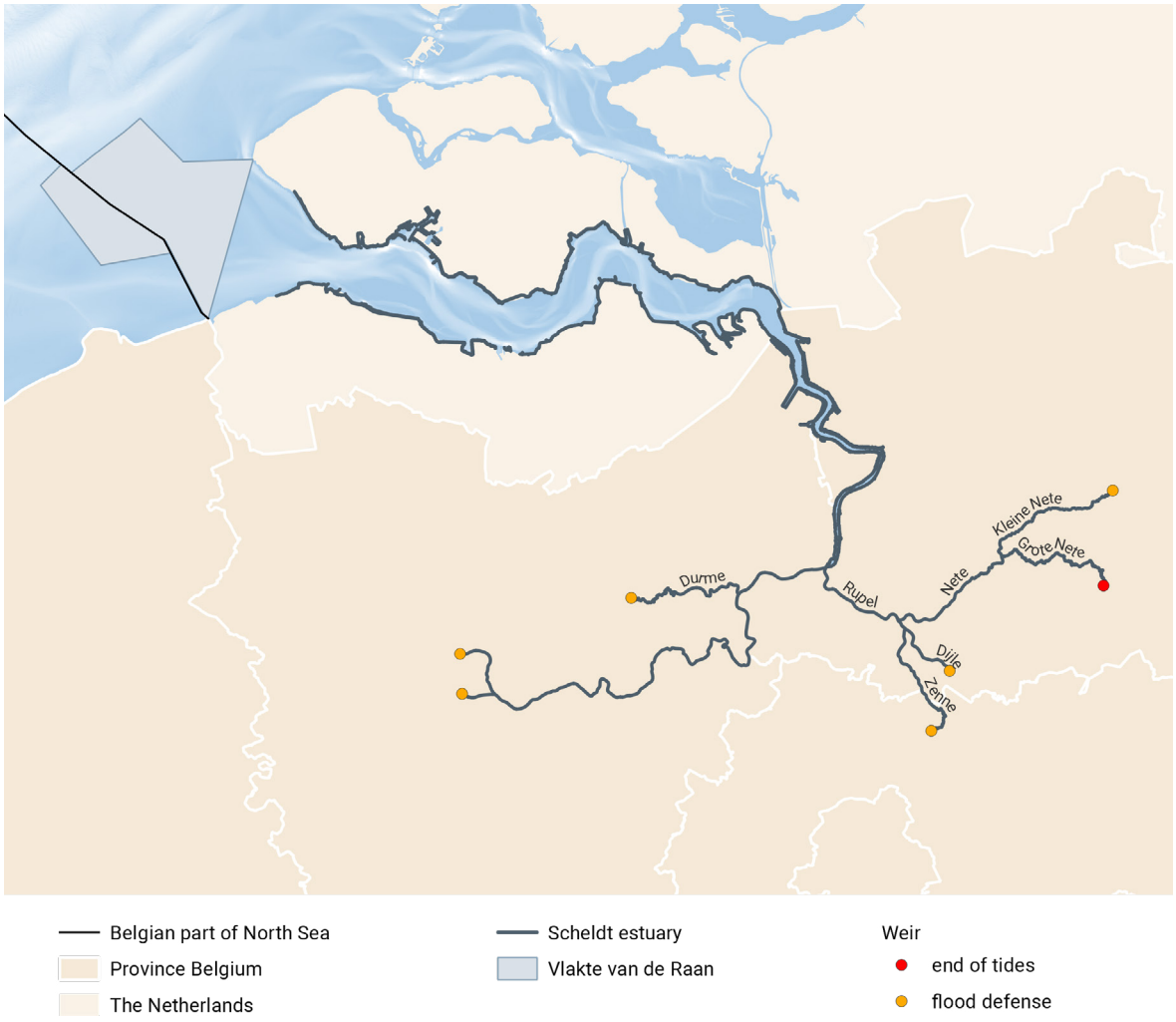


Figure 1. The area of the Scheldt estuary, with an indication of the estuary, the Western Scheldt, the Lower Sea Scheldt and the Upper Sea Scheldt (Source: Natura 2000, RBINS, MarineAtlas.be (based on RD of 22 May 2019 (MSP 2020-2026), ScheldeMonitor, Flemish Hydrography).

14.3 The hydro-morphological system of the Scheldt estuary

The Scheldt estuary is an estuary in which the tidal regime is retained along the entire salt - freshwater gradient (Directorate Zeeland and AWZ 2001). It is characterised by an ebb-dominated main channel and several flood-dominated side channels (Huisman et al. 2021). Over the past years, the hydro-morphological system of the Scheldt estuary has experienced a vast evolution that can largely be linked to human interventions. Sediment extraction and the widening of channels result in an increased trench depth and, as a consequence, an increased tidal range (Vandenbruwaene et al. 2020a). Since the end of the 19th century, an increase in annual mean high water levels has been observed throughout the estuary. Furthermore, low water levels decreased in areas with increased trench depths due to channel widening. The increase in trench depth also results in an increased celerity[1] of low water, leading to a reduction in tidal asymmetry (Vandenbruwaene et al. 2020b). On the other hand, historic land reclamations appear to increase high water celerity and tidal asymmetry. These hydro-morphological changes are mainly observed along the *Hansweert-Liefkenshoek* segment (Vandenbruwaene et al. 2020a, Vandenbruwaene et al. 2020b). Along the estuary, the flood volume and the difference between low and high tide show a clear relationship. Due to the relatively larger effect of top discharge, the slope of this relation increases upstream. A similar relation is found for the ebb volume, with the exception that for the highest flows no increase is observed at larger tidal differences (Plancke et al. 2021).

[1] Velocity.

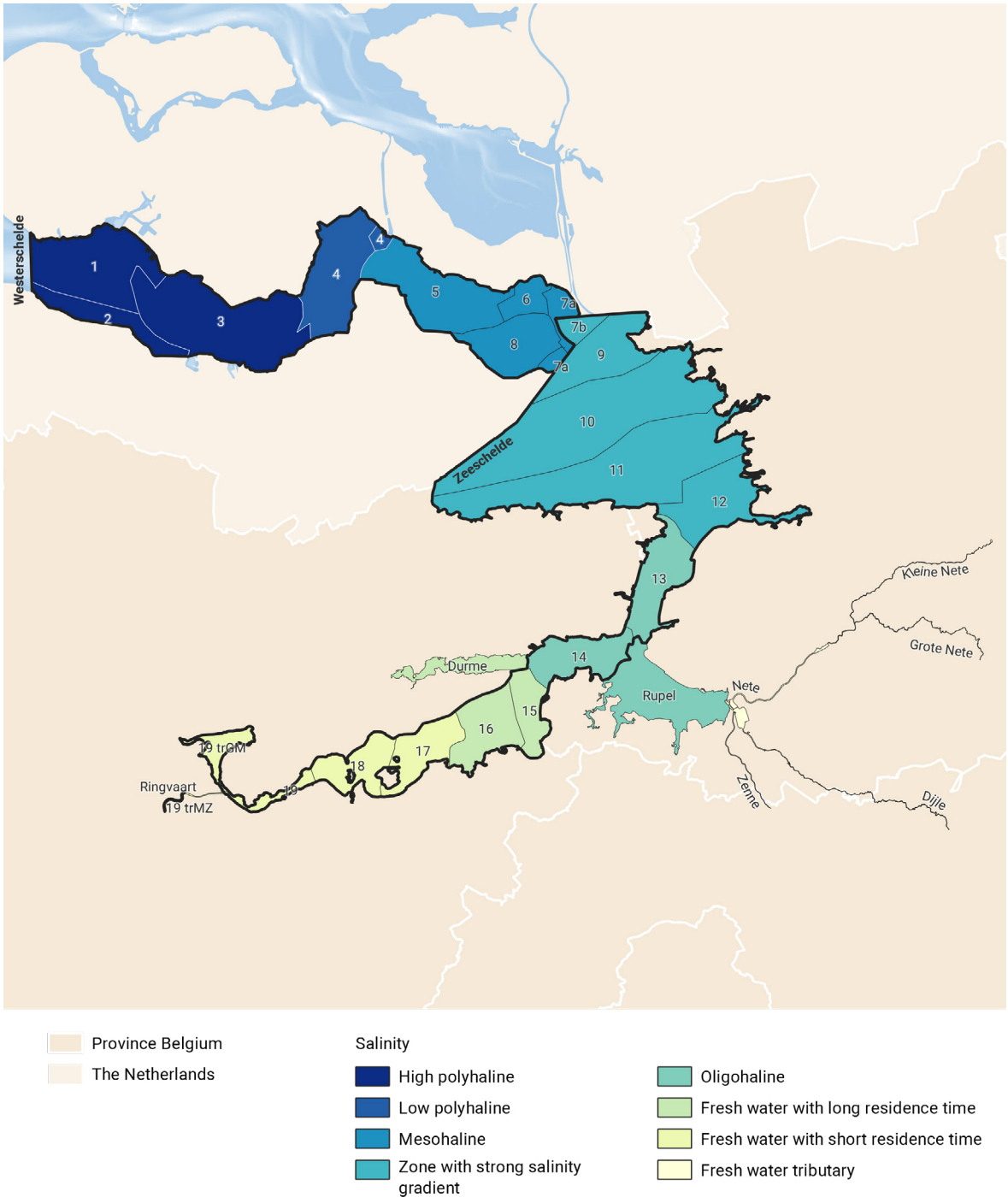


Figure 2. The spatial classification of the Scheldt estuary according to the evaluation methodology for the Scheldt compartments (level 4), Scheldt zones (level 3) and Western Scheldt – Sea Scheldt – Tributaries[2] (level 2) (Source: Maris et al. 2014a, Van Ryckegem et al. 2017, Barneveld et al. 2018).

Additionally, research was conducted on the importance of waves in the estuary, within the framework of the research programme 'Agenda for the Future'. Wave height in the estuary is rather limited due to the fetch length[3] of the waves, not exceeding a few decimetres (Huisman et al. 2021). As part of the project 'Waves in the estuary', various measurements (tidal, current, wind and wave measurements) were collected at four locations along the entire estuary (Meire et al. 2019a, Meire et al. 2020, Meire et al. 2021a, Meire et al. 2021b). Downstream, higher maximum wave heights were measured on every occasion. The wave data measured at the most downstream

[2] With trGM refering to the section Gentbrugge-Melle and trMZ to the section Melle-Zwijnaarde.
[3] The horizontal distance over which wave-generating winds blow.

location were also compared to wave data from measuring stations at the mouth of the Scheldt and on the North Sea. This showed an apparent decrease in wave height towards the Scheldt estuary (Meire et al. 2021b). In these studies, both waves produced by wind and ships were analysed.

The Western Scheldt comprises of three sediment types. The gullies generally consist of sand, whereas the intertidal areas are characterised by silt sediment. In addition, areas with erosion-resistant peat or clay are also present (McLaren 1993, Huisman et al. 2021). The sediment in the Scheldt is subject to the tides and consequently moves up- and downstream (Plancke et al. 2021). The sediment transport in the Scheldt estuary was extensively investigated as part of the 'Agenda for the Future' on different time scales (Plancke et al. 2020a) and areas of the estuary (e.g. see Hassan et al. 2017, Plancke et al. 2018, Plancke et al. 2019a, Plancke et al. 2019b, Plancke et al. 2020b, etc.). A sensitivity analysis of several parameters of the hydro- and sediment dynamics and morphological processes was also carried out at mesocell level (Meire et al. 2019b).

14.4 The ecosystem of the Scheldt estuary

Starting from Vlissingen-Breskens, the incoming tide penetrates 160 km inland, causing the Sea Scheldt to occupy an extensive freshwater tidal area with associated biotic communities (i.e. Maris et al. 2014). As a result, the Scheldt estuary has a special natural value and a rich array of ecosystem services (i.e. the benefits that society receives from nature (ecosystems) such as food production, flood protection, recreation, etc.). Due to its geographic location in an economically important and densely populated area, the Scheldt ecosystem is under constant pressure, such as habitat loss, anthropogenic disturbance and pollution (e.g. Maris et al. 2020a, Maris et al. 2020b). Over the past years, man has strongly influenced the Scheldt by means of reclamation and embankments, straightening and channel widening, sediment extraction, agriculture and urbanisation, with an impact on tidal amplitude (e.g. de Munter et al. 2010, Depreiter et al. 2014, Vandenbruwaene et al. 2016, Vandenbruwaene et al. 2020a, Vandenbruwaene et al. 2020b, Huisman et al. 2021) and a sharp decline in the area of mudflats and salt marshes as a result (e.g. Van Braeckel et al. 2012, Maris et al. 2014b). The quality of the remaining habitats was also under severe pressure due to changes in hydrodynamics (e.g. current velocities, waves, exposure rate) (e.g. see De Vet 2020) and poor water quality.

The Scheldt estuary is by nature a very dynamic system. Mudflats, salt marshes, sandbanks and gullies are constantly subject to changes in tides and salinity. The ecologically valuable habitats in the Scheldt estuary are mainly the low-dynamic (low current velocity) shallow water areas and the intertidal areas (mud flats, sandbanks and salt marshes). An overview of the different ecotopes as well as the trends in their spatial distribution is given in Barneveld et al. (2018). The low-dynamic shallow water areas are essential for the reproduction and growth (nursery function) of fish, crustaceans and molluscs. The intertidal areas are foraging, spawning, breeding or growing sites for many organisms and contribute to the biodiversity of the estuary (e.g. Van Ryckegem et al. 2020). In this way, they are an essential habitat for economically important species such as sole (*Solea solea*) (Maris et al. 2014b). The mudflats and sandbanks are usually rich in bottom-dwellers and provide an important source of food for waders and other birds (e.g. Vanoverbeke and Van Ryckegem 2015, Craeymeersch and Ysebaert 2020). The trophic relationships among species are evaluated by Van De Meutter et al. (2019) and De Neve et al. (2020). Particularly the areas with a moderate exposure rate (the percentage of time that the mudflat or sandbank is above water) are most attractive from an ecological point of view (Milieueffectrapport Verruiming vaargeul Beneden-Zeeschelde en Westerschelde 2007, Wetsteijn et al. 2007, Depreiter et al. 2014). Salt marshes, on the other hand, offer nesting possibilities for many bird species. Moreover, they serve as a refuge area for various species during high tide. Furthermore, the intertidal areas have an important regulating effect on water quality by removing nitrogen and acting as a source of dissolved silica, which is essential for the growth of diatoms (e.g. Gribsholt et al. 2005, Struyf et al. 2005, Struyf et al. 2006, Jacobs et al. 2008). They also provide oxygen enrichment and offer refuge for, *inter alia*, the plankton in case of unfavourable conditions in the gully itself.

Beside these ecosystem services and its ecologically attractive function, the Scheldt estuary provides a whole range of important ecosystem services (Schepers et al. 2018). For example, salt marshes play a role in the buffering of wave action (Heuner et al. 2015, Van Braeckel et al. 2019) and sea level rise (Broekx et al. 2011, Ntegeka et al. 2013, Temmerman et al. 2013, Temmerman and Kirwan 2015, Smolders et al. 2020, van der Werf et al. 2020), indirectly generating an economic value. The monetary valuation of (changes in) ecosystem services is already discussed in several publications (e.g. Liekens et al. 2013, Staes et al. 2017). Numerous reports on the economics of ecosystems and biodiversity have also been published at European level (TEEB website). The SMARTSEDIMENT project studies sediment management in function of ecosystem services provisioning throughout the entire Scheldt delta, including not only the Scheldt estuary but also the Eastern Scheldt. In addition to the known threats to ecosystem services in the Scheldt estuary (pollution, loss of habitat, etc.), the occurrence of invasive species can also be considered a potential threat to species diversity in recent decades (e.g. Van

Damme et al. 1992, Van Damme and Maes 1993, Ysebaert et al. 1997, Faasse and Van Moorsel 2003, Azémar et al. 2007, Soors et al. 2010, Kerckhof 2011, Soors et al. 2013, Adriaens et al. 2014, Boets et al. 2016, Verleye et al. 2020, SEFINS project).

International Directives and Agreements, such as the Ramsar Convention and the European Birds and Habitats Directives, in combination with national legislation, have ensured that mudflats, salt marshes and most parts of the Scheldt estuary and the adjacent valley/polders are (inter)nationally protected. This is because of the unique character and rarity of the entire estuarine salt - freshwater gradient on the one hand, and the importance as a wintering, migration and breeding area on the other hand. In the Western Scheldt, European fishing quotas led, among other things, to regulations for cockle fishing in order to preserve sufficient food for birds. With respect to water quality, an important step was taken with the publication of the European WFD (Maris et al. 2014b).

The ScheldeMonitor collects all available information (expertise, literature, projects, etc.), data (datasets, measurements, etc.) and data products (maps, graphs, indicators, etc.) relating to the various aspects of the Scheldt ecosystem. Important information is also available in the reports produced within the framework of the R&M working group (see the websites of the ScheldeMonitor and VNSC).

14.5 Human activities in the Scheldt estuary

The Scheldt estuary is not only an important ecosystem, but also hosts a number of human activities, such as shipping, dredging for nautical accessibility, recreation, flood protection with associated embankment and alternative measures (e.g. controlled flood plains), embankments, fisheries, etc. Some of these activities are described in more detail below.

14.5.1 Shipping and ports

The Scheldt estuary, particularly the area downstream of Antwerp, is characterised by a large number of shipping movements. In 2019, the number of seagoing vessels that entered the ports of Antwerp and Ghent (North Sea Port Flanders, via Terneuzen) amounted to 17,634, or approximately 48 a day, of which 82% was accounted for by the port of Antwerp. These seagoing vessels represented a total gross tonnage of 453.3 million GT (gigatonnes) (92% for Antwerp), representing a total cargo traffic of 270.7 million tonnes (88% for Antwerp). In addition, inland navigation of goods in the port of Antwerp and Ghent accounted for over 101.3 and 24.6 million tonnes, respectively (Merckx 2020). In 2018, the port of Antwerp also provided direct employment for 62,635 fulltime equivalents (FTEs) (59% of direct employment in Flemish seaports) and generated an added value of 11.1 billion euro (65% of Flemish seaports) (Merckx 2020) (see also thematic chapter **Maritime transport, shipping and ports**).

The location and operation of ports generate effects on the environment. These effects are listed, *inter alia*, in the (plan-)environmental impact assessments (EIAs) of the ports' strategic plans (see also EIA file database, Departement of Environment and Spatial Development).

Vlaamse Waterweg nv is working on an integrated plan for the Upper Sea Scheldt and wants to create a sustainable balance between all of the functions of the river: navigability, recreation and nature development. The EU is equipping its network of waterways for inland navigation, which is why, for example, the Seine and Scheldt will be better connected, allowing the direct transport of large cargoes over water between Paris, Antwerp and Rotterdam. In order to prevent excessive traffic on the Ghent-Terneuzen Canal and the Western Scheldt, the Upper Scheldt should also be easier to navigate for class Va cargo vessels (with a load capacity up to 2,250 tonnes). This new connection between the ports of Ghent and Antwerp will facilitate shipping between the Scheldt basin and the Albert Canal, and thus provide added value for the entire Flemish waterway network. In addition, the Coastal Vision project (previously *Complex project Kustvisie* and *Vlaamse Baaien*) is looking into possibilities for estuarine shipping at an advanced shoreline. The construction of islands could remove restrictions on inland navigation and have a direct impact on coastal safety and safer coastal navigation (Project Group Vlaamse Baaien 2012, Rondelez and Pirlet 2018).

14.5.2 Dredging and dumping

In 2019, the Government of Flanders (Maritime Access division) invested 219.9 million euro to ensure the accessibility of Flemish ports (including the Scheldt estuary, Merckx 2020) (see also thematic chapter **Dredging and dumping**). This investment includes maintenance dredging at sea, on the Western Scheldt and on the Lower Sea Scheldt, wreck salvage and sludge processing (see also the Decision of the Government of Flanders of 13 July 2001).

The aim of the Convention on the Implementation of the Development sketch 2010 Scheldt estuary (Verleye et al. 2018) was to ensure the implementation of a number of projects aimed at optimising the safety, accessibility and nature of the Scheldt estuary. In order to guarantee accessibility to the Scheldt harbours, the fairway was widened to a tidal independent navigation of up to 13.1 m wide that is continuously maintained. To this end, a new dumping strategy was developed in the Western Scheldt (Plancke et al. 2010), based on the principle of Flexible dumping. In addition to preserving the physical characteristics of the system, in accordance with the Scheldt treaties (2005) on the Development sketch 2010 Scheldt estuary and the Common policy and management of the Scheldt estuary, this dumping strategy created new ecologically valuable habitats near a number of sandbank edges by means of targeted dumping of dredged material. Furthermore, the relation between human interventions and water levels during windless periods was also investigated on behalf of the Maritime Access division (Van De Moortel et al. 2021). In recent years, alternative dumping sites have also been explored near deeper parts of the main channel by means of pilot dumping to re-dump the dredged material into the estuary. These new insights will be used in the optimisation of the dumping strategy. For the disposal of the dredged material from the maintenance of the Lower Sea Scheldt, the Maritime Access division obtained environmental permits from the provinces of East Flanders and Antwerp.

For the Sea Scheldt, sludge management is an important point of attention (e.g. increased sludge concentration in the water column, indications of an increased total quantity of sludge in the estuary) (Cox et al. 2019). The Agenda for the Future includes research on sludge management (Vandenbruwaene et al. 2016, Vandenbruwaene et al. 2017, Vandenbruwaene et al. 2020a, Plancke et al. 2021), with the aim of increasing system knowledge of the Scheldt estuary and investigating the extent to which numerical models can reproduce these processes (Evaluatie verdrag beleid en beheer Schelde-estuarium 2014-2018, Werkplan 2020-2023. Onderzoek en monitoring Schelde). Based on these models, research was carried out that led to an optimisation of the current permit for the dumping of dredged material from maintenance dredging in the Lower Sea Scheldt for both the sludge-rich and the sand-rich fractions (Plancke et al. 2016, Plancke et al. 2019c).

The sustainable management plan for the Upper Sea Scheldt includes dredging works that maintain the navigable profile of the river without damaging protected nature. A dredging programme has been developed for the next twenty years to keep the river navigable. The implementation of this sustainable management plan started in 2015.

14.5.3 Protection against flooding

The implementation of the Sigmaplan by the Government of Flanders provides protection against flooding from the Scheldt river and its tributaries, and runs until 2030 (see also **14.1 Policy context**; ScheldeMonitor and website VNSC). For example, the polders of Kruibeke now form a flood control area with reduced tides (FCA-RT) and the de-poldering of Lillo allows more space for flooding. In addition, several models have been developed to map the consequences of flooding and rising sea levels in the Scheldt estuary (Nnafie et al. 2018, Smolders et al. 2020, Vandenbruwaene et al. 2020c). Also, since 2015, under the WFD, EU member states are required to prepare flood risk management plans at river basin level with a special focus on protection against and prevention of floods. The flood risk management plan for the Scheldt was integrated into the River basin management plans for Scheldt and Maas 2016-2021 and the Programme of measures for the river basin management plans for Scheldt and Maas 2016-2021. Within Flanders, the Coordination Committee on Integrated Water Policy (CIW) coordinates the procedures for drawing up all mandatory documents for the WFD and the Floods Directive. Furthermore, the water assessment (watertoets), in which the government assesses the impact of a future project on the water system, also contributes to the prevention of flood damage. The water levels can also be consulted in realtime at www.waterinfo.be and flood-sensitive areas can be searched for on Flanders' Climate Portal (see also thematic chapter **Safety against flooding**).

14.6 Evaluation of the functioning of the Scheldt estuary

In addition to the mandatory assessments, Flanders and the Netherlands have decided to jointly carry out a six-yearly evaluation (under the umbrella of the VNSC working group on R&M) to assess the functioning of the Scheldt estuary and the activities that take place in the estuary. This evaluation makes use of the monitoring results of the integrated monitoring programme for the Scheldt estuary, which is being carried out by various institutions (e.g. Nederhoff 2016, Vandenbruwaene et al. 2020c, Van Ryckegem et al. 2020). The report focuses on the evaluation of the three main functions – 'nature', 'safety' and 'accessibility' – in the form of seven communication indicators for sustainable management (table 1).

Table 1. Overview of the indicators that are part of the evaluation methodology for the T2021 evaluation of the three principal functions of the Scheldt estuary (Source: SchkeldeMonitor).

Principle function	Indicator
Safety	Hydrodynamics
Accessibility	Hydrodynamics
Nature	Water quality
	Ecology
	Habitat
	Morphology

In 2011, an evaluation method was published that describes how each indicator should be evaluated (Holzhauer et al. 2011). This methodology is dynamic and was updated for the first time by Maris et al. (2014a). Within the methodology, each indicator is individually substantiated according to a pyramid structure in which the relevant key parameters, calculation parameters and explanatory parameters are included. In order to be able to evaluate the starting situation, the starting point has been defined unambiguously with 2009 being the reference year (Holzhauer et al. 2011, Maris et al. 2014a). Depreiter et al. (2014) describe the starting situation (T2009) and the trend developments until 2009 of the Scheldt estuary. Barneveld et al. (2018) (T2015) evaluate the situation in the Scheldt estuary between 2010 and 2015 and try to identify the causes for the observed trends. A new update of the evaluation methodology is expected by mid-2022, with which the next six-yearly evaluation (T2021) will be carried out. This update will focus on increasing the coherence between the various pyramids for 'nature', a broader interpretation based on narratives on ecology and the relevant human activities on the Scheldt estuary. Analysis scripts are additionally implemented on the data analysis platform of SchkeldeMonitor and, where possible, linked to the databases of this platform.

Prior to the evaluation method described above, a set of indicators had already been selected in the context of the LTV objectives and aligned with the entire cross-border Scheldt estuary, in consultation with scientists and policy makers (see Indicators for the Scheldt estuary 2011 and the website SchkeldeMonitor).

Finally, a system analysis of the Long-term perspectives on Accessibility and Nature was carried out to identify the current state, developments and bottlenecks. Furthermore, as part of the recovery measures taken in the Scheldt and Durme estuary, a PAN area analysis (Programme-based Approach to Nitrogen) was drawn up in 2018 (Mertens and Van Ryckegem 2018), followed by a climate adaptation plan for the estuarine nature in the Sea Scheldt in 2019 (Van Ryckegem 2019).

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
Canal Ghent-Terneuzen	Verdrag tussen België en Nederland betreffende de verbetering van het kanaal van Terneuzen naar Gent en de regeling van enige daarmede verband houdende aangelegenheden	1960	1961
Scheldte-Rhine connection	Verdrag tussen het Koninkrijk België en het Koninkrijk der Nederlanden betreffende de verbinding tussen de Schelde en de Rijn	1963	1965
Improvement of the waterway at Walsoorden	Overeenkomst tussen de Regering van België en de Regering van het Koninkrijk der Nederlanden betreffende de verbetering van de vaarweg door de Westerschelde nabij Walsoorden	1970	1972
RAMSAR	Convention on wetlands of international importance, especially as waterfowl habitat	1971	1986
Protocol Canal Ghent-Terneuzen	Protocol bij het verdrag tussen het Koninkrijk België en het Koninkrijk der Nederlanden betreffende de verbetering van het Kanaal van Terneuzen naar Gent en de regeling van enige daarmede verband houdende aangelegenheden	1985	1987
Treaty of Charleville-Mézières	Verdrag van Charleville-Mézières inzake de bescherming van de Schelde *(beëindigd in 2006)*	1994	1998
Widening channel 48/43/38 feet	Verdrag tussen het Vlaams Gewest en het Koninkrijk der Nederlanden inzake de verruiming van de vaarweg in de Westerschelde	1995	1996
Ministerial Conference in Middelburg	Verklaring ondertekend door de Regeringen van het Koninkrijk der Nederlanden, de Franse Republiek, het Vlaams Gewest, het Brussels Hoofdstedelijk Gewest en het Waals Gewest, betreffende het integrale beheer en de duurzame ontwikkeling van de Schelde, met de goedkeuring van het Schelde Actieprogramma	1998	1998
Ministerial Declaration of Liège	Ministeriële Verklaring van Luik	2001	2001
MoU Kallo (1th MoU)	Memorandum van overeenstemming tussen Nederland en Vlaanderen met betrekking tot. de onderlinge samenwerking ten aanzien van het Schelde-estuarium	2001	2001
MoU Vlissingen (2th MoU)	Tweede memorandum van overeenstemming tussen Vlaanderen en Nederland met betrekking tot de onderlinge samenwerking ten aanzien van het Schelde-estuarium	2002	2002
Scheldt Treaty	Scheldeverdrag	2002	2005
MoU Den Haag (3th MoU)	Derde memorandum van overeenstemming tussen Vlaanderen en Nederland met betrekking tot de onderlinge samenwerking ten aanzien van het Schelde-estuarium	2005	2005
Pilotage Rates	Verdrag tussen het Vlaams Gewest en het Koninkrijk der Nederlanden inzake de beëindiging van de onderlinge koppeling van de loodsgeldtarieven	2005	2008
Joint Nautical Management	Verdrag tussen het Vlaams Gewest en het Koninkrijk der Nederlanden inzake het gemeenschappelijk nautisch beheer in het Scheldegebied	2005	2008
Common Policy and Management	Verdrag tussen de Vlaamse Gemeenschap en het Vlaams Gewest, enerzijds, en het Koninkrijk der Nederlanden, anderzijds, inzake de samenwerking op het gebied van het beleid en het beheer in het Schelde-estuarium	2005	2008
Development sketch 2010 for the Scheldt Estuary	Verdrag tussen het Vlaams Gewest en het Koninkrijk der Nederlanden betreffende de uitvoering van de ontwikkelingsschets 2010 Schelde-estuarium	2005	2008
Scheldt Council Institution	Besluit van het Politiek College van de Vlaams-Nederlandse Scheldecommissie inzake de instelling en activering van de "Schelderaad"	2014	2014

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Directives			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2007/60/EC	Directive on the assessment and management of flood risks (Floods Directive)	2007	60
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 13 July 2001	Besluit van de Vlaamse Regering betreffende de aanduiding van de maritieme toegangswegen en de bestanddelen van de haveninfrastructuur	2001-07-13/90

15 Blue Economy and Innovation

Authors Chantal Martens[1], Ine Moulaert[1], Hans Pirlet[1], Lien Loosvelt[2], Ann Overmeire[2], Gert Verreet[3]

Lectors Lisa Devriese[1], Fien De Raedemaecker[1]

[1] Flanders Marine Institute (VLIZ)
[2] The Blue Cluster (DBC)
[3] Department of Economy, Science and Innovation (EWI)

Martens, C., Moulaert, I., Pirlet, H., Loosvelt, L., Overmeire, A., Verreet, G. (2022). Blue Economy and Innovation. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 237-252.

There is no unique definition for the term Blue Economy. In the narrowest sense, the term Blue Economy refers to the collection of a number of economic sectors connected to the ocean, seas and coasts, as e.g. defined in Bilsen et al. (2019) or De Backer (2017).This description includes sectors directly active in the marine and coastal environment (such as fishing or maritime transport) as well as land-based sectors with a clear link to marine activities (such as shipbuilding or port activities). The Blue Economy is thus a multi-sectoral and constantly, dynamically evolving part of the economy, where newer sectors such as renewable offshore energy and blue biotechnology, are standing side by side with the more traditional sectors like fishing and maritime transport.

Broader than just the economic aspect, it can be argued that the Blue Economy doesn't only include industries, but also the natural resources and ecosystem services provided by the ocean (such as sea food production or CO_2 capture) (OECD 2016). The origin of this broader interpretation of the Blue Economy can be traced back to the United Nations Conference of 2012 (RIO +20) (Eikeset et al. 2018)[1]. Also the United Nations Conference on Trade and Development (UNCTAD 2014, 2018), the Food and Agriculture Organization of the United Nations (FAO 2018), the World Bank (2017) and the High Level Panel for a Sustainable Ocean Economy (Stuchtey 2020) are examples of organisations that follow this broader interpretation, with two pillars within the Blue Economy: the ecological and the economic aspects. A similar evolution is noticeable at the European level where the Blue Growth strategy, as launched in 2012 (COM (2012) 494), has evolved over the years towards the development of a sustainable Blue Economy as recently confirmed in a new communication (COM (2021) 240). In this last communication, the Blue Economy is put forward as one of the carriers of both the Green Deal (COM (2019) 640) and the European recovery strategy (COM (2020) 442). The ocean and its economy are seen therein as indispensable to achieving the environmental and climate goals. In this context, the Blue Economy is also an essential element in the pursuit of the Sustainable Development Goals (SDGs) defined in the United Nations Agenda 2030. At first, there is a link with SDG 14 'Life below water - Conserve and sustainably use the oceans, seas and marine resources for sustainable development'. There is also a link with other SDGs, such as responsible production and consumption (SDG 12), affordable and clean energy (SDG 7) and zero hunger (SDG 2). A literature review on the link between the Blue Economy and the SDGs was made by Lee et al. (2020).

Innovation is crucial for both the established and emerging marine and maritime sectors in order to grow in a sustainable way (see, among others, OECD 2019). In this context, the North Sea Vision 2050 (De Backer 2017) promotes not only technological innovations, but also social and policy innovation.

Sectors within the Blue Economy

The sectors that are part of the Blue Economy are not firmly set, and the classification and naming of these sectors may differ between approaches and reports (e.g. the socio-economic reports in the framework of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) (Belgian State 2018) or the reports from the European Commission (EC) (e.g. EC 2018, EC 2019)) or the Organisation for Economic Cooperation and Development (OECD 2016)). In the present text, the sectors as named in the EU Blue Economy Report (EC 2021), will be used as a uniform framework (table 1).

The total collection of sectors that make up the Blue Economy is also subject to change. An illustration of this is the offshore wind energy sector, which has evolved from an 'emerging' to an 'established' sector (figure 1). It should also be noted that the qualification of sectors as 'emerging' in the context of the EU Blue Economy reports may also be a reflection of the lack of qualitative data.

15.1 Policy context and actors

15.1.1 Global and European policy context and policy actors

The United Nations Convention on the law of the sea (UNCLOS 1982), which also codified previous generally accepted legal practices, constitutes the current global legal framework for marine and maritime activities. This convention regulates a number of important uses of marine areas and the extent to which a coastal state or a port state (of ships) can have control over those activities. One example is the spatial zoning from the coast with the concept of the Exclusive Economic Zone (EEZ), which is connected to the territorial waters (to which the coastal state has all sovereign rights). The EEZ is the zone within which a coastal state also has all exclusive rights to exploit or conserve resources located in the water, on the seabed or beneath the seabed (RD of 22 April 1999).

[1] In a 2010 publication by the Club of Rome, the Blue Economy is defined even more broadly as a collection of nature-based solutions with a positive impact on the global economy (linked also to the definition of the Green Economy, see Kettunen and Ten Brink 2012 and Silver et al. 2015). Please note that this definition of the term Blue Economy is not linked to the marine and maritime aspect and is not considered further in the present thematic chapter.

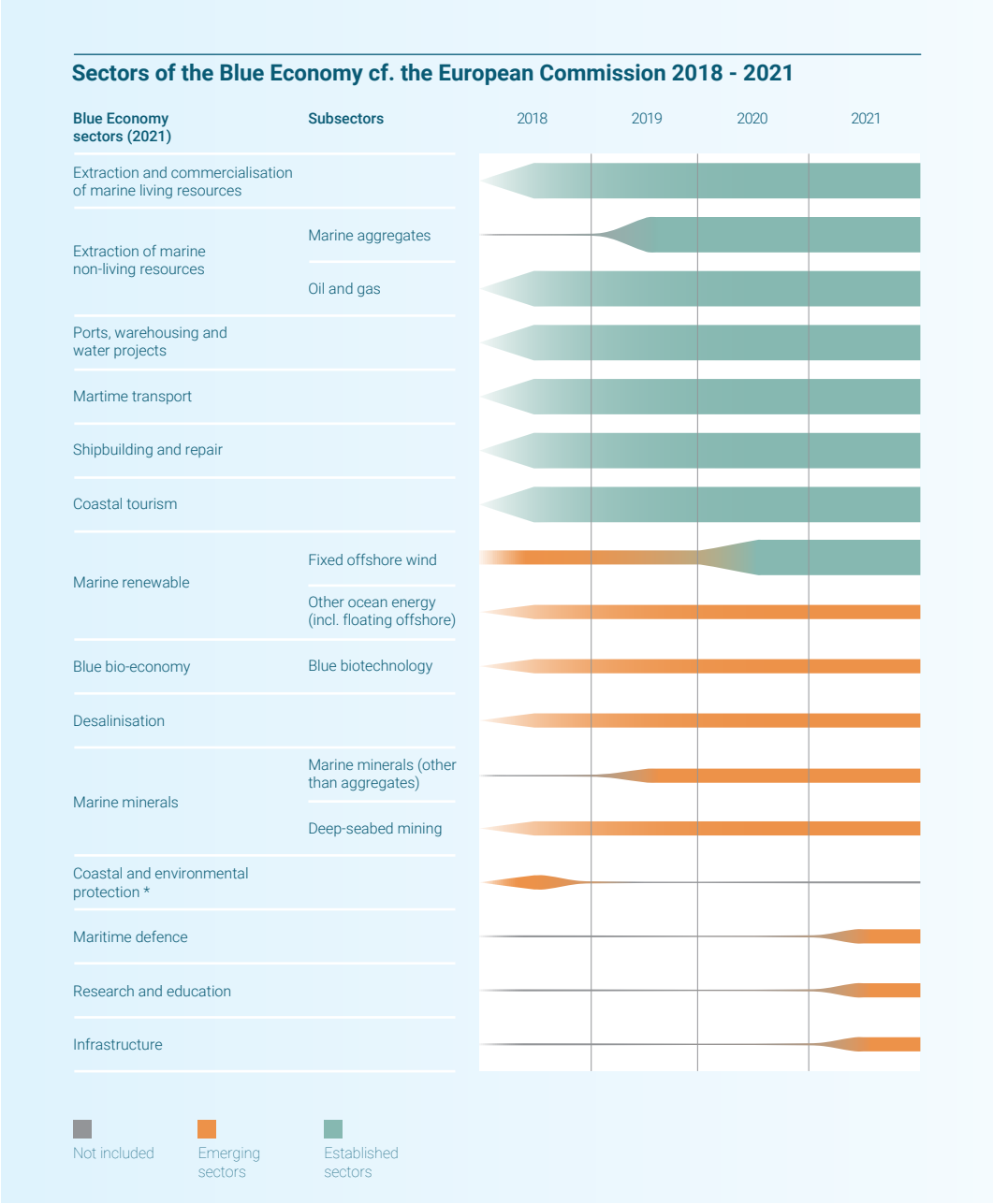


Figure 1. Overview of emerging and established sectors (based on the EU Blue Economy Report for the period 2018-2021 (EC 2018, 2019, 2020 and 2021)). *Coastal defense is not included in the reporting as a separate sector after 2018.

UN organisations operate as regulators for certain aspects of the Blue Economy, such as the International Maritime Organization (IMO) for shipping and the International Seabed Authority (ISA) for the use of minerals from the area beyond state control. Affiliated with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Intergovernmental Oceanographic Commission (IOC) functions as a hub for the promotion of marine scientific research that is indispensable to the "environmental" pillar of sustainable development (see thematic chapter **Integrated maritime policy**).

At the European level, within the EC (with some powers of 'executive' within the EU), the Directorate-General for Maritime Affairs and Fisheries (DG MARE) is responsible for policy preparation and implementation on Blue Economy. The Blue Economy has been on the agenda since the Strategic Objectives 2005-2009, published in 2005 (COM (2005) 12), which expressed the need for an all-encompassing maritime policy, with a view to developing the Blue Economy. This was followed by the publication of the Integrated Maritime Policy (COM (2007) 575), which represents a holistic approach to all EU maritime policy matters. The Blue Growth Strategy (COM (2012) 494) is

the long term strategy for sustainable growth in the marine and maritime sector. Through further iterations (figure 2) this evolved towards the 2021 Communication, on a new approach to a sustainable Blue Economy in the EU (COM (2021) 240). This Communication sets out a detailed agenda that supports the green transition, replacing uncontrolled expansion with clean, climate-resilient and sustainable activities. Therein, the Blue Economy is seen as essential to achieving the ambitions of the European Green Deal (COM (2019) 640). These include climate

Table 1. Overview (emerging and established) Blue Economy sectors (sectors and description according to the EU Blue Economy Report 2021 (EC 2021)).

Sector	Short description of the sector	Relevant thematic chapters in the Knowledge Guide Coast and Sea 2022	Link with Blue Cluster domains*	Link with OECD sectors (OECD 2016)**
Marine living resources	Includes the exploitation of biological resources, their conversion into food, feed, bio-based products and bioenergy (processing) and their distribution along the supply chain. Within European reporting, fisheries and aquaculture are counted together here. The other sectors from the overarching blue bioeconomy, in particular biotechnology and bioenergy, are further included as emerging sectors.	Fisheries; Marine aquaculture	Sustainable seafood and marine biotechnology (incl. bioprospecting)/ Ecosystem approach	*Capture fisheries; Seafood processing; Marine aquaculture (emerging)*
Marine non-living resources	Includes oil and gas exploitation, the extraction of marine aggregates (sand and gravel), clays and salt, as well as support activities for these. Exploitation of other mineral deposits such as manganese or cobalt is included under the emerging sector of marine minerals	Sand- and gravel extraction	Coastal protection and use of mineral resources (excl. oil and gas)	*Marine and seabed mining; Offshore oil and gas*
Marine renewable energy (offshore wind)	Includes the production and transmission of electricity, based on offshore wind energy. Other forms of ocean energy, such as wave or tidal energy, for example, are considered emerging sectors	Energy (including cables and pipes)	Renewable energy & freshwater production	*Offshore wind energy*
Port activities	Includes cargo handling and storage as well as hydraulic engineering and service activities related to water transportation	Maritime transport, shipping and ports; Dredging and dumping	Maritime connection (excl. Port logistics)	*Ports*
Shipbuilding and repair	Includes building, repairing and maintaining ships; as well as manufacturing equipment and machinery	-	Maritime connection (*incl. clean and smart shipping; Smart seas*)	*Shipbuilding and repair*
Maritime transport	Includes both passenger and freight transportation, as well as the provision of equipment for water transportation and support activities	Maritime transport, shipping and ports	Maritime connection	*Shipping*
Coastal tourism	Includes accommodation, transportation and other activities (including sale of goods and catering)	Tourism and recreation	Blue tourism	*Maritime and coastal tourism*
Ocean energy	Includes technologies for renewable energy production, excluding offshore wind energy (with a foundation on the seabed): ocean energy (tidal and wave energy, thermal energy conversion, salt gradient), floating solar photovoltaic (FPV), floating wind energy and renewable hydrogen production offshore.	Energy (including cables and pipes)	Renewable energy and freshwater production	*Ocean renewable energy*
Blue bio-economy and biotechnology	Includes all living marine resources that are not traditionally commercially exploited, such as algae or bacteria.	Marine aquaculture	Sustainable seafood and marine biotechnology	*Marine biotechnology*

Sector (continuation)	Short description of the sector	Relevant thematic chapters in the Knowledge Guide Coast and Sea 2022	Link with Blue Cluster domains*	Link with OECD sectors (OECD 2016)**
Desalination	Includes desalination of brackish and salt water	-	Renewable energy & freshwater production	-
Marine minerals (other than aggregates)	Includes, in addition to the extraction of elements dissolved in seawater (e.g. salt and potassium), the extraction of minerals and metals in or on the seabed such as, for example, manganese, titanium, etc.	-		*Marine and seabed mining*
Maritime defense, security and surveillance	Includes maritime defense, which refers primarily to the Marines, as well as the sectors of maritime security and surveillance.	Military use	*Smart seas*	*Maritime safety and surveillance*
Research and education	Includes the research and innovation , related to the Blue Economy	Indicator report Marine Research and Innovation 2018 (Pirlet et al. 2018)	All domains	*Marine R and D and education*
Infrastructure	Includes submarine cable and robotics sectors	Energy (including cables and pipes)	Renewable energy & freshwater production (incl. *hybrid grids); Smart seas*	*Marine manufacturing and construction; high tech marine products and services*

** For more nuance and details on the thematic links, the Blue Cluster innovatieroadmaps can be consulted.*
*** Not all OECD sectors are included in this table.*

neutrality and zero pollution, the transition to a circular economy, the preservation of biodiversity and investment in nature, sustainable food production and improved marine spatial management. At the EU level, there are several further generic legislative and policy instruments that are relevant to the Blue Economy. The most pertinent instruments are listed in the **Legislation reference list** and figure 2. Sector-specific regulations are addressed in the relevant thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

Europe also identifies Blue Innovation as a key component of the Blue Economy (COM (2014) 254). As such, within the Horizon Programme 2021-2027, new partnerships are being established (including the Sustainable Blue Economy Partnership and the European Partnership on zero-emission waterborne transport). These collaborations between the EU, national authorities and the private sector support a program of research and innovation. These partnerships replace previous forms of financial cooperation between the EU and member states (such as the European Research Area Network (ERA-Net) Cofund scheme). The proposed partnership 'A climate neutral, sustainable and productive Blue Economy', with focus on the Blue Economy, published its draft Strategic Research and Innovation agenda in 2021 (Horizon Europe Candidate Partnership 2021). In addition, the so-called Missions are introduced for the first time. These missions will provide concrete solutions by 2030 in order to take major steps forward on five specific themes. This new concept tries to ensure focus and cooperation from the research and innovation policy perspective so that the necessary efforts, such as funding programs, policies and regulations, citizen participation etc. are facilitated with specific goals as a result (COM (2021) 609). The mission Restore our Ocean and Waters by 2030 specifically focuses on research and innovation around marine and freshwater environments (see thematic chapter **Integrated maritime policy**).

The importance of innovation at European Union level is further underlined by the ambition, stated in the Strategic innovation agenda 2021-2027, to launch a new Knowledge and Innovation Community (KIC) on water, marine and maritime sector and ecosystems in addition to existing KICSs such as those on climate, raw materials or food, within the European Institute of Technology (EIT). However, this KIC is currently still a pipe dream.

15.1.2 Belgian, Flemish and local policy contexts and actors

For Belgium, the special Law of 8 August 1980 defines the division of powers between the federal and regional authorities. The management of the Belgian part of the North Sea (BNS) is a federal competence whereby the minister of the North Sea plays a central role in the roll-out and coordination of economic activities at sea. In the North Sea Policy Statement (Van Quickenborne 2020), the Blue Economy (in general) and specifically Blue Energy are put forward as two of the five pillars for the North Sea policy. It is also stated that these will be based on the science-based policy principle.

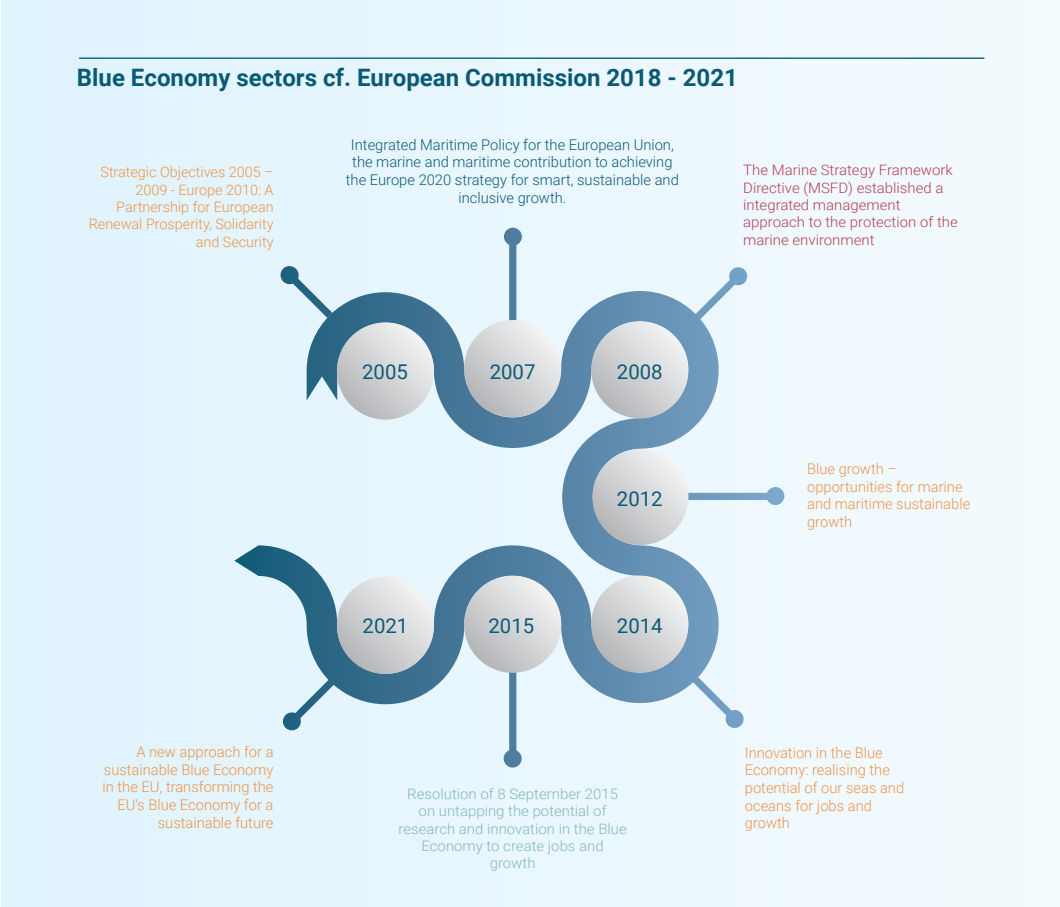


Figure 2. Timeline of EU policies on Blue Economy.

The Flemish Region is competent for a number of the activities within the economic sectors that are exercised on the BNS, namely sea fisheries, (coastal) tourism and the seaports (including the maritime access to these seaports). For an overview of the respective federal and Government of Flanders' services involved in specific aspects of the Blue Economy, we refer to the relevant thematic chapters in the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

On the Flemish level, the policy domain of Economy, Science and Innovation (EWI) is increasingly focusing on Blue Economy and Innovation themes. An important instrument in this context is the so-called cluster policy (see the cluster Decision of 4 March 2016) that provides a framework for collaborations between Flemish companies around innovation and development, coordinated by the Flanders Innovation and Entrepeneurship Agency (VLAIO). Currently, two types of clusters are operational: the innovative business networks (IBN) and the spearhead clusters (with seven active clusters). The latter operate on a larger scale than the business networks and are responsible for realising, in a triple helix cooperation, an ambitious long-term strategy and competitiveness programme. In 2018, a spearhead cluster for the Blue Economy was established: The Blue Cluster (DBC). This cluster currently brings together over 180 companies and partners, including the members of the former Flanders Maritime Cluster (FMC) and IBN Offshore Energy (both incorporated in The Blue Cluster) and the members of the Belgian Offshore Cluster (BOC). The Blue Cluster works on six thematic areas, namely: sustainable seafood and marine biotechnology, blue tourism, coastal protection and use of mineral resources, renewable energy and freshwater production, ocean pollution and waste solutions and maritime connection (table 1). In addition to these domains, there are two transversal domains on ecosystem approach and the smart sea concept. Within the policy domain of EWI, there is also an active commitment to marine research and innovation through thematic calls via the Fund for Scientific Research (FWO) and VLAIO (e.g. the thematic call on blue bioeconomy (2020), in the context of the Flemish policy plan on bioeconomy (2020)). An overview of the Flemish Blue Research and Innovation System, linked to the objectives of the UN Decade for Ocean Science, is given in (EWI/VLIZ/DBC 2021).

Furthermore, the Flanders Marine Institute (VLIZ) acts as the marine research platform within Flanders by actively mapping the wider research community of universities and knowledge institutions (Pirlet et al. 2021), supporting

them with infrastructure and representing them. In doing so, VLIZ also has a specific mission to conduct research and innovation that can be valorised by actors in the Blue Economy.

In addition to the Flemish and federal level, the Blue Economy is a sector that also has links with policy actors on a provincial and local level. In West Flanders, the Blue Economy is supported by the West Flanders Development Agency (*POM West-Vlaanderen*), which has set up so-called 'Factories for the Future', which are committed to, among other things, Blue Energy. Companies, government and research institutions work together in the development of test platforms at the international level (for example the Blue Accelerator test platform). Furthermore, the Technical University Alliance for Economic Transformation in West Flanders (TUA West) is an external agency of the province of West Flanders that brings companies, knowledge institutions and governments together in a triple helix configuration and where Blue Energy is one of the focal points.

The local and (sub-)regional initiatives and actors in Blue Economy and Innovation are geographically linked to the Flemish seaports (see also thematic chapter **Maritime transport, shipping and ports**). For example, in Antwerp there is the Maritime Campus Antwerp, which connects sustainable and water-related companies and houses companies and research institutions (incl.laboratories, workshops and R&D halls). The Port of Antwerp has opened up the port area as a testing ground for new ideas and projects and has a collaboration agreement with the University of Antwerp where research projects are set up on subjects such as autonomous sailing or water quality in the docks.

Port Oostende is actively engaged in the sector of renewable offshore energy, with, among others, the development of the REBO heavy lift terminal. Ostend Science Park, a collaboration between Ghent University, the West Flanders Development Agency, and Port Oostende, is developing a science park where companies linked to the Blue Economy can make use of test facilities and know-how, including the Flanders Maritime Laboratory. The headquarters of Ostend Science Park, Bluebridge, functions as an incubator for innovative companies from the Blue Economy. Near port Oostende, the InnovOcean Campus is located, the joint home of VLIZ and the Ostend branch of the Research Institute for Agricultural, Fisheries and Food (ILVO), which will be inaugurated in 2022. The Eguermin site also hosts the Naval Mine Warfare Centre of Excellence (NMWCO) and the Ostend branch of the Operational Directorate Natural Environment of the Royal Belgian Institute of Natural Institute for Natural Sciences (RBINS-OD Nature).

North Sea Port Flanders (port area of Ghent) is committed to sustainability, with investments in circular energy projects, climate and energy (North Sea Port 2021), among others. In Zeebrugge, the private sector within the port has united in the Association Port of Zeebrugge Interests (APZI). Furthermore, the Port of Zeebrugge is also committed to innovation, working on the rollout of a 5G network in the port and there is a link with innovations from the naval component of Belgian Defense, which has its home base there.

15.2 Spatial use

In the preparation process for the current marine spatial plan (MSP 2020-2026, RD of May 22, 2019, see also Verhalle and Van de Velde 2020) for the BNS, which was outlined in the document North Sea Vision 2050, Blue Economy and Innovation were already put forward as one of the three supporting themes, the other two being naturalness and multi-use of space. Marine spatial planning can help countries grow their maritime economies sustainably (MSP Platform 2018) and is an essential component of the Integrated Maritime Policy (Scholaert et al. 2020). Furthermore, a MSP can also play a role as a catalyst for innovative, high-tech solutions by establishing test zones (Martens et al. 2019). In the BNS, an evaluation of the first MSP 2014-2020 indicated a net positive economic impact (COGEA et al. 2020).

The MSP 2020-2026 regulates the spatial use for the existing sectors of the Blue Economy with the demarcation of specific zones for the relevant user functions. The principle of multiple use of space is hereby put forward as the standard concerning spatial use within the BNS in 2050. Industrial research, trials under realistic conditions and demonstration projects are permitted everywhere, providing certain conditions are fulfilled. In addition, earmarked zones for research and testing are also provided. These zones are more specifically the Ostend zone (for industrial trials), a reference zone for the calibration and evaluation of measuring devices (where bottom-disturbing activities are prohibited) and a zone as a reference area for the study of the impact of wind farms and sand and gravel extraction. In addition, a specific area is foreseen near De Panne to carry out tests on coastal protection. The MSP also identifies specific zones for generic commercial and industrial activities (CIA). There are five zones in total, from zone A to zone E. As of early 2022, zone C has gone through the entire permit process for the operation of the Westdiep[2] marine farm (see thematic chapter **Marine aquaculture**).

[2] Some parties, including the town of Nieuwpoort, appealed the user and environmental permit. At the end of 2021 there was no ruling yet.

Based on the economic sectors of the Blue Economy, as defined in the Blue Economy Report (EC 2021) (see the section **Sectors within the Blue Economy**), the potential space requirement per sector can be calculated (table 2). This space requirement is based on the zones defined in the MSP (2020-2026), whereby only the zones where economic sectors were active and/or authorised in 2021 have been taken into account and whereby for newly defined zones with a clear main function (such as the Princess Elisabeth zone), only its main function (i.e. energy supply) has been taken into account. It should be noted that not every sector from the Blue Economy has been assigned specific zones in the BNS (figure 3). This is partly because not every economic sector is active in BNS (such as desalination, which only takes place in the coastal region), but partly also because for some sectors, such as tourism or research and development, the entire BNS is made available. Taking the above into account, one obtains an area four times larger than the BNS when adding up the total area available to all economic sectors. The GAUFRE project (BELSPO), although using a different calculation method, calculated a user rate of 264% in 2005 (Van den Abeele et al. 2005).

The density of the current economic activities on the BNS (figure 4) illustrates how several economic sectors can be accommodated at each point of the BNS. This figure is not a measure of the intensity of economic activity, but it does illustrate the extensive degree of multiple use of space that is in place at the BNS. This analysis is independent of other (non-economic) functions such as nature conservation.

Table 2. Overview of the spatial use of the established and emerging (*italics*) sectors of the Blue Economy (based on the MSP (2020-2026) and the Blue Economy Report 2021 (EC 2021). The area for the Princess Elisabeth zone is - to avoid double counting - fully included under marine renewable energy (offshore wind).

Sector	Surface area (km²)	% of BNS
Marine living resources	2,936	84.9
Marine non-living resources	566	16.4
Marine renewable energy (offshore wind)	522	15.1
Port activities	75	2.2
Ship building and repair		
Maritime transport	1,234	35.7
Coastal tourism	3,458	100
Ocean Energy		
Blue Bio-economy and biotechnology		
Desalination		
Marine minerals other than aggregates		
Maritime Defence, Security and Surveillance	1,174	34.0
Research and Education	3,458	100
Infrastructure	920	26.6

15.3 Societal relevance

15.3.1 Mapping the economic importance of the Blue Economy

Mapping the economic importance of the Blue Economy, whether at the regional level or not, poses a number of challenges. After all, the Blue Economy is not a clearly delineated economic sector, but rather a transversal aggregate of different sectors, which in turn may consist entirely or partially of marine and maritime components. This means that in many cases a traditional determination based on the NACE codes[3], cannot be applied arbitrarily. In general, the ocean economy is still not sufficiently understood and information on changes in its condition is often less visible than in other economic areas, hence figures can vary between sources. The OECD is attempting to remedy this by developing ocean economy satellite accounts for countries that wish to obtain a more detailed understanding of the importance of the Blue Economy (Joliffe et al. 2021).

[3] NACE is the abbreviation for General Nomenclature of Economic Activities in the European Communities ("*Nomenclature générale des Activités économiques dans les Communautés Européennes*") and is an official list of activity descriptions, at the European level.

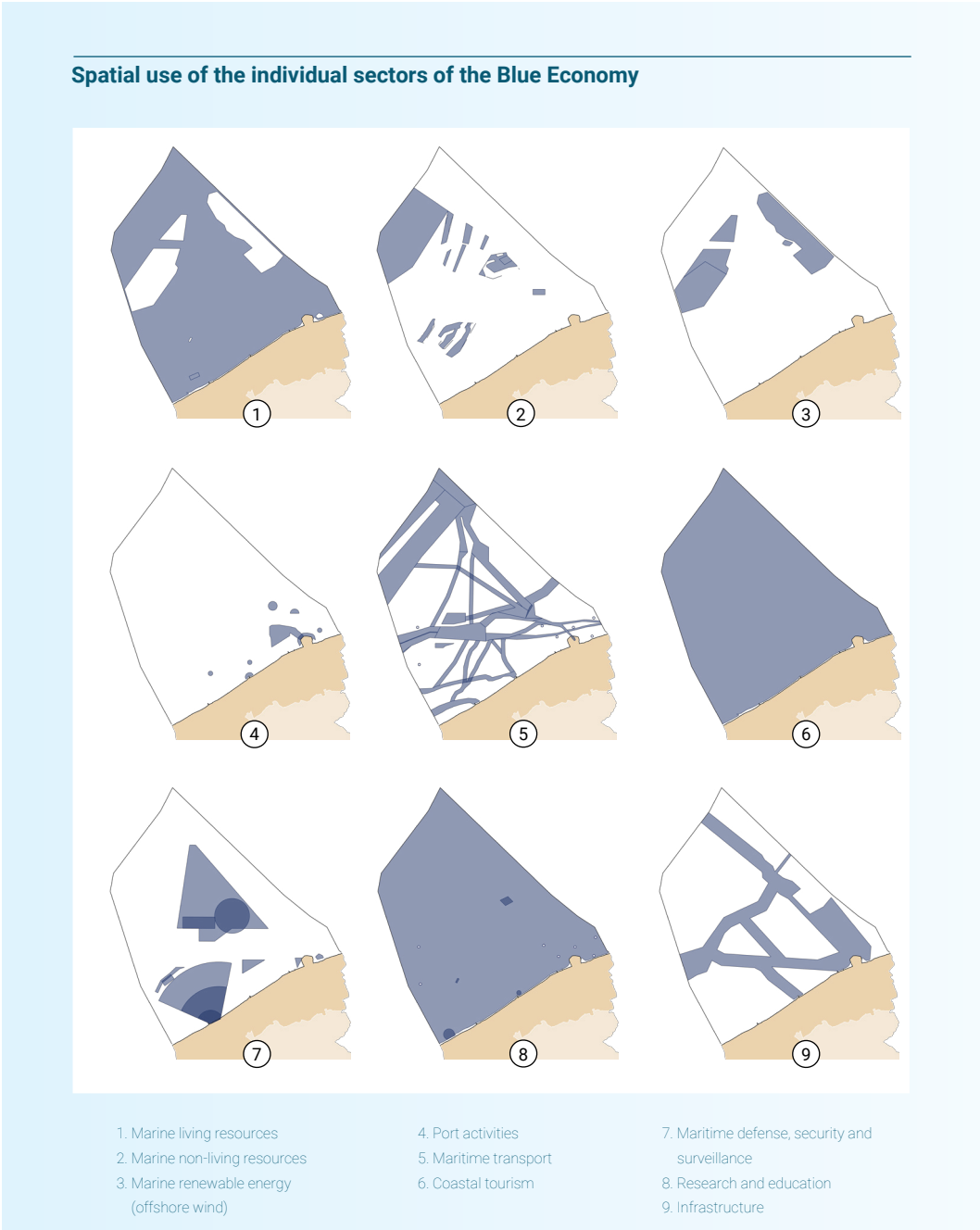


Figure 3. Space use by economic sector on the BNS (sectors based on the EU Blue Economy report 2021 (EC 2021). Zones based on RBINS, MarineAtlas.be (based on RD of 22 May 2019 (MSP 2020-2026)), Coastal Portal.

Specifically for the Flemish level, a mapping of the Blue Economy was carried out in 2019 on behalf of The Blue Cluster (Bilsen et al. 2019), based on the one hand on a top-down approach via the NACE codes and on the other hand on a bottom-up survey of selected companies. From this, a turnover of 30.8 billion euro, with an added value of 7.2 billion euro and an employment of over 75,000 full-time equivalents (FTEs) was calculated. If the direct, indirect and derived impact is taken into account, the turnover is estimated at 48.4 billion euro, with an added value of 13.5 billion euro, which is 5.2% of the Flemish Gross Domestic Product (GDP).

Recently, there has been a growing awareness that the mapping of the Blue Economy should not only take into account the purely economic activities, but that a statistical information system should be created that measures the many ways in which the ocean contributes to the common good on the one hand, and includes the effects of economic activities on the marine environment on the other.(Joliffe et al. 2021). In this way, the focus is on both pillars of the ocean economy: the contribution of economic activities in the ocean and the assets and ecosystem services provided by the marine environment (OECD 2019, Fenichel et al. 2020, Stuchtey 2020).

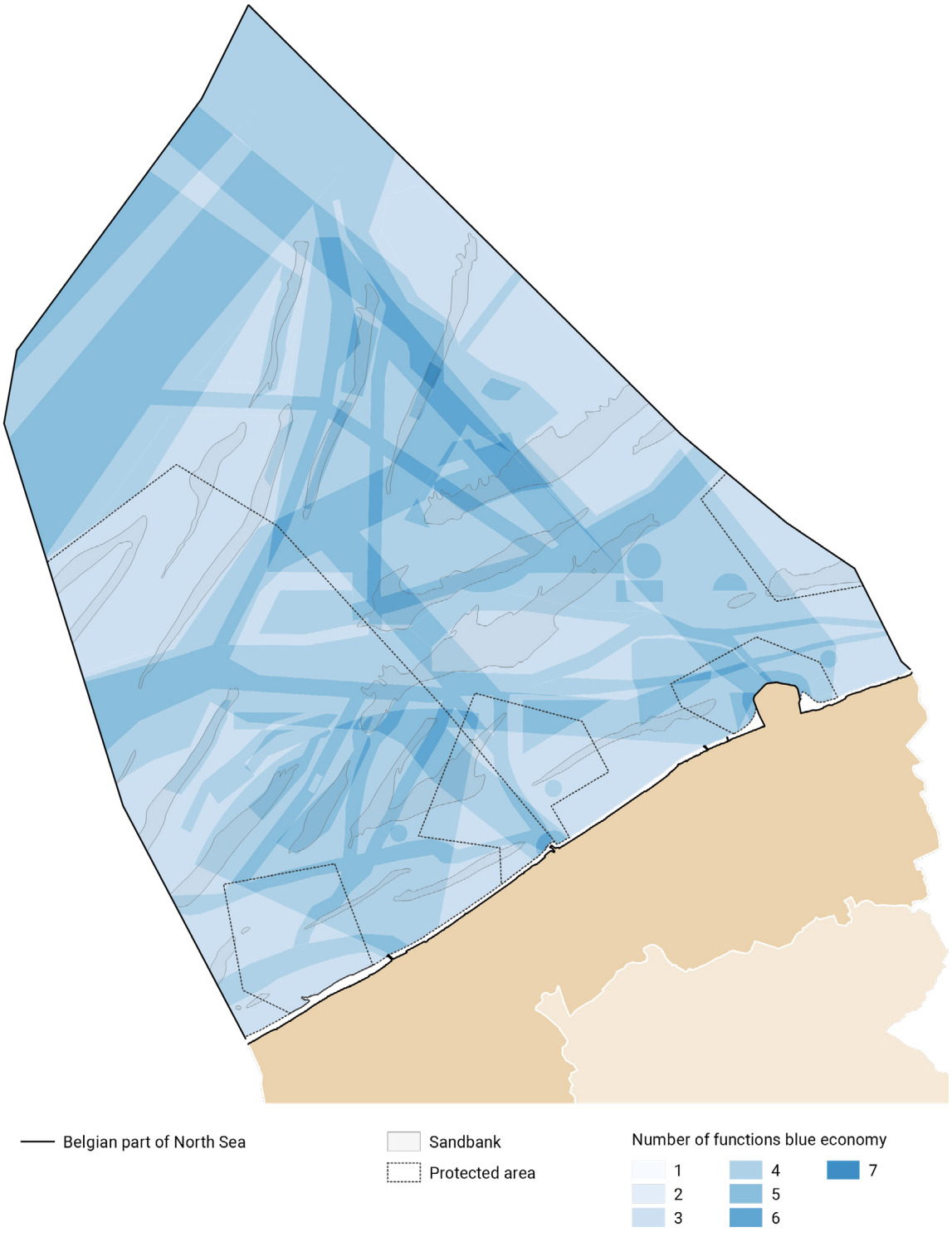


Figure 4. Density of the economic sectors in the BNS (Source: sectors based on the *EU Blue Economy report 2021* (European Comission 2021), Coastal Portal).

15.3.2 The socio-economic importance of Blue Economy sectors

In the majority of the Blue Economy sectors, strong growth rates can be seen between 2009-2018 (EC 2021) (table 3). Due to the different ways in which the Blue Economy can be mapped (cf. supra), these figures may differ from other sources. Table 3 should therefore mainly be seen as a tool for tracing its evolution in Belgium, compared to the period since 2009 and compared to the figures for the European Union as a whole. For the emerging sectors no figures were made available in the EU reporting. They are hence not discussed in the table, but briefly explained in the paragraphs below. For further detailed information on the socio-economic and innovation aspects for both emerging and established sectors, please consult the relevant thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

- **Ocean Energy.** Includes technologies for the production of renewable energy, excluding offshore wind energy (with a foundation on the seabed): ocean energy (tidal and wave energy thermal energy conversion, salt gradient), floating solar photovoltaic (FPV), floating wind energy and renewable hydrogen production offshore. Both in the Long-Term Vision for MSP 2014-2020, as well as the Long-Term Vision for MSP 2020-2026, the ambition is expressed to focus on alternative forms of renewable energy. For several of these designs, innovation and demonstration projects have already been started at the BNS. For further explanation, see the thematic chapter **Energy (including cables and pipes)**;
- **Blue bioeconomy and biotechnology.** This sector includes all living marine resources that cannot be traditionally commercially exploited, such as algae or bacteria. The Flemish policy plan bio-economy (2020) creates the policy framework for supporting the Flemish bio-economy. The BNS has a number of research and innovation projects in this area, which could possibly be incorporated into commercial (aquaculture) projects. For further explanation see the thematic chapter **Marine aquaculture**;
- **Desalination**. Covers the desalination of salt and brackish water. In the water policy note 2020-2025, issued by the Coordinating Committee for Integrated Water Policy (CIW), the desalination of brackish water is put forward as one of the possible avenues for water problems in the coastal zone. In 2020, an installation was built in Ostend, along the Bruges-Ostend canal, which is responsible for the desalination of brackish water for the supply of drinking water with a capacity of up to 24,000 m³ per day (VMM 2021). In 2021, a pilot project for the desalination of brackish and salt water into drinking water was started in Nieuwpoort. In Knokke, the Autonomous Municipal Urban Development Company (AGSO) is conducting a feasibility study on desalinating seawater into drinking water in cooperation with private companies (De Tijd, 16/07/2020). Also in the framework of the Blue Deal of the Government of Flanders and The Blue Cluster, innovation and implementation projects are started by VLAIO and the Department of Environment and Spatial Development (OMG).
- **Marine minerals**. This sector, in addition to the extraction of elements dissolved in seawater (e.g. salt and potassium), also includes the extraction of minerals and metals in or on the seabed such as, e.g., manganese, titanium, etc. These activities do not apply to the BNS, however, Belgium acts as a sponsoring state for the exploration contract of the GSR company for deep sea mining in the Clarion-Clipperton Zone in the Pacific Ocean. Deep-sea mining is regulated in Belgium by the Law of 7 August 2013 and the RD of 13 October 2013;
- **Maritime defense, security and surveillance.** The reason this category is classified as 'emerging' rather than 'established' in the Blue Economy reports is mainly due to the lack of publicly available data on employment and turnover. The European Naval Shipbuilding industry generated a turnover of 26 billion euro in 2019, representing 23% of total European defense revenues (EC 2021). The EU Maritime Security Strategy EUMMS defines strategic maritime interests for the European Union and combines the objectives of the European Security Union strategy with Blue Economy topics. At the Belgian level, reference can be made to the recent investments carried out jointly by the Belgian and Dutch Navies in the context of replacing the mine sweepers and frigates, with an explicit focus on innovation, including the deployment of sailing drones in the context of mine counter measures. The MAiDEN project was set up to ensure a smoother flow of information in the Coast Guard Centre. For further information, see the thematic chapter **Military use**;
- **Research and education.** The Indicator Report - Marine Research and Innovation 2018 (Pirlet et al. 2018) provides an overview of the investments at the European, federal and Flemish level in research and innovation serving the Blue Economy. Therefore, for the detailed overview of investments in marine research and innovation, please refer to this report;
- **Infrastructure (including cables and robotics).** In the EU Blue Economy report from 2021 (EC 2021), both the deployment of robotics and submarine cables (for data, telecommunications and energy) are discussed under this denominator. As far as cables and pipes are concerned, reference is made to the thematic chapter **Energy (including cables and pipes)**. Robotics and drones refer to (semi-)automated vehicles both on land, in or on the water or in the air. A study from 2021 (OECD 2021) indicates that new technologies such as artificial intelligence (AI), cloud computing, the Internet of Things (IoT), process automation, robotics and powerful sensors, have rapidly spread in a wide range of old and new applications

within the mainstream economy. An overview of the robotics that can be deployed in marine environments is given in Langedock (2021). In the BNS, robotics are not only used for research, but also for inspection and maintenance work in the offshore industry, in hydrographic surveys and also in military applications are proving their usefulness. An increased use of robotics also requires an adapted legislative framework (see e.g. Deketelaere 2017). The federal Directorate-General for Maritime Affairs is working, under the umbrella of IMO, on the drafting of an international regulatory framework for autonomous and semi-autonomous ships. The RD of 16 June 2021, which regulates unmanned shipping in the BNS, makes Belgium one of the first countries with legislation on the subject. The importance of robotics for the Blue Economy is also further illustrated by the cooperation and research initiatives that have been set up in this field, such as the partnership Drone Port West-Vlaanderen coordinated by the West Flanders Development Agency, (with projects such as Drone Innovations) and Ostend Drone Hub. The VLIZ Marine Robotics Centre was established in 2019 to give Flemish scientists and their (inter)national partners, as well as other Flemish stakelholders, access to the most advanced technologies in marine research.

15.3.3 Investment platforms for the Blue Economy and Innovation

The European Climate, Infrastructure and Environment Executive Agency (CINEA), established in April 2021, coordinates support for the European Green Deal. The European Maritime, Fisheries and Aquaculture Fund (EMFAF) has a budget of 6.1 billion euro in the period 2021-2027 to support innovative projects that contribute to the sustainable exploitation and management of aquatic and maritime resources. Specifically for the Blue Bioeconomy, the BlueBio Cofund provides a coordinated R&D funding scheme. For further detail on the specific funding of research and innovation, please refer to Pirlet et al. (2018).

When looking at the financing instruments available to innovative Blue Economy companies, a 2018 study reveals that at the European level, the financing sector relevant to the Blue Economy is still emerging and lacks the maturity of more established sectors (Van Aalst et al. 2018). A 2020 report (Sumaila et al. 2020) by the High Level Panel for sustainable Ocean Economy highlights the specific challenges around setting up and financing marine projects and provides an assessment of how economic instruments and financing mechanisms can be deployed to achieve a sustainable ocean economy. Launched in 2020, the BlueInvest Fund is a collaboration between the European Investment Bank (EIB) and the EC, and provides financing for companies with innovative products and services, linked to the Green Deal. This financing is not done directly. The BlueInvest Fund provides funding to funds that focus entirely or partially on the Blue Economy. In addition, the BlueInvest Platform, managed by the EU and running in parallel, supports SMEs and start-ups in accessing funding. In addition to these generic financial instruments there are also more sector-oriented financings, such as e.g. the support from the European Investment Bank (EIB) for the construction of the offshore wind farms in the BNS, whereby the EIB until 2019 has contributed more than 2.5 billion to the sector through the European Fund for Strategic Investments (EFSI) (EC 2019).

The EIB itself, through the Clean and Sustainable Ocean Programme, manages the Blue Sustainable Ocean Strategy (Blue SOS) on the one hand, and the Clean Oceans Initiative on the other, both of which also operate outside Europe. Blue SOS provides long-term loans for (local) governments and private parties, allowing for a doubling of the lending capacity to 2.5 billion euro in the period 2019-2023 on themes such as sustainable coastal defense, green shipping technology, blue biotechnology, and sustainable marine nutrition. Rather, the Clean Oceans Initiative focuses on reducing the input of (plastic) waste to the ocean. The World Bank's ProBlue fund supports the development of integrated, sustainable and healthy marine and coastal resources.

At the Flemish level, VLAIO's grants database collects all basic information on funding, advice and grants. The FIVA (*Financieringsinstrument voor de Vlaamse Visserij- en Aquacultuursector*) and EMFAF (European Maritime Fisheries and Aquaculture Fund) are the instruments used at the Flemish level to support the fisheries and aquaculture sector. It concerns start-up and investment support as well as support for research, auctions, processing and commercialisation.

15.4 Impact and Sustainable use

Each of the Blue Economy sectors has a certain impact on the marine environment. A general overview can be found in the strategic environmental assessment of the draft marine spatial plan (MSP 2020-2026) (Volckaert and Durinck 2018) or in the North Sea Vision 2050 (De Backer 2017). The socio-economic analysis made in the framework of the MSFD in turn provides an estimate of the cost of measures to avoid the degradation of the BNS (Belgian State 2018). For the specific permit processes, monitoring efforts and sectoral impact, see the relevant thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022).

Table 3. Overview for established sectors of employment and value added in 2018, and evolution relative to 2009. Figures based on EC (2021)*.

Sectors (established)	Employment 2018 (% to 2009) - Belgium	Added value at factor cost in million euro (% to 2009) - Belgium	Employment 2018 in 1,000 (% to 2009) - Europe	Added value at factor cost in million euro (% to 2009) - Europe	Breakdown of the Belgian numbers
Marine living resources	7,712 (+41%)	509 (+48%)	538.4 (-3%)	19,100 (+29%)	The figures for both employment and added value show a strong increase over the 2009 figures, an increase that is also more pronounced in Belgium than on the general European level. This increase is mainly due to a significant increase in processing (into ready meals, for example) and the distribution of seafood.
Marine non-living resources	52 (+132%)	7 (+117%)	11.1 (-68%)	4,243 (-62%)	Employment and turnover figures in Belgium increased between 2009 and 2018, going against the European trend. However, the downward trend at the European level is driven by sharp declines in both employment and turnover in the oil and gas exploitation sector (a sector that does not feature in the BNS).
Marine offshore renewable energy (incl. wind energy)	872 (+10,889%)	114 (+3,788%)	9.0 (+2,246%)	1,495 (+3,582%)	The trends for employment and turnover in this sector in Belgium even exceed the explosive growth recorded at the European level, with an increase by a factor of 100 over the period 2009-2018.
Port activities	14,272 (+44%)	1,780 (+16%)	384.0 (+1%)	26,481 (+15%)	The increase in both employment and added value is mainly due to a strong increase in terms of hydraulic engineering projects and storage and warehousing of goods in the ports.
Shipbuilding and repairs	1,444 (-51%)	130 (-41%)	292.0 (-5%)	14,654 (+30%)	The Belgian figures do not follow the European trend here. Across all subsectors (the construction of ships and pleasure craft and the repair and maintenance of ships), employment and added value are declining.
Maritime transport	4,105 (-35%)	1,237 (+90%)	397.6 (+11%)	30,047 (+12%)	Although there is a strong increase (300+%) in terms of employment in marine transportation subsector, there is a strong decrease in employment in support activities subsectors (brokerage, agents, etc.).
Coastal tourism	9,057 (+57%)	446 (+79%)	2,843.1 (+1%)	80,049 (+21%)	The growth noted compared to 2009 is evenly distributed among accommodation, transportation and other activities (including merchandise sales and hospitality).

** The figures, and trends derived from them, in the 2021 Blue Economy Report may differ - due to the way in which the calculations were done - from figures and trends presented in other reports.*

The Blue Economy and ecology cannot, however, be regarded as two separate entities that are only connected by cause-impact relationships. Where in the past, economic activities were strictly separated from ecological aspects, the realisation has grown that a sustainable Blue Economy can be a pillar of the Green Deal at the European level. More specifically for the BNS, during the preparation of the MSP (2020-2026) in the North Sea Vision 2050 (De Backer 2017), it was said that human activities at sea should be arranged in such a way that they have zero impact or even a positive impact. The latter was a.o. further elaborated in Degraer et al. (2020). The Think Thank North Sea will reflect on *Environmentally Sustainable Blue Growth* in 2021-2022.

The concept of ecosystem services has already been used to enable the translation and connection between ecology and economic activities (Reker et al. 2019). The European Marine Board's (EMB) publication Valuing Ecosystem Services (Coopman et al. 2019) highlights the current thinking on valuing ecosystem services for the marine environment. The practical application of the ecosystem services concept to a number of marine infrastructure projects was a.o. elaborated in Boerema et al. (2016), Van der Biest et al. (2017a), Van der Biest et al. (2017b) and Boerema et al. (2021). The SUMES project provides for the construction of a model that assesses the extent to which the marine ecosystem is capable of providing certain goods and services and the extent to which activities (from the Blue Economy) have an impact on ecosystem goods and services. A recent PIP project (Program Innovative Public Procurement) looks at combining elements of ecosystem services within the existing Environmental Impact Assessment (EIA) framework (Dugernier et al. 2021). A clear example of the link between innovation and sustainability in the Blue Economy, is the growing use of Nature-based Solutions in coastal defense, see also the thematic chapter **Safety against flooding**.

In addition to investment platforms (see **15.3.3 Investment platforms for the Blue Economy and Innovation**), there is also a focus on the sustainability of investments. The Action Plan for Sustainable Growth issued by the EC in 2018 called for the introduction of a general classification system for sustainable economic activities, which led to the Taxonomy Regulation (Regulation (EU) 2020/852). This Regulation defines the four conditions an activity must meet to be considered ecologically sustainable, and does so for six ecological objectives, including the sustainable use and protection of water and marine resources. In order to facilitate the dialogue between the various stakeholders involved in the sustainable realisation of the Green Deal, the Sustainable Finance Platform was established. These initiatives from the EU are part of a broader trend to strive for more sustainable financing. An overview of further initiatives worldwide is given in UNEPFI (2021). Because the pursuit of sustainability also extends beyond EU funding, work is currently underway to develop a Blue Economy sustainability framework (CINEA 2021).

Good quality data on the marine environment is indispensable for sustainable use and management of this environment (Larkin et al. 2022). More and more, this involves collaborations between government, researchers and industry (McMeel et al. 2017, Guidi et al. 2020). The European Marine Observation and Data Network (EMODnet) is therefore also developing specific initiatives towards the private sector.

Legislation reference list

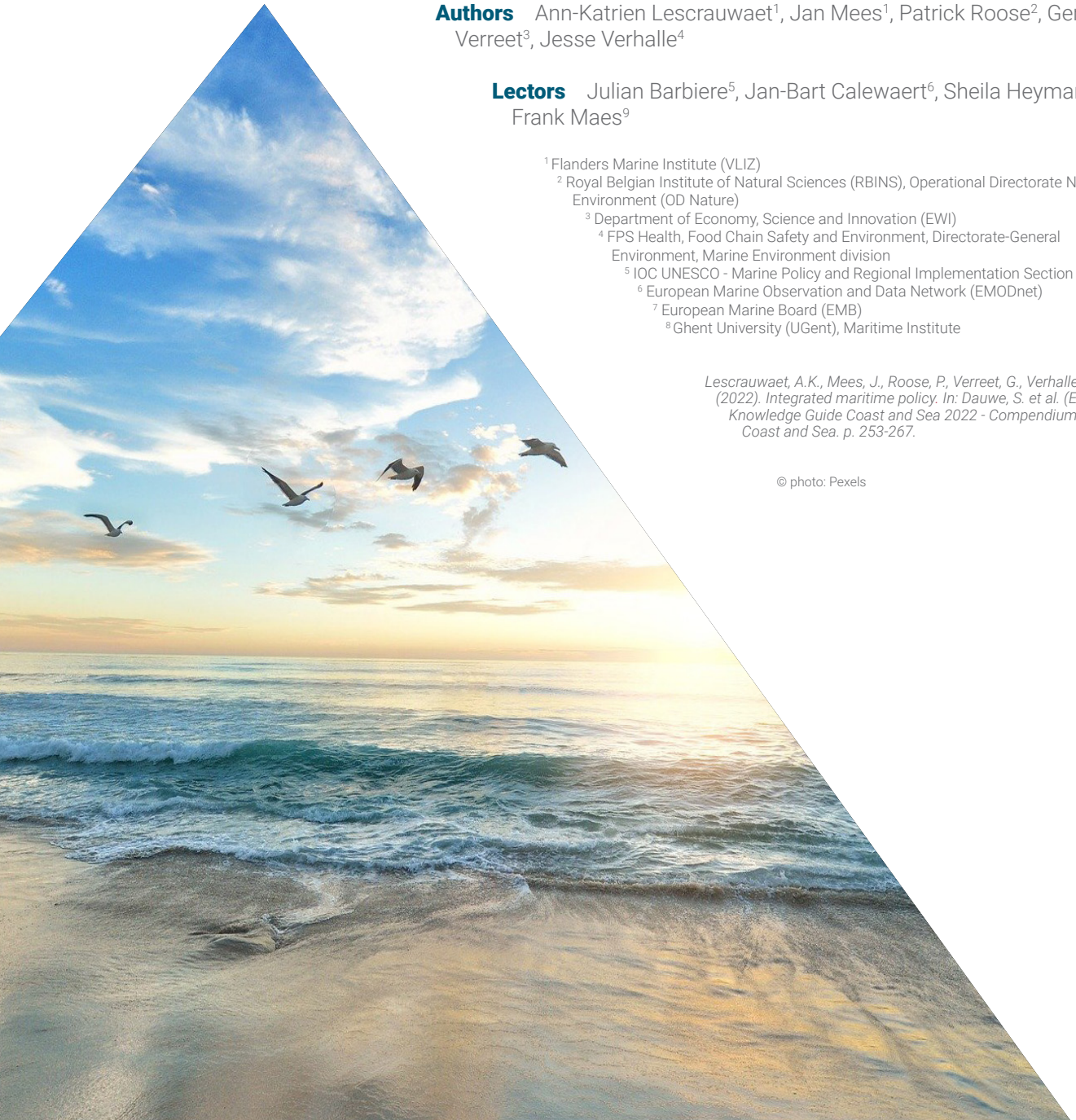
Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
UNCLOS	United Nations Convention on the law of the sea	1982	1994

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Communications			
COM (2005) 12	Strategic objectives 2005-2009 - Europe 2010: A partnership for European renewal prosperity, solidarity and security	2005	12
COM (2007) 575	Communication from the Commission - An integrated maritime policy for the European Union	2007	575
COM (2008) 534	Communication from the Commission - A European strategy for marine and maritime research: a coherent European research area framework in support of a sustainable use of oceans and seas	2008	534
COM (2009) 536	Communication from the Commission - Developing the international dimension of the Integrated Maritime Policy of the European Union	2009	536
COM (2010) 461	Communication from the Commission: Marine Knowledge 2020 marine data and observation for smart and sustainable growth	2010	461
COM (2010) 2020	Europe 2020 - A strategy for smart, sustainable and inclusive growth	2010	2020
COM (2012) 494	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
COM (2014) 254	Communication from the Commission: Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth	2014	254
COM (2019) 640	Communication from the Commission: The European Green Deal	2019	640
COM (2020) 442	Communication from the Commission: The EU budget powering the recovery plan for Europe	2020	442
COM (2021) 240	Communication from the Commission on a new approach for a sustainable blue economy in the EU - Transforming the EU's Blue Economy for a sustainable future	2021	240
COM (2021) 609	Communication from the Commission on European missions	2021	609
Resolutions			
2014/2240(INI)	European Parliament resolution on untapping the potential of research and innovation in the blue economy to create jobs and growth	2014	2240
Directives			
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89
Regulations			
Regulation (EU) 2020/852	Regulation on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088	2020	852

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Decisions of the Govt. of Flanders		
Decision of the Government of Flanders of 4 May 2016	Besluit van de Vlaamse Regering tot regeling van de steun aan de innovatieclusters in Vlaanderen	
Royal Decrees		
RD of 7 September 2003	Koninklijk besluit houdende de procedure tot vergunning en machtiging van bepaalde activiteiten in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-07/32
RD of 9 September 2003	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling in toepassing van de wet van 20 januari 1999 ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-09/30
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 13 November 2012	Koninklijk besluit betreffende de instelling van een raadgevende commissie en de procedure tot aanneming van een marien ruimtelijk plan in de Belgische zeegebieden	2012-11-13/07
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
Laws		
Law of 13 June 1969	Wet inzake de exploratie en exploitatie van niet-levende rijkdommen van de territoriale zee en het continentaal plat	1969-06-13/30
Special Law of 8 August 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 22 April 1999	Wet betreffende de exclusieve economische zone van België in de Noordzee	1999-04-22/47
Law of 20 July 2012	Wet tot wijziging van de wet van 20 januari 1999 ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België, wat de organisatie van de mariene ruimtelijke planning betreft	2012-07-20/39

16 Integrated maritime policy



Authors Ann-Katrien Lescrauwaet[1], Jan Mees[1], Patrick Roose[2], Gert Verreet[3], Jesse Verhalle[4]

Lectors Julian Barbiere[5], Jan-Bart Calewaert[6], Sheila Heymans[8], Frank Maes[9]

[1] Flanders Marine Institute (VLIZ)
[2] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature)
[3] Department of Economy, Science and Innovation (EWI)
[4] FPS Health, Food Chain Safety and Environment, Directorate-General Environment, Marine Environment division
[5] IOC UNESCO - Marine Policy and Regional Implementation Section
[6] European Marine Observation and Data Network (EMODnet)
[7] European Marine Board (EMB)
[8] Ghent University (UGent), Maritime Institute

Lescrauwaet, A.K., Mees, J., Roose, P., Verreet, G., Verhalle, J. (2022). Integrated maritime policy. In: Dauwe, S. et al. (Eds). Knowledge Guide Coast and Sea 2022 - Compendium for Coast and Sea. p. 253-267.

16.1 Integrated ocean policy

16.1.1 The Agenda 2030: a global policy for sustainable development

In September 2015, the United Nations General Assembly (UNGA) adopted the resolution: Transforming our world: the 2030 Agenda for Sustainable Development (figure 1). The Agenda 2030 recognises that climate change is one of the greatest challenges of our time (SDG13) and that increases in global temperature, sea-level rise, ocean acidification, and other impacts are seriously affecting coastal areas, especially in low-lying coastal countries. SDG14 aims to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. The ten targets of SDG14 focus *inter alia* on the reduction of marine pollution and ocean acidification, the conservation and restoration of marine and coastal ecosystems, the ending of illegal, unreported and unregulated fishing (IUU) and perverse subsidies, and the development of marine science capacity and technology transfer.

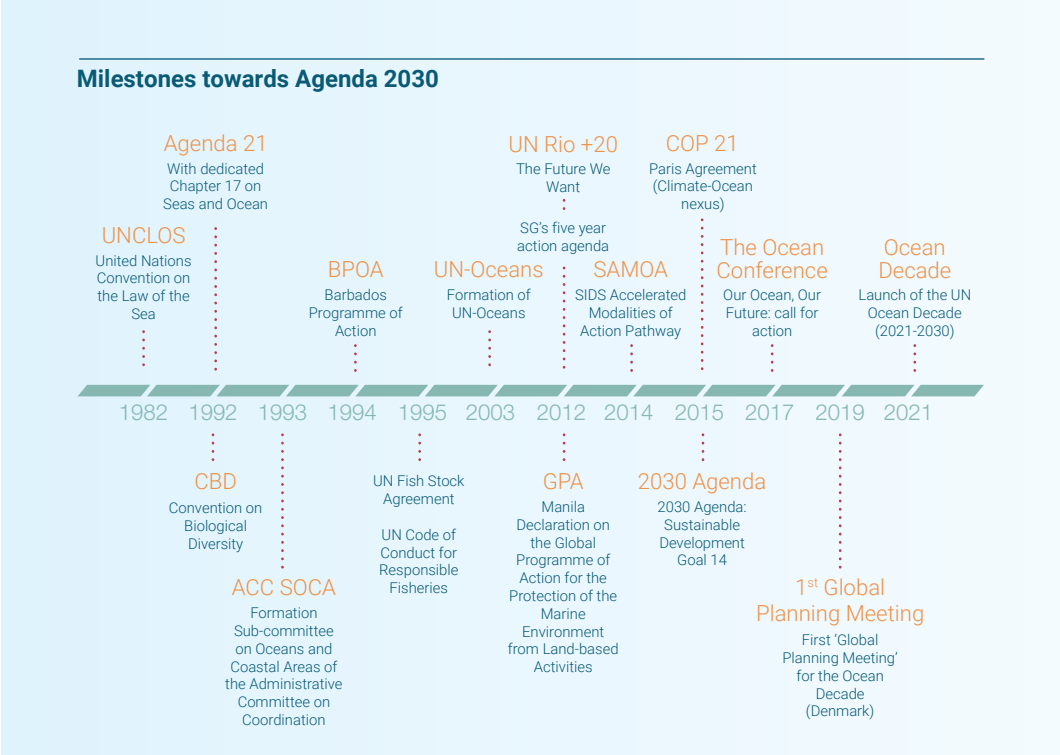


Figure 1. Milestones in the path towards setting the Agenda 2030 and the launch of the United Nations Decade of Ocean Science for Sustainable Development.

The Paris Agreement (2015) was the first of the Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) to acknowledge the intrinsic connection between climate and the ocean (UN 2015). The UNFCCC is crucial in addressing this ocean-climate nexus in support of the Agenda 2030.

Belgium's progress towards achieving the Sustainable Development Goals (SDGs) is assessed at national level by the Federal Planning Bureau. The Flanders Region has set 48 sustainability goals in Vizier2030 to implement the UN Agenda 2030 and the SDGs. Ocean-related SDGs are addressed by supporting the UN Decade of Ocean Science for Sustainable Development (2021-2030), the Ocean Decade.

16.1.2 UN framework and its integrated sustainability agenda for the global ocean

16.1.2.1 UN-Oceans: Inter-agency Coordination Mechanism

The UN-Oceans (2003) (UN Resolution A/RES/68/70) provides the Interagency Coordination Mechanism for various ocean related matters. It reports to the UN General Assembly (UNGA) through the Informal Consultative Process and the Annual Omnibus Resolutions and Annual Reports on Oceans and Seas (figure 2). Ocean related processes established under the UNGA include:

- The UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea (the Consultative Process - ICP established in 2002), an annual intergovernmental forum to discuss ocean issues;
- The Intergovernmental Conference tasked with the development of an international legally binding instrument (ILBI) under the UN Convention on the law of the sea (UNCLOS 1982) on the conservation and sustainable use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ) by 2020 (UN Resolution A/RES/72/249);
- The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-economic Aspects (the Regular Process, UN Resolution A/RES/57/141 and A/RES/58/240), aims to enhance the scientific basis for policy-making. The first cycle of the World Ocean Assessment (WOA) focused on establishing a baseline, while the second cycle extends to evaluating trends and identifying gaps (UN Resolution A/RES/71/257). The WOA-II (Volume I, Volume II 2021) is a collective effort of more than 300 experts to support the achievement of SDGs and the implementation of the United Nations Ocean Decade.

The UN Ocean Conference (New York, June 2017) adopted the intergovernmental agreed political declaration Our Ocean, our future: call for action, emanating from seven partnership dialogues and over 1,400 voluntary commitments to advance the implementation of SDG14 and related targets (UN Resolution A/RES/71/312). Ambassador Peter Thomson was appointed as UN SG Special Envoy for the Ocean in 2017, to follow up on the implementation of these voluntary commitments. The Scientific Advisory Board of the UN Secretary-General identified eight grand societal challenges, including the need for improving ocean science and governance for the development of sustainable ocean knowledge-based economies (UNESCO 2016).

A widely accepted guiding principle in UN (environmental) agreements such as the Convention on Biological Diversity (1992) is the 'ecosystem-based approach', which considers a healthy ecosystem as a basis for sustainable maritime economic activity. The ecosystem approach serves as a guidance in European (marine) legislation and is transposed at national level. An overview of UN Conventions - including UNCLOS, also called the 'Constitution for the oceans' (UNCLOS 1982) - is provided in Maes et al. (2013) and Verleye et al. (2018).

16.1.2.2 UN Ocean Science Agenda: IOC UNESCO

The Intergovernmental Oceanographic Commission (IOC) of UNESCO (figures 2 and 3) is the UN body mandated for the global coordination and implementation of programmes for ocean research, observation, exchange of ocean data and information, early warning, sustainable management and capacity development including training.

In 2017, the IOC published the first Global Ocean Science Report (GOSR 2017), an assessment of the ocean science capacity at the national, regional and global scales, including workforce, infrastructure and publications. A first update in this regular reporting was published in December 2020 (GOSR 2020).

Specific research is conducted in support of the UN organisations responsible for developing policy and regulation e.g. in the domains of fisheries, shipping, nature conservation and biodiversity protection, and on the Arctic and the deep-sea frontiers. UNCLOS part XIII and part XIV provide a legal framework for the conduct of marine scientific research and transfer of marine technology.

16.1.2.3 UN Decade of Ocean Science for Sustainable Development

In December 2017, the UNGA (UN Resolution A/RES/72/73) proclaimed a global UN Decade of Ocean Science for Sustainable Development (2021-2030) as a common framework for ocean science to support countries in the achievement of the SDG14. The UNGA called on the IOC to prepare an Ocean Decade Implementation Plan in consultation with member states, UN bodies, specialised agencies, and relevant stakeholders (see **16.3.2 EU science and innovation agenda for a sustainable use of the ocean**). The Implementation Plan includes a series of high-level Ocean Decade challenges and process objectives, and sets the ambition in terms of data and knowledge management, and capacity development. Bottom-up, it provides a convening framework for scientists and stakeholders to submit transformative Decade Actions that contribute science-based solutions to achieve the 2030 Agenda.

Flanders' marine research and innovation (R&I) community initiated a participative process to disseminate the objectives of the Ocean Decade and create opportunities for solutions-oriented research between researchers, policymaking and the industry (EWI/VLIZ/DBC 2021). A number of Flanders' initiatives, e.g. in ocean biodiversity data and observation, have been acknowledged and adopted as Ocean Decade Actions. In a multilateral context,

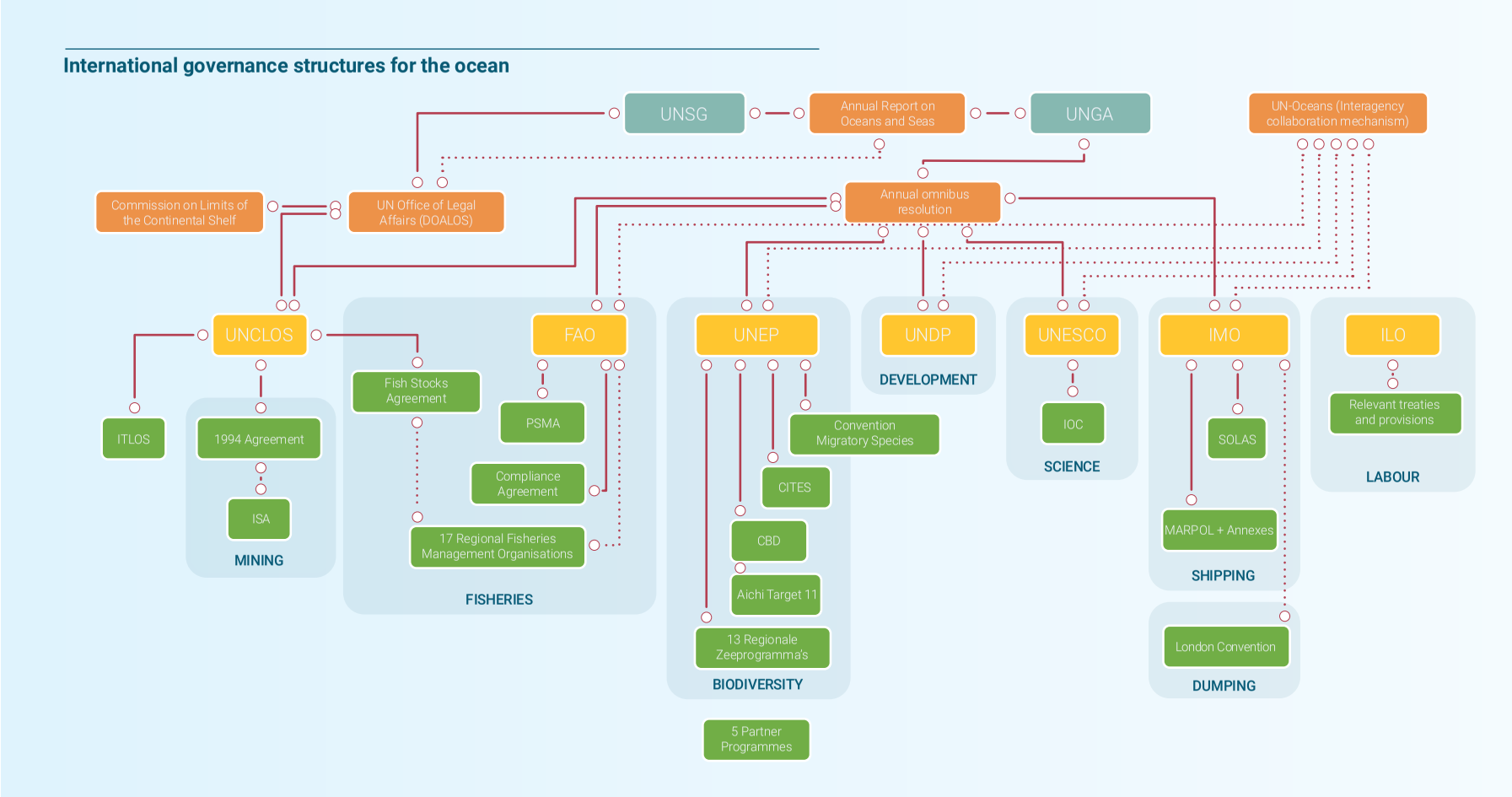


Figure 2. International governance structures for the ocean (Source: Ocean Atlas 2017).

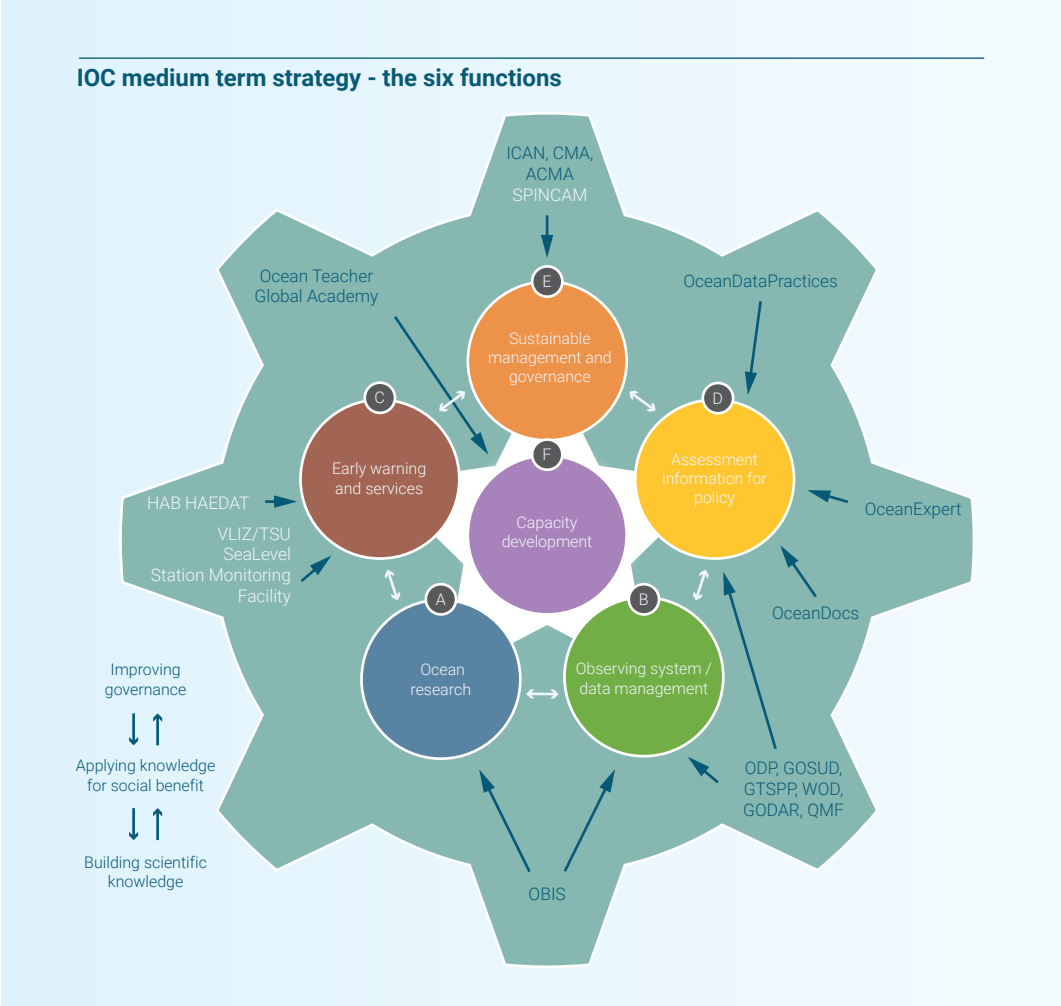


Figure 3. The six main functions in support of IOC-UNESCO Medium-term Strategy 2014-2021.

flagship projects supported by Flanders UNESCO Science Trust Funds support capacity development, training and equitable access to science and technology which is at the heart of an inclusive approach to the Ocean Decade, e.g. the Ocean Teacher Global Academy and the Ocean InfoHub.

16.2 Non-UN agreements

16.2.1 Global and regional conventions

Global, non-UN conventions include the Ramsar Convention (1971) and the International Convention for the Regulation of Whaling (IWC 1946).

At the regional level, the fourteen Regional Seas Programmes have also adopted legally binding, non-UN conventions, for the protection of the marine environment. The four European regional seas conventions include the Helsinki Convention (HELCOM 1974/1992) in the Baltic Sea, the Barcelona Convention (1976) in the Mediterranean Sea, the Bucharest Convention (1992) in the Black Sea and the OSPAR Convention (1992) in the North East Atlantic Ocean and North Sea (figure 4).

OSPAR is the mechanism by which 15 national governments and the EU cooperate to protect the marine environment of the North-East Atlantic, including the North Sea (see thematic chapter **Nature and environment**). The work of the OSPAR Commission is guided by the principle of the ecosystem approach for the integrated management of human activities in the marine environment. The OSPAR secretariat also acts as a secretariat for the Bonn Agreement (1969), which provides a mechanism for the North Sea countries and the EU (the contracting parties) to cooperate in response to pollution in the North Sea area caused by maritime disasters and chronic

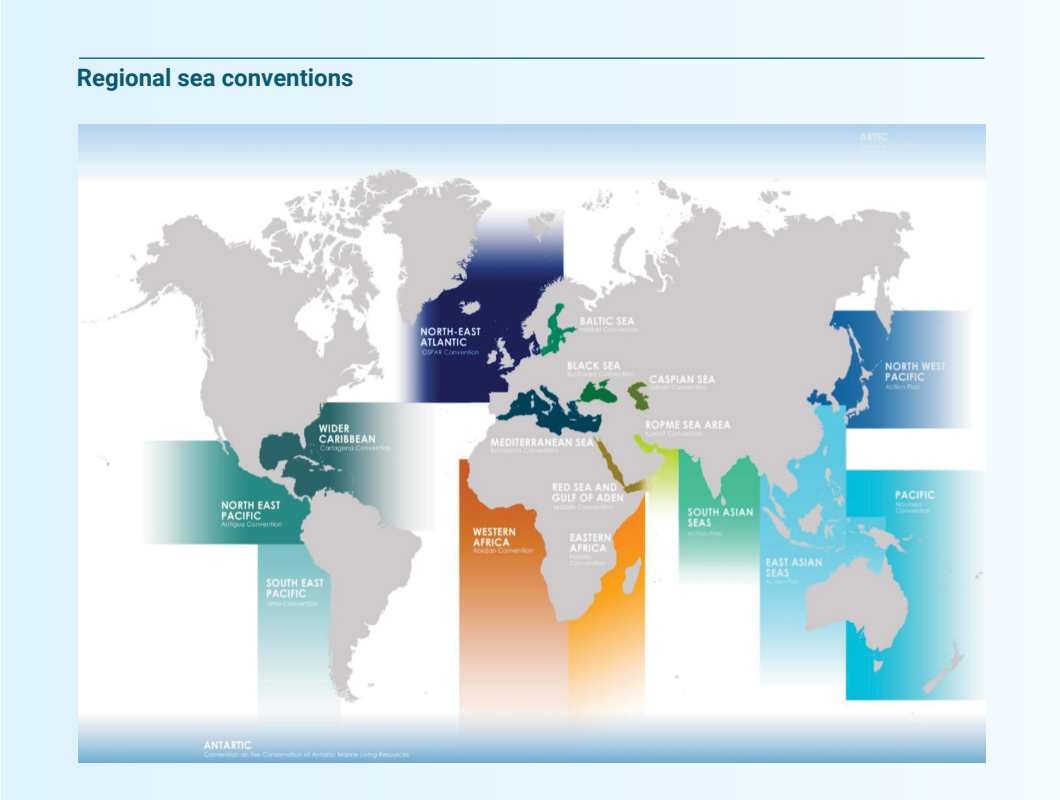


Figure 4. (Non-UN) regional seas conventions worldwide (Source: UNEP).

pollution from ships and offshore installations, and to conduct joint surveillance to assist in the detection and control of marine pollution. In this context, the Ministerial North Sea Conferences and Declarations (1984-2006) have carried out joint actions to assess the state of the environment and to set environmental targets to reduce contamination in the North Sea.

The North-East Atlantic Environment Strategy (NEAES) 2030 (2021) is the means by which OSPAR's 16 Contracting Parties will implement the OSPAR Convention until 2030. It is based around four themes: clean seas; biologically diverse seas; productive and sustainably used seas; and seas resilient to climate change and ocean acidification. The Strategy also emphasises the importance of OSPAR in regional cooperation. Contracting Parties developed an implementation plan to put the Strategy into effect and assess progress. Its implementation is part of OSPAR's contribution to the achievement of the UN Agenda 2030 and the SDGs.

At international level, the Group of Seven (G7) serves as a forum for highly industrialised democracies to coordinate economic, security and energy policy. The G7 members (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) have launched a number of communiqués that are relevant for the ocean, e.g. the Tsukuba Declaration (2016), Turin (2017), the Charlevoix Blueprint (2018), and the Carbis Bay Communiqué (2021). In 2016, the G7 also agreed on the Future of the Seas and Oceans Initiative (FSOI) to enhance the global ocean observing system that provides ocean data required for the health of the ocean, for weather and climate forecasting, and for the development of a sustainable Blue Economy (see **16.3.2 EU science and innovation agenda for a sustainable use of the ocean**, and the Compendium Timeline on Ocean Policy).

16.2.2 Cooperation in global ocean research

At the global level, a number of relevant non-UN systems and networks cooperate in advancing the ocean research agenda and mobilising funding for ocean research. Among the most active are: the Partnership for Observation of the Global Oceans (POGO), the Platform on Biodiversity and Ecosystem Services (IPBES), the Future Earth Programme with its science and technology alliance for global sustainability collaboration, the Scientific Committee on Oceanic Research (SCOR) (under the International Science Council ISC), the Belmont Forum as an international partnership of funding organisations, and the Organisation for Economic Co-operation and Development (OECD) (Future of the Ocean Economy, OECD 2019, Stevens et al. 2021). Several 'think tanks'

incorporate ocean research outcomes in the formulation of strategic policy recommendations on the Ocean-Climate nexus such as the High Level panel for a Sustainable Ocean Economy (Hoegh-Guldberg et al. 2019).

16.3 The European Union

16.3.1 The EU integrated maritime policy

The EU integrated maritime policy (IMP, COM (2007) 575) seeks an increased coordination to EU marine and maritime issues between policy domains. It consists of a number of transversal policy instruments and is coordinated by the Directorate-General for Maritime Affairs and Fisheries (DG MARE). The ecosystem approach is enshrined within the legal framework of the IMP as a guiding principle for the management of human activities in accordance with the precautionary principle.

The EU was a long-standing party to the regional sea conventions around Europe and developed its water policies in interaction with these, mostly member state driven, organisations. A more integrated approach in the management of the marine environment, was taken with the EU Water Framework Directive (WFD, Directive 2000/60/EC). The WFD is applicable in coastal waters up to 1 nautical mile (nm) seaward from the baseline (i.e. low water mark), to achieve a good ecological status, while for certain aspects of chemical water quality the WFD applies to the entire 12 nm territorial sea. The Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) is considered as the environmental pillar of the IMP and aims for a 'good environmental status' (GES) for all seas under the jurisdiction of the member state. Member states have to ensure a good articulation between these two frameworks (MSFD and WFD). The MSFD and WFD are complementary to other environmental directives, such as the Habitats Directive (Directive 92/43/EEC) and Birds Directive (Directive 2009/147/EC) (Natura2000) (see thematic chapter **Nature and environment**).

The Maritime Spatial Planning Directive (MSP, Directive 2014/89/EU) and the Recommendation on integrated coastal zone management (ICZM, Recommendation 2002/413/EC) are important instruments within the scope of the IMP. The MSP Directive supports the EU Blue Growth Strategy (COM (2012) 494) and the EU Strategy for Transforming the EU's Blue Economy for a Sustainable Future (COM (2021) 240), which contributes to achieving the goals of the European Green Deal and the Recovery Strategy. By optimising the (multiple) use of maritime space, MSP also contributes to a better implementation of EU environmental policy instruments by reducing environmental effects.

The EU Green Deal (COM (2019) 640) aims for climate-neutrality of the EU by 2050, while its goals extend to many different sectors, including construction, energy, transport, food and biodiversity. It has strategic implications on the EU approach in addressing the climate-biodiversity-ocean nexus. In this context, the EU Climate Law (Regulation (EU) 2021/1119), in force since 29 July 2021, sets the legally binding European target of climate neutrality by 2050.

The EU joint communication on international ocean governance (JOIN (2016) 49) and the International Ocean Governance (IoG) Agenda form part of the EU response to the UN 2030 Agenda and delivers on the EU Global Strategy. The IoG Agenda selected 50 actions to ensure clean, healthy, safe, secure and sustainably used oceans. It is an integral part of the EU Green Deal and EU's response to, in particular, the SDG14 Life Below Water. The IoG Forum, coordinated by the European Marine Board (EMB), brought together ocean stakeholders to support the development of the IoG Agenda (IoG Consortium 2021).

16.3.1.1 Role of the European Parliament and Council

Several EU Parliament committees address marine and maritime policy issues. The Intergroup on Seas, rivers, islands and coastal areas (SEARICA) has a membership of 107 members of the European Parliament from 23 different member states and six political groups working in an integrated manner on specific ocean and coastal topics. While at the European Commission DG MARE ensures a thematic coordination, in the EU Council the General Affairs and External Relations Council has competence on IMP.

16.3.2 EU science and innovation agenda for a sustainable use of the ocean

Science and technological innovation are instrumental to achieve the sustainability goals for the ocean. The EU Strategy for Marine and Maritime Research (COM (2008) 534), coordinated by the Directorate-General for Research and Innovation (DG RTD), is a reference framework for the integration and gathering of knowledge and coordination of priority research activities. Marine Knowledge 2020 (COM (2010) 461) supports this strategy through a more coordinated approach to marine data collection and assembly.

The DG RTD is responsible for the Framework Programme Horizon Europe (2021-2027) (Regulation (EU) 2021/695), which aims to tackle climate change, help to achieve the UN SDGs and boost the EU competitiveness and growth. Horizon Europe highlights the need for new types of governance in the field of research, focusing on a dialogue between scientists, policymakers, private partners and industry, and societal interest groups (the quadruple helix). These elements also form the pillars of the Ostend Declaration (2010) and the Rome Declaration (2014) and of the implementation and funding mechanisms of EU science policy.

As part of the Horizon Europe programme, the EC launched the Mission Restore our Ocean and Waters by 2030. This Mission aims to deliver on the European Green Deal by restoring ecosystems and biodiversity, eliminating pollution, and making the Blue Economy carbon-neutral and circular. Also to be implemented under Horizon Europe, the Climate neutral, sustainable and productive Blue Economy partnership, due to start in 2023, takes the shape of a public initiative co-funded by the EU, national governments and national research funding agencies. It aims to reduce fragmentation by linking existing activities and efforts to combine and align pan-European, regional and national investments and the identified socio-political priorities for marine and maritime R&I. Both initiatives will be instrumental in delivering the EU Strategy and its contribution the UN Ocean Decade.

The EU approach to strengthen international cooperation in marine research and innovation (COM (2021) 252) also engages to actively contribute to the Ocean Decade and to increase support to the All-Atlantic Ocean Research Alliance (see below).

16.3.2.1 EU Integration of Marine Data and Information Collection Frameworks

Marine Knowledge 2020 (COM (2010) 461) – a component within the IMP – aims at unlocking marine data from different sources stored in data repositories scattered around Europe. In doing so, it aims to increase efficient access to quality-checked marine data, increase knowledge of the ocean and reduce the risks associated with its use. At the heart of Marine Knowledge 2020 is the European Marine Observation and Data Network (EMODnet), which consists of more than 150 partner organisations. EMODnet integrates marine data, data products and metadata from different sources, and provides access in a uniform way through the central web portal. EMODnet provides access to European marine data, metadata, data products and services across seven discipline-based themes: bathymetry, geology, seabed habitats, chemistry, biology, physics and human activities.

Information systems in support of sectoral EU maritime policy instruments include:

- The Data Collection Framework for the CFP (DCF);
- The Infrastructure for Spatial Information in Europe (INSPIRE Directive);
- The Maritime Common Information Sharing for the Environment (CISE);
- The Water Information System for Europe (WISE) and WISE-marine for the MSFD;
- The Biodiversity Information System for Europe (BISE);
- The European Climate Adaptation Platform (CLIMATE-ADAPT);
- The Marine Environment Monitoring Service (CMEMS), marine component of the COPERNICUS initiative (former GMES);
- The European Atlas of the Seas, raising the visibility of maritime Europe.

The data policies of the different systems are evolving rapidly under the influence of the 'Open Access' and the FAIR data Movement. In 2018, the EC launched the Implementation Roadmap for the European Open Science Cloud (EOSC, SWD (2018) 83). EOSC aims to enable the open science concept and the digital transformation of science. It is designed to offer EU researchers access to all publicly funded research data in Europe, across disciplines and borders to add value in terms of scale, interdisciplinarity and faster innovation.

16.3.2.2 Strategic Research and Innovation agendas in support of a sustainable use of the ocean

Ocean research inherently involves high costs and research facilities that are not always accessible to European researchers. Aligning objectives and pooling of available financial resources and capacities facilitates addressing grand societal challenges in a more effective and coordinated way. It stimulates the transfer of scientific information and knowledge towards research and innovative applications (Rome Declaration 2014, Marine Knowledge 2020, Navigating the Future V, European Marine Board 2019).

In the EU, research agendas are mainly determined at member state level and 88% of all public investments in research and development (R&D) are designed, financed and evaluated at national or subnational levels (Acheson et al. 2012). Joint Programming (JP) offers an integration and coordination platform for EU member states to align national budgets and resources from research organisations; e.g. by drafting joint research agendas and aligning priorities for cooperation in the long term. Since 2009, ten Joint Programming Initiatives (JPIs) were launched, including the initiative for Healthy and Productive Seas and Oceans (JPI-Oceans) that develops actions based on its Strategic Framework 2021-2025 (2021).

The JPI Oceans also coordinates the Strategic Research and Innovation Agenda (SRIA) for a Climate neutral, sustainable and productive Blue Economy partnership, building on priorities as defined in existing SRIAs from the EU sea basins. These include the Mediterranean SRIA, the Black Sea SRIA, the joint Baltic and North Sea SRIA, as well as developments in the Atlantic, including the ongoing implementation work under Galway and Belém Statements and the Atlantic Action Plan 2.0. These SRIAs and roadmaps were supported by Horizon 2020-funded Coordination and Support Actions (AORA-CSA, AANChOR-CSA, BlueMed CSA, Black Sea CONNECT and BANOS CSA). They offer demonstrated achievability of policy targets at sea basin scales and allow common issues to be jointly addressed.

The BONUS Joint Research and Development Programme, based on Article 185 of the Treaty on the Functioning of the EU (TFEU), was designed to meet the research and development needs of the Baltic Sea, and jointly funded by the EU and the involved countries. A collaborative action to expand BONUS in a twinning programme with the North Sea (BANOS CSA) was developed (2018-2021) with support of the EU Horizon 2020 programme. The BANOS CSA has considered the EU Strategy for the Baltic Sea Region (EU SBSR) in the development of the SRIA for the Baltic and North Sea.

A maritime strategy for smart sustainable and inclusive growth in the North-East Atlantic Ocean was first agreed by Portugal, Spain, France, Ireland and the UK (2011). Cooperation across the North Atlantic was further enhanced by the signing of the Galway Statement on Atlantic Ocean Cooperation (2013) which established the All-Atlantic Ocean Research Alliance (AORA) between the EU, USA and Canada. The AORA aims to increase collaboration in topics such as ocean observation in the Atlantic Ocean, including the effects from the nearby Arctic Ocean (COM (2013) 279). The Belém Statement, a joint declaration between the EU, Brazil and South Africa (July 2017) following the Galway Statement, is a further step in upscaling this cooperation across the whole Atlantic Ocean and its bordering countries.

16.4 Belgium: federal and Flemish legislation and policy instruments for an integrated maritime policy

16.4.1 Marine spatial plan for Belgium

The Belgian marine/maritime policy is largely governed by international treaties and policy instruments, including European and regional agreements (see **16.1 Integrated ocean policy**, **16.2 Non-UN agreements** and **16.3 The European Union**). In accordance with UNCLOS 1982, coastal states have sovereignty over the territorial sea and certain sovereign rights in the contiguous zone, the exclusive economic zone (EEZ) and on the continental shelf (see figure 5). In implementation of the UNCLOS, Belgium approved two important laws (Somers and Maes 2011):

- The Law on the Exclusive Economic Zone (EEZ) of Belgium (EEZ, Law of 22 April 1999) and amending the Law of 13 June 1969 on the exploitation of the continental shelf;
- The Law for the protection of the marine environment and for the organisation of marine spatial planning in the marine areas under the jurisdiction of Belgium (MMM Law, Law of 20 January 1999, amended several times and most recently by the Law of 20 July 2012).

The Belgian federal government is responsible for most of the activities that take place on the seaward side of the baseline (low-water mark), such as environmental policy, shipping, mineral extraction and offshore energy. The Government of Flanders is responsible for i.a. sea fisheries, shipping assistance, dredging, pilotage, rescue at sea, clearing wrecks and coastal defence works (Special Law of 8 August 1980, see Maes et al. 2013 for an overview of the division of competences in marine waters and the coastal zone in Belgium). The Cooperation agreement of 8 July 2005 between the federal state and the Flemish Region concerning the establishment and the cooperation in a Coast Guard structure, established an organised framework for coordination and mutual consultation between different policy areas relating to the sea (Law of 4 April 2006, Decree of 17 March 2006).

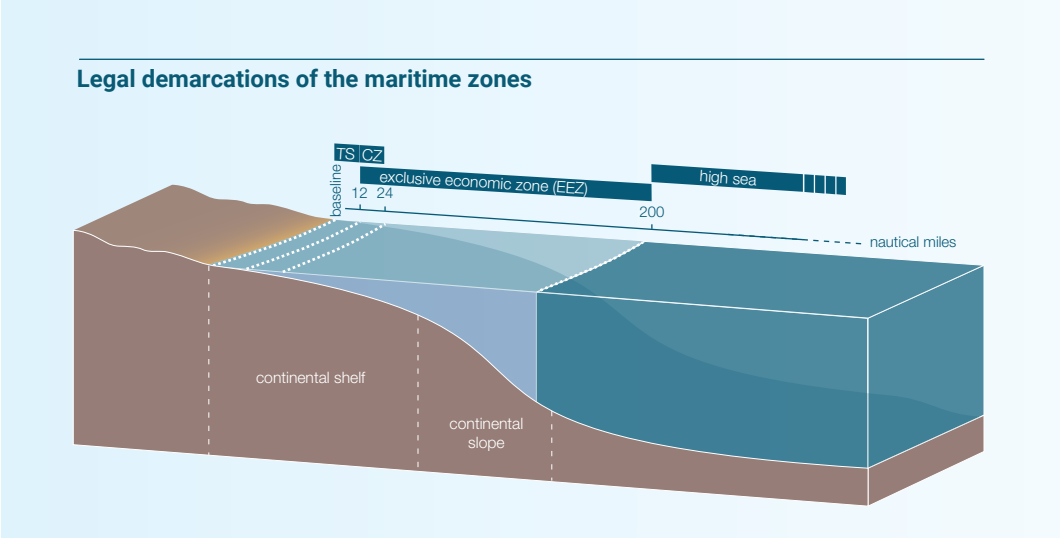


Figure 5. Legal demarcation of the maritime zones, as described in UNCLOS (TS: territorial sea, CZ: contiguous zone).

In 2003, a federal minister was appointed with a coordinating function for all federal competences on the Belgian part of the North Sea (BNS). The minister of the North Sea is also responsible for marine spatial planning (MSP) (Pecceu et al. 2016). In Belgium, through the Law of 20 July 2012, the concept of MSP was introduced in the Law of 20 January 1999 for the protection of the marine environment. The focus of the law is on the planning process, stakeholder participation, public consultation and the strategic environmental impact assessment (EIA). The law defines MSP as 'a plan that organises the desired spatial three-dimensional and temporal structure of human activities, based on a long-term vision and on the basis of clear economic, social and ecological objectives'. The law makes MSP a legally binding instrument and commits to a six-year review. The RD of 13 November 2012 establishes the procedure for the adoption of a MSP, the procedure for introducing an interim amendment, and the establishment of a Consultative Commission (composed of all competent federal and Flemish governmental authorities) with advisory authority. The MSP is also adopted by RD, after a deliberation in the federal Council of Ministers. Because the BNS is fully enclosed by the EEZ of neighbouring countries, the efficient and sustainable use of space and the elaboration of a long-term vision for the use of sea space is potentially subject to policy choices in the surrounding countries. For that reason, the RD also imposes an obligation to organise cross-border consultations in order to ensure coordination with the neighbouring countries.

Belgium has a legally binding marine spatial plan since 2014 (MSP 2014-2020, RD of 20 March 2014, see also Maes and Seys 2014, Van de Velde et al. 2014). The current plan (MSP 2020-2026, RD of 22 May 2019, see also Verhalle and Van de Velde 2020) provides a legal framework for all activities at sea (figure 6). The MSP 2020-2026 introduces i.a. a second Habitats Directive area, establishes the Princess Elisabeth zone for additional renewable energy and provides five zones for commercial and industrial activities (CIA zones) (RD of 22 July 2019, RD of 4 February 2020).

In 2017, the minister of the North Sea initiated a North Sea Council that coordinated a process for the development of a long-term vision for the North Sea until 2050 (De Backer 2017). Currently, the Think Tank North Sea continues on the dynamics of the North Sea Council as a neutral entity in which science, policy, civil society and industry, address issues related to the North Sea. The think tank is coordinated by scientific partners (lead by RBINS-OD Nature and VLIZ) and seeks to tie in with the major societal challenges (see Maes et al. 2013 for an overview and trajectory of MSP in Belgium, and the thematic chapters of the **Knowledge Guide Coast and Sea 2022** (Dauwe et al. 2022) for specific use of space in the MSP according to user function and www.marinespatialplan.be).

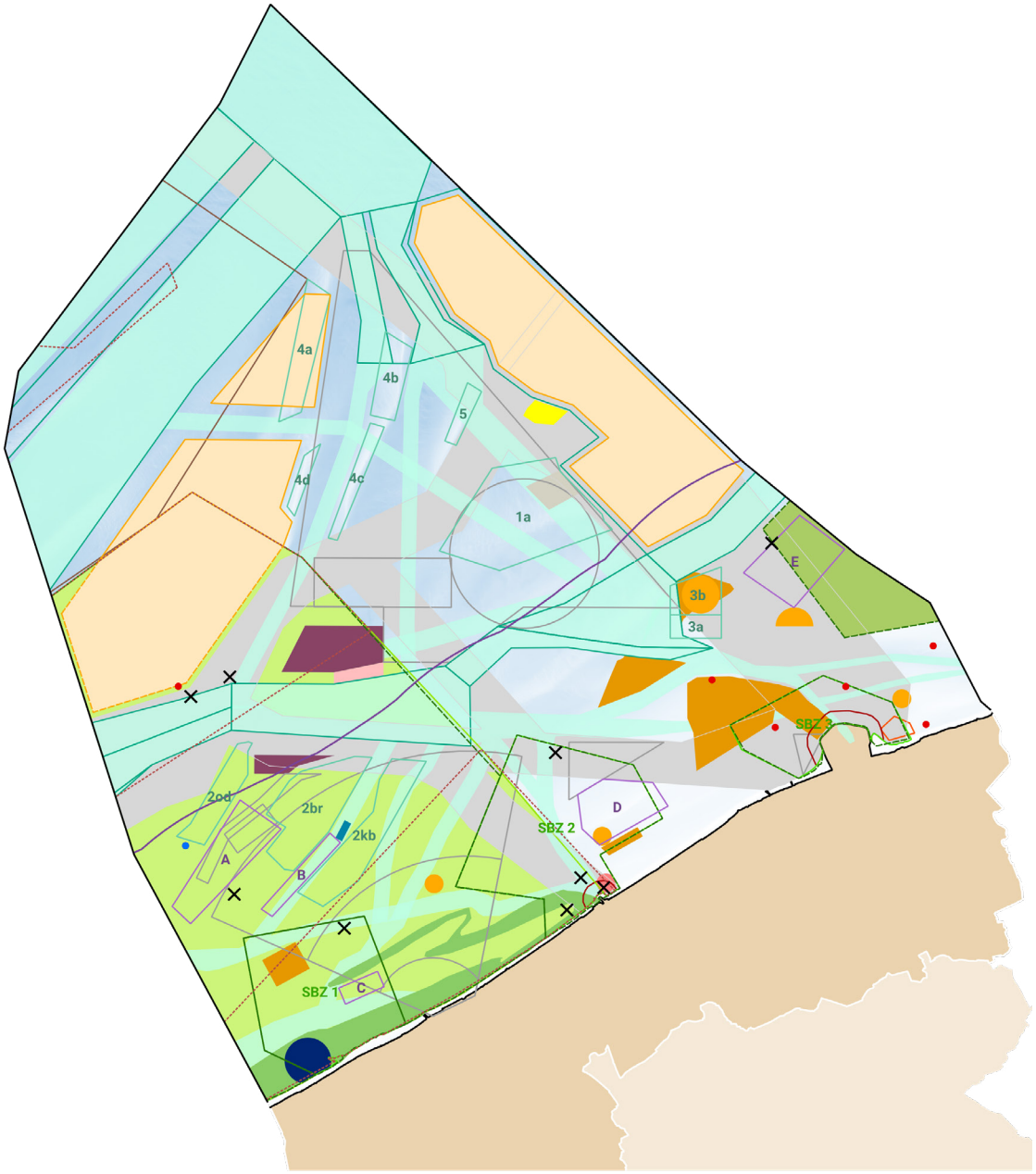


Figure 6. Integrated vision map for the BNS (Source: RBINS, MarineAtlas.be (based on RD 22 May 2019 (MSP 2020-2026)), Coastal Portal).

16.4.2 Sustainable management of human activities at sea

Belgium has pursued its marine policy since the early 1970s in accordance with the resolutions of the international conventions it has signed and the ministerial North Sea Conferences (see **16.2 Non-UN agreements**). The majority of them remain in force up to this day. The legal transposition of the MSFD into national legislation (RD of 23 June 2010) is a cornerstone for the coordination of MSP within the BNS. Following this national implementation and as a first six-yearly revision, Belgium updated the initial assessment of the state of the marine environment for the BNS (Belgian State 2018a), including an update of the socio-economic analysis of the users of the BNS (Belgian State 2018b, RBINS-OD Nature). The description of good environmental status and the establishment of environmental targets (Belgian State 2018c) was also updated. Subsequently the monitoring program was reviewed (Belgian State 2020) allowing to assess the trend in the health status of the marine environment. Based on the analysis of the monitoring results of the first cycle, the Marine Environment Division had drawn up a first program of measures (Belgian State 2016), containing additional measures necessary for achieving good environmental status. The adoption of a new program of measures is expected in 2022. Studies are currently developed in this context to restore and strengthen the gravel beds and the oyster beds that were once present in the BNS. The assessment is revised every six years (2024, 2030, etc.) and, if necessary, amended in consideration of the results achieved on the basis of the monitoring programme and programme of measures (DG Environment 2012) (see also thematic chapter **Nature and environment**)

Human activities at sea must be carried out in accordance with the requirements of protection and conservation of the marine environment and the concept of 'sustainable use of marine goods and services'. Permits and environmental impact assessments (EIA) ensure a harmonisation of the various user functions in the BNS. The RD of 7 September 2003 and the RD of 9 September 2003 introduced a procedure for obtaining an environmental permit and the obligation to carry out an EIA for activities described under Article 25 of the Law of 20 January 1999. To obtain a permit, the applicant must conduct an EIA-report and attach it to the application. This EIA-report estimates the impact of the proposed activity and provides alternatives where necessary. Based on the EIA-report and the application, the Operational Directorate Natural Environment (RBINS-OD Nature) prepares an EIA. This EIA is the scientific advice on the permit application. This advice is then forwarded to the Marine Environment Division of the FPS Health, Food Chain Safety and Environment. This Division can attach its advice, after which the file is submitted to the competent minister for a final decision. Commercial fishing, scientific research at sea and shipping are not subject to this licensing procedure and EIA obligation.

The BNS has three Birds Directive areas and two Habitats Directive areas. Human activities with a possible significant impact on these areas are subject to the so-called 'appropriate assessment' (*passende beoordeling*). The possible environmental effects of the activity are assessed against the conservation objectives set for these specific areas (see thematic chapter **Nature and environment**).

16.4.3 Integrated coastal zone management

Integrated coastal zone management (ICZM) is encouraged in the European member states mainly by the Recommendation on the implementation of integrated coastal zone management in Europe (2002/413/EC). This 'ICZM Recommendation' provides a common vision and standard for all member states as a policy framework. The Recommendation followed a series of European Charters and Decisions aimed at spatial planning and protection of the coastline, and Chapter 17 of Agenda 21 (Maelfait et al. 2013).

Integrated management leads to a more qualitative and sustainable policy, and according to scientific research it is cost-saving (EC 2000). The first Belgian Recommendation report on ICZM (2006) contained a number of recommendations for the joint development of sustainable coastal policies. In the Belgian Recommendation report (ICZM 2010), the achievements following these recommendations were further explained for the period 2006-2010. In a retrospective of 20 years of practitioners' experience in regional development in West Flanders (Mees and Lescrauwaet 2016), the ICZM instrument and its impact were subjected to a critical review.

The Belgian coastal waters are part of the International River Basin District of the Scheldt which is managed by the three Regions, the federal government as well as France and the Netherlands (see thematic chapter **Scheldt estuary**). International coordination takes place via the International Scheldt Commission (ISC) (i.e. Scheldt Treaty), while national coordination takes place via the Coordination Committee for International Environmental Policy (CCIM) (Cooperation Agreement of 5 April 1995), piloted by the federal government. For a comprehensive overview of the relevant authorities and regional, tri- and bilateral treaties for the BNS and adjacent estuaries, Verleye et al. (2018).

Legislation reference list

Overview of the relevant legislation on international ('Year A': adoption; 'Year EIF': entry into force), European, federal and Flemish level. For the consolidated European policy context see Eurlex. The national legislation can be consulted on the Belgian official journal and the Justel-database, the Flemish legislation is available on the Flemish Codex.

International conventions and agreements			
Acronyms	**Title**	**Year A**	**Year EIF**
ICRW	International Convention for the regulation of whaling	1946	1948
Bonn Agreement	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	(1969) - 1983	1989
RAMSAR	Convention on wetlands of international importance, especially as waterfowl habitat	1971	1975
Helsinki Convention	Convention on the protection of the marine environment of the Baltic Sea area	(1974) - 1992	(1992) - 2000
Barcelona Convention	Convention for the protection of the Mediterranean Sea against pollution	1976	1978
UNCLOS	United Nations Convention on the law of the sea	1982	1994
CBD	Rio de Janeiro Convention on biological diversity	1992	1993
Bucharest Convention	Convention on the protection of the Black Sea against pollution	1992	1994
OSPAR	Convention for the protection of the marine environment of the North-East Atlantic	1992	1998
Paris Agreement	Paris Agreement on climate change	2015	2016

European legislation and policy context			
Document number	**Title**	**Year**	**Number**
Communications			
COM (2007) 575	Communication from the Commission - An integrated maritime policy for the European Union	2007	575
COM (2008) 534	Communication from the Commission - A European strategy for marine and maritime research: a coherent European research area framework in support of a sustainable use of oceans and seas	2008	534
COM (2008) 768	Communication from the Commission - Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond	2008	768
COM (2009) 8	Communication from the Commission - Strategic goals and recommendations for the EU's maritime transport policy until 2018	2009	8
COM (2009) 10	Communication from the Commission - Communication and action plan with a view to establishing a European maritime transport space without barriers	2009	10
COM (2009) 536	Communication from the Commission - Developing the international dimension of the Integrated Maritime Policy of the European Union	2009	536
COM (2009) 538	Communication from the Commission - Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain	2009	538
COM (2010) 461	Communication from the Commission: Marine Knowledge 2020 marine data and observation for smart and sustainable growth	2010	461
COM (2010) 2020	Europe 2020 - A strategy for smart, sustainable and inclusive growth	2010	2020
COM (2011) 782	Communication from the Commission: Developing a Maritime Strategy for the Atlantic Ocean Area	2011	782
COM (2012) 494	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
COM (2014) 254	Communication from the Commission: Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth	2014	254

European legislation and policy context (continuation)			
Document number	**Title**	**Year**	**Number**
COM (2014) 451	Communication from the Commission - Better situational awareness by enhanced cooperation across maritime surveillance authorities: next steps within the Common Information Sharing Environment for the EU maritime domain	2014	451
COM (2021) 240	Communication from the Commission on a new approach for a sustainable blue economy in the EU - Transforming the EU's Blue Economy for a sustainable future	2021	240
COM (2021) 252	Communication from the Commission on the Global Approach to Research and Innovation Europe's strategy for international cooperation in a changing world	2021	252
Directive			
Directive 92/43/EEC	Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC	Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2007/2/EC	Directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)	2007	2
Directive 2008/56/EC	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2009/147/EC	Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive 2014/89/EU	Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89
Regulations			
Regulation (EU) 2021/695	Regulation establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013	2021	695
Regulation (EU) 2021/1119	Regulation establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')	2021	1119

Belgian and Flemish legislation		
Dates	**Title**	**File number**
Royal Decrees		
RD of 7 September 2003	Koninklijk besluit houdende de procedure tot vergunning en machtiging van bepaalde activiteiten in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-07/32
RD of 9 September 2003	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling in toepassing van de wet van 20 januari 1999 ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	2003-09-09/30
RD of 23 June 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
RD of 13 November 2012	Koninklijk besluit betreffende de instelling van een raadgevende commissie en de procedure tot aanneming van een marien ruimtelijk plan in de Belgische zeegebieden	2012-11-13/07
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
RD of 22 May 2019	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan voor de periode van 2020 tot 2026 in de Belgische zeegebieden	2019-05-22/23
RD of 11 June 2019	Koninklijk besluit tot wijziging van het koninklijk besluit van 23 juni 2010 betreffende de mariene strategie voor de Belgische zeegebieden	2019-06-11/05
RD of 22 July 2019	Koninklijk besluit tot vaststelling van de procedure tot het bekomen van een gebruiksvergunning voor de zones voor commerciële en industriële activiteiten in de zeegebieden onder de rechtsbevoegdheid van België	2019-07-22/17

Belgian and Flemish legislation (continuation)		
Dates	**Title**	**File number**
RD of 4 February 2020	Koninklijk besluit tot instelling van veiligheidszones in de zeegebieden onder Belgische rechtsbevoegdheid	2020-02-04/12
Laws		
Special Law of 8 August 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Law of 11 May 1995	Wet houdende goedkeuring van het Verdrag inzake biologische diversiteit, en Bijlagen I en II, gedaan te Rio de Janeiro op 5 juni 1992.	1995-05-11/61
Law of 20 January 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 20 July 2012	Wet tot wijziging van de wet van 20 januari 1999 ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België, wat de organisatie van de mariene ruimtelijke planning betreft	2012-07-20/39