Knowledge Guide

Coast and Sea 2018

Flanders Marine Institute (VLIZ)

Colofon

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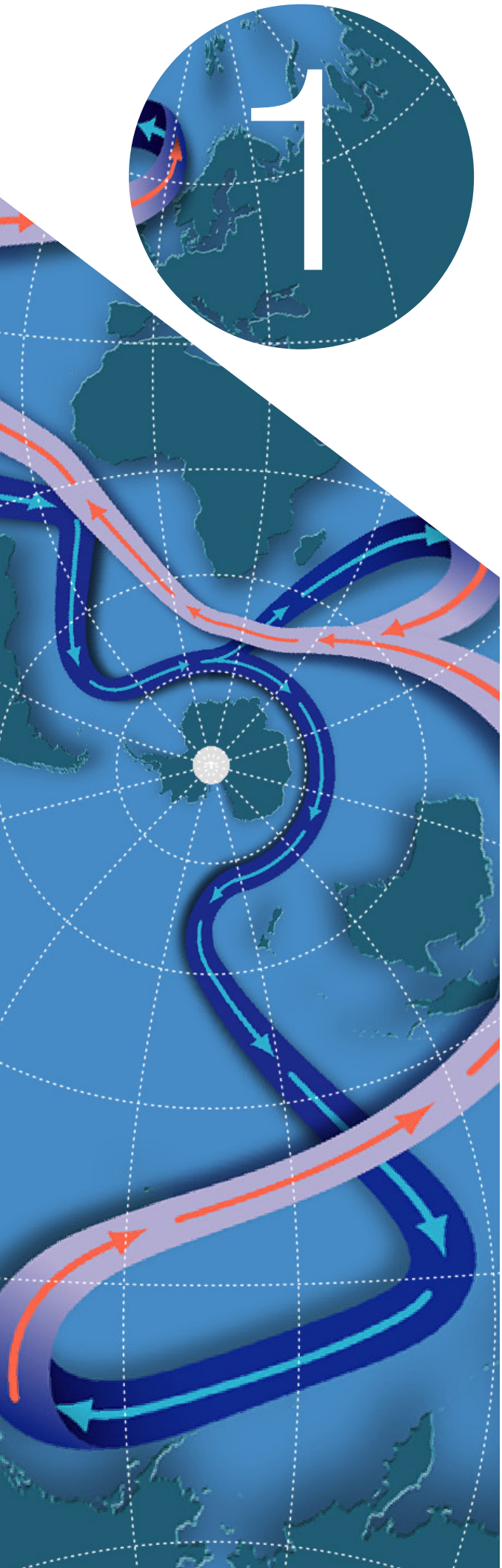

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Integrated ocean policy

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1.1 An integrated global ocean policy

1.1.1 The Agenda 2030: a global policy for sustainable development

Twenty years after the first '*Earth Summit/United Nations Conference on Environment and Development*' (UNCED, Rio de Janeiro, 1992) resulted in the *Agenda 21*, the UN set the scene for a new Global Agenda for Sustainable Development known as *Rio+20* (2012). In September 2015 the UN General Assembly (UNGA) adopted the resolution 'Transforming our world: the 2030 Agenda for Sustainable Development' (figure 1). *Agenda 2030* contains 17 Sustainable Development Goals (SDGs) with 169 targets covering a broad range of SD issues, from ending poverty and hunger, improving health and development, making cities more sustainable and environmentally friendly, and combating conflict and climate change (*UN Resolution A/RES/70/1*). Through Agenda 2030, world leaders pledged for common action in pursuit of a universal SD policy agenda. The Agenda recognises that climate change is one of the greatest challenges of our time 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 (*SDG13*). *SDG14* aims to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. The 10 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.

Sustainable development is inseparable from the health of the Global Ocean. In addition to the SDG14 targets, several other SDGs cannot be achieved without aiming for a healthy ocean and coastal areas in view of the many ecosystem services that they provide (*Singh et al. 2018*). The ocean plays a crucial role in the climate system as it provides so called 'silent' ecosystem services (*Stocker 2015*) in buffering the impact of substances (such as CO_2) and energy (solar radiation) that contribute to global climate change (SDG13). The ocean has so far taken up over 90% of the excess energy in the climate system and has absorbed approximately 30% of the CO_2 emitted by society. The impact of this carbon uptake is ocean acidification, which is already affecting life in the ocean even at great depths (*Stocker 2015*). The SDG target 14.3 calls for minimising and addressing impacts of ocean acidification, e.g. through enhanced scientific cooperation at all levels (*UN 2015*). The Paris Agreement, adopted in 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.

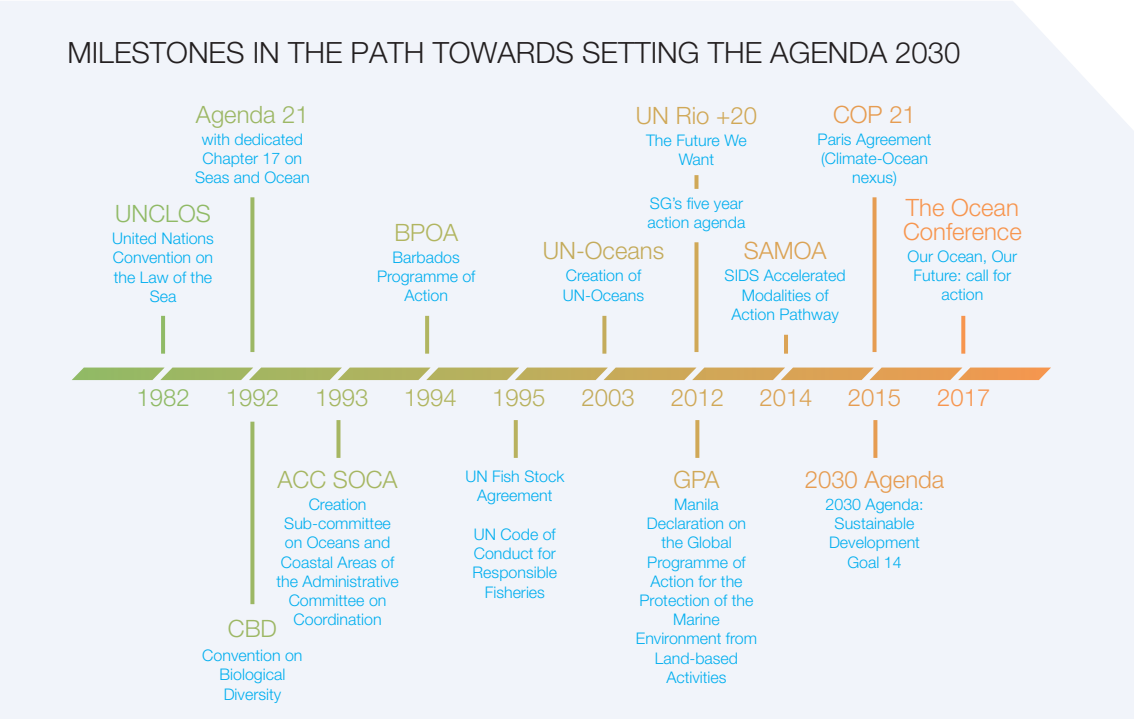

Figure 1. Milestones in the path towards setting the Agenda 2030.

1.1.2 UN framework and its integrated sustainable agenda for the global ocean

UN-OCEANS: INTER-AGENCY COORDINATION MECHANISM

In 1993, the UN agencies dealing with oceans and coastal issues formed the Sub-committee on Oceans and Coastal Areas of the Administrative Committee on Coordination (*ACC SOCA*), in support of the 'Ocean'-chapter (*Chapter 17*) of the Agenda 21. In 2003, *UN-Oceans* was established as a UN inter-agency coordinating mechanism to enhance the coordination, coherence and effectiveness of competent organisations of the UN-system in ocean related matters (figure 2). The Terms of References of UN-Oceans were revised in 2013 (*UN Resolution A/RES/68/70*). The Scientific Advisory Board of the former 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'[1], which considers a healthy ecosystem as a basis for sustainable maritime economic activity, especially in the long term. The ecosystem approach serves as guidance in European (marine) legislation and is transposed at national level.

UN-Oceans provides the Interagency Coordination Mechanism for various ocean related matters. It reports back 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). The following three processes were established under the UNGA:

- The UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea (*the Consultative Process - ICP*), established in 2002, as an intergovernmental forum to discuss ocean issues on a yearly basis;
- The Intergovernmental Conference tasked with the development of 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*) by 2020, established in 2017 (*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*') established in 2004, aims to enhance the scientific basis for policy-making. The First Global Integrated Marine Assessment or World Ocean Assessment (WOA) was completed in 2015. The second WOA (*UN Resolution A/RES/70/235*) will cover five years from 2016 to 2020 (UN Resolutions *A/RES/71/257* and *A/RES/71/362*).

The UN Ocean Conference (New York, June 2017) adopted the intergovernmental agreed political declaration *'Our Ocean, our future: call for action'*. This declaration is the summary of seven partnership dialogues and over 1,400 voluntary commitments to advance the implementation of SDG14 and related targets (*UN Resolution A/RES/71/312*). In October 2017, Ambassador Peter Thomson of Fiji was appointed as UN SG Special Envoy for the Ocean, to follow up on the outcomes of the UN Ocean Conference and the implementation of the voluntary commitments in support of achieving the SDG14 of the Agenda 2030.

An overview of UN Conventions - including the UN Convention on the Law of the Sea also called the 'Constitution for the oceans' (*UNCLOS 1982*) is provided in *Maes et al. (2013)* and *Verleye et al.(2018)*.

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 data and information, early warning, sustainable management and capacity development including training.

In 2017, the IOC published the first Global Ocean Science Report (*GOSR*), an assessment of the status and trends in ocean science capacity around the world. The report identifies and quantifies the key elements of ocean science at the national, regional and global scales, including workforce, infrastructure and publications.

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 to ensure that ocean science can support countries in the achievement of the SDG14. Mandated by the UNGA, the IOC of UNESCO will coordinate the Decade's preparatory process (see **1.3.2 EU science and innovation agenda for a sustainable ocean**, figure 5).

[1] The OSPAR Convention defines the ecosystem approach as the 'the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity'.

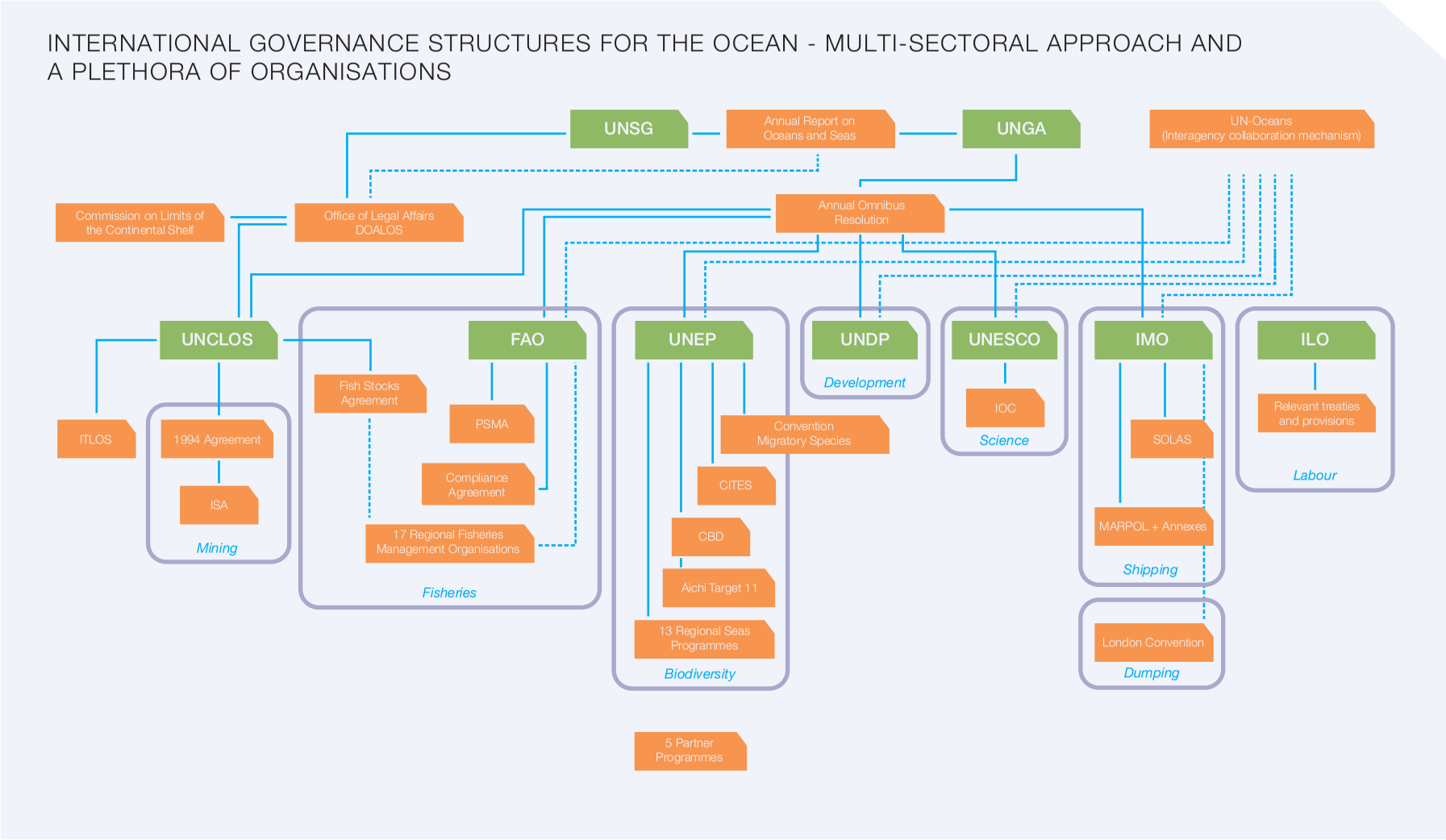

Figure 2. International Governance structures for the ocean (Source: Ocean Atlas 2017).

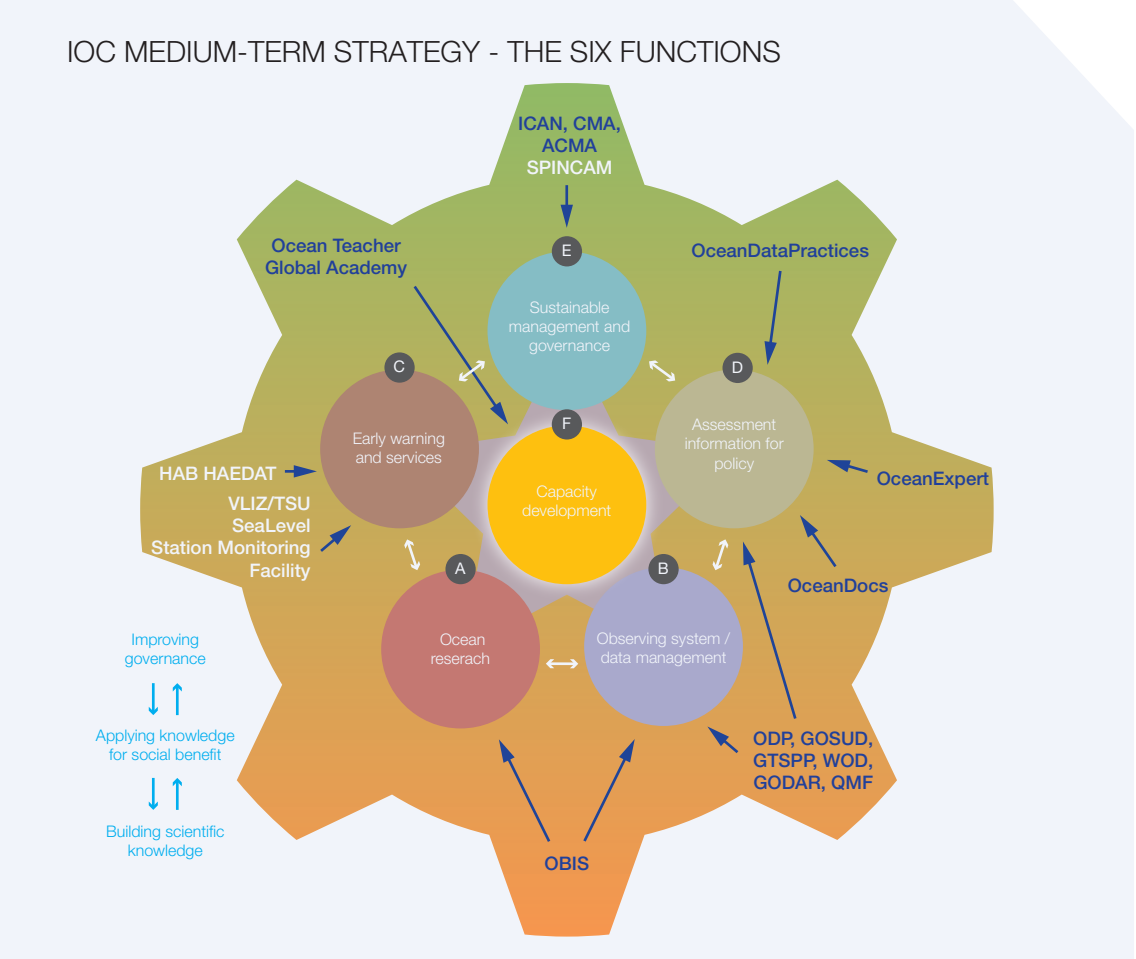

Figure 3. The six main functions in support of IOC-UNESCO *Medium-term Strategy* 2014-2021.

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. The recent expansion of maritime activities into the Arctic and the deep-sea frontiers, require addressing important scientific, technical and policy issues. UNCLOS *part XIII* and *part XIV* provide a legal framework for the conduct of marine scientific research and transfer of marine technology.

1.2 Non-UN agreements

1.2.1 Non-UN 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 sea level, fourteen of the Regional Seas Programmes have also adopted legally binding, non-UN conventions, for the protection of the marine environment as part of the regional seas conventions and action plans framework. The four European regional seas conventions include the *Helsinki Convention* (HELCOM) in the Baltic Sea, the *Barcelona Convention* (UNEP-MAP) in the Mediterranean Sea, the *Bucharest Convention* in the Black Sea and the *OSPAR Convention* in the North East Atlantic Ocean, including the North Sea (figure 4).

OSPAR is the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic, including the North Sea (see theme **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. This is supported by an obligation for the contracting parties to apply the precautionary and polluter pays principles and the use of best available techniques (BAT) and best environmental practice (BEP), including clean technology. The OSPAR secretariat also acts as a secretariat for the *Bonn Agreement* (1969), which

Figure 4. (Non-UN) regional seas conventions worldwide (Source: UNEP).

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 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 as a political basis for establishing measures to reduce contamination in the North Sea.

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 influential communiqués and blueprints that are highly relevant for the ocean, e.g. Tsukuba Declaration (2016), Turin (2017) and the Charlevoix Blueprint (2018) (see **1.3.2 EU science and innovation agenda for a sustainable ocean**, figure 5).

1.2.2 Global ocean research cooperation

At the global level, a number of relevant non-UN systems and networks cooperate in support of the sustainable ocean agenda. They represent collaborative efforts in advancing an 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, Innovation in the ocean economy 2017-2018*).

1.3 The European Union

1.3.1 The EU Integrated Maritime Policy

The EU Integrated Maritime Policy (IMP, COM (2007) 575) seeks a coherent approach to all EU marine and maritime issues and increased coordination between policies and policy domains to draw higher returns from the ocean while reducing impacts on the environment. It consists of a number of transversal policy instruments and is coordinated by the Directorate-General for Maritime Affairs and Fisheries (DG MARE).

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 further strategic step towards a more integrated approach in the management of the marine environment, was taken with the Water Framework Directive (WFD, 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), for the achieving of a good ecological status, while for certain aspects of chemical water quality it applies to the entire 12 NM territorial sea. The Marine Strategy Framework Directive (MSFD, 2008/56/EC) established a relatively similar integrated management approach to the protection of the marine environment. Member States (MS) have to ensure a good articulation between these two frameworks (MSFD and WFD). The MSFD can be considered as the environmental pillar of the IMP and provides a common framework to establish environmental targets for the protection and conservation of the marine environment. The MSFD aims for a 'good environmental status' (GES) for all seas under the jurisdiction of the Member States by 2020. 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 MSFD and WFD are complementary to other environmental directives, such as the Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC) (theme **Nature and environment**). Common implementation strategies (CIS) provide a platform for the Member States and EC DG Environment (DG ENV) to coordinate and follow the implementation of these directives.

The Maritime Spatial Planning Directive (MSP, 2014/89/EU) and the Recommendation on integrated coastal zone management (ICZM, 2002/413/EC) are important instruments within the scope of the IMP. The MSP Directive supports the EU blue growth strategy (COM (2012) 494) that contributes to achieving the goals of 'Europe 2020 - A strategy for smart, sustainable and inclusive growth' (COM (2010) 2020). By optimising the use of maritime space, MSP also contributes to a better implementation of EU environmental laws (MSFD, Natura 2000, etc.) by reducing environmental effects.

The 'EU strategy for Marine and Maritime Research' (COM (2008) 534), drafted within the IMP following the Aberdeen Declaration (2007), aims to support the provision of necessary scientific information for improved decision-making in support of the sustainable use of the Ocean and its resources. Since its adoption, the *IMP* has allowed the implementation of actions with a thematic or regional approach (table 1 and figure 5 for the European dimension).

In the North-East Atlantic Ocean a maritime strategy for smart sustainable and inclusive growth (*COM (2013) 279*) was agreed by Portugal, Spain, France, Ireland and the UK (2011). Cooperation across the North Atlantic was enhanced further by the signing of the *Galway Statement on Atlantic Ocean Cooperation* (2013) which established the Atlantic Ocean Research Alliance (*AORA*) between the EU, USA and Canada. The *AORA* aims to increase the collaboration of the partners in topics such as ocean observation in the Atlantic Ocean, including the effects from the nearby Arctic Ocean. The *Belém Statement*, a joint Declaration between the EU, Brazil and South Africa (July 2017) following the *Galway Statement*, aims for an integrated approach to research and development across the whole Atlantic Ocean and its bordering countries.

The EU joint communication on international ocean governance for safe, secure, clean and sustainably managed oceans (*JOIN (2016) 49*) forms part of the EU's response to the UN 2030 Agenda and more specifically for SDG14, and delivers the *EU Global Strategy* in practice. It calls for an improved international ocean governance framework and aims at strengthening international ocean research and data acquisition, sharing and management. The EU policy level has in recent years tried to reinvigorate globally visible actions to protect the ocean. This also generates new impetus for action within the legal frameworks. For instance, in October 2018, the EU hosted the 5th edition of the international *Our Ocean conference* in Bali. At this conference the EC anounced an additional 300 million euro to fund new initiatives to protect the oceans. This amount is in addition to the 550 million euro announced at the Malta conference a year earlier.

Table 1. Implementation of actions under the European Integrated Maritime Policy (non-exhaustive list).

	Actions in the framework of the integrated ocean policy
Thematic implementation	Commission communication on European Strategy for Marine and Maritime Research (COM(2008) 534)
	Marine Strategy Framework Directive (2008/56/EC)
	Commission communication on offshore wind energy (COM (2008) 768)
	Commission communication on the EU's Maritime Transport policy (COM (2009) 8)
	Communication and action plan establishing a European maritime transport space without barriers (COM (2009) 10)
	Commission communication on Marine Knowledge 2020 (COM (2010) 461)
	EU Sustainable Blue Growth Agenda for the Baltic Sea Region (SWD (2014) 167) adopted by the Commission
	Commission communication on Blue Growth (COM (2012) 494) and innovation in Blue Economy (COM (2014) 254) to release the potential of our seas and oceans for jobs and growth
	Integrated Maritime Surveillance (COM (2009) 538) and Regulation (EU) No 1052/2013 establishing the European Border Surveillance System (Eurosur)
	Directive 2014/89/EU establishing a framework for Maritime Spatial Planning
	Commission communication on the international dimension of the IMP (COM (2009) 536)
	Common Fisheries Policy (CFP) (Regulation (EU) No1380/2013) entered into force 2014.
	Joint Communication on international ocean governance, for safe, secure, clean & sustainably managed oceans (JOIN(2016)49)
Macro-regional sea strategies and action plans	Strategy for the Baltic Sea region (COM (2009) 248)
	Commission communication on IMP for better governance in the Mediterranean (COM (2009) 466)
	EU Strategy for the Black Sea
	Commission communication on a Maritime Strategy for the Atlantic (COM (2011) 782)
	Galway Statement on Atlantic Ocean Cooperation (2013); Atlantic Forum Action Plan (2013)
	Commission communication on the Common Information Sharing Environment (COM (2014) 451)
	EU Strategy for the Adriatic and Ionian Region (COM (2014) 357)
	Joint communication on an integrated European Union policy for the Arctic (JOIN (2016) 21)
	Belém Statement (EU, Brazil, South Africa) on Atlantic Research and Innovation Cooperation (2017)

ROLE OF THE EUROPEAN PARLIAMENT AND COUNCIL

Several EU Parliament committees address maritime policy issues. The Intergroup on 'Seas, rivers, islands and coastal areas' (*SEARICA*) has a membership of more than 80 MEPs from 19 member states working in an integrated manner on specific ocean and coastal topics. While at the European Commission it is DG MARE who ensures a thematic coordination, in the EU Council it is the General Affairs and External Relations Council that has competence on IMP.

1.3.2 EU science and innovation agenda for a sustainable use of the ocean

Science and technological innovation are instrumental to reconcile increasing marine activities with sustainability goals. The EU strategy for Marine and Maritime Research (*COM (2008) 534*), coordinated by the Directorate-General for Research and Innovation (DG R&I), is a reference framework for the integration and gathering of knowledge and coordination of priority research activities. The DG R&I is responsible for EU research and innovation policies and funding instruments, e.g. the current *Framework Programme Horizon 2020* (EU Regulation 1290/2013) (see Indicator Report Marine Research and Innovation 2018, *Pirlet et al. 2018*). It aligns with the EU strategy for economic growth (Europe 2020) and innovation (Innovation Union), one of the seven initiatives within the Europe 2020 Strategy. It highlights the need for new types of governance in the field of research, focusing on a dialogue between scientists, policymakers, industrialists 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.

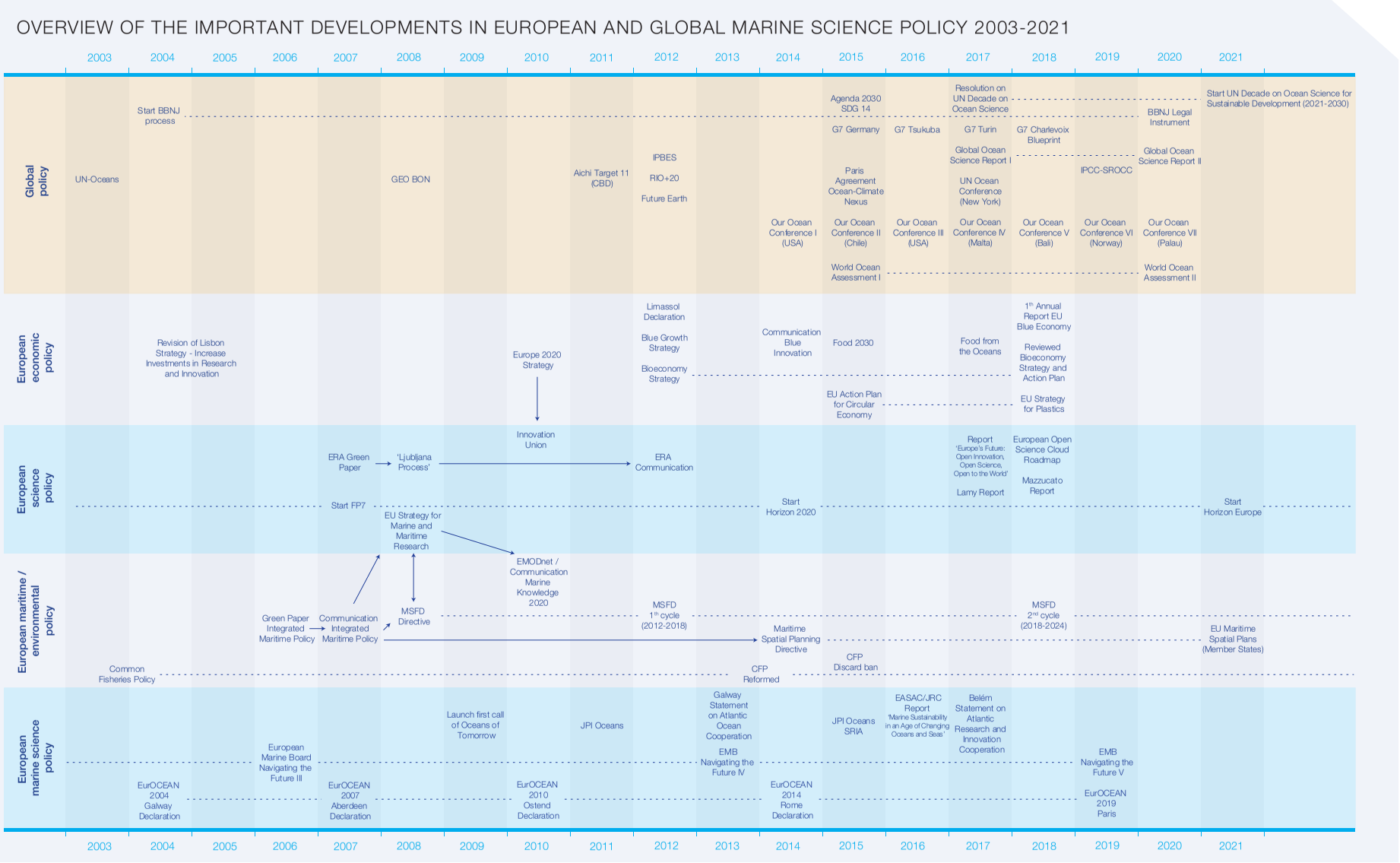

Figure 5. An overview of some of the important developments in European and global maritime/environmental policy and marine science policy between 2003-2021.

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 (*Navigating the Future IV*, *European Marine Board 2013*, *Rome Declaration 2014*, *Marine Knowledge 2020*). A number of networks and consortia with a strong representation of European marine research communities develop of strategic agendas for sustainably using the ocean (table 2).

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, 10 Joint Programming Initiatives (JPIs) were launched, including the initiative for 'Healthy and Productive Seas and Oceans' - *JPI-Oceans*.

Table 2. Pan-European marine research communities with strategic agendas in support of the Agenda 2030 (non-exhaustive list).

Organisation	Description
European Marine Board (*EMB*)	Acts as the interface between marine research and marine/maritime policies; delivers *Position Papers* on research priorities and strategies for European marine research such as *Navigating the Future IV*
European Ocean Observing System (*EOOS*)	Coordinating framework to align and integrate Europe's ocean observing capacity and promote a systematic and collaborative approach to collecting information on the state of the ocean
EurOCEAN conferences	Platform for the marine research-policy interface at the EU level and in Member States, allowing European researchers to participate in shaping the EU marine research agendas through the *Galway Declaration (2004)*, the *Aberdeen Declaration (2007)*, the *Ostend Declaration (2010)* and the *Rome Declaration (2014)*; co-organised, in partnership, by the EC and the EMB
JPI-Oceans	Strategic Research and Innovation Agenda 2015-2020 (*JPI Oceans 2015*)
EFARO	European Fisheries and Aquaculture Research Organisation
EuroGOOS	European Global Ocean Observing System
MARS	European Network of Marine Research Institutes and Stations
ESFRIs	European Strategic Forum for Research Infrastructures, a joint venture between EU and Member States towards strategic planning and investments for research infrastructures. Belgium participates in the EMBRC, LifeWatch and the Ocean Thematic Component (OTC) of the ICOS
ICES	International Council for the Exploration of the Sea, a network of 20 Member States, developing science and advice for the sustainable use of the oceans and advising and informing international commissions (e.g. OSPAR and HELCOM)
ASCOBANS	The Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas focuses on research and protection of small cetaceans and their habitat
EUROMARINE	The European Marine Research Network
EurOcean	European Centre for information on Marine Science and Technology, develops information databases with a focus on Knowledge Output, Research Infrastructures and Public Outreach and Awareness

Specifically, for the North Sea, no common strategy has been developed yet between the EU and the MS, cf. the 'macro-regional strategies' in the framework of the EU regional policy (DG REGIO), or the 'Sea Basin Strategies' or 'Maritime Strategies' in the framework of the IMP (DG MARE) (Regulation (EU) No 1303/2013).

The *BONUS Joint Research and Development Programme*, based on Article 185 of the Treaty on the Functioning of the EU (TFEU), is 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) will be launched in November 2018, with support of the EU Horizon 2020 funding programme.

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 to increase efficient access to quality-checked marine data for industry, policy makers, civil society and scientists. The objective is to support the development of new

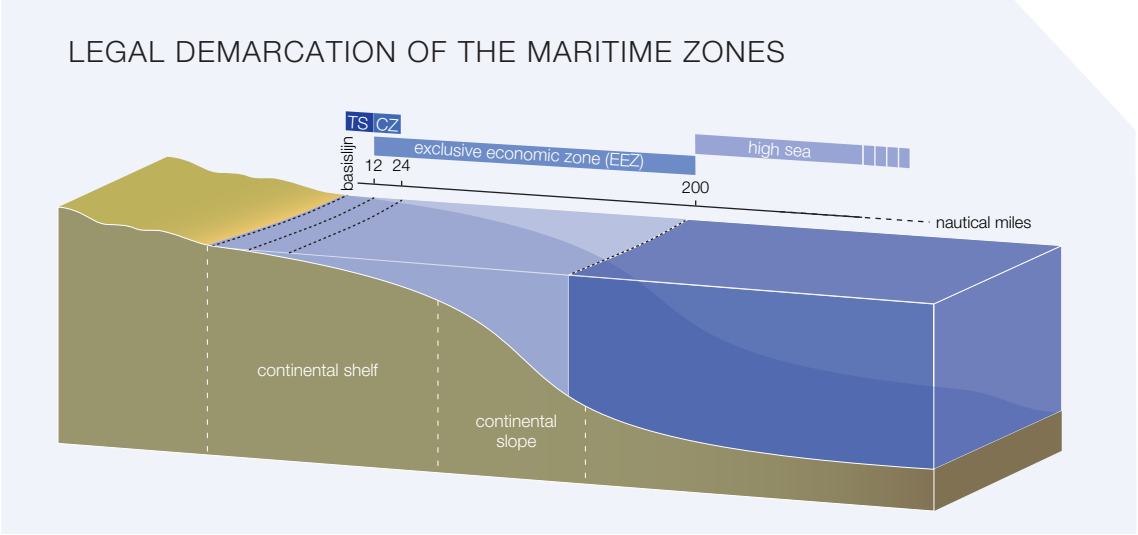

Figure 6. Legal demarcation of the maritime zones, as described in UNCLOS (TS: territorial sea, CZ: contiguous zone).

or improved sustainably sourced products and services, saved costs for offshore operators by avoiding new surveys where data already exists, 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 organisations. EMODnet integrates marine data, data products and metadata from different sources, processes these according to international standards and provides access in a uniform way through the central web portal and seven thematic data sub portals. 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. The *EMODnet Sea Basin Checkpoints* assess the availability, accessibility and adequacy of the current observation monitoring data at the level of the six regional sea-basins, through a series of real-user simulated challenges.

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' 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 publically publicly funded research data in Europe, across disciplines and borders to add value in terms of scale, interdisciplinarity and faster innovation.

1.4 Belgium: federal and Flemish legislation and policy instruments for an integrated maritime policy

1.4.1 Marine spatial plan for Belgium

The Belgian marine/maritime policy is largely governed by international treaties and policy instruments, including European and regional partnerships (see **1.1 An integrated global ocean policy** and **1.2 Non-UN agreements**). In accordance with the international UN Convention on the Law of the Sea (*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 6).

In implementation of the UNCLOS, two important laws were approved in Belgium (*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 of 20 January 1999, amended several times and most recently by the law of 20 July 2012).

In general, 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 and offshore energy. After the various state reforms, the Government of Flanders is responsible for e.g. sea fisheries, shipping assistance, dredging, pilotage, rescue at sea, clearing wrecks and coastal defense works (see *Maes et al. 2013* for an overview of the division of competences in marine waters and 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 (*structuur Kustwacht*) 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).

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 (now secretary of state) of the North Sea also became responsible for marine spatial planning (MSP) (*Pecceu et al. 2016*). In Belgium, the law of 20 July 2012 on the organisation of marine spatial planning introduces the concept of MSP 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. 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 gives MSP a legally binding character and commits to a six-year review. By means of the RD of 13 November 2012, 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, was established by the king. The MSP is also adopted by decision of the king, after a deliberation in the Council of Ministers.

Because the BNS is a limited marine area that is fully enclosed by the EEZ of the neighbouring Member States, the efficient and sustainable use of space and the elaboration of a long-term vision for use of sea space is potentially subject to policy choices and the management of the marine areas in the surrounding MS. For that reason, the RD also imposes an obligation to organise cross-border consultations in order to ensure coordination with the neighboring countries.

Belgium has had a legally embedded marine spatial plan (MSP) since 2014 (RD of 20 March 2014, see also *Maes and Seys 2014*, *Van de Velde et al. 2014*). In addition to establishing the MSP, the RD includes the following information:

- *Appendix 1*: Spatial Analysis of the Belgian marine areas;
- *Appendix 2*: Long-term vision, objectives, indicators and spatial policy choices;
- *Appendix 3*: Actions to implement the marine spatial plan;
- *Appendix 4*: Maps.

The current MSP (2014) runs for a period of six years and provides a legal coordinating framework for all activities at sea. In February 2017, the revision process to approve a new MSP by 2020 – which plans the use of space in the BNS until 2026 – was initiated. The draft of the new MSP 2020-2026 (figure 7) was in public consultation from 29 June to 28 September 2018 (*MSP 2020-2026, public consultation 2018*). In 2017 a process for the development of the long-term vision for the North Sea until 2050 was also coordinated (theme **Nature and environment**). The long-term vision North Sea 2050, developed by the North Sea Council (*De Backer 2017*), is regarded as an integrated vision, while the MSP serves as an instrument to realise this vision. The dynamics of the North Sea Council were continued in the *Think Tank North Sea*: a neutral and unbound entity in which science, policy, civil society organisations, industry and society at large, address issues related to the North Sea. The think tank starts from science (coordinators are 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 theme chapters of the **Knowledge Guide Coast and Sea 2018** (*Devriese et al. 2018*) for specific use of space in the MSP, according to user function).

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 a 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. On the basis of the EIA-report and the application, the Operational Directorate Natural Environment (RBINS-OD Nature) prepares an EIA. This EIA is the

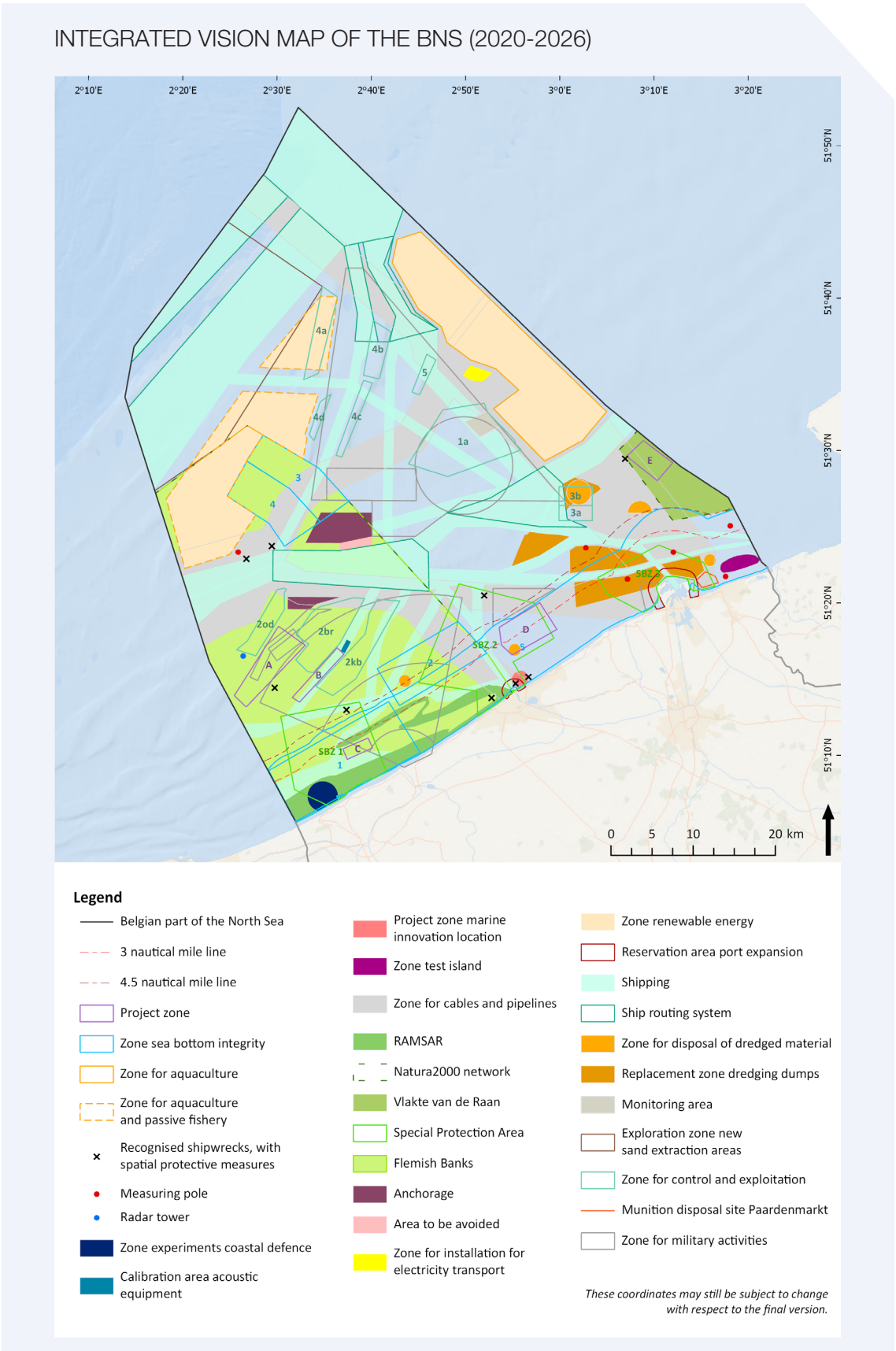

Figure 7. Integrated vision map for the BNS (*MSP 2020-2026, public consultation 2018*). The coordinates used for this map may change as the plan is not yet final.

scientific advice on the license application. This advice is then forwarded to the Marine Environment Service of the FPS Health, Food Chain Safety and Environment. This service 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 and EIA obligation.

1.4.2 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 **1.2 Non-UN agreements**). The majority of them remain in force to this day. With the implementation of the MSFD and the definition of the good environmental status (GES), a legally binding foundation was laid for the ecosystem approach, previously introduced by OSPAR. The carrying capacity of the marine ecosystem has since been legally determined on the basis of the GES in the MSFD (see also theme **Nature and environment**).

Human activities at sea must be carried out in accordance with the requirement of protection and conservation of the marine environment and the concept of 'sustainable use of marine goods and services'. The legal transposition of the MSFD into national legislation is a cornerstone for the coordination of MSP within the BNS. In addition to the legal transposition (RD of 23 June 2010), the following steps were taken in the period 2010-2012:

- An initial assessment of the state of the marine environment (2012);
- An analysis of the pressures and influencing factors and of human activities (2012);
- A socio-economic analysis of the users of the BNS and of the costs associated with the degradation of the marine environment (2012);
- A description of the GES and the adoption of environmental targets (2012).

These elements contribute to the formulation of a definition of GES (2012) as a reference against which all marine activities will be appraised as from 2012. Within the framework of the six-year cycle of the MSFD (*Maes et al. 2013*) these analyses were reviewed and the draft reports were submitted for public consultation in June 2018 (*Belgian State 2018* and *Belgian State 2018b*, public consultation). An update of the socio-economic analysis of the use of Belgian marine waters under the MSFD was published in *Volckaert and Rommens (2018)*. The BNS has three bird directive areas and one habitats directive area: human activities that take place within these areas and may have a significant local impact are subject to the so-called 'appropriate assessment'. The environmental effects of the activity are tested against the conservation objectives set for these specific areas (theme **Nature and environment**).

1.4.3 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 also 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.

Diverse stakeholders have taken initiative on perspectives of coastal development of the coastal zone, as covered in the different thematic texts, for example:

- The *Complex Project Coastal Vision* develops a long-term approach for the protection of Flanders' coast, until 2100 (Government of Flanders, officially launched in December 2017);
- Ecosystem Vision for the Flemish Coast (*Van der Biest et al. 2017a*): an analysis of ecosystem services (based on the CICES v4.3 classification of ecosystem services) in view of the development of a long-term vision 2100 (see theme **Safety against flooding**).

The Belgian coastal waters are part of the International River Basin District of the Scheldt which is managed by the three Belgian regions, the federal government as well as France and the Netherlands (see theme **Scheldt Estuary**). International coordination takes place via the International Scheldt Commission (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, please refer to **Marine Policy – Policy Instruments and Legislation 2018** (*Verleye et al. 2018*).

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entry into force
International Convention for the regulation of whaling	1946	
Agreement to combat pollution in the North Sea Area from maritime disasters and chronic pollution from ships and offshore installations (Bonn Agreement)	1969	1983 (EU)
The Convention on Wetlands, called the Ramsar Convention, is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources (Ramsar)	1971	1975
Convention for the protection of the marine environment and the coastal region of the Mediterranean (Barcelona Convention)	1975	1976
United Nations Convention on the law of the sea (UNCLOS)	1982	1994
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR)	1992	1998
Convention on the protection of the Black Sea against pollution (Bukarest Convention)	1992	1994
Rio de Janeiro Convention on biological diversity (CBD)	1992	1993
Convention on the protection of the marine environment of the Baltic Sea (Helsinki Convention)	1992	1998 (EU)

European legislation

Title	Year	Number
Communication: On an integrated maritime policy for the European Union	2007	575
Commission communication: On offshore wind energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond.	2008	768
Commission communication on European Strategy for Marine and Maritime Research	2008	534
Communication and action plan establishing a European maritime transport space without barriers	2009	10
Commission communication: Strategic goals and recommendations for the EU's Maritime Transport policy	2009	8
Commission communication: Towards the integration of maritime surveillance. A common information sharing environment for the EU maritime domain	2009	538
Commission communication on the international dimension of the Integrated Maritime Policy of the European Union	2009	536
Commission communication on marine knowledge 2020 - Marine data and observation for smart and sustainable growth	2010	461
Commission communication on Europe 2020: A strategy for smart, sustainable and inclusive growth	2010	2020
Commission communication on developing a maritime strategy for the Atlantic Ocean Area	2011	782
Commission communication on Blue Growth opportunities for marine and maritime sustainable growth	2012	494
Commission communication on innovation in the Blue Economy. Realising the potential of our seas and oceans for jobs and growth	2014	254
Commission communication on the next steps within the common information sharing environment for the EU maritime domain	2014	451
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56

Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89

Belgian and Flemish legislation

Abbreviation	Title	File number
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
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

2 Nature and environment

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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*, *website Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences (RBINS-OD Nature)*). The surface of the North Sea amounts to approximately 670,000 km² (*State of Europe's Seas 2015*), of which the Belgian part (BNS) covers a modest 3,454 km², approximately 0.5% of the surface area of the North Sea (*Belpaeme et al. 2011*, *Maes 2016*). More geographical information about the BNS can be found on the digital portal *Het Kustportaal* and the *Marine atlas*. The current text elaborates on the aspects which are characteristic for the BNS and its adjacent coastal area.

2.1 Characteristics of the marine and coastal environment

2.1.1 Sea

BATHYMETRY AND SUBSTRATE

The BNS is a shallow part of the North Sea with a seabed that gradually deepens in a northwest direction up to a depth of 40 to 45 m (figure 1). The relief is characterised by the presence of a complex system of gullies and sandbanks up to 30 m high relative to these 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 further offshore (figure 1). The substrate of the seabed mainly consists of non-consolidated Quaternary sediments with a thickness that varies between a few metres in the gullies to 50 metres around the sandbanks (*Le Bot et al. 2003* (BELSPO), *Mathys 2009*, *Mathys 2010*, *TILES* (*TILES project BELSPO*)). Underneath these Quaternary sediments is Paleogenic clay which is locally found in the trenches (*Lanckneus et al. 2001* (*BUDGET project BELSPO*), *Le Bot et al. 2003* (BELSPO), *Mathys 2009*, *Mathys 2010*, *De Clercq et al. 2016*). 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 water (*Verfaillie et al. 2006*, *Van Lancker et al. 2007* (*MAREBASSE project BELSPO*), *Van Lancker et al. 2015*, *TILES* (*TILES project BELSPO*)).

HYDRODYNAMICS AND SEDIMENT TRANSPORT

The currents in the BNS are dominated by semi-diurnal tides. The tidal range can vary from 3 m during neap tide to more than 4.5 m during spring tide with a decreasing tidal range (between low and high tide) to the northeast. Tidal currents can reach up to 1.2 $m.s^{-1}$ and are an important means of sediment transport, although tides caused by wind may also play an important role (*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*). Along the Belgian coast, a high concentration of suspended sediment occurs resulting in turbidity maximums (*Fettweis and Van den Eynde 2003*, *Fettweis et al. 2007* (*MOCHA project BELSPO*), *Baeye 2012*, *Fettweis en Baeye 2015*, *Fettweis et al. 2016*).

Data and information about the hydrographical and meteorological aspects (tides, currents, waves, wind, etc.) of the BNS can be consulted on the website *Flemish Banks Monitoring Network of the Flemish Hydrography*. This institution is also responsible for the yearly publication of the tide tables (*Getijboekje 2018*). Operational models using e.g. the hydro-meteorological data are available on the *website* of RBINS-OD Nature.

SEAWATER CHARACTERISTICS

The seawater temperature 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 of the Scheldt, Rhine, Seine and Meuse rivers. This inflow reduces the salinity of the water entering via the Channel (salinity 35 PSU or ‰) (*Lacroix et al. 2004*). The carbon chemistry of seawater undergoes a seasonal variation and affects the acidity (pH) of the water with a pH that fluctuates between 7.95 and 8.25 (*Gypens et al. 2011*, *Le Quéré et al. 2015*, *Le Quéré et al. 2016*, see also Integrated Carbon Observation System (*ICOS*)). Information about the nutrients and oxygen levels in the seawater was *inter alia* gathered in the context of the *AMORE* (*AMORE project BELSPO*), *AMORE II* (*AMORE II project BELSPO*) and *AMORE III* (AMORE III project *phase 1* and *phase 2* BELSPO) projects 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 seawater characteristics in the BNS is discussed in *Van den Eynde et al. (2011)* (*CLIMAR project BELSPO*), the *Complex Project Coastal Vision* (formerly Flemish Bays, e.g. *De Maerschalck et al. 2017*) and in the *CREST project* (see also theme **Safety against flooding**).

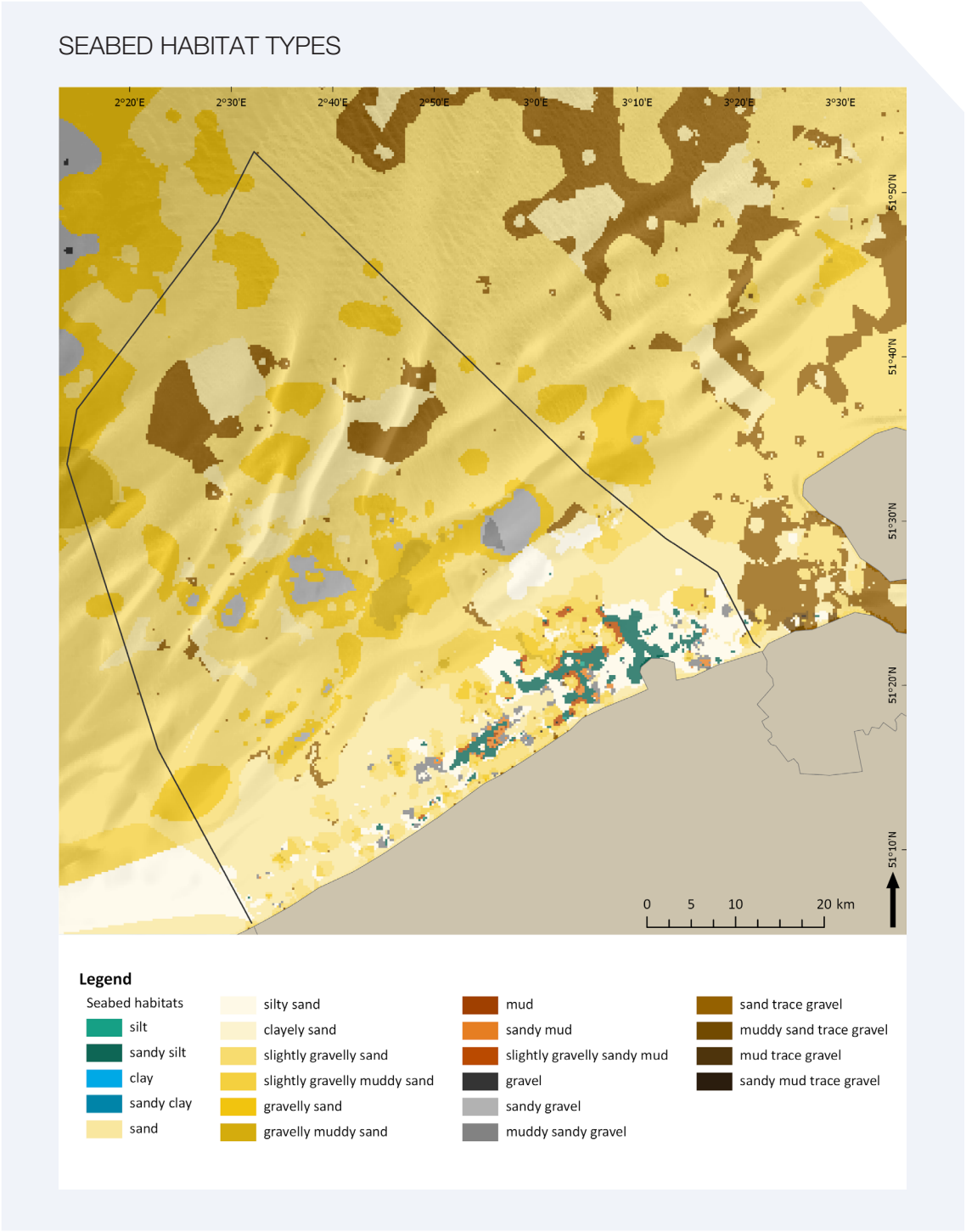


Figure 1. The bathymetry of the BNS and the occurrence and distribution of the seabed habitat types mapped on the basis of the percentages of silt, sand and gravel (Source: *EMODnet Bathymetry*, *Van Lancker et al. 2013*).

MARINE ECOSYSTEM

Within the marine ecosystem, marine organisms are highly dependent on each other. For example, phytoplankton (photosynthetic plankton) is the main source of food for zooplankton. Zooplankton and bottom-dwellers (benthos) are used as food by many organisms, including most fish species. The fish, in turn, are an important source of food for higher trophic levels such as seabirds, (commercial) fish species and marine mammals. Bacteria, microbionts, fungi and macroalgae also play an important role in the marine ecosystem, both in the seabed and in the water column. The marine ecosystem is further discussed by means of a classification into the benthic, the pelagic and the marine mammals and seabirds.

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*). A complete overview of the species lists is available on the Belgian Register of Marine Species (*BeRMS*, *Vandepitte et al. 2010*).

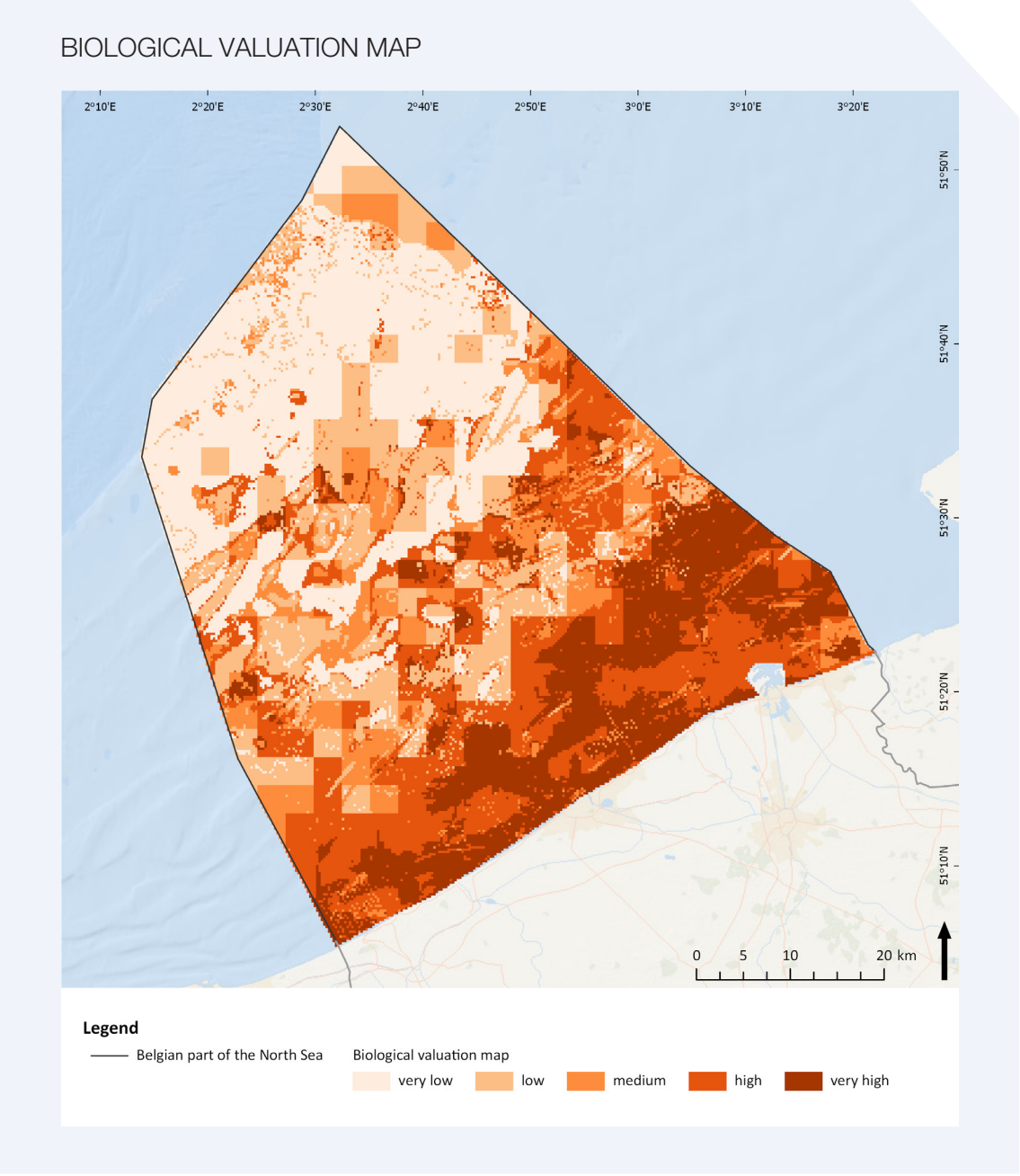


Figure 2. The biological valuation map of the BNS, which combines the valuation maps of the macrobenthos, epibenthos, demersal fish and seabirds (Source: *BWzee project BELSPO*).

BENTHIC LIFE

The sandbanks and channels in the BNS are characterised by a rich benthic life (benthos). Given the high turbidity of the seawater, phytobenthos is almost absent from the (subtidal) BNS. Benthic life here is dominated by the zoobenthos. The benthos has been the subject of intensive research since 1970 (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 BEWG Report 2017*, *Hummel et al. 2017* (*COST Actie EMBOS ES1003*)). 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*, *Courtens et al. 2017*). The following section looks at 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*, *Dewicke 2002*, *Beyst 2001*, *Fockedey 2005*);
- Large numbers of starfish, brittle stars, shrimps, crabs, lobsters and squids can be observed on the seabed. 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*);
- However, most species of soil-dwelling organisms can be found among the sand grains, up to an average depth of about 10 cm below the seabed: these are mainly bivalves, polychaete worms, small crustaceans (macrobenthos[1], *Degraer et al. 2006*), nematodes and copepods (meiobenthos[2]);
- The bacterial community in the seabed is clearly different from that in the water column (*De Tender et al. 2015*). The biochemistry of the seabed, including the carbon cycle, is described specifically for the Belgian coastal zone in *van de Velde et al. (2018)*. The highest richness and diversity of bacteria in the soil is recorded in June, linked to the breakdown of phytoplankton blooms, while ß-AOB[3] and AOA peaks occur in September (*Yazdani Foshtomi et al. 2015*);
- Very little information is available on the infralittoral microphytobenthos of the sandy beaches (*Speybroeck et al. 2005*) of the BNS.

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 seafloor in the BNS is mainly characterised by soft substrates (from silt to fine and coarse sand). The soft mobile substrate of the subtidal sandbanks generally contains five macrobenthic communities (*Breine et al. 2016*):

- the *Limecola balthica* community;
- the *Abra alba* (- *Kurtiella bidentata*) community;
- the *Nephtys cirrosa* community;
- the *Ophelia borealis* (- *Glycera lapidum*) community, revised as *Hesionura elongata* community;
- the *Magelona-Ensis directus* community.

These communities are each characterised by distinctive species with a certain diversity and density, and 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. 2016*).

In addition to the soft substrates, geogenic and biogenic reefs also occur in the BNS. Geogenic[4] reefs contain 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 (*Houziaux et al. 2008*, *Van Lancker 2017*). As hard substrates are important for biodiversity, the evolution of the natural gravel beds will be monitored (*INDI67 project BELSPO*, *Montereale-Gavazzi et al. 2017*, *De Mesel et al. 2017*). 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. offshore wind turbines and artificial reefs) creates new opportunities for benthic organisms. The dense coverage of the structures with a fauna typical of rocky substrates is striking: e.g. the mussel *Mytilus edulis*, the amphipoda *Jassa herdmani* and the sea anemone *Metridium dianthus*. In addition, the anti-erosion coating of these structures offers opportunities for various species: e.g. the European lobster *Homarus gammarus* and the North Sea crab *Cancer pagurus* (*Krone et al. 2017*), macroalgae, fish such as pouting *Trisopterus luscus* and cod *Gadus morhua* (*Degraer et al. 2013*, *Reubens et al. 2013*, *ICES WGMBRED Report 2017*, *Degraer et al. 2017*), etc.

[1] Organisms that live on or in the seabed and are larger than 1 mm.
[2] Organisms that live on or in the seabed and measure between 0.063 and 1 mm.
[3] Ammonium oxidizing bacteria (AOB) and ammonium oxidizing archaea (AOA).
[4] Reefs whose topographical expression is the result of geological phenomena such as the gravel beds of the Hinderbanks.

These structures provide the first space for intertidal fauna to settle in open sea in Belgian waters, which is taken up by a considerable number of non-indigenous species (*Kerckhof et al. 2016*). Furthermore, the effects of these hard substrates on the structure and activity of the communities living in the surrounding soft substrates is monitored (e.g. *Coates et al. 2013*, *Baeye and Fettweis 2015*, *FaCE-IT project BELSPO*, *PERSUADE project BELSPO*, *Derweduwen et al. 2016*).

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 are briefly discussed below:

- Phytoplankton is an important link in the marine food web (*Castellani and Edwards 2017*). Changes in phytoplankton dynamics can strongly influence the zooplankton dynamics (*Lancelot et al. 2007*). Hence, it is important to monitor the problems related to the annual seasonal changes in phytoplankton composition (e.g. *Phaeocystis* blooms) as a result of eutrophication (see theme **Agriculture**) (*Vasas et al. 2007*). The LifeWatch observatory is also making efforts to map these phytoplankton communities (*Flanders Marine Institute 2015, 2018*). The phytoplankton concentration, which typically achieves high concentrations in the coastal waters, is also analysed on the basis of satellite images and chlorophyll-A concentrations (*Rousseau et al. 2006*);
- The zooplankton community[5] of the BNS has a coastal nature but is occasionally influenced by introduced species originating from the inflow of Atlantic water (*Van Ginderdeuren 2013*). The crustaceans (Crustacea) or more specifically the calanoid copepods (holoplankton[6], 66%), dominate the zooplankton with species such as *Temora longicomis*, *Euterpina acutifrons*, *Acartia clausi*, *Paracalanus parvus* and *Centropages typicus* being the most common (*Van Ginderdeuren et al. 2012a*, *Deschutter et al. 2017*, the LifeWatch observatory *Flanders Marine Institute 2017*). Also, meroplanktonic[7] larvae of polychaetes, echinoderms, fish and barnacles are abundant in the BNS. In 2014, a total of 137 zooplankton taxa was listed for the BNS (*Van Ginderdeuren et al. 2014a*). 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 are highest a few kilometres off the coast, in the transition zone from coastal to offshore waters;
- 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. 2015b*) and the common jellyfish *Aurelia aurita* (*Dulière et al. 2014*)), and copepods (e.g. the invasive *Pseudodiaptomus marinus* (*Desutter 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*);
- 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 KP7 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) (*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 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 2012*) also shows that several anadromous fish (such as fint *Alosa falax*) that were included in the Habitats Directive Annex II are recovering (*Breine et al. 2017*).

[5] A collective term for heterotrophic organisms floating or actively swimming in water.
[6] Organisms that are planktonic throughout their entire life cycle.
[7] Organisms that are planktonic only in a certain phase of life.

BIRDS AND MARINE MAMMALS

Marine mammals form a separate group, which is briefly illustrated 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*). 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 stellate* and the common scoter *Melanitta nigra* are often recorded in the BNS in winter, and have both been included in Appendix I of the Birds Directive (see **2.4.2 Policy instruments**).
- The beaches, the groynes and piers along the coast constitute resting places for internationally significant numbers of the European herring gull *Larus argentatus* and 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 harbour of Zeebrugge, the Sluice Dock of Ostend and the Zwin. Although three tern species used to exceed the 1% standard on a regular basis (the Sandwich tern *Sterna sandvicensis*, the common tern *Sterna hirundo* and the little tern *Sternula albifrons*) (*Degraer et al. 2010*), the populations of terns and black-headed gulls in Zeebrugge-Heist and the western outer harbour of Zeebrugge declined sharply after 2008 (*Stienen et al. 2017*). Finally, the BNS functions as an important migration corridor which is used by more than a million seabirds each year. During the migration period, internationally significant numbers of the lesser black-backed gull *Larus fuscus*, the little gull *Hydrocoloeus minutus*, the Sandwich tern and common tern are regularly found (*Stienen et al. 2007*);
- Furthermore, Belgian marine waters are important for two types of marine mammals that are discussed in appendix 2 of the Habitats Directive (see **2.4.2 Policy instruments**) namely the harbor porpoise *Phocoena phocoena* and the harbour seal *Phoca vitulina* (*Degraer et al. 2010*, *Haelters et al. 2016*, *Haelters et al. 2017*). In the period February – April, the numbers of harbour porpoise in the BNS can increase to more than 1% of the estimated North Sea population (*Haelters et al. 2011*). Grey seals (*Halichoerus grypus*) are also increasingly seen in ports, at the coast and on the beach (*Haelters et al. 2017*).

The distribution of both seabirds and marine mammals is influenced by the intervention of human activities such as fishing and the presence of wind farms (see table 1 and **2.3 Impact on the marine and coastal environment**, themes **Fisheries** and **Energy (including cables and pipes)**).

2.1.2 Beach

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 mainly sandy sediments deposited. 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 microrelief 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*).

The beach is also a unique habitat where large numbers of organisms are present. In *Speybroeck et al. (2005)*, *Speybroeck et al. (2008)* and Ecosystem Vision for the Flemish Coast 2017 (*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 are also the habitat for several terrestrial arthropods (the most common species being the sand hopper *Talitrus saltator* and a number of specialised fly species (*Grootaert and Pollet 2004*);
- Microphytobenthos[8], especially diatoms, constitutes an important primary producer at the Belgian coast (*Speybroeck et al. 2005*). The meio[9]- and macrobenthos on the beach include specific communities such as the macrobenthic *Scolelepis squamata-Eurydice pulchra* community. The geomorphology of the beaches,

[8] Microscopically small plants that live on and in the upper centimetres of the soil.
[9] Soil organisms between 1 and 0.063 mm in size.

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*, *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 *Pleuronectes platessa*) and brown shrimps *Crangon crangon* (*Beyst et al. 1999*). It is currently being investigated whether the difference in beach morphology has an impact on the breeding ground function of the intertidal beach sections for juvenile flatfish (*Breine et al. 2018*);
- Birds only breed in the quiet beach reserves of Heist, which are hardly disturbed by recreation, the *Sternenschiereiland* in Zeebrugge and the edges of the new breeding islands in the Zwin and the Sluice Dock in Ostend (e.g. little tern *Sternula albifrons*, common tern *Sterna hirundo*, 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**).

Based on the available biological information about 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 about 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 maintenance of a healthy coastal ecosystem (*Van der Biest et al. 2017a*, *Van der Biest et al. 2017b*).

2.1.3 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. These deposits may date from the last ice age, but are generally not older than a few hundred years. The oldest dunes at our coast are situated between Adinkerke and Ghyvelde in the North of France. They supposedly originated 5,000 years ago and have continuously evolved since (*De Ceunynck 1992*, *De Clercq and De Moor 1996*). At present, most of the coastal dynamics are limited to the dunes bordering the beach (zeereep[10]). However, one decade ago significant aeolian sand transport occurred in the Westhoek area and Ter Yde.

The age of the dunes determines the degree of decalcification of the sand, which 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 in turn is determined by the dune relief in combination with the hydrology. A freshwater supply has built up below the dunes as a result of the percolation of excess precipitation, with the volume of this supply mainly depending 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 and be subject to ecological conditions that can lead to the development of swamp vegetation (*Provoost et al. 2004*).

The complex of soil and vegetation developments and numerous biotic interactions lead to a further differentiation into ecotypes (*Rappé 1996*, *Provoost et al. 2004*). In terms of the European Habitats Directive (see **2.4.2 Policy instruments**), 14 more or less natural coastal ecotypes that are limited to the coastal area within Flanders can be distinguished (*Decleer 2007*) (see also *Natura 2000 in Flanders* website for more information). Six of these ectypes are intertidal, the other 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 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.

In general, half of the species (organisms) in Flanders can also be found at the coast. 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

[10] The row of dunes bordering the beach.

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*). In the context of the European Habitats and Birds Directives (see **2.4.2 Policy instruments**) the following species deserve special attention (see also 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 *Myotis daubentonii* (hibernator), grey long-eared bat *Plecotus austriacus* (hibernator), common pipistrelle *Pipistrellus pipistrellus* (during summer), Nathusius's pipistrelle *Pipistrellus nathusii* (during summer), serotine bat *Eptesicus serotinus* (during summer) and common noctule *Nyctalus noctula* (during summer) (De Maeyer and Velter 2004 in *Provoost and Bonte 2004*);
- Breeding birds in appendix I: black-crowned night heron *Nycticorax nycticorax*, little egret *Egretta garzetta*, European honey buzzard *Pernis apivorus*, common tern *Sterna hirundo*, little tern *Sternula albifrons*, European nightjar *Caprimulgus europaeus*, middle spotted woodpecker *Dendrocoptes medius*, Sandwich tern *Thalasseus sandvicensis*, 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*.

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 the external factors (atmospheric deposition of nitrogen and climate change), recreation, water extraction and expansion of exotic species (*Provoost et al. 2004*).These triggers put the typical dune biodiversity under pressure (*Provoost 2014*). Despite growing awareness of the role of dune dynamics in supporting human well-being and biodiversity, redynamisation of dunes is rarely implemented in coastal zone management. A dynamic dune complex is not only of great ecological importance but would also provide substantial economic added value for coastal protection and recreation (*Van der Biest et al. 2017*, see also theme **Safety against flooding**).

2.1.4 Estuaries, mudflats and marshes

Intertidal mudflats and marches 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: Ecosystem Vision Flemish Coast 2017 (*Van der Biest et al. 2017a*)), 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 marshes also occur in the Scheldt Estuary (see also theme **Scheldt Estuary**). The bibliography of all these areas can be searched thematically in the *catalogue* of the VLIZ library. Mudflats and marches are by nature dynamic systems. A healthy and dynamic system is therefore characterised by the interaction between sedimentation processes and erosion processes. The trend and speed of habitat changes tells if the dynamics in the system are too large, too small or in balance (*Maris et al. 2014*, Ecosystem Vision Flemish Coast 2017 (*Van der Biest et al. 2017a*)).
The Atlantic salt marshes and salt meadows are included in three European habitat types (*Decleer 2007*):

1310 – One-year pioneering vegetation colonising mud and sand areas;
1320 – Coastal salt muds with cordgrass vegetation;
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*). At present, the Zwin park 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 discussed in *Bot (2007a)*. The tidal area serves as an important place to rest, forage, moult, breed and migrate for several birds, including different species which are protected by the European Birds Directive (see *Bot 2007b*). Several of these species make use of the food availability that is present in large numbers as benthos in the Zwin nature reserve (*Van Colen et al. 2009*). Due to the siltation of the Zwin, measures have been taken in the context of the Development Sketch 2010 for the Scheldt Estuary (see theme **Scheldt Estuary**) to restore the mudflats and

marshes and expand the nature reserve (*Verhaegen et al. 2010*, *Van Nieuwenhuyse et al. 2016*, see also: *The Zwin in transformation*).

On the right bank of the Yser, between its mouth in the North Sea and the Ganzenpoot sluice complex, there is an area that is still under tidal influence. This area is part of the Flemish nature reserve of the Yser Estuary (*Hoffman 2006*). As a result of a nature restoration project, the natural transitions of the various components of the coastal ecosystem (including tidal mudflats and marshes) were restored (*Hoffman et al. 2006*). The protection of nature in the Yser Estuary by the European Habitats and Birds Directives was elaborated in more detail in *Spanoghe et al. (2003)*.

The Bay of Heist constitutes an ecological beach where estuarine vegetation has developed in a central depression (*Cosyns et al. 2002*).

2.1.5 Polders and Polder complex

'The Polders' is the name of the former intertidal areas, which have been almost completely excluded from the marine influence by land reclamation since the early Middle Ages. It is a flat and low-lying landscape with inversion relief, caused by the consolidation of clay layers and the subsidence of peat (*Baeteman 2007*, *Baeteman 2013*). It is also the name of the habitats directive area in the coastal zone (MD of 24 May 2002) which overlaps with the birds directive area 'Polder complex' (MD of 17 July 2000) (see **2.4.2 Policy instruments**) (More information about 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 21 European protected animal species (*Paelinckx et al. 2009*). The habitat types include marshes, salt meadows, nutrient-rich herb communities, grasslands, fens and swamp forests. The species for which the habitats directive area has been established are the pond bat *Myotis dasycneme* and northern crested newt *Triturus cristatus*. For this last species, only very few recent observations in the Polders are known;
- The birds directive area 'Polder complex' has been established because the following European protected species breed in this area: Eurasian bittern *Botaurus stellaris*, little bittern *Ixobrychus minutus*, ruff *Philomachus pugnax*, short-eared owl *Asio flammea* and bluethroat *Luscinia svecica*. Also some non-breeding birds directive species are relevant for the poldercomplex: red-throated loon *Gavia stellata*, 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 significant numbers of geese stay in this area during winter months. The pink-footed goose *Anser brachyrhynchus* and the greater white-fronted goose *Anser albifrons* annually exceed the 1%-limit (*Kuijken et al. 2005*, *Wetlands International 2006 – Waterbird Population Estimates*, *Devos and T'Jollyn 2016*).

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 historical permanent grasslands (HPG) in the agricultural region of the Polders (see theme **Agriculture**).

2.2 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 average economic value of the services the marine and coastal ecosystems deliver has been estimated by *Costanza et al. (1997)* to be 252 and 4,052 US dollars per hectare per year respectively. According to a study by WWF (*Hoegh-Guldberg et al. 2015*), the overall value of ocean 'gross marine product' amounts to 24 trillion US dollars. The demarcation of 20 to 30% of all seas would create 1 million jobs worldwide (*Balmford et al. 2004*). This equals an estimated yield of 294 billion euro (compared to a cost up 15 billion euro in protection measures) (*Seys 2006*, *Slabbinck et al. 2008*).

The *BEES project* aims to map ecosystem services in Belgium, and the *ECOPLAN toolbox* has been developed to assess ecosystem services on land. *Jacobs et al. (2010)* published the first inventory of ecosystem services (and potential ecosystem profits) for Flanders. The new version of the nature report for Flanders (*NARA*, 2014-2018) has been drafted as an ecosystem assessment in which 16 ecosystem services have been further elaborated (*Stevens 2014*). An entire chapter is dedicated to coastal protection (*Provoost et al. 2014*). Furthermore, nature valuation studies are also available (e.g. *Hutsebaut et al. 2007*). The *calculation instrument 'Natuurwaardeverkenner'* has been

developed as a support for 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. 2013*).

Scientific knowledge about the ecosystem goods and services of the BNS (and the wider North Sea) and the adjacent coastal zone has not yet been studied to any great extent:

- A preliminary overview of the types of goods and services delivered by marine biodiversity in the BNS can be found in *Beaumont et al. 2007*;
- Within the renewed Ecosystem Vision for the Flemish Coast (*Van der Biest et al. 2017a*), an analysis of ecosystem services is made based on the *CICES v4.3* classification of ecosystem services for the purpose of the development of the long-term vision 2100. *Van der Biest (2018)* presents the scientifically based methods developed for assessing and managing ecosystem services. It is mentioned here for the coastal ecosystem that the most important economic value is created in the dunes by recreation, and in the second place by protection against flooding (*Van der Biest et al. 2017)*. The extraction of drinking water is also an important ecosystem service, although the net extraction of natural groundwater has a significant negative impact on biodiversity. This ecosystem vision emphasises that, despite current scientific knowledge on the impact of human use 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 (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 2012*, *Börger et al. 2016*), and an update of this socio-economic analysis in the framework of the MSFD was published in 2018 (*Volckaert and Rommens 2018*). In this study, the costs of the measures to prevent contamination of the BNS are calculated at a minimum of 2.5 million euro per year (*Volckaert and Rommens 2018*);
- In the context of this socio-economic analysis, the potential of an ecosystem services approach is also offered (*Volckaert and Rommens 2018*). This approach provides information on the value of the difference in ecosystem goods and services that would be provided in the event of good environmental status (GES as defined in the MSFD) compared to normal use, and focuses here on the Flemish banks for the aggregate extraction sector (see also theme **Sand and gravel extraction**). At present, the methodology and empirical application are not yet sufficiently developed to apply the ecosystem approach within the current reporting cycle of the MSFD;
- 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*);
- The 2018 *MAES report* (Mapping and Assessment of Ecosystems and their Services) report proposes a list of policy-relevant core indicators to assess the pressure of ecosystem services on the marine ecosystem and the condition of the marine ecosystem.

2.3 Impact on the marine and coastal environment

The marine and coastal environment, described above, is a region where various human activities take place, each of which have a specific impact on the environment (see theme **Integrated ocean policy**: figure 7). In a number of reports, an overview of the activities and 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)*, *Initial assessment of the state of the marine environment (Belgian State 2012a)*, *Review of the initial assessment for Belgian marine waters*. The Marine Strategy Framework Directive *(Belgian State 2018, public consultation)*, the second federal environmental report (*2015a* and *2015b*), as well as *State of Europe's Seas (2015)* and *OSPAR IA (2017)* at a larger geographical scale. Next to these integrated reports, numerous studies exist on the (direct and indirect) impact of a specific user function. These publications are discussed in the texts of the different user functions under the section '**Impact**'. In table 1, a list of the various **theme texts of the Knowledge Guide Coast and Sea** is given, in which information sources 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. In addition, the problems of marine litter are specifically addressed below, as this theme is not specifically linked to any particular user function.

LITTER

The presence of marine litter is a global problem on land and at sea. Litter is caused by multiple activities and/or sectors and has a potential negative impact on multiple user functions. For more than ten years, the occurrence and effects of litter and microplastics on the beach and in the sea has been studied in Flanders (*Devriese et al. 2016*,

Table 1. Reference table with an overview of the type of impacts discussed within the specific theme texts of the Knowledge Guide Coast and Sea of the Compendium for Coast and Sea.

Impact	Theme texts
Impact on air quality	Maritime transport, shipping and ports; Tourism and recreation; Fisheries; Agriculture; Sand and gravel extraction; Safety against flooding; Energy (incl. cables and pipes)
Impact on the pelagic ecosystem (eutrophication, pollution, etc.)	Energy (incl. cables and pipes); Agriculture; Tourism and recreation; Aquaculture; Maritime transport, shipping and ports; Military use; Dredging and dumping; Fisheries; Sand and gravel extraction
Impact on fish stocks	Fisheries; Aquaculture; Tourism and recreation; Energy (incl. cables and pipes)
Impact on seabirds and marine mammals	Energy (incl. cables and pipes); Maritime transport, shipping and ports; Fisheries; Aquaculture; Military Use
Impact on the seabed/ habitats	Sand and gravel extraction; Dredging and landfill; Energy (including cables and pipes); Military use; Safety against floods; Fisheries; Aquaculture; Agriculture
Impact on hydrographic properties	Energy (incl. cables and pipelines); Maritime transport, shipping and ports; Military use; Safety against floods; Aquaculture; Dredging and landfilling; Sand and gravel extraction
Impact on spatial use (incl. Impact on nature area)	Social and economic environment; Tourism and recreation; Energy (incl. cables and pipes); Fisheries; Aquaculture; Agriculture; Safety against floods; Sand and gravel extraction; Maritime transport, shipping and ports
Impact on beach and dunes	Tourism and recreation; Safety against floods
Impact on groundwater	Tourism and recreation; Agriculture; Safety against floods

Devriese and Janssen 2017). In order to protect the marine environment, marine litter has already been included in the OSPAR targets and in the MSFD environmental targets (descriptor 10) (see below **2.4 Protection of the marine and coastal environment**). The revision of the initial assessment for Belgian marine waters (*Belgian State 2018, public consultation*) shows that on average 136 objects of litter per 100 m beach are found on Flemish beaches (of which approximately 80% are plastic), and an average of 126 objects per km² are found on the seabed (of which approximately 90% are plastic). The intermediate assessment of the OSPAR Commission also showed that plastic is the most common material on the seafloor and the beach (*OSPAR IA 2017*, *ICES WGML Report 2018*). These pieces of plastic can further fragment into very small pieces of plastic, the so-called microplastics or nanoplastics. Not only large plastic objects, but also microscopically small particles can cause a negative impact, both socially, economically and ecologically (see overview in *Devriese and Janssen 2017*, *Everaert et al. 2018*). Both in the field of fundamental and applied scientific research, and in the context of (government) policy, there are clear needs to tackle the problem of litter and microplastics in Flemish aquatic environments (*Devriese and Janssen 2017*). On 23 November 2017, the federal *Action Plan Marine Litter* was approved by the Council of Ministers, in which measures and actions were formulated as concretely as possible. The Flemish Integrated Action Plan Marine Litter (*OVAM 2017*) also proposed 21 objectives and 36 measures to tackle this problem at the Flemish level.

2.4 Protection of the marine and coastal environment

2.4.1 Policy context: administrations and organisations

The environmental policy concerning the coast and sea is directed by several international, European and regional organisations (see also theme **Integrated ocean policy**). In 2015, the Sustainable Development Agenda 2030 (United Nations - *UN*) was adopted, including 17 Sustainable Development Goals (*SDG*). Sustainable Development Goal 14 (SDG 14) addresses the conservation and sustainable use of the seas, oceans and marine resources and addresses threats such as climate change, overfishing and pollution. The International Maritime Organisation (*IMO*) of the United Nations is a specialised agency responsible for the safety and security of shipping and the prevention of marine pollution caused by ships (see also theme **Maritime transport, shipping and ports**). The United Nations Environment Programme (*UNEP*) aims to coordinate the development of the environmental policy on a global and regional level by bringing the environment to the attention of the governments and international community and by signalling new points of interest.

On a European level, the Directorate-General for the Environment (*DG ENV*) of the European Commission (EC) aims to protect, maintain and reinforce the European environment. The Directorate-General for Maritime Affairs and Fisheries (*DG MARE*) of the European Commission (EC) operates in two policy areas: the Common Fisheries Policy (*CFP*, see theme **Fisheries**) and the Integrated Maritime Policy (*IMP*). The IMP aims to provide an integrated answer

to the current challenges of the Europe's seas: marine pollution, environmental protection, coastal development, job creation, etc. The European Marine Strategy Framework Directive (MSFD) is an important instrument for the protection of the marine environment. The European Environment Agency (*EEA*) of the European Union provides reliable and objective information about the environment to anyone involved or interested in environmental policy. In the *OSPAR commission*, 15 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 Service* of the FPS Health, Safety of the Food Chain and Environment is competent for the environmental policy in the BNS. The department also presides 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 Models of the Royal Institute of Natural Sciences (*RBINS-MUMM*). With regard to sand and gravel extraction, the *Continental Shelf Service* of the FPS Economy, SMEs, Self-Employed and Energy is the competent authority. The objectives of the *policy statement (2016)* of the secretary of state of the North Sea include further nature development, a revision of the marine spatial plan and the expansion of a North Sea vision by 2050. In 2017, an initiative was launched with the aim of drawing up this 2050 vision for the future of the North Sea. This vision will be used as a guideline for the new marine spatial plan (MSP) 2020-2060 (see also theme **Integrated ocean policy**). Three working groups were set up for this initiative (naturality, multiple use of space and blue economy and innovation). Within the working groups, naturality was defined and the necessary steps towards sustainable naturality by 2050 were formulated, which are reflected in the long-term vision for the North Sea (*De Backer 2017*). The initiative has since been renamed the *Think Tank North Sea*, which, under the chairmanship of RBINS-OD Nature and Flanders Marine Institute (VLIZ), will facilitate bottom-up consultation on the future of the BNS.

All aspects of the environmental policy with regard to the coast (landward of the baseline) are an exclusive competence of Flanders (*Policy Memorandum on the environment 2014-2019*). The Environment Department (*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. The OMG Department is also responsible for operational matters such as environmental enforcement, environmental permits and approvals, environmental impact and safety reports, environmental and nature education, and nature conservation and development. In addition to the OMG Department, the following relevant entities are included in the policy area Environment: the Agency for Nature and Forest (*ANB*), the Research Institute for Nature and Forest (*INBO*), the Flemish Energy Agency (*VEA*), the Public Waste Agency of Flanders (*OVAM*), the Flemish Environment Agency (*VMM*) and the Flemish Land Agency (*VLM*).

The *province of West Flanders* acts as an intermediary between the federal Government, the regions and the municipalities, and has competences with regard to the environment as it is responsible for the coordination of an integrated water policy, 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 about 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.

2.4.2 Policy instruments

The intense activities at sea and at the coastal zone have led to an elaborated package of legislations and regulations with the aim of mitigating, reducing or avoiding the impact of certain user functions on the environment (see *Verleye et al. 2018*). These mostly sectoral legislations and regulations (e.g. MARPOL Convention) are discussed in the theme texts 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 briefly discussed below (see also theme **Integrated ocean policy** for more information).

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.

OSPAR CONVENTION (1992)

The *OSPAR Convention (1992)* constitutes an overarching legal 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 theme **Integrated ocean policy**), and the use of best available techniques (BAT) and best environmental practice (BEP), including clean technology. The implementation of the Ecosystem Approach is undertaken in OSPAR's North-East Atlantic Environment Strategy (*NEAE Strategy*). The NEAE Strategy was drawn up in 2010 based on the holistic approach in the *OSPAR QSR 2010* and focusses on a suite of five thematic strategies that address the main threats (hazardous substances, eutrophication, radioactive substances, biodiversity and ecosystem loss and the impact of offshore activities). The OSPAR mid-term review (*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 Marine Strategy Framework Directive (MSFD, see below).

The OSPAR secretariat also acts as secretariat for the *Bonn Agreement* (1969). This is the mechanism by which the North Sea States, and the European Union (the Contracting Parties), work together to help each other in combating pollution in the North Sea Area from maritime disasters and chronic pollution from ships and offshore installations; and to carry out surveillance as an aid to detect and combat pollution at sea.

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 oceans. 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.

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*, *Actualisation 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.

HABITATS DIRECTIVE (1992)

The European Habitats Directive (92/43/EEC) aims to maintain and restore the threatened 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. Together with the birds directive areas, these habitats directive areas constitute the European Ecological *Natura 2000 network*. Of the entire 3,190 ha of undeveloped dunes, 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 an area of 109,993 ha (Flemish Banks) is designated as SPA-H. The area consists mainly of shallow, flooded sandbanks, but also of biogenic and geogenic reefs.

The aim is to achieve a good conservation status 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 *T'Jollyn et al. 2009* (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 aims of the MSFD, formed the basis of the MD of 2 February 2017 on the adoption of conservation targets for marine protected areas.

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 *Louette et al. (2013)* for the period 2007-2012. A methodology was developed for monitoring the quality of nature within the habitats directive areas on the landside, based on a mapping of habitats, a monitoring network for monitoring habitat quality (*Westra et al. 2011*) and a monitoring network for monitoring the populations of a selection of internationally important species (*Adriaens et al. 2011*). On the sea side, there was a general evaluation of the conservation status at *Degraer et al. (2009)* on which the reporting to the EC was based.

DECREE OF THE DUNES (1993) – 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 provides direction to 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 of these instruments is constituted by the regional spatial plans of the seventies. In the context of the Dune decree (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 (*FEN*) comprises currently 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 help build 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 Flanders*, *Provincial Structure Plan West Flanders*), subsequently implemented as spatial implementation plans (SIPs) (formerly: regional plans).

LONG-TERM VISION OF 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 theme **Scheldt Estuary** (and the *VNSC website*). Within the framework of the Long-Term Vision of the Scheldt Estuary (LTV, *Directie Zeeland and AWZ 2001*), the permanent working group Research and Monitoring (R&M) of the Flemish-Dutch Scheldt Commission was established. The R&M working group 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 Scheldt Estuary (evaluation method: *Holzhauer et al. 2011*, *Maris et al. 2014*). 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 is 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 the data on the Scheldt Estuary from 2010 up to and including 2015 (*Barneveld et al. 2018*).

MARINE ENVIRONMENT ACT (1999) AND MARINE SPATIAL PLANNING ACT

The law on the marine environment and marine spatial planning act (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. The MMM 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.

WATER FRAMEWORK DIRECTIVE (2000)

The European Water Framework Directive (WFD, 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[11], 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 purposes 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 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, the revised zoning plans and the area-wide implementation plans (*website Coördinatiecommissie Integraal Waterbeleid*, *Programme of measures for the river basin management plans for Scheldt and Maas 2016-2021*). On 20 January 2017, an amendment to the revised zoning plans and the area-wide implementation plans for Landen, Ostend, Sint-Katelijne-Waver and Zandhoven was published. 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 Belgian coastal waters (*River basin management plan Belgian coastal waters 2016-2021*). Coordination takes place between the managing authorities of the river basin district (the Netherlands, France, the three regions and the federal Government of Belgium) via the International Scheldt Commission (*ISC*) and at Belgian level via the Coordination Committee on International Environmental Policy (*CCIEP*).

The WFD is supplemented by the Subsidiary Directive on Groundwater (2006/118/EC) (on the protection of groundwater against pollution and deterioration) and the Subsidiary Directive on Priority Substances (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 theme texts. These include the Urban Waste Water Directive (91/271/EC), the Nitrates Directive (91/676/EC) (see theme **Agriculture**), the Bathing Water Directive (2006/7/EC) (see theme **Tourism and recreation**) and the Floods Directive (2007/60/EC) (see theme **Safety against flooding**).

The implementation of the WFD is provided for by the RD of 23 June 2010 – surface water status at the federal level and the decree on Integrated Water Policy (decree of 18 July 2003) at the Flemish level. Flanders has opted for an area-oriented approach, in which the aim is to achieve good environmental status by 2021 in the spearhead areas and by 2027 in the focus area. Article 19(2) of the Framework Directive states that the Commission shall review the directive at the latest 19 years after the date it came into force and shall propose any amendments necessary to achieve the objective of the directive. To this end, the Commission published a roadmap on 20 October 2017 (*Fitness Check of the Water Framework Directive and the Floods Directive*).

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 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*). 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*. With the adoption of the MSFD, OSPAR is expected to play a key role in harmonising the environmental objectives and the programmes of measures drawn up and implemented by the EU Contracting Parties.

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

Table 2. An overview of the 11 descriptors and the 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), Belgium has prepared an *initial assessment of the state of the marine environment (Belgian State 2012a)* for the BNS, including a *socio-economic analysis of the users of the BNS (Belgian State 2012b)*. Furthermore, a document with the *Description of the good environmental status and determination of environmental targets (Belgian State 2012c)* was published for the BNS. On this basis, a *monitoring programme (2014)* was drawn up by MUMM to measure the evolution of the state of the environment's health. Subsequently, the Marine Environment Service developed a programme of measures (*Programme of measures for Belgian marine waters 2016*), describing additional measures necessary to achieve good environmental status. In the meantime, studies are being carried out specifically with regard to nature values to restore and strengthen the gravel beds and the (lost) oyster beds. Every six years (2018, 2024, 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*). At the end of 2018, the final evaluations for the initial assessment for each MSFD descriptor will be made public (*Belgian State 2018* and *Belgian State 2018b*, public consultation).

BIRDS DIRECTIVE (2009)

The European Birds 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 which are found 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) that 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 (see also the **Habitats Directive**). The most recent report under the Birds Directive covers the period 2007-2012 (see *Anselin et al. 2013*). The next official report to Europe will be in 2019, in which the status of these bird species will be compared with the conservation objectives. 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 support of the setting of COs.

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 14 October 2005, the RD of 5 March 2006 and the RD of 27 October 2016. The decision of the Government of Flanders 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 conservation objectives (see additional information and approved conservation objectives at *www.natura2000.vlaanderen.be*).

PROGRAMME-BASED APPROACH TO NITROGEN (PAN)

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 theme **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 for the coast will be carried in 2018, proposing the most appropriate restoration measures for a set of habitat types.

2.4.3 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 decree of the Dunes, protected landscapes and the Flemish Ecological Network (FEN) (see **2.4.2 Policy instruments**). The working areas of two or more of the mentioned regulations often overlap. In total, more than 1,200 km² or about 36% of the BNS has been designated as a marine protected area (table 3, figure 3).

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 **2.4.2 Policy instruments**). The target date for achieving all nature objectives is 2050, for which six-yearly cycles are used. The Flemish 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 2016*).

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 **2.4.2 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 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.

The marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*, *Pecceu et al. 2016*, *Marine atlas*) does not add any additional areas to the protected areas delimited by previous RDs (table 3, figure 3). The MSP aims to better align activities in existing areas with the protection of the environment. For example, a number of subareas within the nature reserve of the Flemish Banks are delimited where restrictions apply to seabed disturbance activities such as beam trawling (*Pecceu et al. 2014*) and sand extraction. The current MSP runs for a period of 6 years (2014-2020). A revision of the MSP was launched in 2017: the new MSP shall enter into force in 2020 and run until 2026. It was proposed to provide a solution for the '*Vlakte van de Raan*' in the new MSP. This site is on the European list of sites of community importance (*Commission Implementing Decision (EU) 2015/2373 of the Commission*) but was suspended by the State Council, resulting in the fact that Belgium does not comply with the EU obligation to protect this site. A new nature conservation zone '*Vlakte van de Raan*' is proposed, which is an extension of the original zone. This creates an area of high ecological value that also includes the gradient of the sand bank from top to trench (*Degraer and Hostens 2016*, *MSP 2020-2026, public consultation 2018*). Nevertheless, in view of the ever-increasing use of space by human activities at sea, consideration is being given to allow new human activities into the Natura 2000 areas under the new MSP (pre-draft approved by the Council of Ministers on 20 April 2018).

Approximately 22% of the surface of the coastal communities has been assigned some kind of protection with regard to nature conservation (figures 4 and 5). This share is higher compared to the hinterland (+/- 16%) and Flanders (+/- 14%) (*Maelfait et al. 2012*). The maps and surface area of the Natura 2000 areas in the coastal zone can be consulted on the website *Natura 2000 in Flanders*.

The remaining ecologically valuable dune areas with a total surface area of approximately 2,830 ha are almost entirely protected. 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 decree of the Dunes (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.

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

Protected areas in the BNS			
Protected area	Surface area	Status	Legislation
Special Protection Area SPA-1 (Birds Directive)	110.01 km²	Conservation objectives (COs) adopted	RD of 14 October 2005 – special protection zones for the conservation of nature RD of 27 October 2016
		Management plan drawn up andadopted on 19 January 2018	MD of 2 February 2017
Special Protection Area SPA-2 (Birds Directive)	144.80 km²	COs adopted	RD of 14 October 2005 – special protection zones for the conservation of nature RD of 27 October 2016 MD of 2 February 2017
		Management plan drawn up and adopted on 19 January 2018	
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 H2 Vlakte van de Raan (Habitats Directive)	19.17 km²	Destruction of the designation of the Habitats Directive site by the State Council in 2008	RD of 14 October 2005 – special protection zones for the conservation of nature
Special protection area 'Flemish Banks' (Habitats Directive)	1,099.939 km²	Expansion of the 'Trapegeer-Stroombank' area for which a policy plan is already available	RD of 14 October 2005 – special protection zones for the conservation of nature RD of 16 October 2012 amending the RD of 14 October 2005 RD of 27 October 2016 MD of 2 February 2017
		Study for demarcation of area: *Degraer et al. (2009)*	
		COs adopted	
		Management plan drawn up, yet to be adopted	
Marine reserve (Bay of Heist)	6.76 km²	Policy plan available	RD of 5 March 2006
Ramsar site Western Coastal Banks	19 km² (list Ramsar areas)		

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 Conservation 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 (HPG) 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 theme **Agriculture**).

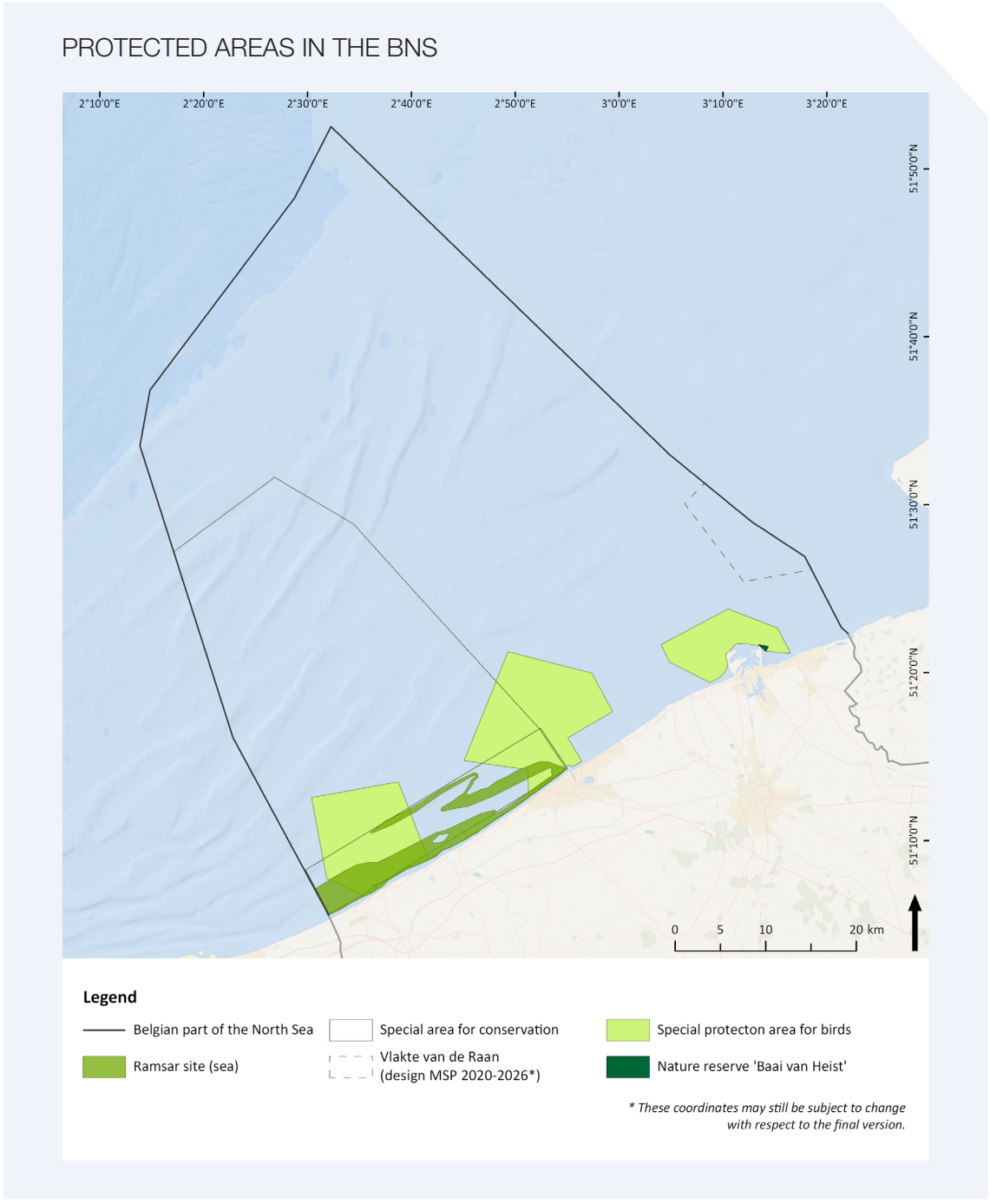


Figure 3. Demarcation of the protected areas in the BNS (Source: RBINS, *marineatlas.be* (based on RD of 20 March 2014, *MSP 2020-2026, public consultation 2018*).

PROTECTED AREAS IN THE COASTAL ZONE

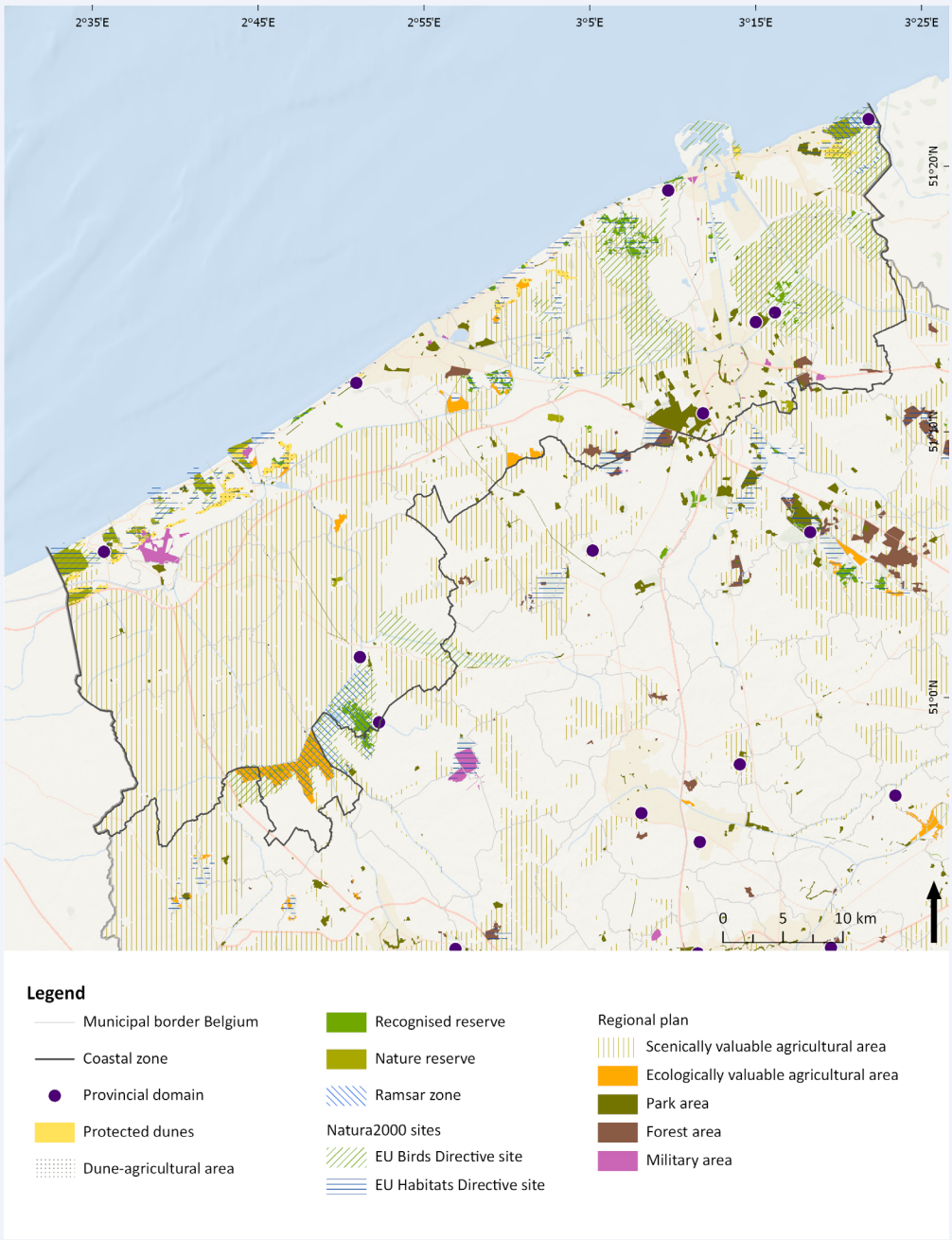


Figure 4. Protected areas and nature areas in the coastal zone (Source: Province of West Flanders, Agency for Nature and Forest, Natura 2000, Environment Department (Government of Flanders) - Section Vlaams Planbureau voor Omgeving).

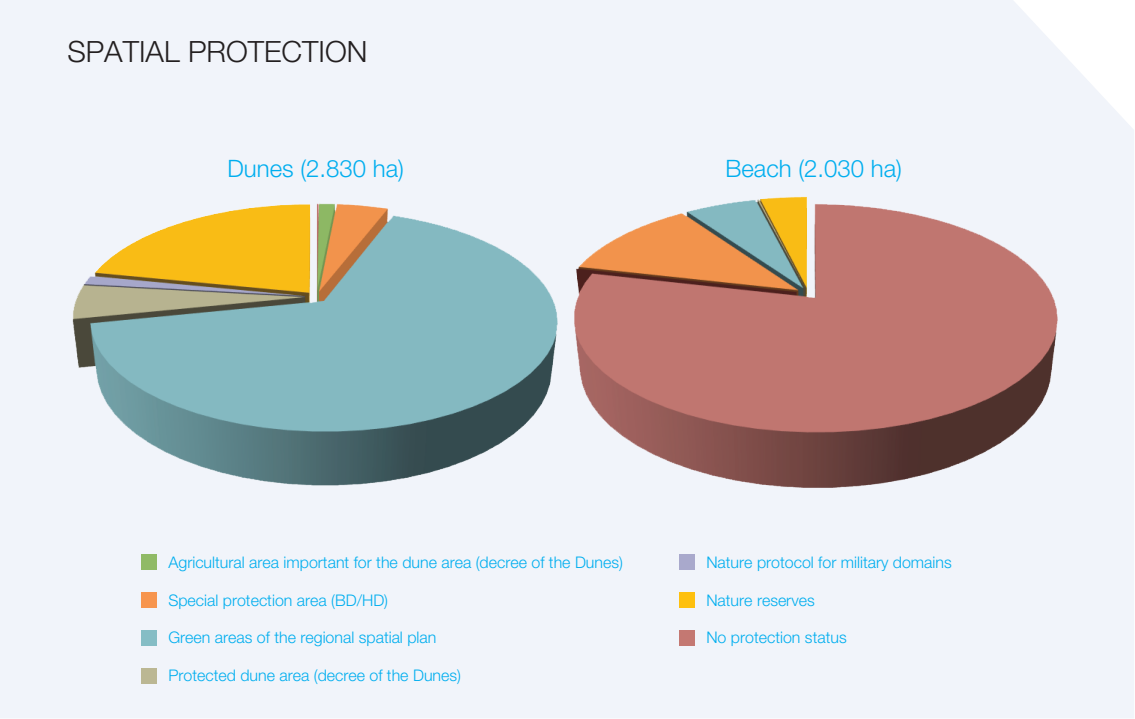


Figure 5. Spatial protection of the ecologically valuable dune ecotypes and beaches according to the different statutes for nature conservation. In the context of the decree of the Dunes, both categories of protection were added to the analysis (*Dumortier et al. 2003*).

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex,* the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

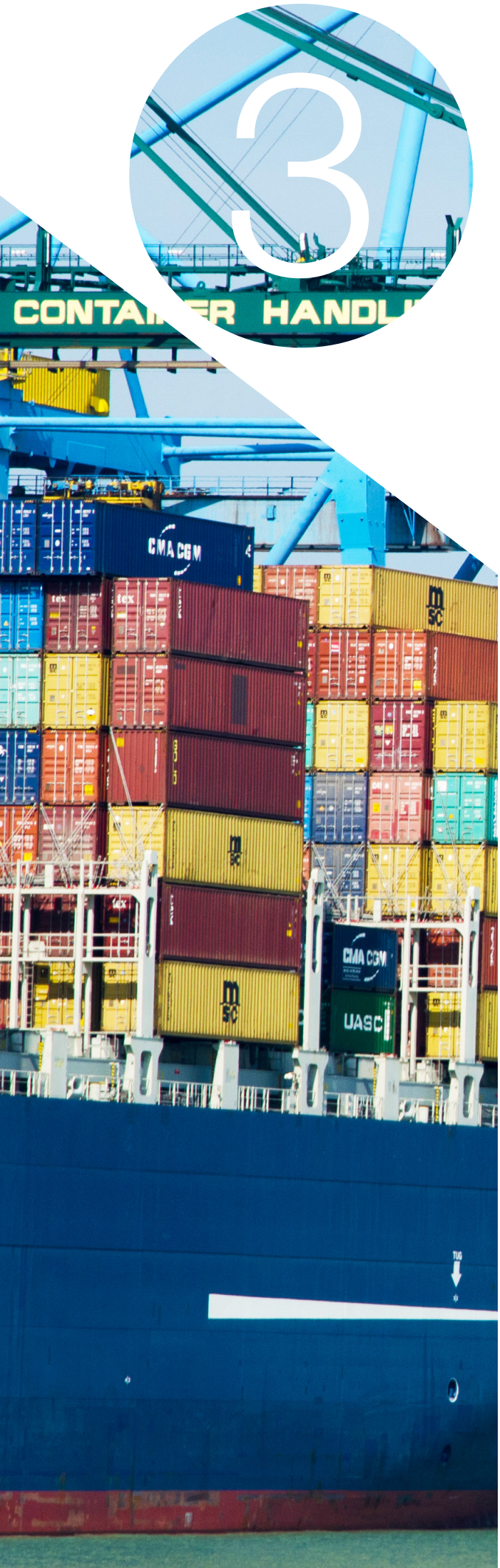
Title	Year of conclusion	Year of entering into force
The Convention on Wetlands, called the Ramsar Convention, is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources (Ramsar Convention)	1971	1975
International Convention for the prevention of pollution from ships, as modified by the Protocol 1978 (MARPOL Convention)	1973	1978
United Nations Convention on the law of the sea (UNCLOS)	1982	1994
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR Convention)	1992	1998
Rio de Janeiro Convention on biological diversity Convention on Biological Diversity (Convention on Biological Diversity)	1992	1996

European legislation

Title	Year	Number
Decision of the Commission of 1 September 2010 on establishing criteria and methodological standards for the good environmental status of marine waters	2010	477
Communication from the Commission (COM): An integrated maritime policy for the European Union (Integrated Maritime Policy)	2007	575
Directive concerning urban waste water treatment	1991	271
Directive on the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive)	1991	676
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2006/118/C of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration (Groundwater Directive)	2006	118
Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Floods Directive)	2007	60
Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 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 (Proprietary substances directive)	2008	105
Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning (MSP Directive)	2014	89

Belgian and Flemish legislation

Abbreviation	Title	File number
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
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
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 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
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



Maritime transport, shipping and ports

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Maes, F., Merckx, J.-P., Pirlet, H., Verleye, T. (2018). Maritime transport, shipping and ports. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 47-67.

Currently more than 80% of the globally traded goods (in volume) are transported by sea. In 2016, this amounted to 10.3 billion tonnes of goods which were transported by seagoing ships. On the 1st of January 2017, the world merchant fleet consisted of 93,161 ships, equaling a total of 1.86 billion DWT (dead-weight tonnage). During the past years the total load capacity increased rapidly (2016: +2.5%) in comparison to the demand (+2.1%), which results in a continuous situation of global overcapacity. The primary flag states are Panama, Liberia and the Marshall Islands, together accounting for 42% of the global DWT. In 2017, Belgium had 263 seagoing ships, comprising 1.27% of the global DWT (*Barki and Deleze-Black 2017* - UNCTAD, see also *list Belgian seagoing ships*). The evolution of the Belgian merchant fleet is also discussed in a triennial study of the *Royal Belgian Shipowners' Association* (*RBSA 2017*).

The Belgian sea ports are situated at one of the busiest shipping routes in the world. The total transshipment of goods in the Le Havre-Hamburg range (including Ostend) amounted to 1.195 billion tonnes in 2017. The market share of the Flemish sea ports[1] consisted of 294.7 million tonnes (24.7%), of which Antwerp accounted for 223.6 million tonnes (*Coppens et al. 2018*, *Merckx 2018*).

Maritime transport and shipping in the Belgian part of the North Sea (BNS) will be discussed in detail below. With regards to the ports, only sea ports (with the main purpose of handling seagoing ships) are taken into account, whereas fishing ports (mooring for fishing boats, see theme **Fisheries**) and marinas (mooring for recreational boats, see theme **Tourism and recreation**) are not considered (*Jargon list website Flemish Port Commission*).

3.1 Policy context

The United Nations Convention on the Law of the Sea (*UNCLOS 1982*) can be regarded as the primary piece of legislation. 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*). Furthermore, the IMO is responsible for a significant amount of other conventions about, *inter alia*, safety and security at sea, traffic regulations, the training of crew members and pollution prevention (accidental as well as operational discharges) (see *list at IMO website*). Some of these conventions are discussed further under **3.5 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 every authority needs to maintain an efficient port state control system so foreign freighters visiting their ports, or anchoring in front of the ports, are in line with the standards as described in the international treaties mentioned above.

On a European level, the Directorate-General for Mobility and Transport (*DG MOVE*) is, *inter alia*, competent for maritime transport and ports. The strategic goals as well as recommendations for the European policy concerning maritime transport until 2018 have been elaborated in the *Maritime Transport Strategy 2018* (COM (2009) 8). In 2016, a temporary report concerning the implementation of the strategy was published (*SWD (2016) 326*). On 8 June 2017, the Conclusions of the European Council regarding the priorities for the European maritime transport policy until 2020 were published (*9976/17*), in which competitiveness, decarbonisation and digitalisation are highlighted to ensure global connectivity, an efficient internal market and a maritime cluster of world class. These conclusions endorse the content of the *Valletta-Statement* of the 29th of March 2017 concerning the European maritime policy. 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 accidents, pollution by ships and the loss of human lives at sea. An overview of the European legislation and the policy concerning ports and marine transport is provided in the publication Harbour Light (*Merckx et al. 2012*). Several of these policy instruments are also further elaborated in *Verleye et al. (2018)*.

In Belgium, maritime transport is a federal matter, covered by the *FPS Mobility, Directorate-General (DG) Shipping* (*Policy statement Mobility 2014*, *Policy statement Social Fraud*, *Privacy and North Sea 2014*, other federal actors are listed in table 1). DG Shipping ensures that ships sailing under a Belgian flag, or ships 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. The DG Shipping represents Belgium within the IMO. The rules with regard to ship navigations are listed on the *website* of the FPS Mobility and Transport. Furthermore, a review of the current Belgian maritime legislation has been included in the *coalition agreement of the federal Government (2014)*.

[1] The Flemish sea ports include the ports of Antwerp, Ghent, Zeebrugge and Ostend. Since December 2017, the port of Ghent is merged with Vlissingen and Terneuzen into the "North Sea Port". When this text mentions the port of Ghent, it's now referring to "North Sea Port, subport Ghent".

The law of 8 August 1980 defines that waterways and their appurtenances, ports and their appurtenances, pilotage and fairway services towards the ports, as well as rescue and towing services at sea are the responsibility of the Flemish Region, within the policy domain of Mobility and Public Works (*MOW*, see also *Policy Note MOW 2014-2019*) (see list of Flemish actors in table 1). The legal framework concerning Flemish ports is covered by the Port decree (2 March 1999, as modified). The coordination and the consultation between the federal and the Flemish Region services (table 1) and 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 ANIP North Sea (general emergency and intervention plan) (see Belgian Official Journal of 20 October 2016). The Coast Guard cooperation agreement also includes the creation of the Coast Guard Centre.

Table 1. Overview of the Flemish and federal partners of the Coast Guard structure.

Flemish Partners of the Coast Guard	Federal Partners of the Coast Guard
International Environmental Policy Division	FPS Interior (Civil protection, Crisis Centre and Waterway Police)
Fisheries Service	FPS Foreign Affairs
Coastal Division	FPS Economy, S.M.E.s, Self-Employed and Energy
Shipping Assistance Division	FPS Finances (Belgian customs)
Pilotage	FPS Mobility and Transport (DG Shipping)
Fleet	FPS Health, Food Chain Safety and Environment (Marine Environment Service)
Ports and Water Policy Division	Ministry of Defence
Maritime Access Division	PPS Sustainable Development
	PPS Science Policy (Management Unit of the North Sea Mathematical Models (MUMM), scientific service of the Royal Belgian Institute of Natural Sciences (RBINS))
	PPS Sustainable Development

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 and the first contact point for ships in distress and in charge of the coordination of rescue operations) and the Maritime Security Centre Belgium (*MIK*) in Zeebrugge (cooperation between the Marine Component, the Shipping Police, Border Control and DG Shipping to make sure the laws at sea are applied). Their tasks have been stipulated in the decree of 16 June 2006, the agreement of the Government of Flanders of 26 October 2007 and the RD of 6 February 2009.

Other relevant organisations and clusters not listed in table 1 are:

- The Flemish Port Commission (*VHC*) – advising and informing function on socio-economic aspects of ports and port's policy;
- Environment and Nature Council of Flanders (*Minaraad*) – advice on environmental and technical aspects of port projects over 10 million euro which have requested subsidies.

An overview of the legislation concerning shipping and ports is also available in the Codex Coastal Zone, themes *Shipping* and *Port and Industry*. The environmental context of port policy, management and exploitation is discussed in detail in *Van Hooydonk et al. (2003)*.

3.2 Spatial use

In the marine spatial plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014*) 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. However, ships are not obligated to follow these routes. Since 1 June 2017, *new shipping routes* are present within Belgian and Dutch waters, which are mainly necessary for the safety of the Belgian offshore wind parks on, and in the surroundings of, the Thornton Bank (no access for ships) and consequently to promote the safety of shipping and to limit the risk of collisions with possible environmental pollution as a result

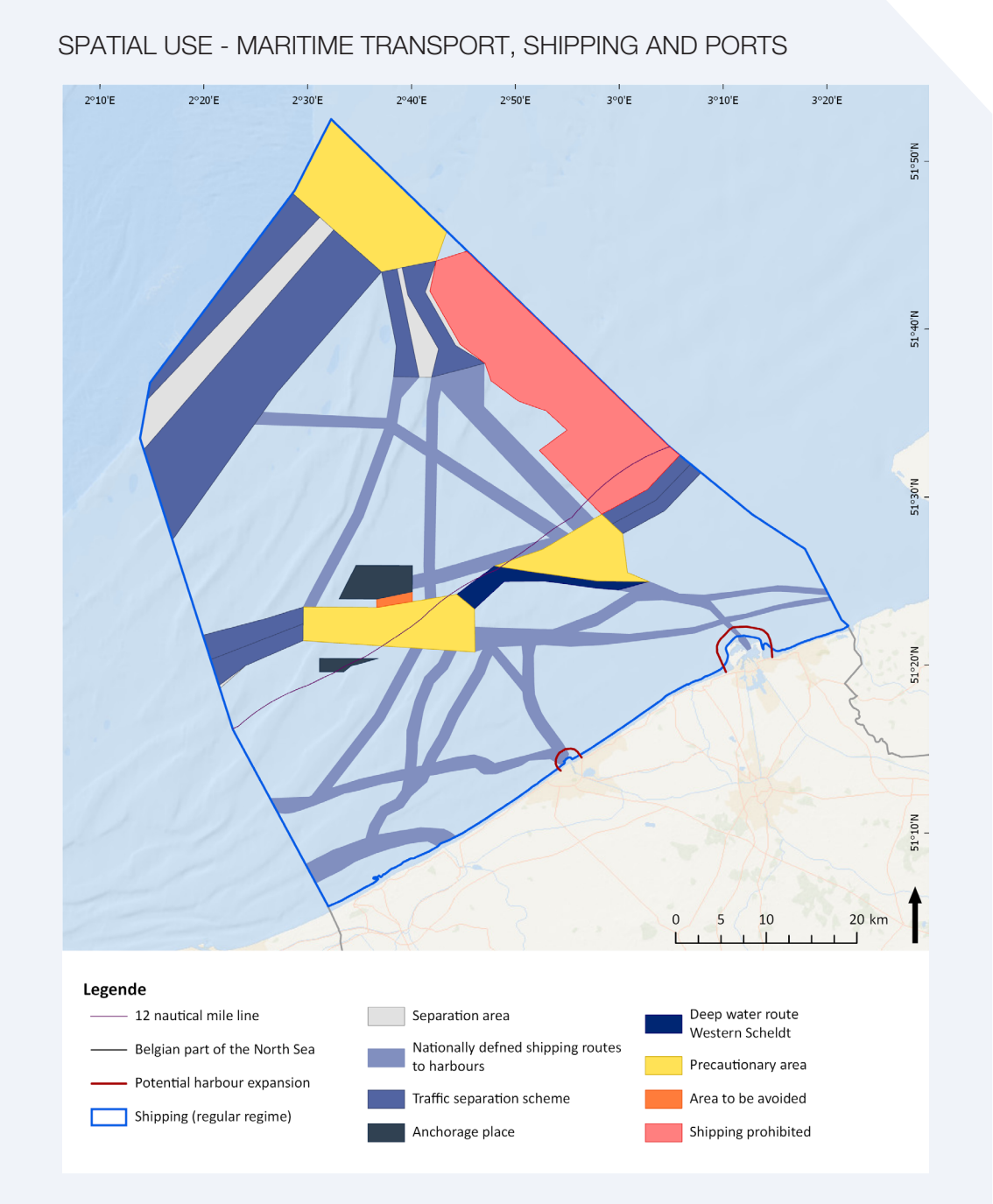


Figure 1. (Source: RBINS, *marineatlas.be* (based on RD of 20 March 2014), *MSP 2020-2026, public consultation 2018*, *IMO 2017*).

(figure 1). The new shipping routes also take into account the planned development of offshore wind parks by the Netherlands, known as the area of Borssele. Other activities may be allowed within these demarcated zones, as long as they don't compromise the shipping. For a number of these routes, a routeing system (*Ship's routeing*) has been adopted within the IMO for which the current situation is in force since 1 June 2017:

- Traffic separation scheme Noordhinder South;
- Precautionary area (where ships have to navigate carefully) Noordhinder Junction;
- Traffic separation scheme Westhinder;
- Precautionary area Westhinder;
- Area to avoid Westhinder;
- Deepwater route (specifically for ships 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 of the Scheldt area exist in the BNS. These routes are used by ships because they are marked and/or dredged, guaranteeing a safe shipping depth. 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 exploitation of installations producing electricity from water, currents or winds (with a safety zone of 500 m). In the MSP, the anchorage zones of Oostdyck and Westhinder are demarcated. There is also a safety zone of 500 m around every fixed construction within the concession zone (RD of 11 April 2011, see also theme **Energy (including cables and pipes)**).

Information concerning shipping in the BNS is communicated via the Notices to Mariners (*Coastal Division, Notices to Mariners*, more information: general provisions *BaZ 2018 nr. 1*).

3.2.1 Port zones

According to the spatial structure plan Flanders (*RSV*), the Port decree and the consecutive coalition agreements, every Flemish sea port should have a strategic plan (including an Environmental Impact assessment (EIA) (see also **3.4 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 sea ports in a regional spatial implementation plan (*GRUP*) (GRUP demarcation for the port of Ghent: 2005, Zeebrugge: 2009, Ostend: 2013, Antwerp: 2013). The spatial development and the access to the ports are also addressed in the Green Paper *Groenboek Vlaanderen 2050: mensenmaat in een metropool (2012)* and in the White Paper of the policy plan: *Beleidsplan Ruimte Vlaanderen (2017)*.

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 sea ports are presented in table 2.

The ports are not only discussed in spatial planning on land. In the MSP (RD of 20 March 2014, see also *Van de Velde et al. 2014*), space is reserved at the seaside to expand the ports of Zeebrugge and Ostend.

Table 2. Overview of the Flemish sea ports and their total surface area and water surface area (*Merckx 2018*).

Port	Total surface area	Water surface area
Port of Ostend	658 ha	199 ha
Port of Ghent	4,648 ha	623 ha
Port of Zeebrugge	2,857 ha	986 ha
Port of Antwerp	12,068 ha	2,005 ha

3.3 Societal interest

3.3.1 Employment

The total employment in the Flemish sea ports in 2016 amounted to 230,340 full-time equivalents (FTEs), of which 103,333 direct FTEs (figure 2). In the field of direct employment, Antwerp is the main Flemish port with 60,849 direct jobs (58.9%), followed by Ghent (27,983 FTEs; 27.1%), Zeebrugge (9,589 FTEs; 9.3%) and Ostend (4,912 FTEs; 4.8%). This difference in employment is partly related to the type of industry and the shipment of goods in the different ports (see below). At the sectoral level, 34% is working in the maritime sector. The total employment (direct + indirect) in the ports amounted to 10% of the total wage-earning Flemish employment in 2016 (*Merckx 2018*, *Coppens et al. 2018*, *Kwartaalbericht Vlaamse Arbeidsmarkt april 2018*).

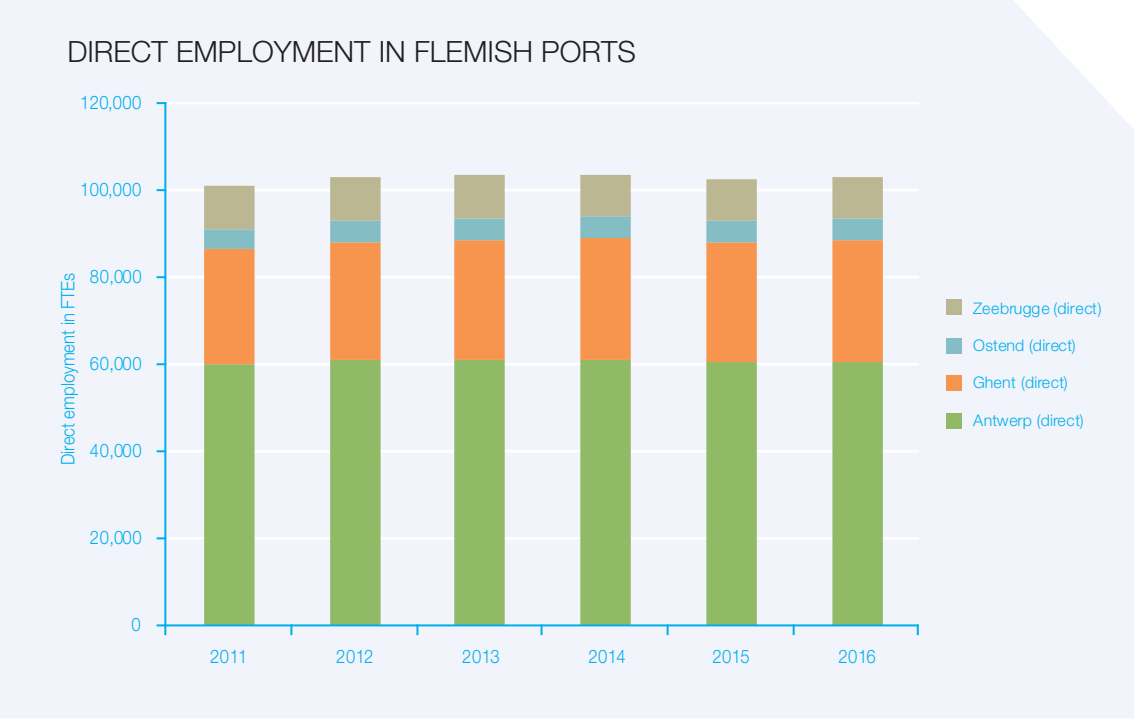


Figure 2. The direct employment in the Flemish ports (Source: *Merckx 2018*, *Coppens et al. 2018*).

The ports of Liège and Brussels jointly amounted to a total direct employment of 11,807 FTEs. This brings the total direct employment for Belgium to 115,139 FTEs, of which Liège and Brussels jointly account for 10.2%. The total Belgian employment (direct + indirect) amounts to 252,537 FTEs (*Coppens et al. 2018*). The workforce in the Belgian ports remains relatively unchanged since several years and concerns mainly male employees (83%). The majority of the port personnel consists of blue-collar workers (52% in 2015), followed by the white-collar workers (44%) and the other staff (4%) (*Mathys 2017*).

3.3.2 Added value

The total added value of the Flemish ports amounted to 31 billion euro in 2016, of which 16.2 billion euro was direct added value (figure 3). Between 2011 and 2016 the direct added value of the ports increased with 11%. The port of Antwerp generates the highest direct added value and accounts for 10.8 billion euro (66.8%), followed by Ghent (3.9 billion euro; 23.8%), Zeebrugge (1 billion euro; 6.2%) and Ostend (0.5 billion euro; 3.1%) (*Merckx 2018*, *Coppens et al. 2018*).

The ports of Liège and Brussels have a direct added value of respectively 1.2 and 0.7 billion euro, and a relative share of 10.5% of the total of the Belgian ports (*Coppens et al. 2018*).

3.3.3 Ship movements

In 2017, a total of 29,793 seagoing ships have visited a Flemish seaport, with a total of 650.9 million gross tonnage (GT). The number of seagoing ships that visit a Flemish sea port on a yearly basis is characterised by a decline during the last four decennia (-19% since 1980). This decline is however compensated by the increasing size of the ships, i.e. an increase in total GT of 338% (figure 4). On the level of the ship, this means an increase of the mean GT from 5,237 GT to 21,847 GT. The mean GT per ship varies strongly among ports: Antwerp (28,599 GT) and Zeebrugge (24,099 GT) have remarkably higher mean GT compared to Ghent (11,950 GT) and Ostend (1,007 GT) (*Merckx 2018*).

3.3.4 Shipment of goods

As a consequence of the global financial and economic crisis in 2009, the total maritime traffic in the Flemish ports declined with 14.3%, which was almost completely compensated (+13.6%) in 2010. With the exception of the year

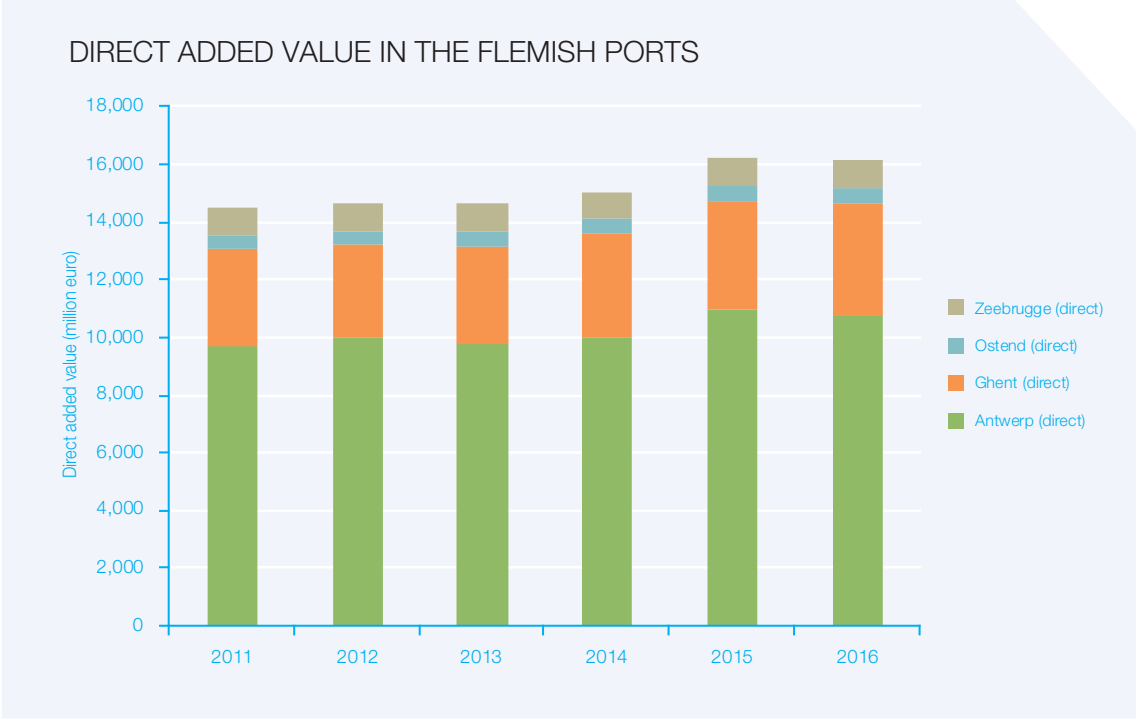


Figure 3. The direct added value in the Flemish ports in million euro (Source: *Merckx 2018*, *Coppens et al. 2018*).

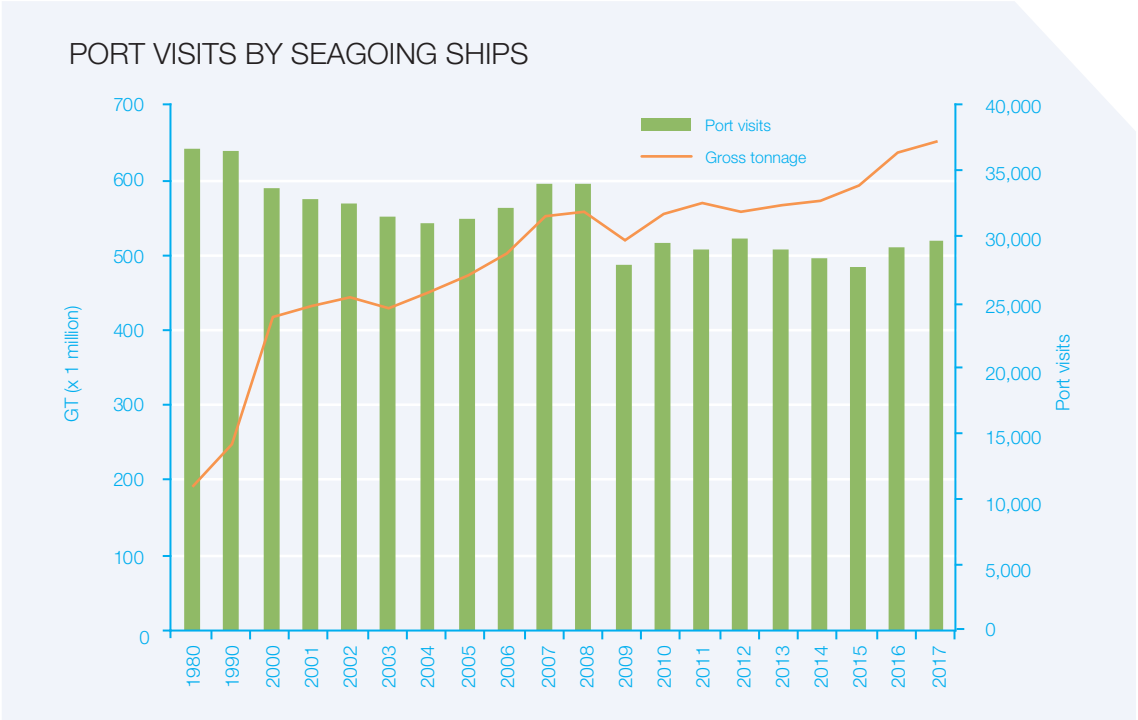


Figure 4. The number of port visits by sea ships and the associated total gross tonnage (GT) (Source: *Merckx 2018*).

2009, and to a lesser extent 2012, the traffic numbers are increasing gradually throughout the years. In 2017, a total of 294.7 million tonnes of goods were processed in the Flemish sea ports, which is an increase of 4% compared to 2016 (figure 5). This represents 24.7% of the Le Havre-Hamburg range, the highest share in history. Antwerp is the main Flemish port in terms of total cargo traffic with 223.7 million tonnes (18.7%), followed by Zeebrugge (37.1 million tonnes; 3.1%), Ghent (32.5 million tonnes; 2.7%) and Ostend (1.4 million tonnes; 0.1%) (*Merckx 2018*).

At the level of tonnage, the port of Antwerp is leader within Flanders in the field of fluid bulk (73.2 million tonnes; 88.5%), containers (123 million tonnes; 88.8%) and break bulk cargo (10.3 million tonnes; 67.4%). Zeebrugge is the main port for roll-on roll-off (15 million tonnes; 66.9%), while Ghent handles the biggest amount of dry bulk (21.1 million tonnes; 58.7%) (*Merckx 2018*).

A large share of the goods processed by Flemish ports is of European origin. With 43.8%, Antwerp has the lowest percentage of goods with a European origin, while Ostend has the highest relative share with 99% (including sand and gravel). With the exception of Antwerp, between 71.2% (Zeebrugge) and 100% (Ostend) of the goods have a European destination. For Antwerp this is only 27.5%, while 31.9% of the goods have an Asian destination (*Merckx 2018*).

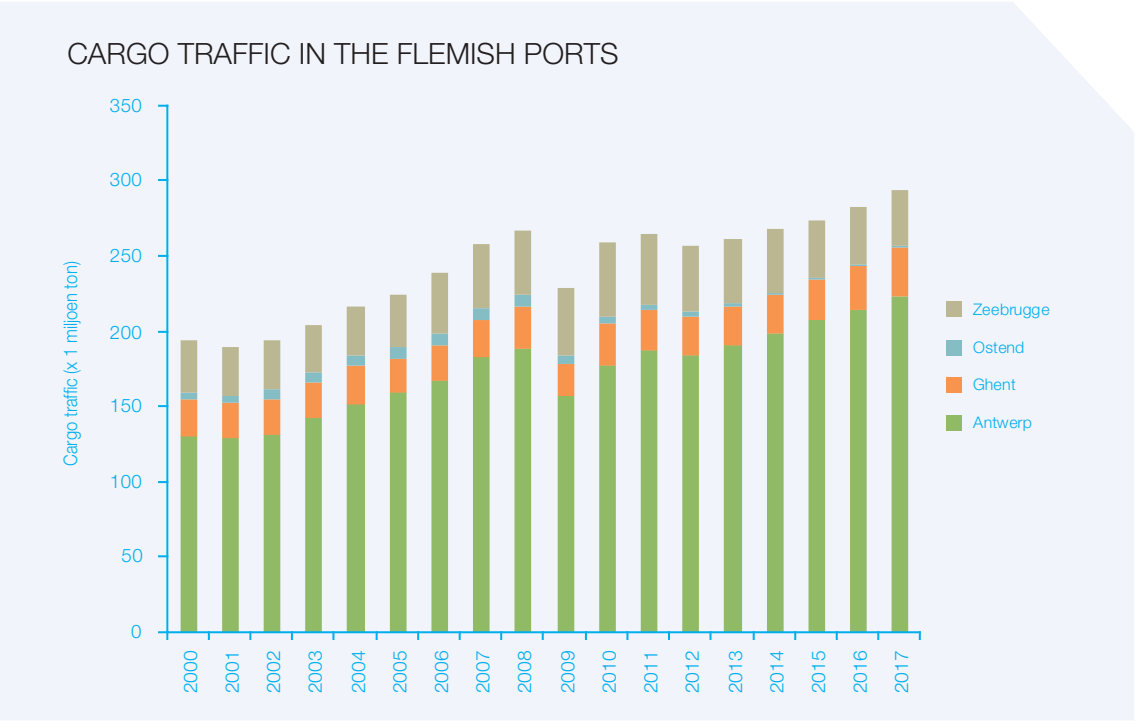


Figure 5. The cargo traffic in the Flemish ports (in tonnes) (Source: *Merckx 2018*).

3.3.5 Passenger traffic

A total of 1.1 million passengers embarked or disembarked in the Flemish seaports in 2017. Passenger traffic is almost entirely attributable to Zeebrugge (1.09 million passengers; 99.4%). This is the highest number since 2003, but still represents a decrease of 79% compared to 1980 (5.11 million passengers) (figure 6). This decline is due to the commissioning of the Channel Tunnel, the cessation of the *Regie voor Maritiem Transport* (RMT) ferry service and the cancellation of certain ferry lines to the United Kingdom (*Notteboom 2004*). Whereas Ostend accounted for more than 54% of passenger traffic in the 1980s, it now has an interest of just 0.2% (*Merckx 2018*).

3.3.6 Inland navigation to and from Flemish seaports

In 2017, a total of 126.4 million tonnes of goods were loaded and unloaded in and from inland vessels in the Flemish seaports, an increase of 5% compared to 2016. This represents 73.7% of the total cargo traffic by inland navigation in Flanders (171.5 million tonnes). Antwerp (102.3 million tonnes) and Ghent (23 million tonnes) together account for 73% of the total Flemish cargo traffic from inland vessels and represent 99% of the share of the sea ports (figure 7) (*Merckx 2018*).

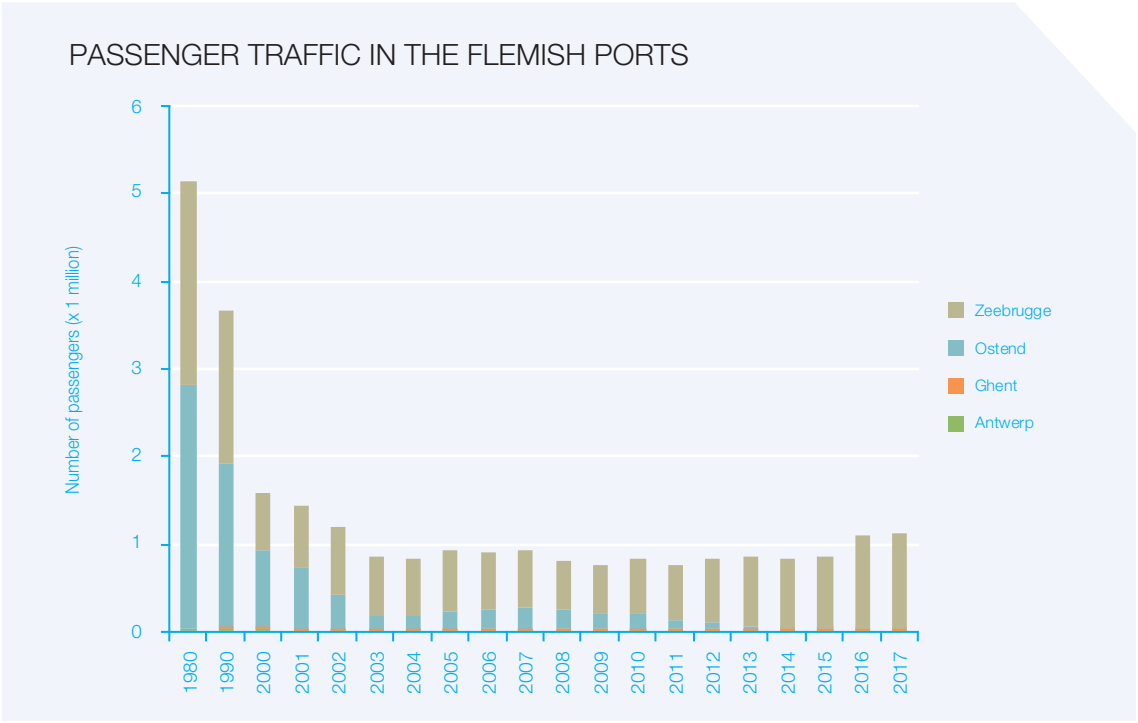


Figure 6. Passenger traffic in the Flemish ports (Source: *Merckx 2018*).

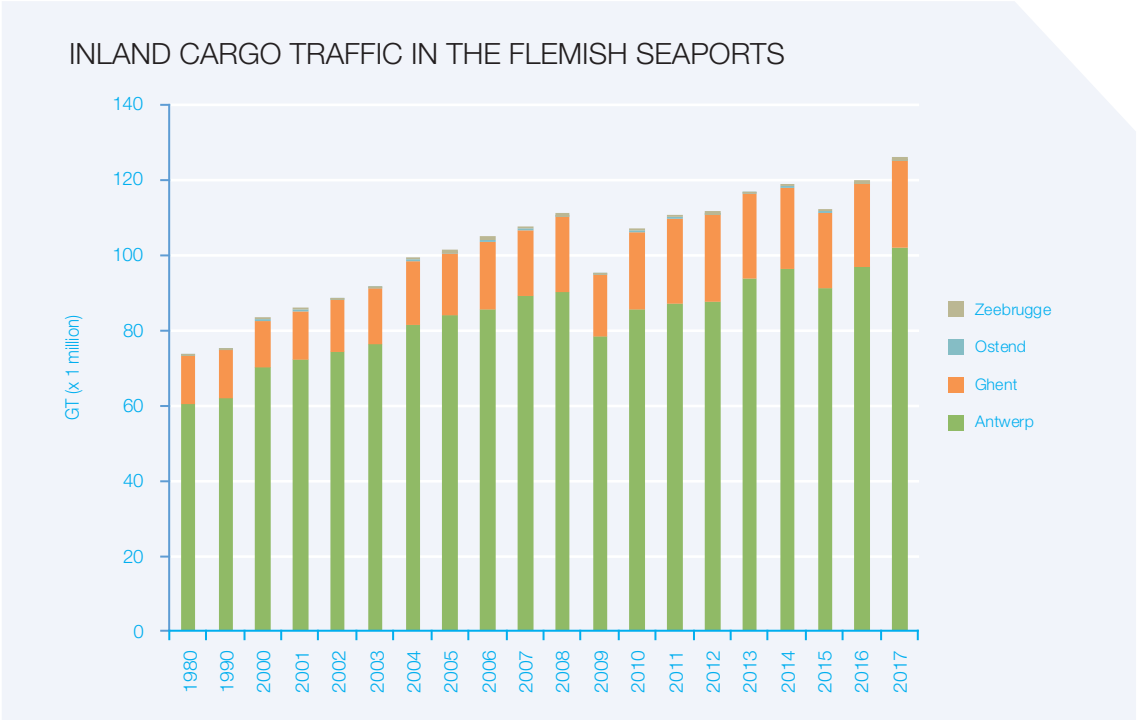


Figure 7. Inland cargo traffic in the Flemish seaports (Source: *Merckx 2018*).

3.3.7 Investments

In 2016, direct investments in Flemish seaports amounted to 4.3 billion euro, an increase of 41% since 2011 (figure 8). The port of Antwerp accounts for 79.1% of total investments, 3.429 billion euro. This is followed by the seaports of Ghent (530.8 million euro; 12.2%), Zeebrugge (294.6 million euro; 6.8%) and Ostend (81.4 million euro; 1.9%) (*Merckx 2018*, *Coppens et al. 2018*).

Investments in the ports of Liège and Brussels in 2016 amounted to 195.4 million euro and 64.7 million euro respectively. Together they represent 5.7% of the total investments in Belgian ports (4.596 billion euro) (*Coppens et al. 2018*).

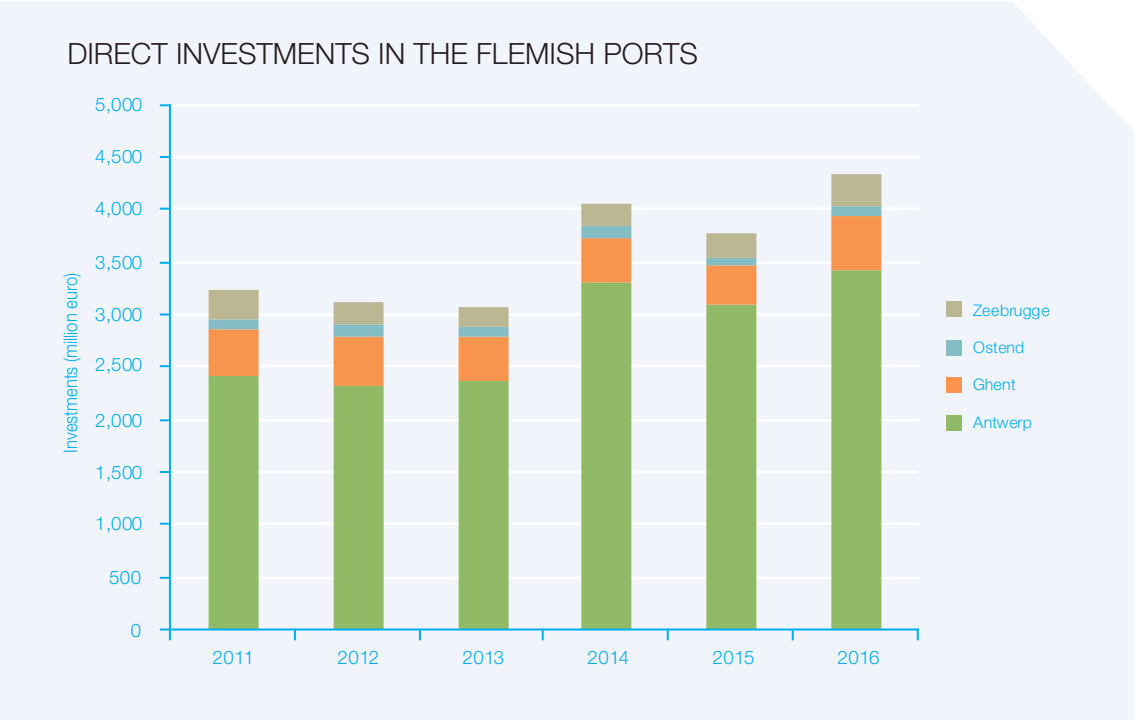


Figure 8. Direct investments in Flemish ports in million euro (Source: *Merckx 2018*).

3.3.8 Government expenditure

Total government spending on the Flemish seaports amounted to 414.9 million euro in 2017. With 255 million euro, 'maritime access' accounts for 61.5% of total government spending. This includes maintenance dredging at sea and on the Westerscheldt, various deepening programmes, wreck removal, vessel traffic services (VTS) and sludge processing. Among the port-related expenditures (120.4 million euro), the largest budget was provided for the port of Antwerp (68.9 million euro), followed by Zeebrugge (38.5 million euro), Ghent (7.9 million euro) and Ostend (5.2 million euro) (figure 9) (*Merckx 2018*).

3.4 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 *file database, Department Environment*).

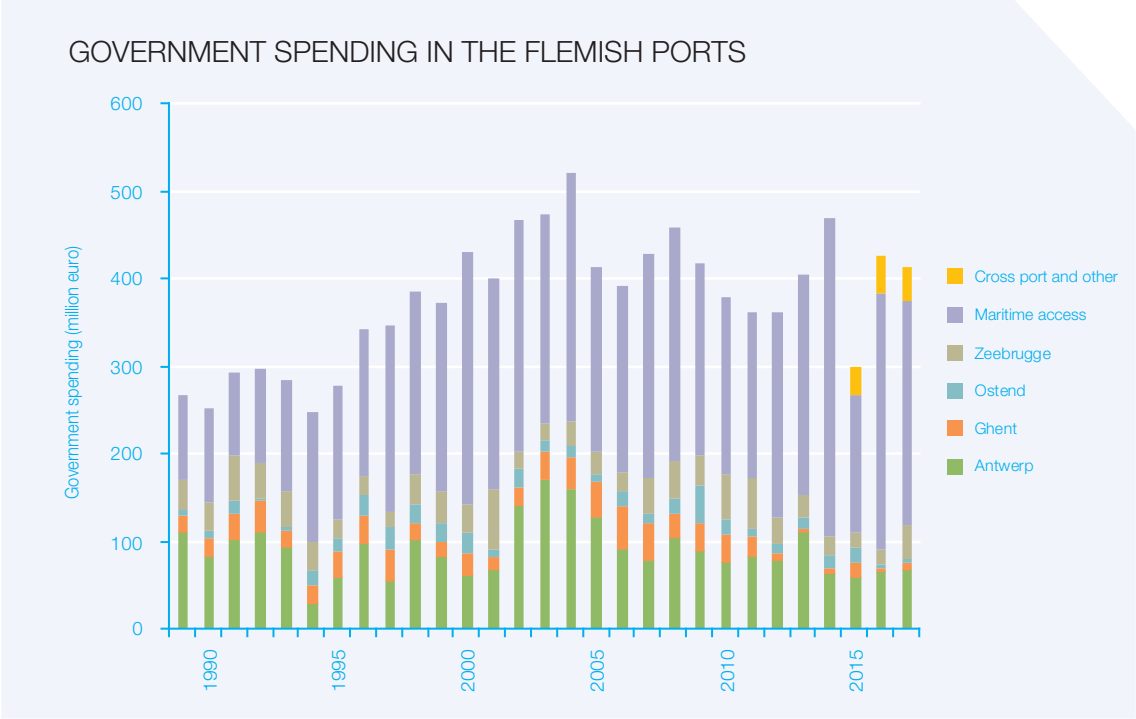


Figure 9. Government spending in Flemish ports (in million euro) (Source: *Merckx 2018*).

Table 3. Overviews of the shipping-related environmental impacts.

Impact	Literature
Pollution from oil and other harmful substances by accidental, operational or illegal discharges	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *Schrijvers en 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)*, *Tweede Federaal Milieurapport 2015*, *Hjorth et al. 2015 (BE AWARE II Summary Report)*, *Schallier en Van Roy 2016*, *OSPAR IA 2017*
Air pollution due to the emission of particles in the exhaust gases of ship engines (NO_x, SO_x, CO_2, etc.)	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *Schrijvers en 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 en Scheldeman 2016*
The accidental or illegal discharge of waste or material	*Goffin et al. 2007*, *OSPAR QSR 2010*, *Claessens et al. 2013 (AS-MADE project BELSPO)*, *Tweede Federaal Milieurapport 2015*, *Devriese en Janssen 2017*
Leaching of harmful anti-fouling substances (e.g. tributyltin (TBT))	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *Schrijvers en Maes 2005 (GAUFRE project BELSPO)*, *Goffin et al. 2007*, *OSPAR QSR 2010*, *OSPAR IA 2017*
Introduction of non-native species by hull fouling or ballast water discharges	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *Schrijvers en 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 en Verleye 2015*, *OSPAR IA 2017*
Pollution and physical impact due to loss of ships 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*
Impact on other users (safety, spatial impact, etc.)	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *Schrijvers en Maes 2005 (GAUFRE project BELSPO)*, *Le Roy et al. 2006 (RAMA project BELSPO)*, *Volckaert et al. 2006 (MIMAC project BELSPO)*

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

Port	(Plan-)EIAs
Ostend	*Plan MER strategisch plan haven Oostende (kennisgevingsnota) 2004* *Plan MER kustverdediging en maritieme toegankelijkheid Oostende 2007*
Antwerp	*Kennisgeving plan MER Strategisch plan haven van Antwerpen 2006* *Plan MER strategisch plan haven van Antwerpen (niet-technische samenvatting) 2008* *Kennisgeving Verruiming vaargeul Beneden-Zeeschelde en Westerschelde 2006* *Tussentijds strategisch plan haven van Antwerpen 2006* *Alternatievenonderzoeksnota Complex project "Realisatie van extra container-behandelingscapaciteit in het havengebied Antwerpen" 2017*
Zeebrugge	*Plan MER strategisch plan haven van Zeebrugge 2004* *Kennisgeving project MER van het strategisch haveninfrastructuurproject (SHIP) in de westelijke achterhaven van Zeebrugge 2011* *Strategische milieubeoordeling Verbetering nautische toegankelijkheid tot de (achter)haven van Zeebrugge 2017*
Ghent	*Gewestelijk ruimtelijk uitvoeringsplan 'Afbakening Zeehavengebied Gent - Fase 2* *MER Nieuwe Sluis Terneuzen 2015*

3.5 Sustainable use

3.5.1 Roadmap towards a sustainable EU maritime transport

COM (2009) 8 (see also **3.1 Policy context**) developed strategic objectives and recommendations for the EU's maritime transport policy until 2018, followed by Resolution 2009/2095(INI) of 5 May 2010 in which the European Parliament called on the Commission to take further action against the abuse of flags of convenience, to draw up new State aid rules, to propose guidelines for ports, to take more account of maritime transport within the framework of the Trans-European Transport Networks (TEN-Ts), to reduce emissions from ships and to develop a European maritime transport area 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, Resolution 2011/2096(INI) was adopted at the end of 2011. In this resolution, specifically for maritime transport, the European Parliament called, *inter alia*, for the establishment of a European policy for short- and medium-distance maritime traffic and a proposal for the development of a European maritime transport space without barriers (the 'Blue Belt'). The latter was followed up through COM (2013) 510, which aims to simplify customs formalities in order to reduce costs and facilitate trade. Regulation (EU) No. 1315/2013 provides guidelines for setting up a long-term strategy for the development of a TEN-T by road, rail, air and water. Through the Connecting Europe Facility (*CEF*) funding channel, TEN-T projects can be financed to remove bottlenecks in this network. 'Motorways of the Sea', with Short Sea Shipping (*SSS*) (COM (2004) 453) as the main transport mode, is the maritime component of TEN-T and contributes to the creation of a European Transport Space without Barriers. *Multimodaal.Vlaanderen* was established at the Flemish level in 2017 to act as an independent point of advice for companies with regard to the optimal choice of transport mode (including SSS) for each flow of goods.

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

A lot of legislation exists concerning maritime safety, the prevention of maritime disasters and the safety of human life at sea. Table 5 lists the most relevant international conventions. These treaties are explained in more detail in *Verleye et al. (2018)*.

DG Shipping (FPS Mobility and Transport) ensures that ships flying the Belgian flag comply with the international maritime regulations on shipping safety and protection of the marine environment (via, *inter alia*, the maritime inspection regulations - RD of 20 July 1973 and frequently amended). The Belgian Port State Control Department (FPS Mobility and Transport) inspects ships flying foreign flags that call at Belgian ports, in order to check whether they comply with the applicable international ILO (International Labour Organization) and IMO standards. In the event of infringements, port departure may be refused or conditions may be imposed, such as sailing to the nearest shipyard if the defects in a Belgian port cannot be repaired and are of such a nature that the safety of the ship and its crew may be endangered (for regional cooperation on Port State Control, see Memorandum of Understanding on Port State Control (*Paris MoU*) and the European Port State Control Directive (2009/16/EC)).

The *Shipping Assistance Division* (Agency for Maritime and Coastal Services) 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).

Table 5. Most relevant international conventions regarding maritime safety.

Convention	Explanation
SOLAS Convention	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 minimum standards for the construction, equipment and operation of ships in order to ensure the safety of human life at sea.
COLREG Convention	This convention provides guidelines to determine safe speed limits, reduce the risk of collisions and to provide guidance to ships operating in, or in the vicinity of, traffic separation schemes.
Load Line Convention	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 draught marks.
Maritime Labour Convention	The Maritime Labour Convention brings together all the existing maritime and other labour conventions of the International Labour Organization (ILO).
SAR Convention	The purpose of this convention is to establish an international search and rescue (SAR) plan so that, wherever a person is in distress at sea, the rescue is coordinated by a SAR organisation. Nowadays, more emphasis is also placed on the regional approach and coordination between SAR operations at sea and in the air.
STCW Convention	The STCW Convention is an international convention that stipulates the minimum requirements that have to be met by seafarers with regard to training, certification and watchkeeping. The convention also aims to promote the safety of human life and goods as well as the protection of the marine environment. The EU guidelines on the minimum level of training of seafarers are described in Directive 2008/105/EC.
TONNAGE Convention	The TONNAGE Convention provides for a universal tonnage measurement system for ships.

3.5.3 Preventing and combating pollution from shipping

There is a wide range of regulations to prevent and combat pollution of the marine environment due to shipping. The United Nations Convention on the Law of the Sea (*UNCLOS 1982*) provides the general international legislative framework covering, *inter alia*, marine pollution (Part XII). The *MARPOL Convention (1973/1978)* is the most important international treaty on accidental or operational pollution of the marine environment by shipping. In addition, there are a number of important conventions under the umbrella of the *IMO* (table 6, more explanation of the relevant regulations in *Verleye et al. (2018)*).

Other relevant international conventions and agreements not drafted within the IMO concern the *Bonn Agreement* and the *OSPAR Convention*. The Bonn Agreement regulates cooperation between the coastal states of the North Sea in the detection, reporting and combating of pollution in the North Sea caused by oil and other harmful substances from ships and offshore installations. Since 1991 air surveillance has been organised within the framework of this agreement in the BNS in order to detect illegal discharges by ships 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 Institute of Natural Sciences (*RBINS-MUMM*) in cooperation with the Ministry of Defence. The annual results of aerial surveillance are reported on the *MUMM-website*. Since the start of airborne observations in 1991, there has been a downward trend in the number of oil spills and in the estimated oil volume (figure 10). This shows that the measures taken within the framework of the European directive concerning port reception facilities (Directive 2000/59/EU) and MARPOL, as well as the increased supervision, have a positive effect (*Lagring et al. 2012*, *website MUMM*). There is no clear trend in the number of operational discharges of pollutants other than oil (*website MUMM*). Action was taken within the *Coast Guard* against this by drawing up more detailed follow-up procedures in a MARPOL roadmap.

In the framework of the OSPAR Convention, which aims at protecting the marine environment in the North-East Atlantic through international cooperation, the oil pollution rate of common 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 level of the birds washed up on the Belgian beaches is reported annually by the Research Institute for Nature and Forest (INBO) (e.g. *Stienen et al. 2014*) and can be consulted online on the website of *bird victims*. In the revision of the initial assessment for Belgian marine waters (*public consultation, Belgian State 2018*), the oil pollution is evaluated (e.g. oil-stained guillemots, illegal oil discharges, acute oil pollution from the 'Flinterstar' incident in 2015) in relation to MSFD descriptor 8.

Furthermore, under the umbrella of OSPAR, operational discharge practices are tackled by a network of police experts and prosecutors called NSN (North Sea Network of Prosecutors and Investigators).

Following the Erika shipwreck in 1999, Europe adopted a series of measures known as Erika I (COM (2000) 142), II (COM (2000) 802) and III (COM (2005) 585) to improve maritime safety. Several EU directives and regulations implement these measures (table 7). In addition, the Marine Strategy Framework Directive (MSFD) (2008/56/EC)

Table 6. IMO Conventions on marine pollution.

International IMO policy		
Convention	**Explanation**	**Ratification by Belgium**
MARPOL Convention	The purpose of this convention is to prevent the voluntary and accidental discharge of oil, chemicals, hazardous substances in packaged form, sanitary and household waste from ships, either directly through strict operational discharge conditions or a prohibition on discharge, or indirectly through the imposition of technical measures related to the construction and equipment of the ship.	x
AFS Convention	The convention prohibits 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.	x
BWM Convention	The aim of the convention is 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 onboard ships.	x
OPRC Convention	The convention deals with the preparedness for, response to and cooperation in oil pollution.	x
OPRC HNS protocol	The protocol deals with the preparedness, response and cooperation for pollution incidents from noxious and potentially hazardous substances.	x
HNS Convention – 2010 Protocol	The convention organises the liability and compensation for damage in connection with the carriage of hazardous and noxious substances by sea (not yet entered into force).	-
CLC Convention	This convention organises the civil liability for oil pollution damage.	x
FUND Convention	This convention foresees in the establishment of an international fund for compensation for pollution damage from persistent oil.	x
Bunker Convention	This convention organises the civil liability for bunker oil pollution damage.	x
LLMC Convention	This convention sets out the rules on limitation of liability for maritime claims.	x
Wreck Removal Convention	This convention organises the removal of wrecks.	x

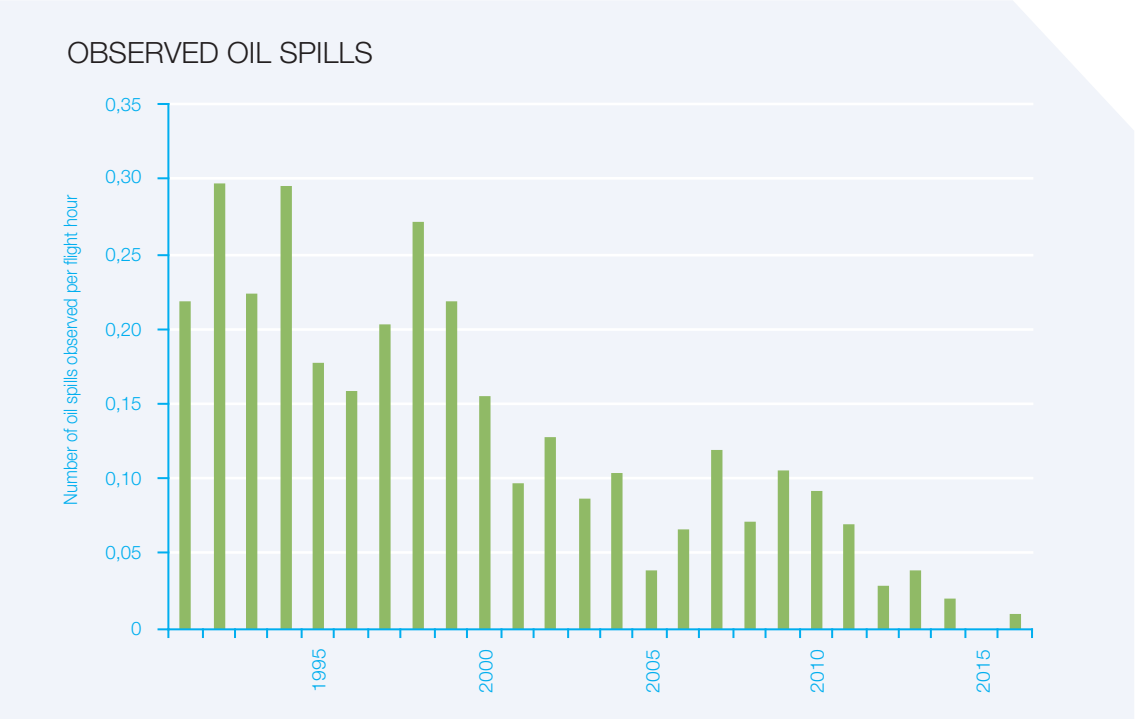


Figure 10. Number of oil spills observed per flight hour (*RBINS-MUMM*).

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

Selection of measures	Objective
Monitoring Directive (2002/59/EC)	To establish a vessel traffic monitoring and information system to enhance the safety and efficiency of maritime traffic within the EU.
Directive 2005/35/EC	Introduction of Community rules for the imposition of penalties for the discharge of oil or other polluting substances from ships in EU waters.
Framework Decision 2005/667/JHA	Improving the penal framework to combat ship-generated pollution.
Directive 2009/15/EC	Formulation of common rules and standards for the organisations competent for the inspection and survey of ships and for the relevant activities of maritime administrations.
Port State Control Directive (2009/16/EC)	Reformation of the control mechanisms in ports to ensure effective verification of ships' compliance with applicable regulations on maritime safety, maritime security, protection of the marine environment and living and working conditions.
Directive 2009/18/EC	Establishing the fundamental principles governing the investigation of accidents in the maritime transport sector.
Directive 2009/20/EC	Insurance of ship-owners against maritime claims.
Directive 2009/21/EC	Compliance with flag State requirements.
Reporting Directive (2010/65/EU)	Simplifying and harmonising the various administrative procedures applicable to maritime transport by introducing electronic data transmission (by 1 June 2015 at the latest) and rationalising reporting formalities.
Regulation (EC) No. 530/2012	Introduction of 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.
Regulation (EC) No. 1406/2002	The establishment of a European Maritime Safety Agency (EMSA). This agency aims to reduce the risk of maritime accidents, pollution from 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) No. 391/2009	Formulation of common rules and standards for ship inspection and survey organisations.
Regulation (EC) No. 392/2009	Rules governing the liability of carriers of passengers by sea in the event of accidents.

included concentrations of pollutants as one of the descriptors to assess good environmental status and identified pollution from ships as an aggravating factor (more information: *Law et al. 2010*).

At the Belgian level, the law of 6 April 1995 on the prevention of marine pollution from ships constitutes the legal framework for the implementation of the MARPOL Convention. In the event of serious pollution, action in the BNS is regulated by the ANIP North Sea (ANIP: General Emergency and Intervention Plan, see Belgian Official Gazette 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 the MUMM) provides scientifically based support to policymakers in the event of oil pollution. 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 around the clock. In addition, since the Erika disaster (1999), the Belgian government has a more extensive core of specific oil spill combat resources at its disposal. If Belgium's control capacity is not attainable, it can call on the support of neighboring countries through the Bonn Agreement (see also *Verleye et al. (2018)*). The request for additional funds has been centralised in the 'Common Emergency Communication and Information System (CECIS) Marine Pollution' of the European Commission (*European Civil Protection and Humanitarian Aid Operations*). In 2005 (update 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*).

3.5.4 Measures against the disposal of ship-generated waste

The *MARPOL Convention* is the main international convention for the prevention of marine pollution from shipping. In the case of operational discharges, the convention limits pollution by setting discharge standards (or prohibition of discharge). 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 2000/59/EC, as amended). This directive intends to oblige ships to return their waste to the ports in a sustainable way. In the MSFD (2008/56/EC), marine litter is one of the descriptors for assessing good environmental status and has been identified as a physical disturbance of the environment. The criteria and methodological standards for determining good environmental status with regard to marine litter were laid down in *Galgani et al. (2010)* (see also theme **Nature and environment** and the EC Decision *2017/848/EU* and *public consultation, Belgian State 2018*).

In Flanders, the policy with regard to the management of ship-generated waste in 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 arising from navigation on inland waterways). The quantities of collected waste have evolved positively and can be consulted in *the waste management plan for the port area of Bruges-Zeebrugge (2018-2020)*, *the waste management plan for the port area of Antwerp (2018-2020)* and *the waste management plan for the port of Ghent (2018-2020)*. In the past, *Maes and Douvere (2004)* and *Belpaeme (2006)* mapped out the specific waste streams from fishing vessels. The *'Fishing for Litter' project* enables the waste caught by fishing vessels to be landed and its composition to be assessed. In addition, there is a European cooperation with fishermen in which the collected waste is evaluated and processed for upcycling (*Waste Free Oceans*).

3.5.5 Measures against air emissions from shipping

Air pollution from seagoing ships is regulated by Annex VI to the *MARPOL Convention*. The 2008 revision of the Annex provides for stricter limits on the sulphur content of fuel up to 3.5% (0.5% after 1 January 2020) and 0.1% since 1 January 2015 in Emission Control Areas (ECAs). The Convention also prohibits emissions of ozone-depleting substances, including halons and CFCs, and imposes nitrogen emission limits. In 2018, the 72nd session of the IMO Marine Environment Protection Committee (*MEPC 72*) adopted a strategy aimed at reducing greenhouse gas emissions from international shipping by at least 50% by 2050 compared to those in 2008. Furthermore, an amendment to Annex VI from 2011 introduced an improved Energy Efficiency Design Index (EEDI) for new build vessels and a ship energy efficiency management plan for all ships above 400 GT. In 2017, the North Sea and the Baltic Sea were designated as low emission zones for nitrogen oxides (entry into force from 1 January 2021). For an overview of all amendments, reference is made to the *IMO website*.

By means of Directive 2016/802/EU, the European Union also adopted a number of measures to combat air pollution from shipping. As a result, parallel conditions such as those set out in Annex VI of MARPOL 73/78 apply within the EU. Implementing Decision (EU) 2015/253 provides for the adoption of sampling and reporting requirements for the sulphur content of marine fuels.

At national level, the measures to combat air pollution from ships are discussed in the RD of 27 April 2007 (transposition of the MARPOL Convention and the European measures at Belgian level). Specially trained inspectors from *DG Shipping* carry out regular MARPOL Annex VI controls on moored ships in ports (including fuel sampling and analysis). Since January 2015, MUMM has been measuring the sulphur emissions from ships during offshore monitoring flights using a '*sniffer sensor*'. These results are systematically communicated to inspectors of DG Shipping so that targeted controls can be carried out within the framework of port inspections. This pioneering work forms the basis of the current international consultation within the framework of the Bonn Agreement to roll out these controls across the entire North Sea (*CompMon project*, *Schalier et al. 2018 in De Grote Rede 47*).

At the Flemish level, the Government of Flanders decided on 23 April 2014 to set up a Programmatic Approach to Nitrogen Depositions (*PAS*). The PAS is a program that aims to address the problem of nitrogen deposition in special protection areas under the European Habitats Directive (92/43/EC) by means of source-oriented (emission side) and effect-oriented measures .

In addition, the switch from ships to liquefied natural gas (LNG) as an alternative fuel and the provision of shore-based power facilities (*cold ironing*) are also important measures against air emissions from shipping (*Margarino 2014*). The use of LNG results in negligible emissions of sulphur and fine particles, while NOx and carbon emissions of this fuel are respectively 85-90% and 15-20% lower. Preparations are being made in all Flemish seaports to enable LNG supplies. The shore-side electricity facilities in turn ensure that ships can switch off their engines or generators while at berth. In various Flemish ports and at quays on the inland waterway network, shore-based power facilities are provided for recreational boating, inland shipping and seagoing vessels (including *Shore Power in Flanders (TEN-T project)*). Furthermore, in the context of European Directive 2000/59/EU, a file can be submitted to the Flemish Public Waste Agency (*OVAM*) for a reduced contribution for ships sailing on environmentally friendly fuels.

3.5.6 Measures against the introduction of non-native species

In order to prevent the spread and introduction of non-native species through ships' ballast tanks, the *Ballast Water Convention* (IMO 2004) requires ships to draw up a ballast water and sediment management plan and to carry a ballast water record book in which all ballast operations are recorded. In addition, the ballast water must be managed in accordance with standard procedures (*website IMO*) and the ballast water must be treated by the systems recognised by the IMO. The convention entered into force on 8 September 2017. More information on the

treaty can be found in *Verleye et al. (2018)*. Exceptions to the application of this convention may be granted in certain circumstances. Prior to the entry into force of the convention, a *harmonized procedure* was developed by HELCOM/OSPAR for this purpose so that exceptions can be granted in a uniform manner without harming the environment, human health, property or resources. A first risk analysis for Belgium was drawn up by *Saelens and Verleye (2015)* in accordance with the HELCOM/OSPAR procedure (2015).

The International Council for the Exploration of the Sea (*ICES*) set up two working groups to study biological invasions and non-native 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) No. 1143/2014 regulates the prevention and control of the (deliberate and unintentional) introduction and spread of invasive non-native species. This regulation applies to terrestrial, freshwater and marine species. Furthermore, the introduction of non-native species is identified as a biological disturbance in the MSFD (2008/56/EC) and is also included as a descriptor of good environmental status. The criteria and methodological standards for determining good environmental status for non-native species were laid down in *Olenin et al. (2010)*.

In Belgium, both the deliberate and unintentional introduction (via ballast water) of non-native species is prohibited by the law of 20 January 1999 and the RD of 21 December 2001. Invasive species are also included as one of the ten processes with the greatest negative impact on ecosystem components in the Ecosytem vision for the Flemish Coast (*Van der Biest et al. 2017b)*. The coordinated implementation of Regulation (EC) No. 1143/2014 by the federal state, the Communities and the Regions, as well as the necessary exchange of information between the parties concerned will be regulated by a cooperation agreement (in signing phase). For this purpose, a National Committee, a National Scientific Council and a National Secretariat on Invasive Alien Species are established. In the framework of the *Belgian forum on invasive species*, protocols (invasive species environmental impact assessment (ISEIA – *Branquart 2009*) and the *Harmonia+ protocol* – *D'hondt et al 2015*) were developed to assess the impact of species on the environment and the possibility of spreading and colonisation. The non-native species in the BNS are reported by the MUMM to the Marine Environment Service within the framework of the *Monitoring programme for Belgian marine waters* (MSFD) and the ICES working group *WGITMO*. An overview of the non-native species in the BNS is given in *Kerckhof et al. (2007)* and the *list* of the *VLIZ alien species consortium* (more information: *Vandepitte et al. 2012*). An update of the latter list will be published in 2019.

Projects such as *RINSE*, *MEMO*, *SEFINS* and *TrIAS* focus on the problem of invasive non-native species in the Southern Bight of the North Sea and the adjacent estuaries by means of research, the development of instruments, the exchange of good practice examples, etc.

3.5.7 Measures against harmful anti-fouling substances

On 5 October 2001, the *International Convention on the Control of Harmful Anti-fouling Systems on Ships* (AFS Convention) was adopted by the *IMO* in London and entered into force on 17 September 2008. The convention prohibits the use of harmful substances, including organotin compounds, in anti-fouling paints for 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 European level, the use of organotin compounds in anti-fouling substances on ships as active biocides is prohibited by Regulations (EC) No 782/2003 and (EC) No 1907/2006. However, Decision 2009/425/EC provides for the possibility to allow dibutyltin dichloride compounds (DBT) to act as a catalyst in paints and coatings for an additional period of time if no suitable alternative is available, subject to compliance with the maximum concentration of 0.1% by weight of tin. The Water Framework Directive (WFD, 2000/60/EC) includes organotin compounds 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.

3.5.8 Measures against underwater noise from ships

At international level, within the *Marine Environment Protection Committee* (*MEPC*) of the IMO, recommendations were formulated to limit underwater noise effects on cetaceans (*Guidelines MEPC 2014*). In addition, *ASCOBANS* is also discussing measures to address the impact of submarine noise on small cetaceans (*ASCOBANS Resolution 2003*, *ASCOBANS 2006 Resolution*, *CMS Family Guidelines - Prideaux 2016*).

At European level, the problem of underwater noise was included in the MSFD (2008/56/EC), in which the supply of energy, including underwater noise, is identified as one of the descriptors for good environmental status (*Tasker et al. 2010*) (see also theme **Energy (including cables and pipes)**). The RD of 23 June 2010 provides for the transposition of the MSFD measures into national legislation.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex,* the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
Convention of facilitation of international maritime traffic (FAL)	1965	1967
International Convention on load lines	1966	
International Convention on tonnage measurement of ships (TONNAGE)	1969	1982
International Convention on civil liability for oil pollution damage (CLC)	(1969) - 1992	(1975) - 1996
International Convention on the establishment of an international fund for compensation for oil pollution damage (FUND Convention)	1992 - (2003)	1996
Convention on the international regulations for the prevention of collisions at sea (COLREG)	1972	1977
International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978 (MARPOL)	1973	1978
International Convention for the safety of life at sea (SOLAS)	1974	1980
Convention on limitation of liability for maritime claims (LLMC)	1976	1986
International Convention on standards of training, certification and watch keeping for seafarers(STCW)	1978	1984 (large revisions in 1995 and 2010)
International Convention on maritime search and rescue SAR	1979	1985
United Nations Convention on the law of the sea (UNCLOS)	1982	1994
Memorandum of Understanding on port state control (Paris MoU)	1982	
Agreement for cooperation in combating pollution of the North Sea by oil and other harmful substances (Bonn Agreement)	1983	1989
International Convention on liability and compensation for damage in connection with the carriage of hazardous and noxious substances by sea (HNS)	1984	
International oil pollution preparedness, response and cooperation convention (OPRC)	1990	1995
Agreement on the conservation of small cetaceans in the Baltic, North-East Atlantic, Irish Sea and North Sea (ASCOBANS)	1991	1994
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR Convention)	1992	1998
Protocol on the preparedness for, response to and cooperation in the event of pollution by noxious and potentially hazardous substances (OPRC-HNS)	2000	2007
International Convention on the control of harmful anti-fouling systems on ships (AFS)	2001	2008
International Convention on civil liability for bunker oil pollution damage (Bunker)	2001	2008
International Convention for the control and management of ships' ballast water and sediments (BWM)	2004	2017
Nairobi International Convention on the removal of wrecks	2007	2015

European legislation

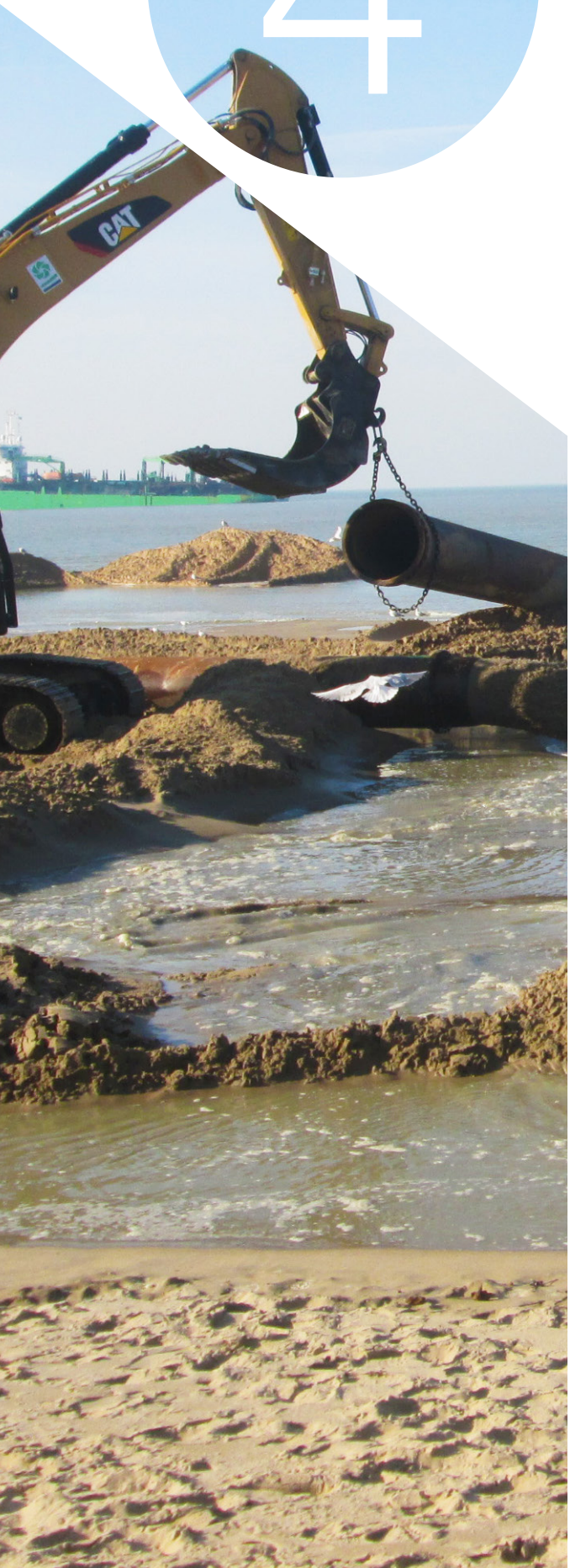
Title	Year	Number
COM: Communication from the Commission (COM): On the safety of the seaborne oil trade (Erika I)	2000	142
COM: Communication from the Commission (COM): A second set of Community measures on maritime safety following the sinking of the oil tanker Erika (Erika II)	2000	802
COM: Communication from the Commission (COM): on short sea shipping	2004	453
COM: Communication from the Commission (COM): Third package of legislation on maritime safety in the European Union (Erika III)	2005	585
COM: Communication from the Commission (COM): Strategic goals and recommendations for the EU's maritime transport policy until 2018	2009	8

COM:White Paper (COM): Roadmap to a Single European Transport Area - Towards a competitive and resource-efficient transport system	2011	144
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive on port reception facilities for ship-generated waste and cargo residues	2000	59
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive on the minimum level of training of seafarers	2001	25
Directive establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC	2002	59
Directive 2005/35/EC of 7 September 2005 on ship-generated pollution and on the introduction of penalties for infringements	2005	35
Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive on common rules and standards for ship inspection and survey organizations and for the relevant activities of maritime administrations	2009	15
Directive on Port State Control	2009	16
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 on the insurance of ship owners for maritime claims	2009	20
Directive on compliance with flag State requirements	2009	21
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 on marine equipment and repealing Council Directive 96/98/EC	2014	90
Directive relating to a reduction in the sulphur content of certain liquid fuels	2016	802
Regulation establishing a European Maritime Safety Agency	2002	1406
Regulation banning organotin compounds from ships	2003	782
Regulation concerning the registration, evaluation, authorization and restriction of chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC	2006	1907
Regulation on common rules and standards for ship inspection and survey organizations	2009	391
Regulation on the liability of carriers of passengers by sea in the event of accidents	2009	392
Regulation on the accelerated phasing-in of double hull or equivalent design requirements for single hull oil tankers	2012	530
Regulation (EU) on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU	2013	1315
Regulation (EU) concerning the prevention and control of the introduction and spread of invasive alien species	2014	1143
Commission Implementing Decision (EU) 2015/253 of 16 February 2015 laying down the sampling and reporting requirements under Council Directive 1999/32/EC as regards the sulphur content of marine fuels	2015	253
Implementing Regulation specifying the requirements for the design, construction, performance and testing standards of marine equipment	2017	306

Belgian and Flemish legislation		
Abbreviation	**Title**	**File number**
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 (VLAREMA)	Besluit van de Vlaamse regering tot vaststelling van het Vlaams reglement betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen (VLAREMA)	2012-02-17/18
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
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
RD of 21 December 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
RD of 27 April 2007	Koninklijk besluit betreffende de voorkoming van luchtverontreiniging door schepen en de vermindering van het zwavelgehalte van sommige scheepsbrandstoffen	2007-04-27/37
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 11 April 2012	Koninklijk besluit tot instelling van een veiligheidszone rond de kunstmatige eilanden, installaties en inrichtingen voor de opwekking van energie uit het water, de stromen en de winden in de zeegebieden onder Belgische rechtsbevoegdheid	2012-04-11/15
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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
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 in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Law of 6 April 1995	Wet betreffende de voorkoming van de verontreiniging van de zee door schepen	1995-04-06/94
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

4

Dredging and dumping



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Dredging comprises all activities required to remove sand, silt and other layers of the bottom of waterbodies for the maintenance of shipping channels and harbours, but also for land reclamation and nature development. This theme text deals in more detail with the dredging and dumping of sediment for the purpose of maintaining and deepening the maritime access channels and harbours. The main focus is on dredging and dumping activities in the Belgian part of the North Sea (BNS). The Scheldt Estuary is not only an important ecosystem, but also provides space for a number of activities such as shipping, which require dredging (see also *ScheldeMonitor* and the *VNSC* website). A different context applies to the dredging works in the Scheldt Estuary, which are discussed in the theme text about the **Scheldt Estuary**.

In the case of dredging, a distinction must be made between capital dredging and maintenance dredging. Capital dredging is a dredging operation for the creation of new waterways and docks or the deepening of the existing ones. Maintenance dredging is a dredging operation in which the deposed sediment in shipping channels and harbour basins is removed without deepening or broadening the waterway or harbour basins beyond its original size.

A large share of the sediments dumped each year is dredged and dumped in the southern part of the North Sea, largely due to the maintenance of the fairways to big ports such as Hull, Zeebrugge, Rotterdam, Bremen, Emden, Hamburg, Esbjerg, etc. (*OSPAR QSR 2010*). Between 2008 and 2014, more than a thousand million tonnes (dry weight) of material were deposited in the OSPAR[1] region (North-East Atlantic and North Sea) (*OSPAR IA 2017*, *OSPAR 2017*). Belgium and Germany were at the forefront in the OSPAR[1] region for the dumping of sediment at sea with respectively 267.2 million tonnes and 228.7 million tonnes (dry weight) in the period 2008-2014, followed by France, the Netherlands and the United Kingdom with respectively 174.0, 158.4 and 103.2 million tonnes (dry weight) (*OSPAR IA 2017*, *OSPAR 2017*). In Belgium, 13.2 million tonnes (dry weight) were deposited in 2015 (*Lauwaert et al. 2016*). The evolution of the amount of dredged material in the BNS has been monitored by the Management Unit of the North Sea Mathematical Models of the Royal Institute of Natural Sciences (*RBINS-MUMM*) since 1991 (figure 1). In the future, the amount of dredged and dumped sediments might increase due to the growing vessel size and the associated widening and deepening of the shipping and port channels (*OSPAR QSR 2010*, see also implementation of the *Coastal Safety Masterplan* and the *Complex Project Coastal Vision* in theme **Safety against flooding**). The most common dredging and dumping techniques and the type of the dredged sediment in the BNS are described in more detail in section **4.4 Impact**.

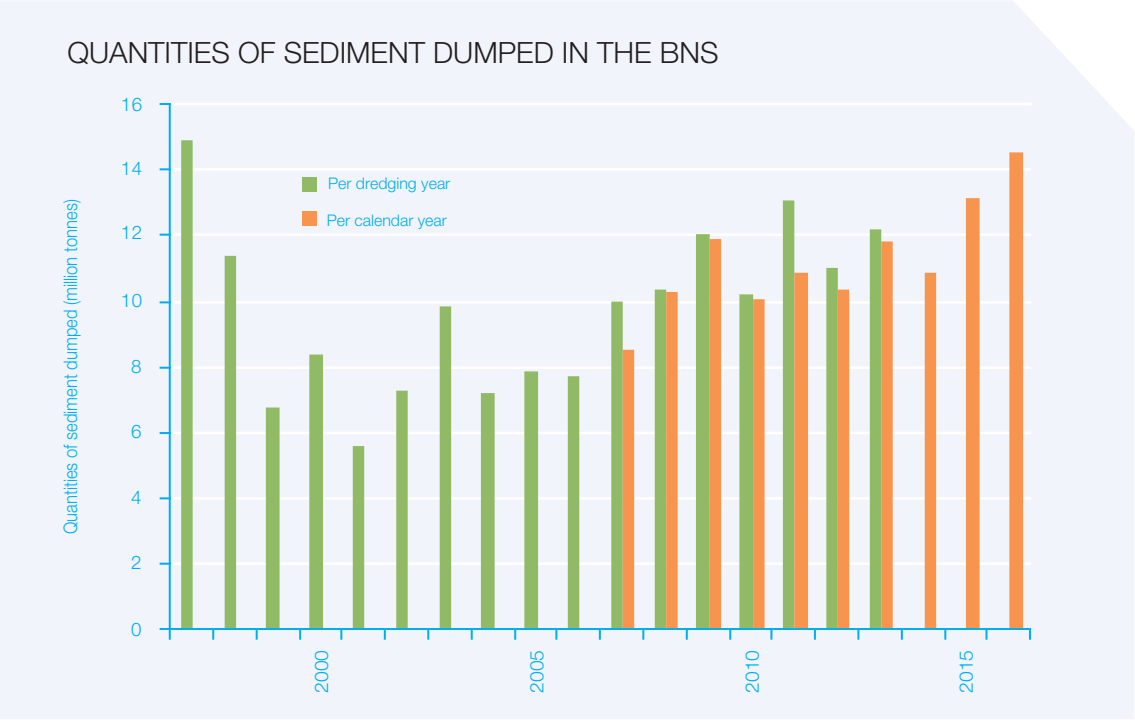

Figure 1. Quantities of sediment dumped in the Belgian part of the North Sea, expressed in million tonnes of dry matter (Source: RBINS-MUMM). A dredging year is defined as the period between 1 April and 31 March of the subsequent year.

[1] OSPAR Convention for the protection of the marine environment of the North-East Atlantic.

4.1 Policy context

The maintenance and deepening of the maritime access channels to ports and the maintenance of the depth in the ports is governed at the Flemish level. The Department of Mobility and Public Works (MOW), *Maritime Access Division*, is responsible for the fairways as well as the engineering structures and properties located along the maritime access channels to the Flemish harbours, such as Zeebrugge; while the Agency for Maritime and Coastal Services (MDK) - *Coastal Division* is responsible for the maintenance of the Flemish marinas of Ostend, Blankenberge, Zeebrugge and Nieuwpoort. However, the competence with regard to the dumping of dredged materials at sea is a federal matter. Hence, the management of dredged materials in Belgium is a shared competence, for which a cooperation agreement was signed on 12 June 1990 between the Flemish Region and the federal state. This agreement was updated by the cooperation agreement of 6 September 2000. The conditions for the re-use of dredged material from watercourses or water bodies (including fairways, harbours and docks) as soil or building material are included in the Code of Practice for dredging and disposal dredged material and implemented in Article 5.3.4.3. of the decree of the Government of Flanders, establishing the Flemish regulation on sustainable management of material cycles and waste materials (*VLAREMA*) and were also included in the MD of 5 November 2015.

The procedure for obtaining a permit to dump dredged materials 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 material and the location of the dredging and dumping sites of the permits that have been granted to the Maritime Access Division and to the MDK Agency since 2004, can be found in several ministerial decrees (see *Belgisch Staatsblad*).

4.2 Spatial use

In the marine spatial plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014* and theme **Integrated ocean policy**), five sites for sediment dumping have been demarcated: Bruggen en Wegen Zeebrugge Oost (ZBO), Ostend (OST), Nieuwpoort (NWP), S1 and S2 (see figure 2) (*Lauwaert et al. 2014*, *Lauwaert et al. 2016*). In the MSP, an area west of the port of Zeebrugge is reserved as a 'search area' for an alternative dumping site to reduce the reflux of dredged sediments. In the process of the new MSP (2020-2026), dumping sites are being revised for various reasons such as dumping capacity and nature protection (*MSP 2020-2026, public consultation 2018*). For example, the site at Nieuwpoort will be relocated to a location outside the Flemish banks, and a solution for the site S1 will be provided in terms of capacity.

On request of the Maritime Access Division, a field test was carried out between October and November 2013 to investigate the alternative dumping site west of Zeebrugge (*Fettweis et al. 2016*, *Lauwaert et al. 2016*). Research into the implementation of this alternative dumping site and the environmental impact is being continued, and will serve as input for considering the different options. In *Van Hoey et al. (2014a)*, the impact of a possible new dumping site west of Zeebrugge on shrimp fishing has already been studied.

An alternative dumping method, using a fixed pressure pipeline close to the coast, has been proposed for the marinas of Nieuwpoort and Blankenberge (*Lauwaert et al. 2016*). A fixed point discharge method would require a revision of the MMM law (20 January 1999). It is currently expected that this method will have a greater impact on the environment, but in order to follow up this method intensively, a scientific study is being launched and a pilot project is recommended (*Lauwaert et al. 2016*). A prospective study with the alternative Water Injection Dredging (WID) technique was carried out by *Van Oyen et al. (2016)*. The silted-up sediment is relocated by using natural forces in accordance with the principle of gravity driven density flows. By fluidising the sediment, it can flow out of the port under specific conditions.

4.3 Societal interest

The Flemish ports are important economic gateways (see theme **Maritime transport, shipping and ports**). Because of the increase of the scale of the vessels, it is necessary to continuously maintain the port's shipping lanes, as well as to deepen and widen these fairways. In 2017, the Government of Flanders invested about 255 million euro to safeguard the accessibility of the ports (including the Scheldt Estuary, see figure 3, *Merckx 2018*). The accessibility of the Flemish ports of Ostend, Zeebrugge, Ghent and Antwerp is guaranteed by the *Maritime Access Division* of the MOW Department. The tasks of this department include e.g. maintenance dredging works, wreck salvage, deepening of the channels and silt processing (also see decision of the Government of Flanders of 13 July 2001).

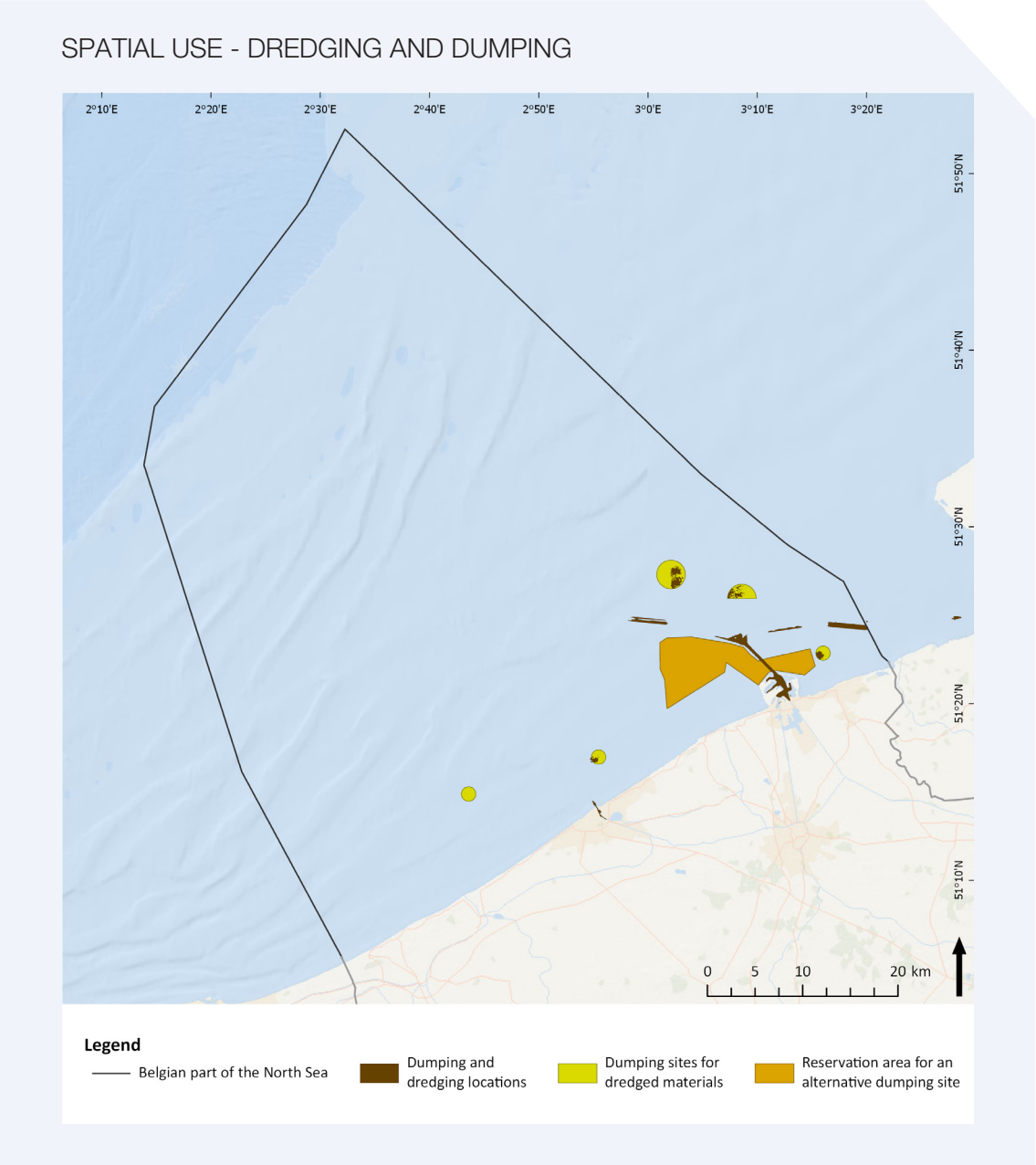

Figure 2. The location of dredging and dumping sites in the BNS for the year 2016 (Source: RBINS, *marineatlas.be* (based on the RD of 20 March 2014), Maritime Access Division).

The ministerial decrees of 22 December 2016 granted four permits for the dumping of 26.450 million tonnes of dry weight at four dumping sites in the BNS to the Maritime Access Division, on an annual basis from 1 January 2017 until 31 of December 2021. In addition, the Agency for Maritime and Coastal Services (MDK) was granted four permits for the dumping of a total of 700,000 tonnes of dry weight annually during this period (also see MD of 22 December 2016). The Maritime Access Division also has disposal permits from the provinces of East Flanders and Antwerp (Sea Scheldt) for the disposal of dredged materials from the maintenance of the Sea Scheldt and Western Scheldt, as well as the necessary extraction and dumping permits from the competent Dutch authorities (Western Scheldt) (see also the theme **Scheldt Estuary**).

Dredging works in Flanders have a considerable budgetary interest. Over the period 2009-2014, the cost of the dredging works in the fairways of the North Sea, the Western Scheldt and the Flemish navigable inland waterways, including the processing of contaminated dredged material, amounted to an average of 204.5 million euro annually, varying between 150.1 and 243.7 million euro. If the dredging works, financed by the Flemish Region, in the port of Antwerp are included, this amount increases to an average of 210.5 million euro annually (Court of Audit - Flemish Parliament, 37-C (2015-2016) - No. 1).

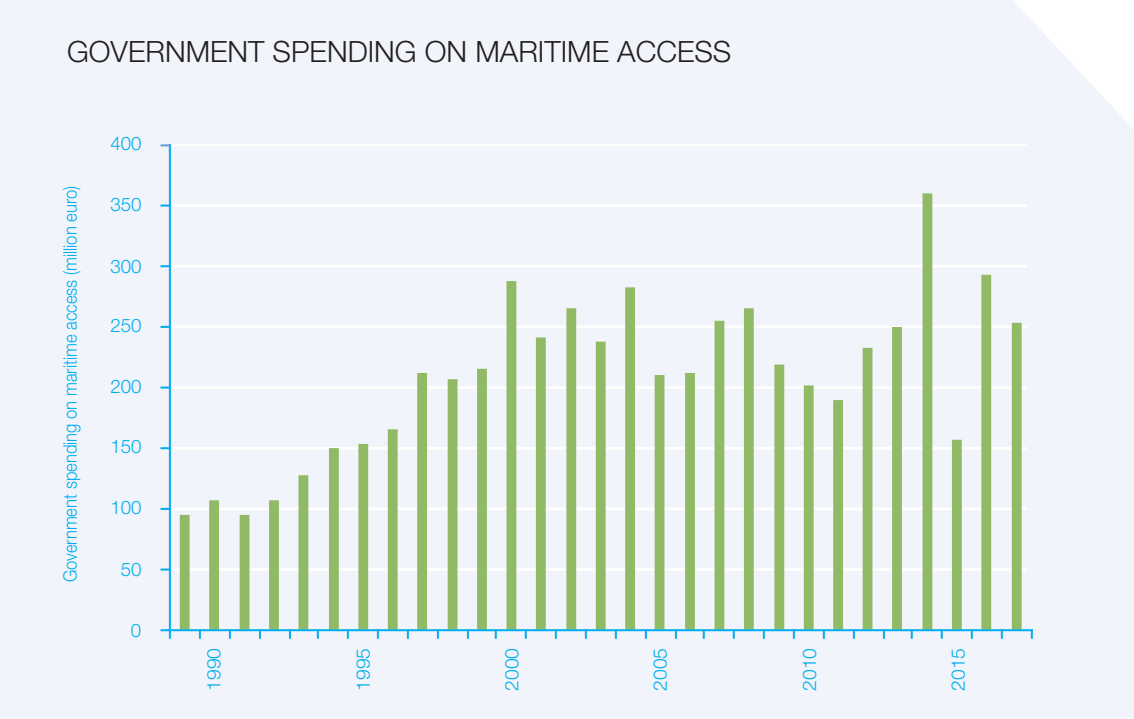

Figure 3. The government spending on maritime access by the Flemish Community in millions of euro for the period 1989-2017 (*Merckx 2018*).

4.4 Impact

The most common type of dredging ship which is used for the maintenance dredging works is the trailing suction hopper dredger. This ship is equipped with one (exceptionally two) suction pipe(s) and a large dredge head that functions as an enormous hoover, sucking the sediment out of the channels. This type of ship has the advantage of being very mobile, hence on the one hand it does not hinder shipping and on the other hand it can transport the dredged materials over longer distances. In this process, the sediment is removed until the minimum guaranteed nautical depth is achieved, including a small margin to anticipate future sedimentation. The sediment ends up in the hopper of the ship and can be dumped at the licensed dumping sites by means of a system of bottom doors or sliders located downwards in the hopper. In certain cases, it can be opted to mix the dredged material on board of the ship with water and then hydraulically pump it through a bow coupling and a system of floating and onshore pipelines and bring it ashore.

Besides the trailing suction hopper dredger, the cutter suction dredger is also commonly used for capital and deepening works. This is a stationary or autonomous vehicle that disaggregates, sucks up and hydraulically transports material from the seabed by using a rotating cutting head. Currently, feasibility studies and demonstration projects to evaluate alternative methods (e.g. Water Injection Dredging, or fixed pressure pipelines) are being carried out (*Lauwaert et al. 2016*, *Van Oyen et al. 2016*).

The nature of the dredged sediment varies according to the location along the coast. The composition of the dumped material may affect the sediment composition of the dumping sites (e.g. silt fractions in the sediment). In addition, the natural sediment composition on the different dumping sites also varies. The dumping site in Nieuwpoort is characterised by a large fraction of sand and a small fraction of silt. The site Bruggen en Wegen Ostend and Bruggen en Wegen Zeebrugge have the lowest average grain size (< 200 µm) and the highest concentration of silt (30-40%) (*Van Hoey et al. 2012*, *Lauwaert et al. 2016*).

The impact of the dredging and dumping activities on the marine environment is monitored and investigated in terms of physical, chemical and biological aspects (*Lauwaert et al. 2014*, *Lauwaert et al. 2016*, table 1, and figure 4 outlines the general framework, not specific to BNS). For the period 2013-2016, research was carried out to the occurrence of marine litter at the dumping sites (*Lauwaert et al. 2016*). The impact of dredging and dumping on other users is discussed in *Verfaillie et al. (2005)* (*GAUFRE project BELSPO*) and *Van Hoey et al. (2014a)*.

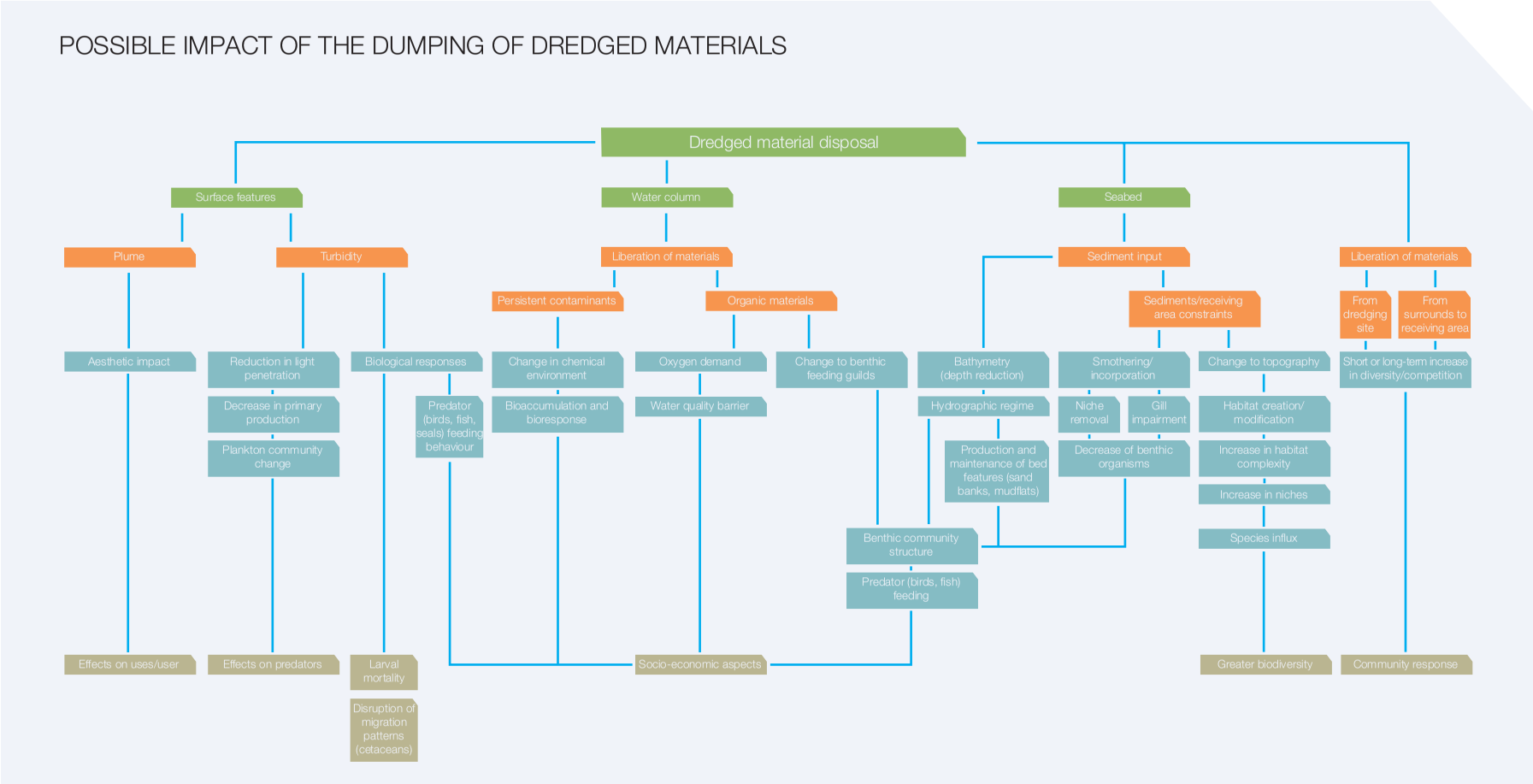

Figure 4. Conceptual diagram of the possible impact of the dumping of dredging materials (not all is applicable for BNS) (derived from *Elliot and Hemingway 2002*).

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

Environmental impact	Literature
Physico-chemical impact: changes in seabed morphology, composition (grain size) and sedimentological effects (sediment plumes, turbidity, release of contaminants, etc.)	*Verfaillie et al. 2005 (GAUFRE project BELSPO)*, *Lauwaert et al. 2006*, *Fettweis et al. 2007b (MOCHA project BELSPO)*, *Goffin et al. 2007*, *Du Four en Van Lancker 2008*, *Lauwaert et al. 2008*, *Lauwaert et al. 2009*, *Van Hoey et al. 2009*, *André et al. 2010*, *Fettweis et al. 2011*, *Lauwaert et al. 2011*, *Lauwaert et al. 2014*, *Vanhellemont en Ruddick 2015*, *Fettweis et al. 2016*, *De Witte et al. 2016*, *Lauwaert et al. 2016*
Biological impact: effects on fauna and flora (disruption of benthos, influence of released contaminants, etc.)	*Verfaillie et al. 2005 (GAUFRE project BELSPO)*, *Lauwaert et al. 2006*, *Lauwaert et al. 2008*, *Lauwaert et al. 2009*, *André et al. 2010*, *Lauwaert et al. 2011*, *Lauwaert et al. 2014*, *De Backer et al. 2014*, *Lauwaert et al. 2016*

4.5 Sustainable use

In order to address the impact of the dumping of dredged materials on the marine environment, this activity is globally governed by the *London Convention (1972)* and the London Protocol (1996) on pollution due to the dumping of materials at sea. In our region, these activities are also covered by the *OSPAR Convention (1992),* which aims to protect the marine environment in the North-Eastern part of the Atlantic Ocean (including the North Sea). OSPAR provides guidelines for the sustainable use of dredged materials (*OSPAR Guidelines for the management of dredged material at sea 2014*). There is currently no obligation under the OSPAR Convention to assess the environmental impact of dumping dredged material, but many OSPAR countries monitor these activities within the framework of national monitoring campaigns (*OSPAR IA 2017*).

On the European level, the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) identify the changing concentration of sediments in the water column due to human intervention as one of the most important pressures on the marine environment. In the MSFD, some of the descriptors for a good environmental status (GES) of the marine environment are relevant for dredging and dumping (*OSPAR IA 2017*, *Lauwaert et al. 2016*): seafloor integrity (descriptor 6, more information: *Rice et al. 2010*), introduction of energy including underwater noise (descriptor 11, more information: *Tasker et al. 2010*), concentrations of contaminants and marine litter (descriptor 8 and 10, more information: *Law et al. 2010*, *Galgani et al. 2010*) and the permanent alteration of the hydrographical conditions (descriptor 7). In addition, the descriptors biodiversity and marine food webs are also (indirectly) affected by the dumping of dredged material (descriptor 1 and 4, *Cochrane et al. 2010*, *Rogers et al. 2010*). In the MSFD, the change in silt deposition as a result of dredging and dumping activities is no longer directly included in the list of anthropogenic pressures on the marine environment (Directives *2008/56/EC* and *2017/845/EC*). Since the 2017 revision, the dredging and disposal of materials has been included as 'use 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 Belgian marine waters (*Belgian State 2018, public consultation*), the impact in the context of the dumping of dredged material is evaluated with respect to MSFD descriptors 1, 4, 6 and 10. The implementation of the MSFD in Belgian legislation is foreseen by the RD of 23 June 2010 (see theme **Nature and environment**). The potential application of the MSFD evaluation scheme in the assessment of the activity 'dumping of dredged material' was elaborated on in *Lauwaert et al. (2016)*. Ten relevant MSFD environmental targets were selected. In addition, the Birds Directive (2009/147/EC) and the Habitats Directive (92/43/EEC) constitute an important framework for the reduction of the impact of dredging and dumping activities. In the publication of *Van Hoey et al. (2014b)*, a Benthic Ecosystem Quality Index (BEQI) was established in the context of the WFD, MSFD and Habitats Directive for the evaluation of the state of the soft substrate fauna which can be applied to assess the dumping of dredged matter.

In the BNS, dredging and dumping is governed 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 five-yearly synthesis report must be submitted to the competent minister. In these reports, the effects of the dredging and dumping activities are discussed, and recommendations supporting the development of a stronger environmental policy are formulated (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*). Moreover, the dredged material that is deposited needs to meet certain sediment quality criteria (*website BMM*, *Goffin et al. 2007*, *OSPAR national action levels for dredged material 2008*). This is checked every 10 years by sampling and analysing in situ samples at the dredge deposit locations. A new survey for this will be carried out in 2018. In addition, samples are taken from the ship's hold and analysed on a regular basis (approximately every four months) and evaluated based on the limit and target values set in the permits granted.

In the context of these permits, a monitoring and scientific programme is imposed to the Government of Flanders. In the MOMO programme, the MUMM is responsible for monitoring and modelling cohesive sediment transport and for evaluating the effects on the marine ecosystem of dredging and dumping activities (see, *inter alia* *Fettweis et al.*

2015 (MOMO)). The Research Institute for Agriculture, Fisheries and Food (*ILVO*) studies the biological and chemical aspects of the various dumping sites. Attention is paid to knowledge gaps such as the presence of marine litter, microplastics and other emerging contaminants in dredging material, as well as potential cumulative effects (*OSPAR IA 2017*, *Lauwaert et al. 2016*).

Currently, there is a trend in the dredging industry (in cooperation with research institutions) to adapt dredging activities to natural processes or to deliberately construct certain ecosystems (see *inter alia* the so-called 'Building with nature concept'). Furthermore, alternative suppletion approaches are developed for the construction of beaches in the context of coastal security, accommodating rivers to increase discharge and storage capacity, land reclamation, nature development, etc. (*Temmerman et al. 2013*, *de Vriend 2014*, *de Vriend et al. 2014*, *de Vriend et al. 2015*).

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
Convention on the prevention of marine pollution by dumping of wastes and other matter (London Convention)	1972	1975
The Protocol to the 1972 Convention on the prevention of marine pollution by dumping of wastes and other matter and Annexes 1, 2 and 3 (London Protocol)	1996	2006
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR Convention)	1992	1998

European legislation

Title	Year	Number
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive establishing a framework for Community action in the field of water policy (Marine Strategy Framework Directive)	2008	56
Directive on the conservation of wild birds (Birds Directive)	2009	147

Belgian and Flemish legislation

Abbreviation	Title	File number
Decision of the Government of Flanders 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
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 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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 van 28 oktober 1999 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
Cooperation agreement of 12 June 1990	Samenwerkingsakkoord tussen de Belgische Staat en het Vlaamse Gewest ter vrijwaring van de Noordzee van nadelige milieueffecten 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 milieueffecten ingevolge bagger-specielossingen in de wateren die vallen onder de toepassing van de Conventie van Oslo	2000-09-06/31

5

Sand and gravel extraction

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Van Lancker, V., Vandenreyken, H., Lauwaert, B., De Backer, A., Devriese, L. (2018). Sand and gravel extraction. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea. 2018 - Compendium for Coast and Sea. p. 79-89.

Between 75 and 95 million m³ of marine sediment was extracted annually in the OSPAR region (North-East Atlantic and North Sea) during the years 2012-2015 (*ICES WGEXT Report 2016*). Mainly sand and gravel are mined for the construction industry and beach nourishments. Furthermore, marl is extracted to improve farmland and to filter water (*OSPAR QSR 2010*). Most of the marine sediment is extracted in the North Sea by countries such as the Netherlands (26.1 million m³ in 2015; 15.7 million m³ in 2016), the United Kingdom (19.5 million m³ in 2015; 11.3 million m³ in 2016), France (2.9 million m³ in 2015; 3.0 million m³ in 2016) and Denmark (4.9 million m³ in 2015; 6.4 million m³ 2016) (*ICES WGEXT Report 2016*, *ICES WGEXT Report 2017*). In the Belgian part of the North Sea (BNS), most of the extracted sediment is sand with an annual volume that fluctuated in the last ten years between 2 and 4 million m³. In 2014, this volume was significantly higher at almost 6 million m³, 60% of which was used for beach nourishment. In 2017, approximately 4 million m³ was mined. At that time, almost 40% was used for coastal protection (Source: *FPS Economy*, Continental Shelf Service, 2018). Gravel is not extracted in the BNS due to low quantities in extraction areas, the small grain size and the heterogeneity of the material in the permitted areas (*Brochure Continental Shelf service 2014*).

5.1 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 *Reglementering Zand- en Grindwinning in het BNZ 2014*). The coordination of the parties involved in the management of the exploration and exploitation on the continental shelf (CS) and in the territorial sea is executed by an Advisory Committee (RD of 12 August 2000).

5.2 Spatial use

The various zones for sand and gravel extraction are legally demarcated in the marine spatial plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014* and theme **Integrated ocean policy**). In addition, reference zones may be established where sand and gravel extraction is prohibited in order to monitor the environmental impact in an area similar to the sand extraction areas in terms of sediment and habitat composition. In the current MSP, this zone is situated on the Thornton Bank (see THBREF zone in figure 1) and also serves as a reference area for wind turbine activities.

The geographic demarcation and accessibility of the control zones[1] for which the exploitation and exploration of mineral and other non-living resources in the territorial sea and the CS have been registered in the RD of 1 September 2004 relating to the allocation procedure (table 1 and figure 1, amended by the RD of 19 April 2014) (see also the *Sand and Gravel Regulation in the BNS 2014*). Prior to this delimitation, a study on the possible concession zones for sand extraction was conducted (*Schotte 1999*). In total, three control zones were demarcated in 2004 and divided into sectors for which concessions can be obtained. A fourth control zone was defined in 2010, in which 4 new sectors were demarcated based on new exploration data. For Belgium, the extracted region (= the effectively extracted area) amounted to about 32% of the legal concession zone in 2015, and only 12% in 2016 (*ICES WGEXT Report 2016*, *ICES WGEXT Report 2017*). If a negative seabed evolution occurs due to extraction that does not meet the legal requirements (max. 5 m relative to a reference level), certain sections of the zones can be closed. For example, the areas of KBMA in the central part and KBMB in the northern part of the Kwintebank were closed on 15 February 2003 and 1 October 2010 respectively; and one area in the central part of the Buiten Ratel (BRMC) has been closed for exploitation since 1 January 2015 (*Degrendele and Vandenreyken 2017*, figure 1)

Since the demand for sand and gravel is expected to increase further (e.g. the needs for coastal protection, the demand for construction sand and gravel on land), space is reserved for sand and gravel extraction in the new MSP (2020), which manages the use of space in our part of the North Sea until 2026. The pre-draft MSP 2020-2026 was approved by the Council of Ministers in April 2018 and in the summer months of 2018 there was a public consultation (*MSP 2020-2026, public consultation 2018*). This draft MSP offers a new sand extraction area on the Blighbank. As the draft MSP is not yet final, changes may still occur (*MSP 2020-2026, public consultation 2018*).

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 1 September 2004 about the environmental impact assessment (EIA) defines that an EIA-report has to be submitted to the Management Unit of the North Sea Mathematical Models of the Royal Institute of Natural Sciences (*RBINS-MUMM*) (*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *MER voor*

[1] A control zone is an area stipulated by law where sand extraction is permitted (delimitation stipulated in the MSP – RD of 20 March 2014).

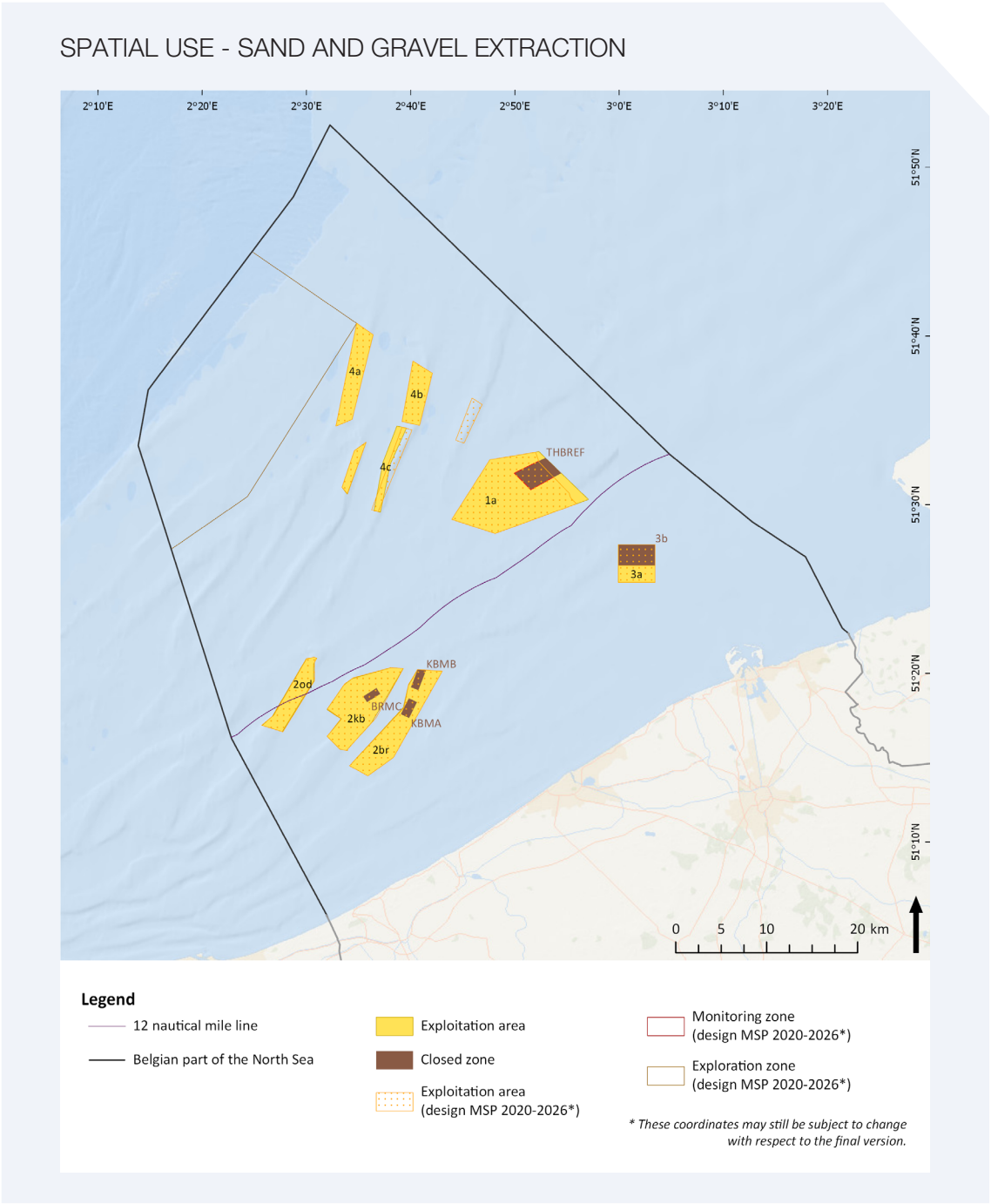

Figure 1. The demarcation of the control zones for sand extraction in the BNS (Source: *website FPS Economy, Continental Shelf Service*, RBINS, *marineatlas.be* (based on RD of 20 March 2014), *MSP 2020-2026, public consultation 2018*).

de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*). The EIA-report by MUMM 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 (Source: *Reglementering Zand- en Grindwinning in het BNZ 2014*).

The concessions that have been granted for the exploration and exploitation of the mineral and other non-living resources in the BNS are to be found in the ministerial decrees in the Belgian Official Gazette (*Belgisch staatsblad*) (table 2). Each concessionaire pays a fee in line with the volume he has extracted, with an annual minimum of EUR 18,592.02 euro (Source: FPS Economy, Continental Shelf Service). The amounts of the allowance are adjusted annually and vary according to the type of material: sand from control zones 1, 2 and 4: 0.72 euro/m³ in 2018; sand from control zone 3 (lower quality): 0.46 euro/m³ in 2018; and gravel: 1.51 euro/m³ in 2018. A new concessionaire may

exploit a maximum of 100,000 m³ in the first year. Each year, an Advisory Committee advises the minister competent for Economy on the quantities that each concessionaire may mine in the following year.

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

Control zone	Sector	Location	Accessibility
Zone 1	1a	Thorntonbank	Open, except for the area THBREF
Zone 2	2kb	Kwintebank	Open, except for KBMA and KBMB
	2br	Buiten Ratel	Open, except for the area BRMC
	2od	Oostdyck	Open
Zone 3	3a	Sierra Ventana	Open
	3b	Sierra Ventana	Closed as long as this sector is used as a dumping site for dredged material
Zone 4	4a	Noordhinder	Open
	4b	Oosthinder	Open
	4c	Oosthinder	Open
	4d	Westhinder	Open

Table 2. An overview of the concessionaires for sand extraction in the BNS with the maximum volume awarded for 2018 (Source: FPS Economy, Continental Shelf Service).

Concessionaire	Maximum volume of extraction awarded for 2018
Charles Kesteleyn NV	100,000 m³
Dranaco NV	100,000 m³
SATIC NV	150,000 m³
TV Zeezand Exploitatie NV	100,000 m³
Alzagri NV	200,000 m³
Van Oord België	100,000 m³
Belmagri NV	200,000 m³
CBR - Sagrex	600,000 m³
De Hoop Bouwgrondstoffen BV c.o. SATIC NV	100,000 m³
DEME Building Materials NV	1,000,000 m³
Government of Flanders - Coastal Division	1,200,000 m³
Government of Flanders – Maritime Access division	350,000 m³
DC Industrial NV	800,000 m³
NHM NV	550,000 m³
Betoncentrale Van den Braembussche	200,000 m³

5.3 Societal interest

The extraction of sand and gravel in the BNS has strongly increased over the past few years (figure 3). In 1976, a sediment volume of 29,000 m³ was extracted; which amounted to 4 million m³ in 2017 (Source: FPS Economy, Continental Shelf Service). Between 1976 and 2016, 65 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 zone 2, especially on the Kwintebank (2kb). After closing two regions on the Kwintebank (2kb), a shift took place since 2007 to zone 2br (Buiten Ratel) until the central part of the Buiten Ratel was 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 in the control zones over a period of five years (not taking into account exceptional projects such as coastal protection). Half of this sediment was landed in Flanders in 2016. The other half was unloaded in Dutch, French and UK ports (Source: FPS Economy, Continental Shelf Service).

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. Of course, there is also a major indirect impact, such as the economic growth of port activities, the Belgian construction

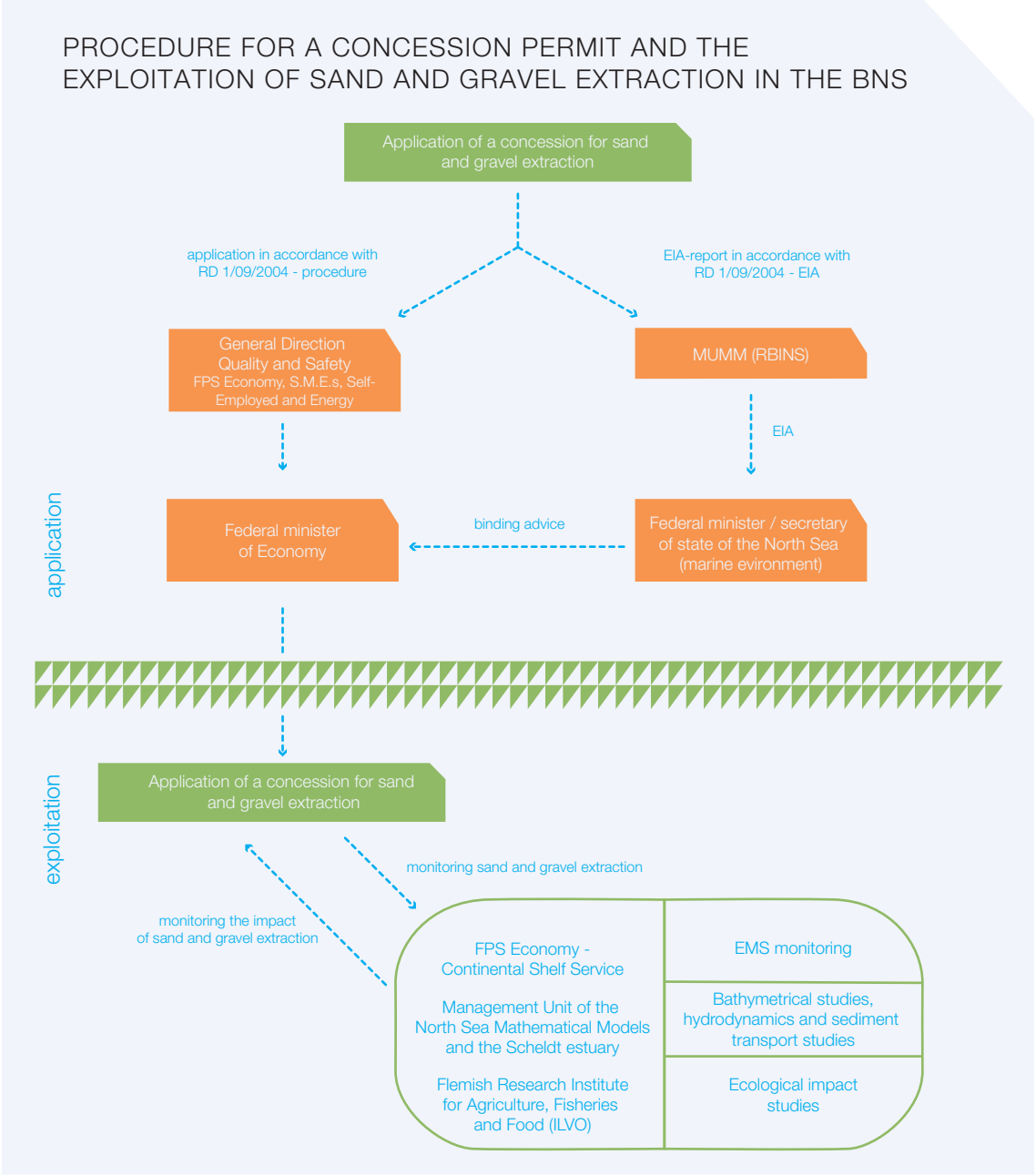

Figure 2. Flowchart of the procedure for a concession permit and the exploitation of sand and gravel extraction in the BNS (law of 13 June 1969 and implementing decrees).

industry, road transport, suppliers, etc. Some relevant facts and figures are listed here:

- 13 private companies with a concession permit employ 130 people in Belgium and 138 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 sea gravel in Belgium (in 2016) amounted to more than 70 million euro;
- The concessionaires do not only mine on the BNS, but also extract or buy sand in neighbouring countries (table 3). In 2016, both the sand extracted in Belgium as well as the sand extracted or purchased in the Netherlands amounted to approximately 3 million m³. In the United Kingdom and Germany, almost 1 million m³ and about 40,000 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 (54%), precast concrete (18%) and other concrete products (10%). In addition, sea sand is used for the production of asphalt, as sand filling used for e.g. drainage, foundation and beach works;
- In addition to the use of sea sand in the construction sector, sea sand is also used for coastal protection (see theme **Safety against flooding**);

Table 3. Volumes (m³) of sand extracted or purchased in Belgium and neighbouring countries in 2016.

Country	Volumes extracted or purchased in 2016
Belgium	3.031.410 m³
The Netherlands	2.953.469 m³
United Kingdom	922.450 m³
Germany	37.015 m³

- The implementation of beach nourishment (rainbowing) is currently the most important coastal protection measure. 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 is used, while this is ± 200 µm for pre-shore nourishment. Since 2010, new concession zones have been defined in the Hinderbanks region (e.g. *Van Lancker et al. 2015*, *Van Lancker et al. 2016*, *Roche et al. 2017*, *Van Lancker et al. 2017*). It is planned to extract 35 million m³ of sediment over 10 years, mainly in the context of the *Masterplan Coastal Safety* and the 'public works' OW-plan Ostend (plan for the protection against the sea and the maritime accessibility of Ostend) (*MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *Mathys et al. 2011*, *Rumes et al. 2011*);
- The indirect impact of the sand extraction sector is more difficult to quantify. In addition to the purchase of marine granulates, more than 40 million euro was spent in the private sector in Belgium during 2016 on the required infrastructure and 20 million euro in the rest of Europe. Investments were also made in the public sector, such as ports and pilotage, explicitly almost 4 million euro in Belgium and more than 7 million euro in the rest of Europe.

It can be stated that the extraction of sea aggregates is not only of strategic importance, but has undoubtedly become an economic activity with high added value that generates growth and prosperity for Belgian construction companies (Source: FPS Economy, Continental Shelf Service).

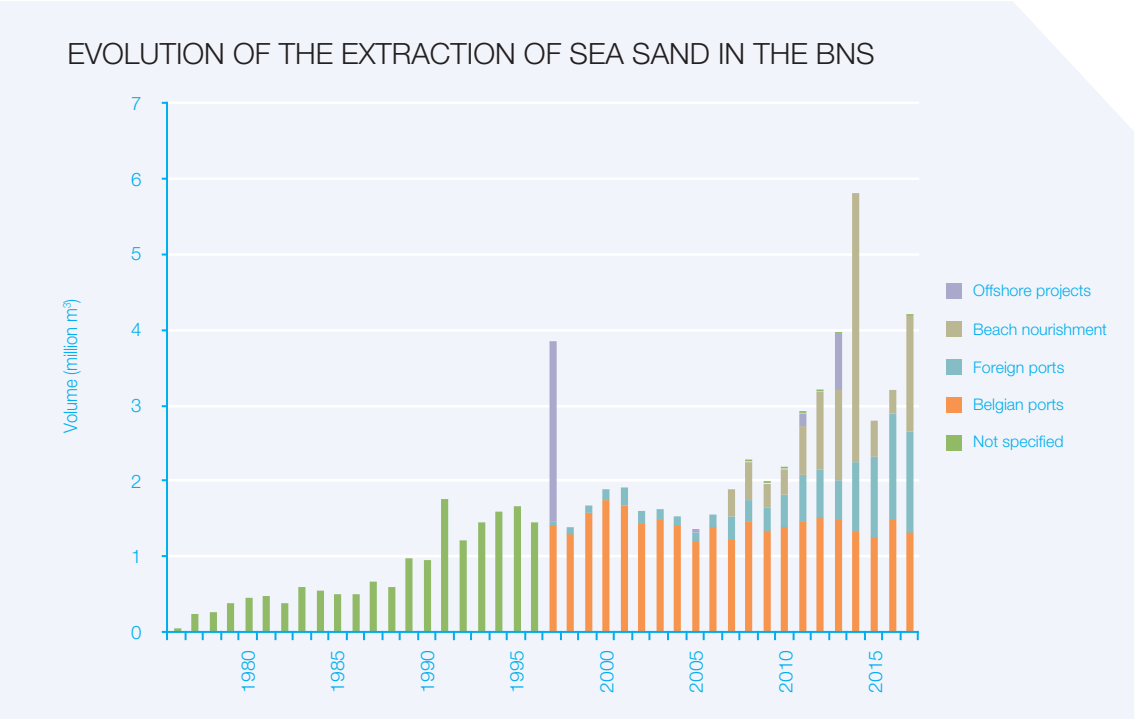

Figure 3. The evolution of the extraction of sea sand in the BNS between 1976 and 2017. Comment: construction of submarine gas pipelines in 1991 and 1997 (Source: *FPS Economy, Continental Shelf Service*).

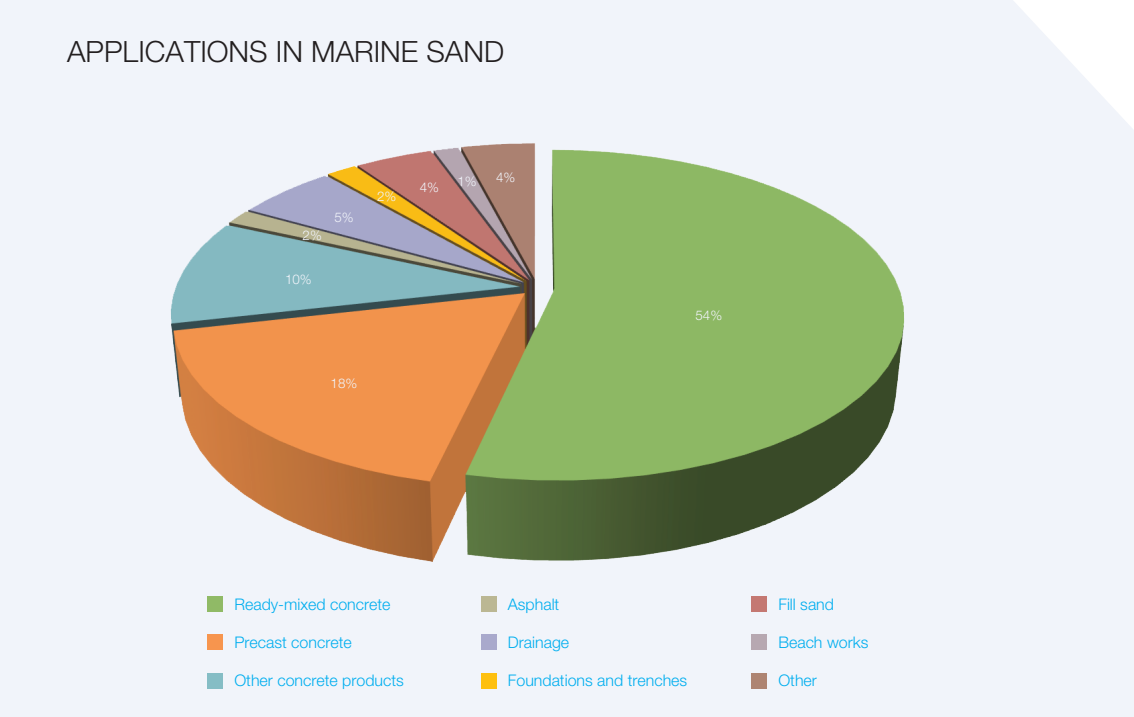

Figure 4. The different applications (with their % share) of sea sand in 2016 (private sector).

5.4 Impact

The most commonly used method for sand extraction is the trailing suction hopper dredger, that creates channels of 1-3 m wide and 0.2-0.5 m deep in the seabed (*Degrendele et al. 2010*, *Newell and Woodcock 2013*). The RD of 1 September 2004 regarding the environmental impact assessment, stipulates the different effects of sand extraction on the marine environment that need to be taken into account in the environmental assessment report (tables 4 and 5). Only references relating to the BNS are listed below, supplemented with publications that are widely applicable or provide a general overview, including the Belgian part (e.g. ICES reports). Sediment extraction is also included in the Ecosystem Vision for the Flemish Coast (*Van der Biest et al. 2017b*) as one of the processes with the greatest negative contribution to ecosystem components and ecosystem services.

5.5 Sustainable use

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. 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 WGEXT Report 2003*). These also discuss nature conservation and spatial conflicts among users. Belgium, Denmark, Germany, France, the Netherlands and the United Kingdom demand the use of '*black box*' systems which monitor 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 *MUMM* and the Research Institute for Agriculture, Fisheries and Food (*ILVO*).

At the European level, the impact on the marine environment caused by the extraction of sediments is also included in the Water Framework Directive (WFD, 2000/60/EC), Marine Strategy Framework Directive (MSFD, 2008/56/EC, see also RD of 23 June 2010) and Habitats Directive (92/43/EEC) (see theme **Nature and environment**). Since sand extraction in the BNS does not take place within the ecological scope of the WFD, i.e. the 1-mile zone, the regulations of the MSFD and the Habitats Directive apply in the concession zones. 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 integrity of the seafloor is particularly important (more information: *Rice et al. 2010*), but also the direct and indirect effect of

Table 4. A literature overview of the environmental impact of sand extraction.

Impact on the environment	Literature
Seabed and water (changes in the bathymetry, sedimentology, sediment plumes, turbidity, hydrodynamic regime, etc.)	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *Van Lancker et al. 2007 (MAREBASSE project BELSPO)*, *Vanaverbeke et al. 2007 (SPEEK project BELSPO)*, *Van Lancker et al. 2009 (QUEST4D project BELSPO)*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *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 en 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. 2016*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Van den Eynde et al. 2017*, *Van Lancker et al. 2017*, *Baeye et al. 2017*, *Van Lancker et al. 2017b*
Fauna, flora and biodiversity	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *Vanaverbeke et al. 2007 (SPEEK project BELSPO)*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Backer 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. 2016*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *De Backer et al. 2017*, *Van Lancker 2017*
Air quality and climate	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Sutter and Mathys 2011*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Francken et al. 2017*
Noise and vibrations	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Sutter and Mathys 2011*, *Heinis et al. 2013*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Jones and Marten 2016*, *Durinck and Casteleyn 2017*

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

Impact on users	Literature
Risk and safety (shipping, oil pollution, coastal protection, etc.)	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *Verwaest 2008*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Sutter and Mathys 2011*, *Liste Muñoz et al. 2011*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Van den Eynde et al. 2017*
Seascape and cultural heritage	*MER voor de extractie van mariene aggregaten op het BNZ 2006*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Sutter and Mathys 2011*, *Van Haelst and Pieters 2014*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Missiaen et al. 2016*
Interaction with other human activities (including coastal protection)	*Verwaest and Verelst 2006*, *MER voor de extractie van mariene aggregaten op het BNZ 2006*, *Verwaest 2008*, *MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *De Sutter and Mathys 2011*, *Vandenborre 2014*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Van Lancker et al. 2016*, *Van den Eynde 2017*
Cumulative effects (e.g. in combination with the activities in the offshore wind farms)	*MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ 2010*, *Van Lancker et al., 2010*, *De Sutter and Mathys 2011*, *Van Lancker et al. 2015*, *MER voor de extractie van mariene aggregaten in controlezones 1, 2 en 3 in het BNZ 2016*, *Walker et al. 2016*, *Van Lancker et al. 2016*, *Van Lancker et al. 2017*

sand extraction on the conservation of biodiversity (descriptor 1, more information: *Cochrane et al. 2010*), and the marine food webs (descriptor 4, more information: *Rogers et al. 2010*). There is also an influence on descriptor 7 on the permanent alteration of hydrographical conditions (*Walker et al. 2016*, *ICES WGEXT Report 2016*, *ICES WGEXT Report 2017*) and descriptor 11 on the introduction of energy, including underwater noise (more information: *Tasker et al. 2010*). For each descriptor, a number of primary and secondary criteria and indicators have been proposed (*Commission Decision (EU) 2017/848*). Trends and changes are evaluated every six years. The evaluation of the first MSFD cycle (2012-2018) will be transferred to Europe in October 2018. This revision of the initial assessment for Belgian marine waters (*public consultation, Belgian State 2018*) assesses the impact of aggregate extraction in relation to MSFD descriptors 1, 6 and 11. The selective extraction of living and non-living resources from the seafloor has been included in the list of pressures. Furthermore, the European Habitats Directive (92/43/EEC) (see also RD of 14 October 2005) offers a framework to protect ecologically important areas such as the gravel beds in the BNS (*Degrendele et al. 2008*, *Houziaux et al. 2008*, *Degraer et al. 2009*, *Raeymaekers et al. 2011*, *De Mesel et al. 2017*) against pressures such as aggregate extraction activities. The most ecologically valuable natural gravel beds are located south of the extraction areas of the Hinder Banks. In the context of the two aforementioned directives, the sediment mobility in the gravel beds has thus been incorporated into the monitoring programme (Government of Flanders) related to the sand extraction (*Van Lancker et al. 2014a*, *Van Lancker et al. 2014b*, *Van Lancker et al. 2015*, *Van Lancker et al. 2016*, *Montereale-Gavazzi et al. 2017*, *Van Lancker et al. 2017b*). In the marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*) a reference zone has been demarcated in order to monitor the impact on the environment (control zone 2). The maximum volume that can be extracted in this zone decreases annually with 1% (17,000 m^3) and gravel extraction is prohibited.

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 operator in proportion to the volume mined (see **5.2 Spatial use**) (*Degrendele 2008*, *Brochure Dienst Continentaal Plat 2014*, *Reglementering Zand- en Grindwinning in het BNZ 2014*). The results of this monitoring are presented at a three-yearly conference organised by the Continental Shelf Service (e.g. *Degrendele and Vandenreyken 2017*). Over the years, the European guidelines have helped to determine the monitoring approach (*Van Lancker 2011*).

An important part of the monitoring is the control of the extraction operations. This is done by checking the registers kept on board of the dredging vessels, and by a *black-box* system (Electronic Monitoring System, EMS) on the other (*Brochure Continental Shelf service 2014*, *Reglementering Zand- en Grindwinning in het BNZ 2014*, *Van den Branden et al. 2017*). This system was introduced in 1996, modernised in 2014 and is managed by MUMM, as commissioned by the Continental Shelf Service (*Degrendele et al. 2014*, *Roche et al. 2017*). Furthermore, the physical impact of extraction on the seabed is monitored by the Continental Shelf Service (FPS Economy) and MUMM. The sediment volumes in the control zone are followed up using the research vessels RV Belgica and RV Simon Stevin. In this regard, a maximum of 5 m of sediment may be removed compared to the original level of the seabed (*Degrendele et al. 2014*). Currently, the possibility for a new reference level for sand extraction is being explored which is unlike before, defined based on scientific and juridical criteria (*De Mol et al. 2014*, *Degrendele 2016*, *Degrendele et al. 2017*). The aim of this new reference level is to limit the impact of extraction in the most sensitive areas and to increase economic sustainability by using available volumes of quality sand. The MUMM is responsible for monitoring the hydrodynamics and the sediment transport 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. 2017*, *Van den Eynde et al. 2017*). 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*). In exploitation zone 4 (demarcated in 2010) an elaborate 'baseline' study has been executed to 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. 2016*, *Van Lancker et al. 2017*).

Furthermore, specific studies and research projects such as *BUDGET* (*Lanckneus et al. 2001*, *BUDGET project BELSPO*), *SPEEK* (*Vanaverbeke et al. 2007*, *SPEEK project BELSPO*), *MAREBASSE* (*Van Lancker et al. 2007*, *MAREBASSE project BELSPO*), *EUMARSAND* (*Van Lancker et al. 2010*, EU FP6 project), *RESOURCE-3D* (*Van Lancker et al. 2009, BELSPO*), QUEST4D (*Van Lancker et al. 2009*, *QUEST4D project BELSPO*) and *TILES* (*TILES project BELSPO*) (*Van Lancker et al. 2014c*, *Van Lancker et al. 2017c*, figure 5) contribute to a better understanding of the impact and a sustainable management of the sand and gravel extraction. In the *TILES* project a harmonised geological knowledge-base is developed which supports natural 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*) and seismic data will be combined into 3D geological models that map the quality and quantity of the exploitable geological layers ('the raw material or resource') (*Hademenos et al. 2018*). After linking the resource models with numerical impact models, parameters are calculated that can support a more sustainable exploitation strategy (*Terseleer et al. 2017*, *Van Lancker et al. 2018*). However, the ultimate minable 'reserve' is mainly determined by all

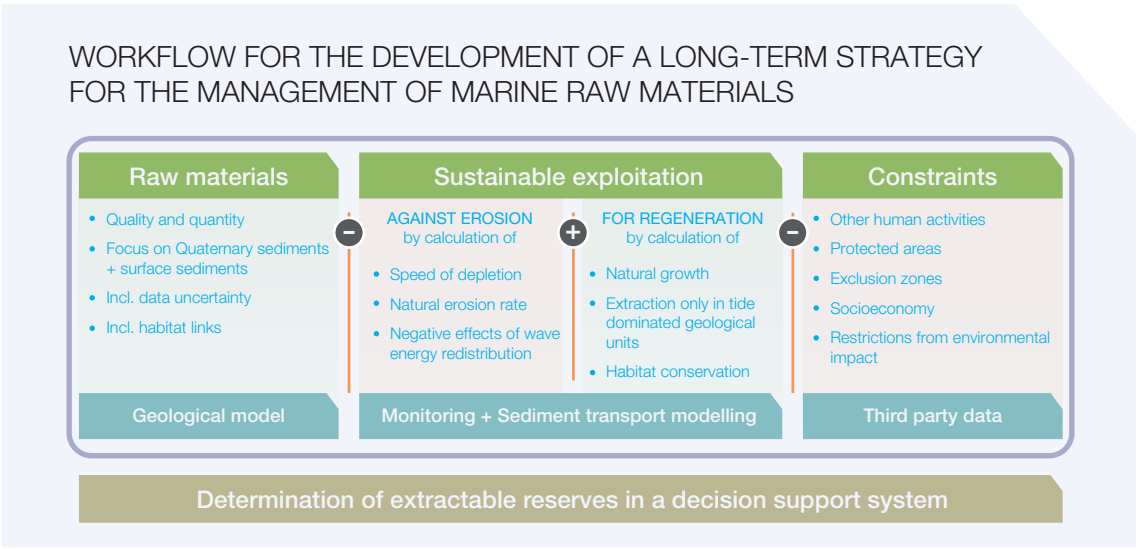

Figure 5. Conceptual workflow for the development of a long-term strategy for the management of marine raw materials at the BNS (*Van Lancker et al. 2017c*).

kinds of restrictions that do not permit exploitation (e.g. the use of space by other activities). Finally, the knowledge and information generated is offered in a multi-criteria decision support system in which data quality is taken into account (*Kint et al. 2018*, *De Tré et al. 2018*). The information obtained from such a system contributes to a better support of the evaluation of sand extraction in the BNS.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
Directive on the assessment of the effects of certain public and private projects on the environment	1985	337
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56

Belgian and Flemish legislation

Abbreviation	Title	File number
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 1 September 2004	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling 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	2004-09-01/50
RD of 14 October 2005	Koninklijk besluit tot instelling van speciale beschermingszones en speciale zones voor natuurbehoud in de zeegebieden onder de rechtsbevoegdheid van België	2005-10-14/35
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 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
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

6

Energy (including cables and pipes)

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Heylen, B., Moerman, D., Mouffe, L., De Maeyer, J., Mathys, P., Rumes, B., Devriendt, C., Weijtens, W., Dauwe, S., Pirlet, H. (2018). Energy (including cables and pipes). In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 91-113.

6.1 Offshore wind energy

Europe is the world leader in offshore wind energy. In 2017, 4,149 turbines were installed and connected to the power grid in European seas, with a total installed capacity of 15,780 MW. These wind turbines are distributed over 92 wind farms in eleven different countries (*Offshore wind in Europe: Key trends and statistics 2017*). Most wind turbines are located in the North Sea, with the United Kingdom, Germany and Denmark being the leading European actors in offshore wind energy. In Belgium, four wind farms were operational in 2017 (C-Power, Belwind, Nobelwind and Northwind), totaling 232 wind turbines and a total installed capacity of 877.2 MW (*MUMM*, *BOP*, *4C Offshore*). This ranks us in fifth place in Europe and sixth worldwide (*Offshore wind in Europe: Key trends and statistics 2017*).

In the following years, five more offshore wind farms will become operational in Belgium: Rentel (2018), Norther (2019) and Seastar, Mermaid and Northwester 2 (2020). Once these projects have been realised, the offshore wind farms will have a total capacity of 2,230-2,280 MW and will produce approximately 8 TWh per year for a total of nearly 500 wind turbines. This corresponds to 10% of the total Belgian electricity consumption and approximately 50% of the electricity consumption by households (*MUMM*, *BOP*, *Vande Velde 2014*, *CLIMACT 2017*, *Degraer et al. 2018*). Plans for further expansion in newly designated areas after 2020 are being examined in the context of the revision of the marine spatial plan (*4C Offshore*, *MSP 2020-2026, public consultation 2018*). In the preliminary draft MSP (2020-2026), approved by the federal Council on 20 April 2018, three zones with a total surface area of 221 km² at 35-40 km off the coast are reserved for the production of renewable energy (figure 1). The focus lies on wind energy with an estimated production value of 2,000 MW.

6.1.1 Policy context

At the European level, the energy policy is developed by the European Commission's Directorate-General for Energy (*DG ENER*) the European Council and the European Parliament. An important aspect of this energy policy concerns the renewable energy strategy (which includes offshore wind energy). A key instrument in this context is directive 2009/28/EC on the promotion of the use of energy from renewable sources. This directive stipulates that Belgium must include 13% renewable energy in its final energy consumption[1] by 2020. Furthermore, this directive obliges each Member State to elaborate a national action plan on how to achieve the renewable energy goals (*Nationaal actieplan België hernieuwbare energie 2010*). Work is in progress to amend this directive in order to better respond to climate change with the original objective of achieving at least 27% renewable energy in Europe by 2030 (COM (2016) 767). On 18 June 2018, it was decided to adjust this target to 32% renewable energy (*EC communication*) within the same timeframe. The Directorate-General for Maritime Affairs and Fisheries (*DG MARE*) also developed a 'Blue Growth' policy (COM (2012) 494). This is a long-term strategy for a more sustainable growth in marine and maritime sectors which includes offshore energy production (Blue Energy, COM (2014) 8), see also *DG MARE – Ocean Energy*.

The Belgian renewable energy policy is, in principle, a regional competence. However, as the Belgian part of the North Sea (BNS) falls under federal competence the policy on the production of electricity from water, currents or winds and the transmission grid at sea is developed at federal level by the federal minister responsible for energy and the federal minister (or secretary of state) responsible for the North Sea (*FPS Economy, S.M.Es, Self-Employed and Energy*, more information on the division of competences: the *Nationaal actieplan België hernieuwbare energie 2010*).

An overview of the European and national legislation concerning the electricity market is given on the website of the *CREG* and the *FPS Economy, S.M.Es, Self-Employed and Energy*.

6.1.2 Spatial use

In the current marine spatial plan (RD of 20 March 2014), the wind farms are located near the eastern border of the BNS at approximately 23 km from the coast, in a zone dedicated to the development of energy from wind, water and currents (*FPS Health, Food Chain Safety and Environment*). The offshore wind sector has submitted an application to the federal Government to provide additional space for new offshore wind energy projects with an additional capacity of 2,000 MW in the renewed MSP (2020-2026) (*BOP, Marine Spatial Plan 2020-2026*, *4C Offshore*). The draft MSP (2020-2026) includes three new concession zones for renewable energy (221 km²), located some 35-40 km off the coast and allowing an additional production of approximately 2,000 MW of wind energy. The preliminary draft MSP was approved by the federal Council on 20 April 2018 and is scheduled to be passed by the king in 2019 (*MSP 2020-2026, public consultation 2018*).

[1] Target for the share of energy from renewable sources in the gross final consumption of energy.

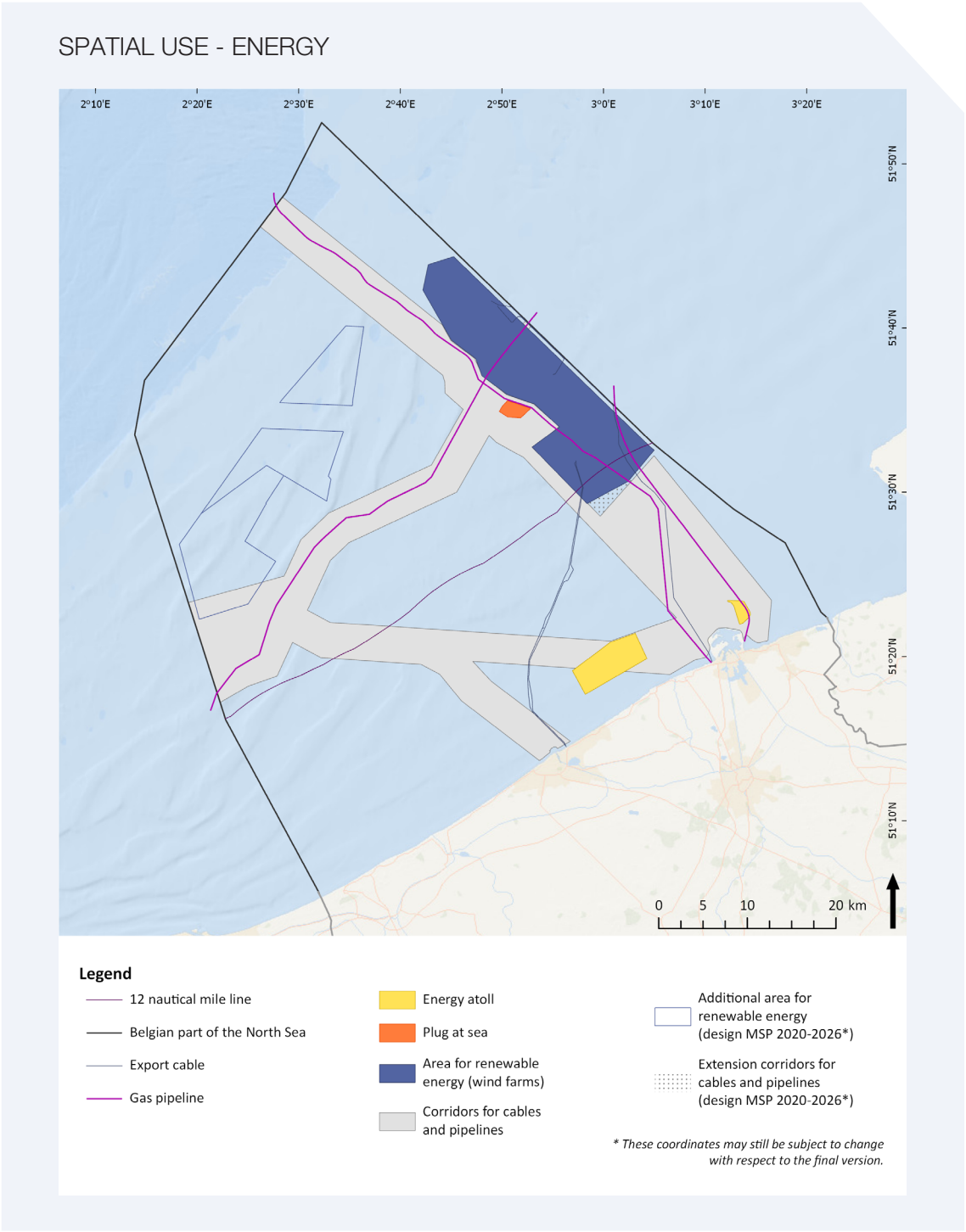

Figure 1. The location of the concession zones for wind farms and energy atolls, the Modular Offshore Grid and the pipeline and cable corridors in the BNS (Source: RBINS, *marineatlas.be* (based on the RD of 20 March 2014), *MSP 2020-2026, public consultation 2018*).

Prior to the installation of the wind farms, a study was carried out on the seabed, the wind supply and the transmission capacity for an optimal development of renewable energy at sea in the eastern concession zone (*Le Bot et al. 2004*, *project BELSPO*).

In addition, the spatial needs for other users of the sea must also be taken into account (see sources in **6.1.4 Impact on the marine environment**). In this context, a ban on regular (non-wind park related) shipping has been introduced in Belgium in the zone of the wind farms, as well as in the areas reserved for hydroelectric energy storage installations

(the so-called energy atoll) and offshore substations of the transmission system operator (RD of 11 April 2012). From the operational phase onwards, a safety zone of 500 metres (measured from the outer boundary) will be established around artificial islands, installations or infrastructure for the generation of energy from water, currents and winds (e.g. offshore wind farms) (RD of 11 April 2012) (see also theme **Maritime transport, shipping and ports**).
The spatial demarcation of the domain concessions for wind farms in the BNS and the history of this demarcation are discussed in more detail in figure 1 and tables 1 and 2.

In order to actually realise an offshore wind farm, the project must have several permits (see also **Procedure domain concession** and **Procedure environmental permit**). Currently, the following federal permits are required:

- A ministerial decree for the granting of a domain concession by the federal minister for Energy and the North Sea;
- A ministerial decree for the granting of an authorisation by the federal minister/secretary of state responsible for the North Sea for the construction of the wind farm, the cables and operation following an advice from the MUMM (RBINS) and an Environmental Impact Assessment (EIA);
- A ministerial decree for the granting of a permit for the installation of offshore cables by the federal minister for Energy and the North Sea (see also **6.6 Pipes and cables**).

Table 1. History of the spatial demarcation of the concessions zones for offshore wind farms in the BNS.

History of the spatial demarcation of the concession zones	
RD of 20 December 2000	Procedure and preconditions to obtain a concession zone (no demarcation yet).
Cabinet of 19 December 2003	Ministers responsible for North Sea and Energy are instructed to demarcate an area for offshore energy parks.
RD of 17 May 2004	Demarcation of an area for offshore wind farms of 264 km².
Cabinet of 3 December 2010	Ministers responsible for the North Sea and Energy are instructed to adjust the north-western part of the demarcated area as a result of frequent and incompatible use.
RD of 3 February 2011	Modification of the northwestern part of the demarcated zone (area of 238 km²).
RD of 20 March 2014	Establishment of a marine spatial plan in which, *inter alia*, the zone stipulated by the RD of 17 May 2004 and amended by the RD of 2011 is included (see also *Van de Velde et al. 2014*).
Federal cabinet, 20 April 2018	Approval of a draft MSP with a new concession zone for offshore wind energy of 221 km². This zone is located about 35-40 km off the coast and represents a production of 2 GW. The draft version is expected to be adopted by the king in 2019.

Table 2. An overview of the location and utilised space of the different concession zones for offshore wind in the BNS (*FPS Economy, S.M.E.s, Self-Employed and Energy*, *MUMM*, *BOP*), see also EIAs for the respective parks under 6.1.4 'Impact on the marine environment'.

Project name	Location	Total surface area (excl. safety zone)	Water depth	Distance to coast
C-Power	Thorntonbank	19.8 km²	12 - 27.5 m	27 - 30 km
Belwind	Bligh Bank	17 km²	15 - 37 m	46 - 52 km
Northwind (former Eldepasco)	Lodewijkbank	14.5 km²	16 - 29 m	37 km
Nobelwind (former Belwind phase 2)	Bligh Bank	18 km²	15 - 37 m	46 - 52 km
Rentel	Southwest Schaar	22.7 km²	26 - 36 m	33 km
Norther / North Sea Power	South of the Thorntonbank	44 km²	14 - 30 m	23 km
Mermaid	Northwest of the Bligh Bank	16.7 km²	24.4 - 50.0 m	50 - 54 km
Seastar	In between the Lodewijkbank and the Bligh Bank	18.4 km²	22 - 38 m	40 km
Northwester 2 (former Mermaid Zuid)	Northwest of the Bligh Bank	11.7 km² (potential expansion in EIA up to 15.2 km²)	24.2 - 39.9 m	51 km
Total surface area reserved for windfarms (incl. safety zone)		**238.0 km²**		

PROCEDURE DOMAIN CONCESSION

Each project must pass the procedure for the designation of a domain concession zone for the proposed project area (figure 2). This procedure and the conditions for granting a concession are stipulated in the RD of 20 December 2000. As a result of an amendment of the aforementioned RD by the RD of 28 September 2008, applications for obtaining a domain concession for the construction and operation of installations in the maritime areas, in which Belgium can exercise its jurisdiction, are directed to and dealt with by the representative of the minister. His proposal to grant or refuse the permit is then passed on to the federal minister for Energy (see also the MD of 16 March 2009) (*MUMM*, *CREG*, *Degraer et al. 2018*).

PROCEDURE ENVIRONMENTAL PERMIT

Each project must go through an environmental permit procedure, in accordance with the law on the protection of the marine environment (law of 20 January 1999), the RD of 7 September 2003 (procedure for the licensing and authorisation of certain activities in the BNS) and the RD of 9 September 2003 (rules of the environmental impact assessment) (figure 2). The Environmental Impact Assessment (EIA) is carried out by the Management Unit of the North Sea Mathematical Models of the Royal Institute of Natural Sciences (*RBINS-MUMM*) on the basis of an Environmental Impact Report (EIR) drawn up on behalf of the permit applicant. The MUMM subsequently advises the competent minister (or secretary of state) on the expected environmental effects (website *OD Natural Environment, RBINS*). The latter then approves or rejects the application by ministerial decree. A granted permit also imposes by law a monitoring of the effects of the project on the marine environment.

When additional permits are required by other legislation for installations in the concession zone (e.g. the environmental permits), the permit of the concession zone remains suspended until any additional license or authorisation has been granted and until notification is made in accordance with the applicable legislation. If any of the additional required permits or authorisations is definitely refused, the domain concession expires on the day of notification of this refusal. In Belgium, nine domain concessions have already been granted to different project developers (table 2)[2].

6.1.3 Societal interest

THE ENERGY PRODUCTION OF OFFSHORE WIND FARMS

Based on modelling by WindEurope, the central scenario estimates that by 2020 204 GW of wind energy will be installed in Europe with a share of approximately 25% for offshore wind energy (*Wind energy in Europe: outlook to 2020, WindEurope 2017*). By 2030, the installed capacity of wind energy would increase to 320 GW, of which 66 GW coming from offshore wind energy. This would cover 24.4% of European electricity demand (*Wind energy scenarios for 2030, WindEurope 2015*).

The total capacity that could theoretically be installed in the BNS was already assessed in 2009 by *Mathys et al. (2009)* (*OPTIEP-BCP project, BELSPO*), taking into account a number of preconditions, as well as other user functions. The total capacity of all projects that were granted a concession in the BNS amounts to approximately 2.2 – 2.3 GW, although this figure can still vary slightly depending on the configuration of the last 3 parks (table 3, *MUMM*, *BOP*). In 2017, four wind farms were fully operational with a total installed capacity of 877.2 MW (*MUMM*, *BOP*, *Degraer et al. 2017*) (figure 3). With Rentel becoming operational at the end of 2018 the installed capacity will reach over 1,000 MW for 274 wind turbines (*Degraer et al. 2018*). The annual production of the wind farms that are already operational is shown in table 3.

EMPLOYMENT

According to estimates, the offshore wind energy sector in Europe could create 170,000 jobs by 2020, with an additional 130,000 jobs by 2030 (COM (2012) 494). The more recent *Wind energy scenarios for 2030* report from *WindEurope* estimates these figures to be slightly higher (minimum 307,000 jobs).

In Belgium, approximately 5,000 jobs were created during the construction of the first three offshore wind farms. The construction of an average offshore wind project (300 MW) generates approximately 1,400 direct jobs and an equal

[2] A modified permit procedure for the new wind farms (preliminary draft MSP 2020-2026) will be determined within the current legislature (2014-2019).

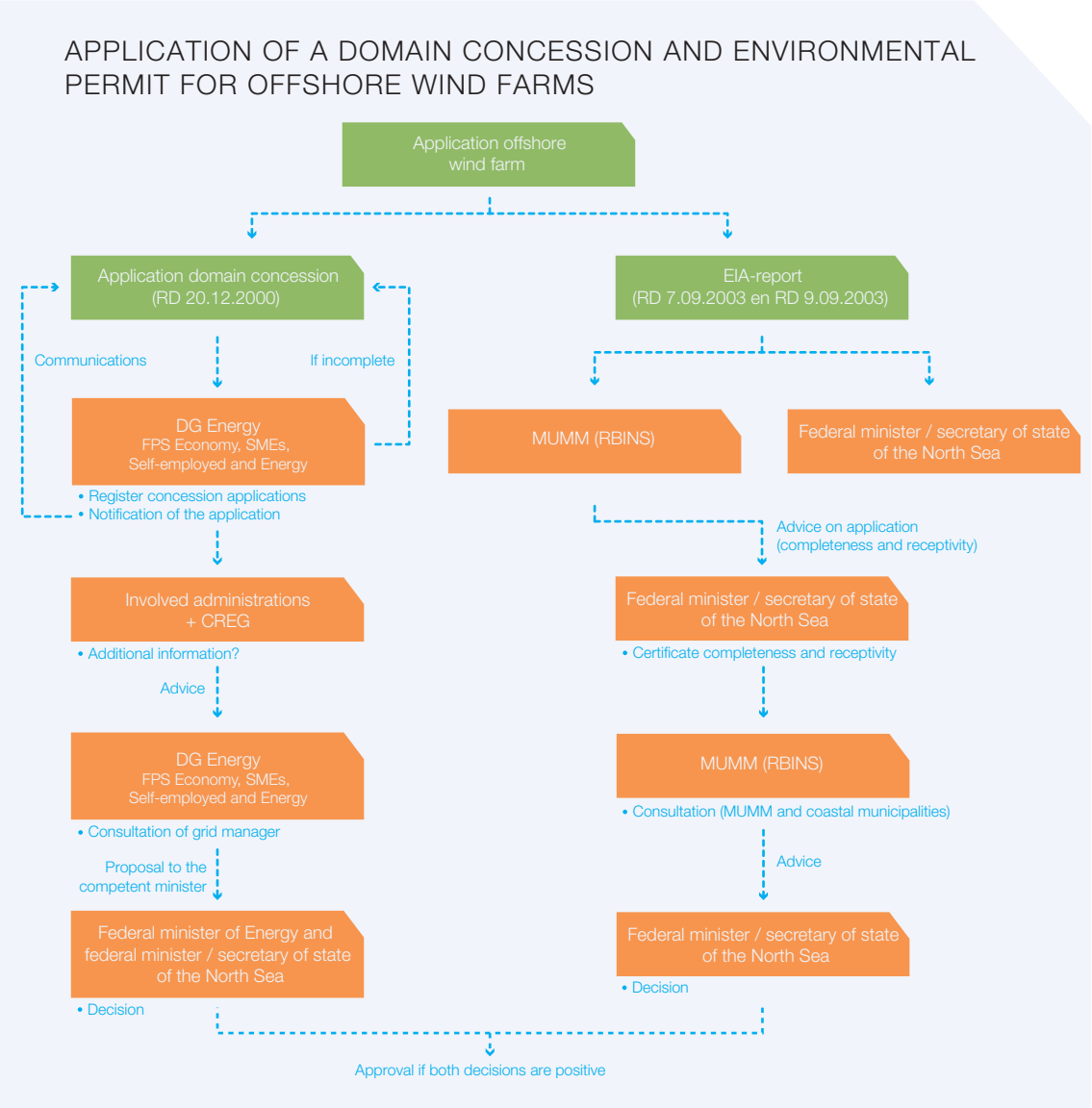

Figure 2. Flowchart for the application of a domain concession and environmental permit for offshore wind farms (RD of 20 December 2000, RD of 9 September 2003).

amount of indirect jobs during the development and construction phase. The exploitation phase creates an average of 100 new jobs per wind farm. The realisation of the planned parks would therefore lead to approximately 20,000 temporary jobs (expressed in man-years) and 800 new permanent jobs during exploitation (minimum 20 years) (*BOP 2014*). A recent socio-economic study of the *BOP* (*CLIMACT 2017*) adjusted these figures to 15,000 to 16,000 jobs in the offshore wind industry (by 2020) and also demonstrated strong economic benefits with in the long term (2030) an annual increase in GDP of over 1 billion euro, an improved trade balance by more than 1.4 billion euro, etc. (see also *Economic impact study Belgian shipping cluster: Update 2017 2017*).

The construction of offshore wind turbines also creates new jobs in the ports, with the port of Ostend specifically presenting itself as an energy port. This resulted into 366 new, mainly specialised, jobs in 2016 (*Annual report Port of Oostende 2016*). It should be noted that economic activities concerning offshore wind farms are also happening in the port of Zeebrugge. However, no figures are available for this.

6.1.4 Impact on the marine environment

The installation of wind farms in the BNS has a number of positive and negative effects on the ecosystem and on the users of the sea (tables 4 and 5). The impacts on the marine environment that should be addressed in the

Table 3. An overview of the status, the number of turbines and the total capacity of the wind farms in the BNS. (This information was collected from various sources: website *MUMM*, *BOP*, *4C Offshore*, see also EIAs of the respective farms under 6.1.4 Impact on the marine environment (depending on the source, the figures may differ slightly)).

Project name	Status	Number of turbines	Total capacity	Annual production
C-Power	Operational since 2009, fully operational since 2013	54	325 MW	1,050 GWh/year (power for 300,000 households)
Belwind	Fully operational since 2011 + GE Haliade (6 MW) operational since 2013	56	171 MW	560 GWh/year (power for 162,000 households)
Northwind (former Eldepasco)	Fully operational since 2014	72	216 MW	875 GWh/year (power for 250,000 households)
Nobelwind (former Belwind phase 2)	Fully operational since 2017	50	165 MW	679 GWh/year (power for 180,000 households)
Rentel	Concession and environmental permit granted	42	309 MW	1,140 GWh/year (power for 300,000 households)
Norther / North Sea Power	Concession and environmental permit granted Under construction (2018), operational by 2019	44	370 MW	1,340 GWh/year (power for 400,000 households)
Seastar	Concession and environmental permit granted Construction planned in 2019, operational by the end of 2020	30*	252 MW*	power for 263,437 households
Mermaid	Concession granted Environmental permit (April 2015) Construction planned in 2019, operational by the end of 2020	28*	235 MW (+5 MW** wave energy)*	power for 233,593 households
Northwester 2	Concession granted Environmental permit December 2015 Construction planned in 2019, Operational by 2020	23*	219 MW*	770 GWh/year (power for 220,000 households)

** Number of turbines and total capacity can vary from final value.*
*** The most recent values, as communicated by the BOP, suggest an installed capacity up to 20 MW.*

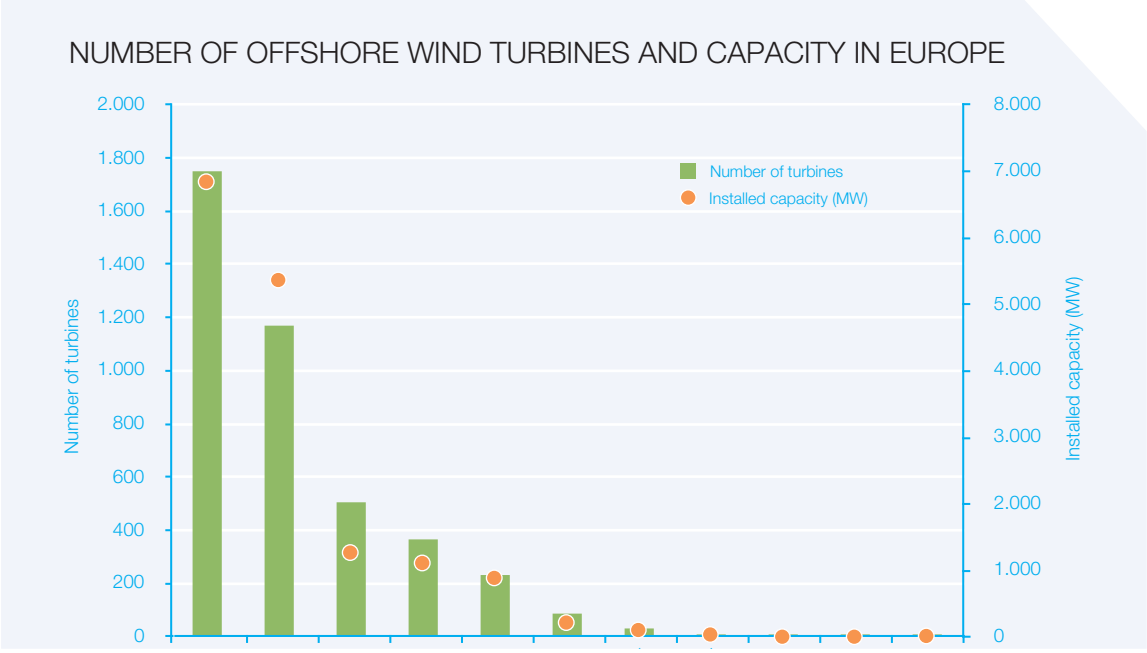

Figure 3. Number of offshore wind turbines and installed capacity (MW) in Europe in 2017 (*Offshore wind in Europe. Key trends and statistics 2017*).

environmental impact assessment (EIA) have been stipulated in the RD of 9 September 2003 on EIA. The EIAs, Environmental Impact Reports (EIRs) and any amendments can be consulted on the relevant *website* of the RBINS-OD Natural Environment (table 4). In addition, numerous scientific studies have been conducted to better understand the impact of the wind farms on the marine environment in the BNS (non-exhaustive overview in table 5).

Table 4. An overview of the EIRs, EIAs and additional documents of the wind farms in the BNS.

Wind farm	EIRs, EIAs and additional documents
C-Power	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* + *MER - Wijziging en uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010*, *MEB C-Power 2004*, *MEB C-Power wijziging 2006*
Belwind / Nobelwind	*MER Offshore Windpark Bligh Bank. Belwind NV 2007*, *Di Marcantonio et al. 2007 – MEB Belwind*
Northwind (former Eldepasco)	*MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008*, *Di Marcantonio et al. 2009 – MEB Eldepasco*
Rentel	*Milieueffectenrapport windpark Rentel 2012*, *Rumes et al. 2012 – MEB Rentel*
Norther / North Sea Power	*MER Norther project en wijzigings MER*, *Rumes et al. 2011 – MEB Norther*, *Rumes et al. 2013 – MEB wijzigingsaanvraag*
Mermaid	*MER Mermaid en Northwester 2*, *Rumes et al. 2015 – MEB Mermaid*
Seastar	*MER - windpark Seastar 2013*, *Rumes et al. 2013 – MEB Seastar*
Northwester 2	*MER Mermaid en Northwester 2*, *Rumes et al. 2015 – MEB Mermaid*

Table 5. An overview of scientific studies concerning the effects of offshore wind parks on the environment and other users.

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*, *Verhaeghe et al. 2011*, *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*, *Norro and Degraer 2016*, *Debusschere et al. 2016*, *Debusschere 2016*, *Norro 2017*, *Norro 2018*
Effects on fish and benthos (introduction of hard substrate, habitat loss, 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*, *Coates et al. 2012*, *Vandendriessche et al. 2012*, *Coates et al. 2013a*, *Coates et al. 2013b*, *Vandendriessche et al. 2013a*, *De Mesel et al. 2013*, *Vandendriessche et al. 2013b*, *Reubens et al. 2013*, *Reubens 2013*, *Coates 2014*, *Rumes et al. 2013*, *De Mesel et al. 2015*, *Kerckhof and Degraer. 2016*, *Reubens et al. 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 WGMBRED Report 2017, PERSUADE project BELSPO*, *De Backer and Hostens 2018*, *De Backer and Hostens 2018*, *Lefaible et al. 2018*, *Kerckhof et al. 2018*
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. 2010*, *Vanermen et al. 2011*, *Verhaeghe et al. 2011*, *Vanermen et al. 2012*, *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*
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 en Debosschere 2018*
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*
Disturbance 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 theme **Maritime transport, shipping and ports**)
Spatial impact (including conflicts 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*

6.1.5 Sustainable use

MEASURES CONCERNING THE IMPACT ON THE MARINE ENVIRONMENT

On an international level, OSPAR published a guide (*OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development 2008*) about the impact of wind turbines on the marine environment. Within the context of the *ASCOBANS-agreement* (on the conservation of small cetaceans), the impact of wind turbines on marine mammals was evaluated (*Evans 2008*). In 2009, a resolution was issued against the adverse effects on marine mammals caused by underwater noise as a result of the construction of installations (pile-driving of the turbine foundations in the seabed, burial of the sea cables, etc.) for the generation of renewable energy at sea. As a consequence, a list of guidelines for reducing underwater noise has recently been published (*Prideaux 2016*). Based on the monitoring results of the construction phase of the first wind farms, a seasonal ban on piling for the coming wind farms from 1 January to 30 April is put into place in the BNS.

At the European level, the Marine Strategy Framework Directive (MSFD, 2008/56/EC) provides a framework to reduce or avoid the environmental impact of wind farms at sea. For instance, the supply of energy, including underwater noise, is identified as one of the descriptors for a good environmental status (GES) (*descriptor 11*). Other descriptors in the MSFD relevant to the installation of wind turbines at sea are: seabed integrity (*descriptor 6*), the introduction of non-indigenous species (*descriptor 2*) and the permanent alteration of hydrographic conditions (*descriptor 7*).

At the Belgian level, a monitoring programme has been established in the BNS to monitor the impact of wind turbines on the marine environment. This programme is co-ordinated by the *MUMM* and has a dual objective:

- To adapt, reduce or even stop the activities in the event of extreme damage to the marine environment;
- To gain a proper insight into the impact of wind turbines at sea on the environment in order to be able to support the policy, management and design of future wind turbines.

The monitoring programme studies the physical, biological and socio-economic aspects of the marine environment (e.g. *Degraer and Brabant 2009*, *Degraer et al. 2010*, *Degraer et al. 2013*, *Degraer et al. 2016*, *Degraer et al. 2017*, *Degraer et al. 2018*) in relation to a baseline condition (e.g. *De Maersschalck et al. 2006*, *Henriet et al. 2006*, *Van den Eynde 2005*).

The offshore wind parks can be used as a laboratory for multiple use of space. In this context, the Actieplan Zeehond examined the impact of artificial reefs and resting places within the parks on biodiversity and productivity (*Action Plan Zeehond 2012*). In addition, two pilot projects for integrated aquaculture have already been identified within the *AQUAVALUE roadmap*, for example, the *EDULIS project* tests mussel farming within the C-Power and Belwind wind farms. The marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*) and the *Long-term vision of the North Sea 2050* encourage multiple use of space within the wind farms, with opportunities for aquaculture, nature development, wave and tidal energy, etc. However, given the current high density of the wind farms, the possibilities are limited.

THE DEVELOPMENT OF OFFSHORE WIND ENERGY – BOTTLENECKS AND MEASURES

At the European level a number of policy initiatives have already been taken to promote the development of offshore wind energy. These include (not exhaustive):

- The *Strategic Energy Technology Plan* (SET-Plan, COM (2007) 723) – A strategic plan to accelerate the development of cost-effective, low carbon technologies. Ideas about a new, integrating strategy for the coming years was communicated in 2015 (C (2015) 6317);
- COM (2008) 768 on offshore wind energy – Action is needed to achieve the energy policy objectives for 2020 and beyond;
- 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 has been developed (Blue Growth, COM (2012) 494). Specifically, for the blue energy sector (including offshore wind energy), COM (2014) 8 developed eight measures to exploit the potential of ocean energy in Europe's oceans and seas by 2020 and beyond;
- COM (2016) 860 on Clean energy for all Europeans – Communicates a regulatory framework in which Europe aims to achieve the transition to 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* (2016) in which they confirm a policy of cooperation. The objective is twofold: on the one hand, to facilitate the cost-effective use of wind energy and, on the other hand, to improve interconnection between the countries in the region;

- In support of the European energy policy, and at the request of the European Commission, *ETIPWind* (a SET-plan product) developed a strategic research and innovation agenda (*SRIA 2018*). It presents visions for cost reduction, the facilitation of network integration, the maintenance of technological leadership and the retention of expertise in Europe.

Furthermore, Europe has invested in research on offshore wind energy (COM (2008) 534). The different aspects of the development of offshore wind energy have been investigated in multiple projects, including FP7-*Oceans of Tomorrow 2014* and the Horizon 2020 programme (*Blue Growth-calls*). Taking into account the age of the first wind farms and the current European energy policy aiming at a switch to sustainable energy, attention is rising for the dismantling of (old) offshore wind turbines with an increasing demand for more scientific substantiation on this matter (*EMB Policy Brief 2017*).

The federal Government has decided on a series of measures to stimulate the generation of electricity from renewable energy in the BNS:

- The electricity law of 29 April 1999 defines measures with regard to the organisation of the energy market to ensure that a certain volume of electricity is delivered by renewable energy sources at a certain price;
- The law of 29 April 1999 stipulates, *inter alia*, that transmission system operator Elia has to finance one third of the cost of the submarine cable connecting the turbines to the coast, with a maximum of 25 million euro per project (see also **6.6 Pipes and cables**);
- The RD of 16 July 2002 develops a system for granting certificates which guarantee the origin of the produced energy as well as 'green certificates' (GC) for electricity produced from water, currents or wind in the BNS. The Commission for the Regulation of Electricity and Gas (*CREG*) grants GCs to energy producers that hold a concession zone and a certificate with a guarantee of the origin. Minimum prices are set for the resale of certificates received for green energy production. For energy generated by offshore wind turbines, the transmission system operator is obliged to purchase the GCs from the green energy producer who requests it at a minimum price:
    - For the Belwind, C-Power and Northwind wind farms, this is set at 107 euro/MWh for the production that follows from the first 216 MW installed capacity. This minimum price falls to 90 euro/MWh for production from an installed capacity above the first 216 MW;
    - For Nobelwind (part of the initial Belwind-domain concession), the minimum price is 107 euro/MWh for the first 45 MW installed capacity and 90 euro for the remaining 120 MW;
    - For Rentel and Norther, the minimum price per GC depends on the electricity price. The minimum price is set by the *CREG* in accordance with the applicable provisions of the RD of 16 July 2002 (Article 14 §1, 1ter)[3]. It provides for an LCOE (levelised cost of energy) of 124 euro/MWh for Norther and 129.8 euro/MWh for Rentel. The support period and purchase commitment is set at 19 years;
    - For the last three wind farms (Northwester 2, Mermaid and Seastar), the minimum price is set at 79 euro/MWh LCOE for 16 years and renewable by one year and for a maximum of 63,000 full load hours (*BOP*).

In addition, a number of platforms and clusters have been set up to promote the interests of the sector and its development:

- The Belgian Offshore Platform (*BOP*) unites the main Belgian actors that invest in renewable (wind)energy on the Belgian part of the North Sea (concessionaires and direct investors). The BOP aims to stimulate further development through *inter alia* representing the interests of its members in the public sector, utilities and with other instances or people;
- Belgian Offshore Cluster (*BOC*) aims to represent the interests of the offshore industry (suppliers) and to ensure that its Belgian know-how is represented and put on the international map. The BOC intends to create a broad and independent (industrial) support base that maintains the necessary connections between the sector, government and international institutions aiming for qualitative improvement as well as achieving relevant results for the Belgian Offshore Industry;
- The *Blue Cluster*, a spearhead cluster of the Government of Flanders for sustainable and innovative economic development on the BNS, also includes offshore energy. In a first phase, the focus will be on opportunities relating to energy storage and nearshore wind (in which coordination will be sought with the activities of IBN Offshore Energy, see further);
- Flanders' Maritime Cluster (*FMC*), the network organisation for the marine and maritime industry in Flanders, also supports companies active in the Blue Growth sector in general and therefore the offshore energy sector. FMC has been included in the Blue cluster since 2018 (see above).

[3] A new offshore support regime was stipulated in the aforementioned RD of 16 July 2002, which was promulgated and ratified on 9 February 2017. This is a guaranteed minimum price, where the amount of support decreases with increasing electricity price. 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-transmission loss factor)].

In order to support the Flemish companies active in the value chain of offshore energy with regard to their innovation plans, the innovative company network Offshore Energy (*IBN Offshore Energy*) was launched at the Flemish level. This innovation cluster was developed in early 2017 with the support of the Flemish Agency for Innovation and Entrepreneurship (*VLAIO*) with the core objective of providing support in the realisation of innovative project plans in the field of offshore energy. The IBN is open to both large companies and innovation-centered organisations and is supported through the knowledge institutions by the Offshore Wind Infrastructure Application Lab (*OWI-Lab*). OWI-Lab is conceived from a partnership between Sirris and VUB, to which UGent joined more recently. In addition to its involvement in this cluster, OWI-Lab also has specific test infrastructure and coordinates several projects on cost reduction in offshore wind energy production through research and innovation.

Other initiatives that support the development of the offshore wind sector and facilitate innovation from a regional perspective are:

- *Factories for the Future Blue Energy* – an initiative of the *POM West-Vlaanderen* to bring together various actors from the government, knowledge institutes and companies on 'Blue Energy' (wind, wave and tidal energy) to enforce the sector (*Dangreau 2014*). This is achieved by realising concrete objectives and actions in partnership within three domains: product and process, research and testing, and internationalisation;
- *TUA West* of the province of West Flanders aims to stimulate the integration of knowledge from provincial higher education and research in economic developments. TUA West focuses on selected knowledge acquisition within West Flanders, including Blue Energy.

6.2 Wave and tidal energy

The European Commision's Blue Growth Strategy (COM (2012) 494, *website DG MARE*) highlights blue energy as one of its priority areas. In order to make optimal use of the potential of marine energy (tidal energy, wave energy and energy extraction from temperature and salinity gradients), a number of measures were listed by the Commission (COM (2017) 8). Hence, the potential of marine energy is impressive (*World energy resources marine energy 2016*). The European Commission estimates that, given the right development climate, 10% of Europe's energy needs could be covered by blue energy by 2050 (*website DG Research and Innovation*). However, irrespective of small exceptions, marine energy production in European waters is still limited due to the fact that, unlike wind energy, technology is still in the development phase. By mid-2016, the cumulative capacity reached 252 MW, excluding test and validation infrastructure. Member States' plans indicate an ambition to install a capacity of 665-850 MW by 2020 (*Ocean energy strategic roadmap 2016*, *JRC Ocean Energy Status Report 2016*).

Currently, research to further develop marine energy technologies is ongoing (see for example *website DG Research and Innovation* and *Ocean Energy ERA-NET Cofund*). The status of research (see also *Uihlein and Magagna 2016*), production, projects and policy at national level is followed up in the *Annual Report Ocean Energy Systems (2016)* and the *JRC Ocean Energy Status Report (2016)*. Recently, in the context of the implementation of the SET-plan, a working group was established by the EC to examine the feasibility of the technological research on ocean energy production known as *ETIPOcean*. To this end, a strategic research agenda has been developed (*Strategic research agenda ocean energy 2016*). Publications and research projects related to the development of ocean energy in the Belgian part of the North Sea are listed in table 6 that *inter alia* make clear that the BNS is particularly suitable as a test location due to its low wave climate (estimated potential within wind farm concession zone 4.5 – 5.8 Kw m^{-1}). In

Table 6. An overview of the research on wave and tidal energy on the BNS.

Research subject		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*
	Economic aspects	*Beels 2010*, *Mathys et al. 2012 (BOREAS project BELSPO)*
	Ecological aspects	*MER Mermaid en 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*
	Prototype development	*FlanSea project (project description, 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)*
	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)*

order to further stimulate wave and tidal energy in Flanders, partners from the academic community, industry and the government developed an action plan called *Gen4Wave*. The platform's operation has since been integrated into the operation of *IBN Offshore Energy*. At the impulse of the Hydraulic Laboratory (WatLab, MOW), KULeuven and UGent, Gen4Wave's operation also resulted in the construction of a coastal and ocean basin (COB) in *Greenbridge* (Ostend) providing test opportunities for developers of wind, wave and tidal energy and land-sea interactions (*Troch et al. 2017*). This COB test infrastructure is complementary to the plans for a multifunctional offshore test platform (including offshore energy production) in the context of the Blue Accelerator project (*MER Blue Accelerator 2017*). Furthermore, the development of wave energy is also supported by *Factory for the Future Blue Energy* of the West Flanders Development Agency (POM West-Vlaanderen) (*Dangreau 2014*, *Vanden Berghe 2014*).

In the area of the BNS reserved for wind farms, the construction and exploitation of installations for the production of electricity from water and streams is also permitted (RD of 20 March 2014 (MSP) and RD of 20 December 2000, amended by RD of 3 February 2011). In the Mermaid concession zone a pilot project with wave converters is being planned with a capacity of 5 MW[4] for commercial use (*Application Mermaid 2014*). The EIA of this concession zone also discusses the potential impact of these converters on the environment (*Rumes et al. 2015 – MEB Mermaid*, *Rumes et al. 2015*).

The energy production zones included in the draft of the MSP 2020-2026 also provide space for alternative energy sources to wind energy such as tidal, solar and wave energy (*MSP 2020-2026, public consultation 2018*).

6.3 Renewable energy in the coastal zone

The coastal zone has a number of natural characteristics that makes it an interesting region for certain forms of renewable energy. A study into the average wind speeds in Flanders (*Een windplan voor Vlaanderen*) showed that the coast has a considerably higher wind supply (see also *Dehenauw 2002* and *Debrie 2017*). In our wind climate, a production factor[5] of ±11% inland, ±23% near the coast and ±34% offshore (*Brouwers et al. 2011*) can be expected, although this can be estimated more accurately within the offshore parks as they become operational. In addition, measurements reveal that the average duration of sunshine in the coastal zone is 1,700 hours per year compared to 1,550 hours in Uccle (inland). The biggest differences occur in the summer when the coast can receive up to 20 more hours of sunshine per month (*Dehenauw 2002*). The *climate atlas* of the Royal Meteorological Institute of Belgium (RMI) also provides parameters such as sunshine duration and solar radiation for Belgium, that clearly reveal elevated values for the coastal zone. Hence, the coastal zone has an increased potential for solar energy. Of course, other forms of energy production are also present in the coastal zone (e.g. biomass, biogas, etc.). However, given that the coast does not provide a specific climate for this, they will not be discussed further here.

At the European level, the energy policy is developed by the *Directorate-General Energy*. A key instrument in this context concerns the Directive 2009/28/EC on the promotion of the use of energy from renewable sources. This directive stipulates that Belgium must include 13% renewable energy in its final energy consumption by 2020[6]. Furthermore, this directive obliges each Member State to elaborate a national action plan to achieve the renewable energy goals (*Nationaal actieplan België hernieuwbare energie 2010*). A modification with directives to new renewable energy goals towards a share of at least 27% renewable energy by 2030 is currently under preparation (COM (2016) 767). On 18 June 2018, it was decided to adjust this target to 32% renewable energy by 2030 (*EC Statement/18/4155*).

Unlike nearshore energy production, renewable energy on land is a Flemish competence which is largely regulated by the Energy decree of 8 May 2009 (*Department Environment*, *Vlaamse beleidsnota energie 2014-2019*). The Flemish Energy Agency (VEA) implements this policy (*website VEA*). A comprehensive overview of renewable energy legislation and regulations can be found on the *VEA website*. At the end of 2017, a total of 33 concession zones were present in the coastal zone that qualify for green certificates (GC). These represent a total installed capacity of 145.4 MW. The vast majority of the installed capacity is located in Bruges and Ostend (Source: *Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

More specifically, 17 wind farms were present in the coastal zone in March 2018, mainly in Zeebrugge (strekdam), Bruges, Gistel, Diksmuide and Middelkerke. These account for an installed capacity of 67.7 MW or 6.6% of the capacity of the Flemish wind turbines (Source: *Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

[4] Recent numbers suggest an installed capacity of up to 20 MW (BOP).
[5] The production factor indicates the average power at which energy is produced, expressed as a percentage of the maximum power. It is used in determining the effective power (installed power x production factor).
[6] Target for the share of energy from renewable sources in gross final consumption of energy.

As far as photovoltaic panels for solar electricity are concerned, 17,126 installations with a capacity of less than or equal to 10 kW were present in the coastal zone, representing a total installed capacity of 74.8 MW (31 March 2018). In addition, 404 installations with a capacity of more than 10 kW, with a total installed capacity of 59.5 MW were present (Source: *Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

6.4 Natural gas installations at Zeebrugge

Belgium imports over 19 billion m³ of natural gas per year (*Statbel*). In addition, approximately 95 billion m³ of natural gas is reserved in the long term for border-to-border transport. It concerns Dutch and Norwegian natural gas for France and Spain, British natural gas for continental Europe, including Russian natural gas for the United Kingdom as well as natural gas for the Grand Duchy of Luxembourg. Zeebrugge plays an important role in the European gas market. The landing capacity in Zeebrugge corresponds to approximately 10% of the total border capacity needed to supply the EU (*België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010*). In 2016, a second jetty was put into service in the outer port of Zeebrugge, allowing the simultaneous handling of small and large LNG vessels, and a fifth storage tank of 180,000 m³ LNG (liquefied/liquid natural gas) is currently under construction and is due to be operational by 2018 (*Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*, *Fluxys*).

6.4.1 Policy context

The European policy on energy is developed by the *Directorate-General Energy*. A list of the (European) legislation relevant to natural gas is given on the websites of the *CREG* and the *FPS Economy, S.M.E.s, Self-Employed and Energy*.

The federal Government (*FPS Economy, S.M.E.s, Self-Employed and Energy*) is responsible for the major energy storage, transport and production infrastructures and defines the rate policy for the operators (in this case Fluxys and Fluxys LNG). The transport of gaseous products is regulated by the federal law of 12 April 1965 (the Gas Law) and by a number of royal decrees on rates and more technical aspects relating to network access (code of conduct) (more information: *website Fluxys*, *website CREG*, *website F.P.S. Economy, S.M.E.s, Self-Employed and Energy*). In addition, there is a federal regulator: the Commission for the Regulation of Electricity and Gas (*CREG*). Flanders is competent for, *inter alia*, the public distribution of gas, which is managed by so called *intercommunales*, as well as for the rational use of energy (special law on institutional reform (BWHI) (law of 8 August 1980), more information: *website FPS Economy, S.M.E.s, Self-Employed and Energy*).

6.4.2 Spatial use

The LNG terminal is located in the eastern part of the outport of Zeebrugge. The peninsula on which the LNG terminal is located covers an area of approximately 32 ha. Work is currently being carried out on a fifth storage tank, which is scheduled to become operational in 2018, after which the Zeebrugge LNG terminal will be expanded to include a storage tank, landing platform and additional transmission capacity (*Open season: second capacity enhancement of the Zeebrugge LNG-terminal. Binding phase: offer description 2011*, *Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*).

The marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*) provides space for the expansion of the port of Zeebrugge, which, in addition to the LNG terminal also hosts the terminals of the Seapipe and Interconnector gas pipelines (see **6.6 Pipes and cables**).

6.4.3 Societal interest

Zeebrugge is a cornerstone in the supply chain of natural gas to Northwest Europe. In addition to the LNG terminal and the terminals of the Seapipe and Interconnector gas pipelines (see **6.6 Pipes and cables**), the Zeebrugge Hub also forms one of the leading short-term markets in Europe (*Belgium as a natural gas hub for northwestern Europe: the road ahead 2010*, *Brouwers et al. 2011*). As a result of a recent drop in natural gas prices and a high demand from Asia, the transhipment of natural gas in Zeebrugge dropped to 1.3 billion m³ in 2017. In 2010, 62 billion m³ of gas was still traded, at that time worth over 10% of the total natural gas supply capacity of the European Union (*Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011*, *Maatschappij van de Brugse Zeehaven 2017*).

The installations of the LNG terminal in Zeebrugge are equipped for the reception of ships carrying liquefied natural gas (LNG). Since 2008, there are four active storage tanks with a total handling capacity of 9 billion m³ of natural gas per year, equalling 110 LNG ships with a capacity of up to 217,000 m³ of LNG (*Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011*, *Brouwers et al. 2011*). An additional storage tank of 180,000 m³ LNG (*Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*) will come into service in 2018 (*Fluxys*), allowing for a transhipment capacity of 11 billion m³ of liquefied natural gas (*Indicatief inversteringsprogramma Fluxys 2017-2026*). Fluxys has also opted for a model of cooperation for the development of an LNG terminal in Dunkirk and participates for 25% in this project. The two terminals will be connected via a new interconnection point in Alveringem and Maldegem, which will allow to bring up to 8 billion m³ of gas to Belgium and elsewhere in Europe from the LNG terminal in Dunkirk.

6.4.4 Impact and sustainable use

The construction of natural gas installations in Zeebrugge implies a certain impact on the environment as well as on other users. These effects are dealt with in the corresponding environmental impact assessments (EIAs, see *MER-database Vlaamse overheid*, *Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*). A number of measures have already been proposed in these EIAs to mitigate or avoid the impact of the LNG terminal on the surrounding area.

The use of natural gas as an energy source has a number of environmental benefits compared to other fossil fuels (*website Fluxys*). Today, the use of LNG as ship fuel is being promoted and is gaining in importance because it emits less harmful substances than diesel or heavy fuel oil (*Policy Statement 2017 North Sea*, *In-Focus LNG as ship fuel 2015*, *Margarino 2014*, see theme **Maritime transport, shipping and ports**).

6.5 Energy storage in the North Sea

Some renewable energy sources such as wind energy, are characterised by a discontinuity in the amount of energy produced. In order to guarantee a continuous supply of offshore energy that is adapted to the temporal variation in use, the *federal Government's coalition agreement (2014)* focuses on the storage of electricity. To enable this, the feasibility of hydroelectric energy storage (pumped storage plant principle) in a so-called energy atoll off the Belgian coast is being studied (see, *inter alia*, a study by the former Environmental-Innovation Platform *(MIP 2013)* of the Government of Flanders).

The marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*) defines two zones for energy storage in an energy atoll: off the coast of Wenduine and near the port of Zeebrugge. Concerning the zone near the port of Zeebrugge, such an atoll must be adapted to current port activities and future port expansion. The MSP also stipulates that an energy atoll can only be realised if active environmental management measures are in place. The conditions and the procedure for granting the domain concessions for such an energy atoll were laid down in the RD of 8 May 2014 implementing the law of 29 April 1999 (figure 4). Prior to this RD, the Commission on the Regulation of Electricity and Gas (*CREG*) *advised (2013)* that it is pertinent to reserve a zone for energy storage. Furthermore, the construction of an energy atoll needs to comply to the provisions of the environmental permit procedure, in accordance with the law on the protection of the marine environment (law of 20 January 1999), the RD of 7 September 2003 (procedure for permits and authorisation of certain activities in the BNS), the RD of 9 September 2003 (regulation on environmental impact assessment) and the RD of 12 March 2002 (permit for the laying of sea cables).

The consortium THV iLand submitted an application for obtaining a concession zone for the construction and exploitation of an offshore energy atoll situated near the Wenduine bank (zone 1 in the marine spatial plan). The application was built around a basic scenario with an installed capacity of 550 MW and an available energy content of 2 GWh (*Projectfiche THV iLand 2014*). However, the application was withdrawn in September 2015. Notwithstanding ideas still exist among project developers for an adapted multifunctional island with an energy storage function off the Belgian coast.

The draft of the MSP 2020-2026 no longer includes the two previously defined zones, but includes zones for commercial and industrial activities in which multiple use of space is targeted with energy storage being one of the possible activities (*MSP 2020-2026, public consultation 2018*).

In *Zimmerman et al. (2013)*, the effects of an energy atoll on currents, coastal morphology and coastal safety were investigated. In the study of the former Environmental-Innovation Platform of the Government of Flanders (*MIP 2013*), the ecological, legal and financial-economic aspects of an atoll at four different locations are discussed including a SWOT analysis for each location.

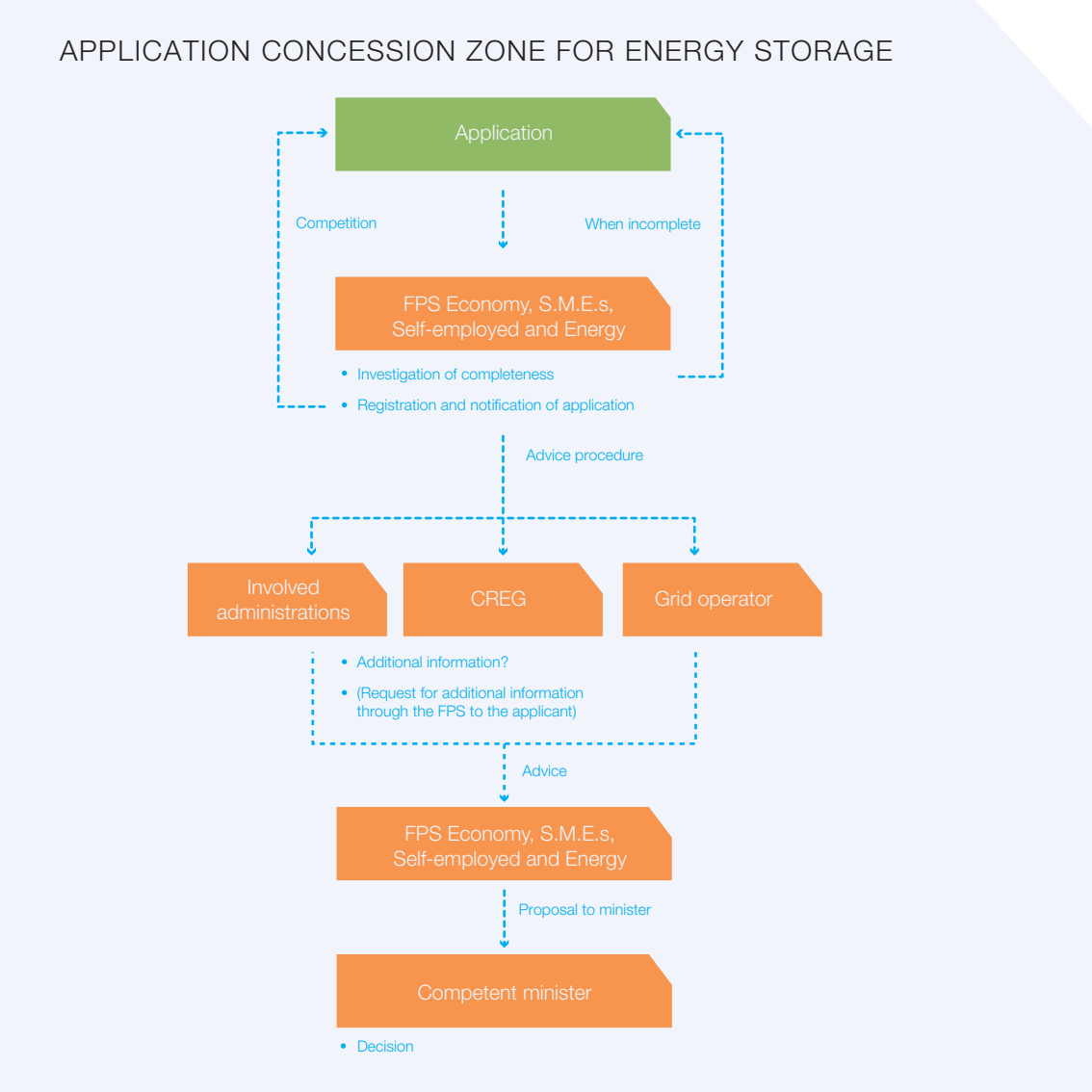

Figure 4. Flowchart for the application of a domain concession for energy storage (RD of 8 May 2014).

Another option to compensate fluctuations in energy generation is to convert the generated energy into hydrogen, the so-called 'Power-to-Gas' principle. The feasibility and valorisation of this technique is being investigated by an Innovative Business Network (IBN) '*Platform Power to Gas*' within the 'Power-to-Gas' project (2014-2020). The first tests in which hydrogen gas generated by offshore wind is produced and then transported through existing gas pipes are currently being prepared in cooperation with the Netherlands (*Power-to-Gas Roadmap for Flanders 2016*).

6.6 Pipes and cables

In the OSPAR area, the 1,300 oil and gas platforms are connected by a pipeline network of more than 50,000 km (*OSPAR QSR 2010*). In the Belgian part of the North Sea (BNS) there are three gas pipes with a total length of 163 km (*Verfaillie et al. 2005*, *GAUFRE project BELSPO*, *MUMM*):

- The Sea Pipe Pipeline (40" diameter) connects the Gassco AS terminal in the port of Zeebrugge with a pipeline on the Norwegian shelf and has a total length of 814 km. Seapipe has been operational since 1993 and has a capacity of approximately 15 billion m³ on an annual basis;
- The Interconnector pipeline is 215 km long (with a diameter of 40") and is located between the port of Zeebrugge en Bacton (south coast of the UK). The import capacity to Belgium amounts to 20 billion m³ on an annual basis. Interconnector has been operational since 1998. The Interconnector is configured to control gas flow in two directions. The export capacity to the United Kingdom is approximately 25.5 billion m³ on an annual basis;

- The Franpipe pipeline (formerly known as Norfra) is a 840 km long pipeline (with a diameter of 42") between the Norwegian Draupner E-platform and the French port of Dunkirk, which 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 19.6 billion m^3.

In addition, the North Sea and the North-East Atlantic are intersected by telecommunication and power cables. Telecommunication cables are mainly located in the southern part of the North Sea, the Celtic Seas and the transatlantic corridor. Power cables can be found in the North Sea and the Celtic Seas (*OSPAR QSR 2010*). On the Belgian Continental Shelf (BCS) there are a total of 27 telecommunications cables, 16 of which are actively used, representing a length of 914 km (*Verfaillie et al. 2005*, *GAUFRE project BELSPO*). In the future, the share of power cables will increase considerably as a result of the installation of wind turbines off the Belgian coast (see **6.1 Offshore wind energy**). Cable permits were issued in mid-2018 for nine complete cable routes (1 cable for Mermaid, Northwester 2, Seastar, Rentel and Norther; 2 cables for Belwind-Cabelco and C-Power; and 3 cables (partial routes) for Elia) (*MUMM*). Five cables are currently in use (Belwind-Cabelco, C-Power en Rentel). The other wind farms (including Rentel and excluding Norther) will be connected to Elia's Modular Offshore Grid (see also **Modular Offshore Grid**) (*Elia*, *Federaal Ontwikkelingsplan van het transmissienet 2015-2025*, *Degraer et al. 2018*). Finally, within the framework of the *NEMO project*, an submarine and underground power cable is being laid between Belgium and the United Kingdom (*Milieueffectenrapport - NEMO LINK 2012*, *Brochure NEMO-STEVIN 2013*) (see also **NEMO Link**). The possibility of a second HVDC interconnector cable between the UK and Belgium is currently being investigated within the so called Nautilus project (*Elia*, *Volckaert and Durinck 2018*).

6.6.1 Policy context

The procedure for the installation of cables on the BCP is stipulated in the RD of 12 March 2002 (see also MB of 8 May 2008) (figure 5). Applications are addressed to the federal minister for Energy or his delegate. This application for a permit is submitted to the minister. The dossier is accompanied by the evaluation of the impact on the environment and the advice of all administrations involved. The granting of the permit is motivated by a ministerial decision that specifically takes into account the conclusions of the environmental impact assessment (EIA). The impact on the environment is assessed on the basis of an environmental impact report (EIR) by the Management Unit of the North Sea Mathematical Model (*RBINS-MUMM*).

The procedure for laying pipelines is stipulated in the law of 12 April 1965 on the transport of gaseous products and others by pipelines. This basic law has been supplemented by various royal decrees.

The agreement between Norway and Belgium relating to the Franpipe pipeline was formalised in the law of 13 May 2003 and in the law of 19 September 1991 concerning the Seapipe pipeline. The agreement with regard to the transport of gas in the Interconnector pipeline between Great Britain, Northern Ireland and Belgium was formalised in the law of 26 June 2000. For an overview of the regulations concerning the cables and pipelines in the BNS, see the *Codex Coastal Zone, theme Cables and pipelines* and *Bijlagen bij het KB tot vaststelling van het marien ruimtelijk plan*.

6.6.2 Spatial use

In the marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014* and *Bijlagen bij het KB tot vaststelling van het marien ruimtelijk plan*) an area ('corridor') is defined in which cables and pipelines must be bundled as much as possible. Activities that threaten the installation or exploitation of these cables and pipelines are prohibited in this area. The preliminary draft of the MSP 2020-2026 maintains this zone with its limitations (*MSP 2020-2026, public consultation 2018*). The use of space around power cables in the BNS is further elaborated in the RD of 12 March 2002 (table 7).

The connection points for the power cables of the offshore wind farms are located in Ostend (Slijkens) (C-Power) and Zeebrugge (Belwind, Norther, Nobelwind and Northwind). For the remaining wind farms (Rentel, Seastar, Mermaid and Northwester 2), the onshore connection will be provided via the Modular Offshore Grid, also in Zeebrugge. The onshore connection of power generated by the offshore wind farms is largely dependent on the reinforcement of the power grid in the coastal zone as part of the Stevin project, which involves the construction of a high-voltage connection between Zomergem en Zeebrugge (*Tant 2014*, *website Elia*).

By analogy with the spatial regulations for power cables, special provisions apply to the use of space around pipelines (RD of 19 March 2017, table 8).

Table 7. An overview of the use of space in the proximity of power cables in the BNS (RD of 12 March 2002).

Spatial use in the proximity of power cables (RD of 12 March 2002)	
Protected zone (250 m on both sides)	**Reserved area (50 m on both sides)**
Anchoring prohibited	No installation, no construction of cable or pipeline
No activity with 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

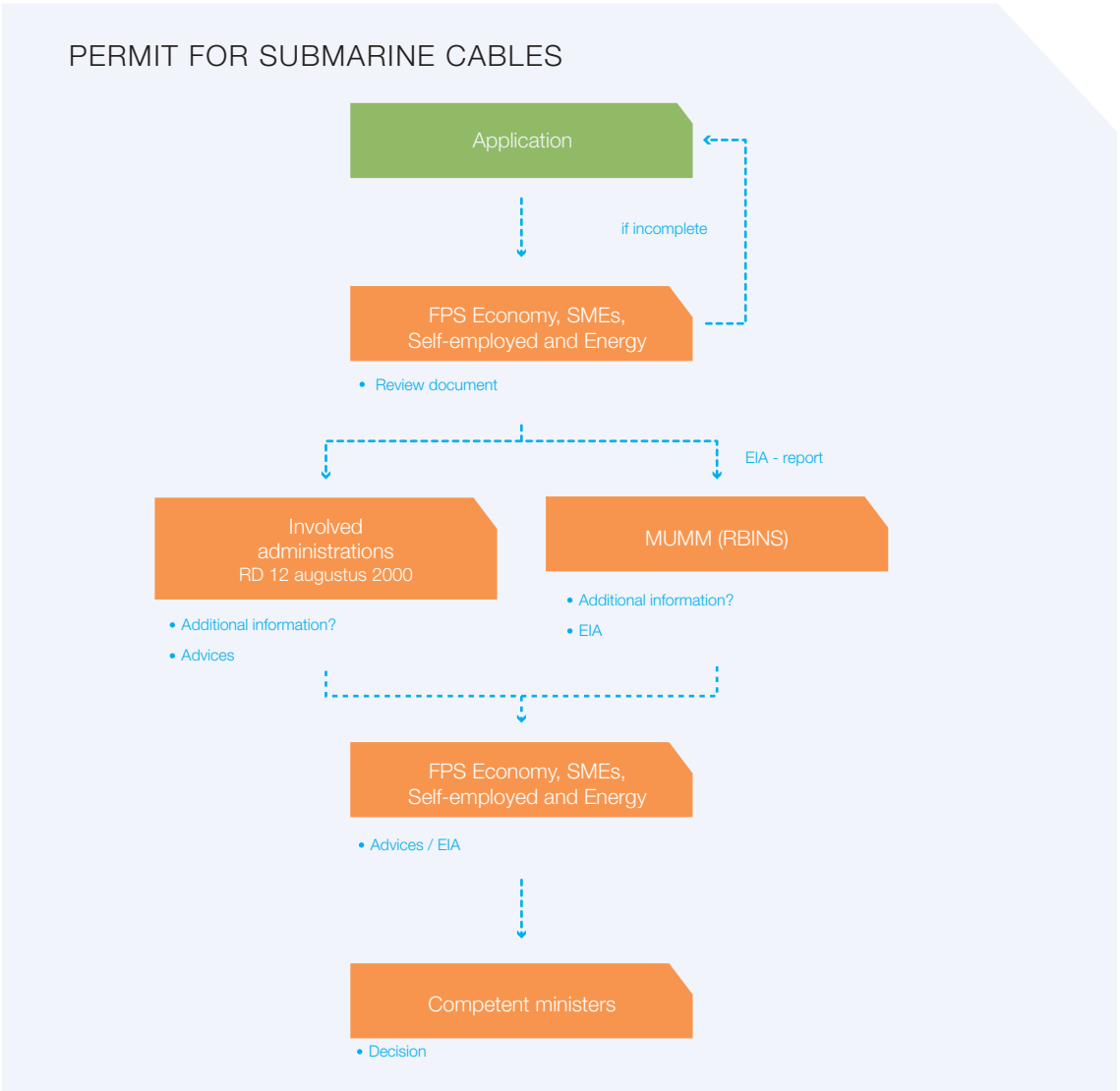

Figure 5. Flowchart for the application for a permit for sea cables (RD of 12 March 2002).

Table 8. An overview of the use of space around offshore pipelines in the BNS (RD of 19 March 2017).

Spatial use in the proximity of offshore pipelines (RD 19 March 2017)	
General provision	**Commentary**
Protected zone (1,000 m on both sides)	Each zone is 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 (pipelines, 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 pipelines must be requested and approved in writing by the operator of the crossed pipelines.	

6.6.3 Societal interest

Modular Offshore Grid

Due to the increasing importance of energy production at sea (see also **6.1.3 Offshore wind energy – Societal interest**), there is a growing demand for submarine power cables for the transmission of energy 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 '*Modular Offshore Grid*' (MOG), work is being done to ensure that the landing of offshore energy takes place in a more coordinated manner, as this provides technical, economic and ecological benefits. The MOG consists of a meshed offshore power network, or '*plug at sea*', whereby primarily wind farms (Rentel, Seastar, Northwester 2 and Mermaid), but in the future also other alternative energy sources (wind, waves) will be connected to high-voltage substations, which will subsequently connect to the onshore transmission grid (*offshoreWIND, Federaal Ontwikkelingsplan van het transmissienet 2015-2025*). These actions will enable the further development of offshore energy.

The MOG – phase I will consist of one so-called Offshore Switch Yard (OSY) at the Rentel concession zone (figure 6) and of installations placed on the Rentel Offshore High Voltage Station, in the Rentel domain concession. The construction started in 2018 and will be modular, adjusted to the realisation of the wind farms to be built in the eastern part of the BNS. This modular approach also allows a possible future international power interconnection. For this reason, Elia is involved in studies as part of the '*North Seas Countries Offshore Grid Initiative*'. The platform will become operational in 2020 (*visie Elia Offshore Grid 2012*, *MER - Belgian Offshore Grid 2013*, *Aanvraagdossier Belgian Offshore Grid 2013*, *Beleidsverklaring 2017 Noordzee*, *Elia*, *Durinck 2017*, *Degraer et al. 2018*). The cables of the MOG will be landed via a connection with the Stevin station in Zeebrugge. The Stevin project reinforces the onshore transmission grid and concerns a 380 kV high-voltage connection between Zeebrugge and Zomergem (*Tant 2014*, *website Elia*). The Stevin station was put into operation at the end of 2017 and its final completion, including sub projects, is planned for 2020. Work is also currently underway on additional power cables between the United Kingdom and Belgium in the context of the so-called *NEMO Link project* (see below **Nemo Link**), which after completion will (partly) be integrated into the Stevin project.

NEMO LINK

A secure and reliable power supply is essential for everyone's activities and for economic growth. A sufficiently large and reliable energy production that can meet the power demand for electricity at all times is crucial in this. An important role lies in the development of international connections between diversified, renewable or non-renewable, energy sources (*Federaal Ontwikkelingsplan van het transmissienet 2015-2025*).

The *Nemo Link project* has an important role in this. The Nemo Link project is a partly submarine and partly underground electrical HVDC connection (bi-directional cable connection of approximately 1,000 MW) between Zeebrugge and Richborough (United Kingdom) (*Milieueffectenrapport - NEMO LINK 2012*, *Brochure NEMO-STEVIN 2013*, *Federaal Ontwikkelingsplan van het transmissienet 2015-2025*).

This project aims to improve the connection between the high-voltage grid in the United Kingdom and the European mainland. Economic studies have shown the relevance of such a link and the project was selected by the European Commission as a 'Project of Common Interest' in the framework of the Trans-European Energy Infrastructure (TEN-E,

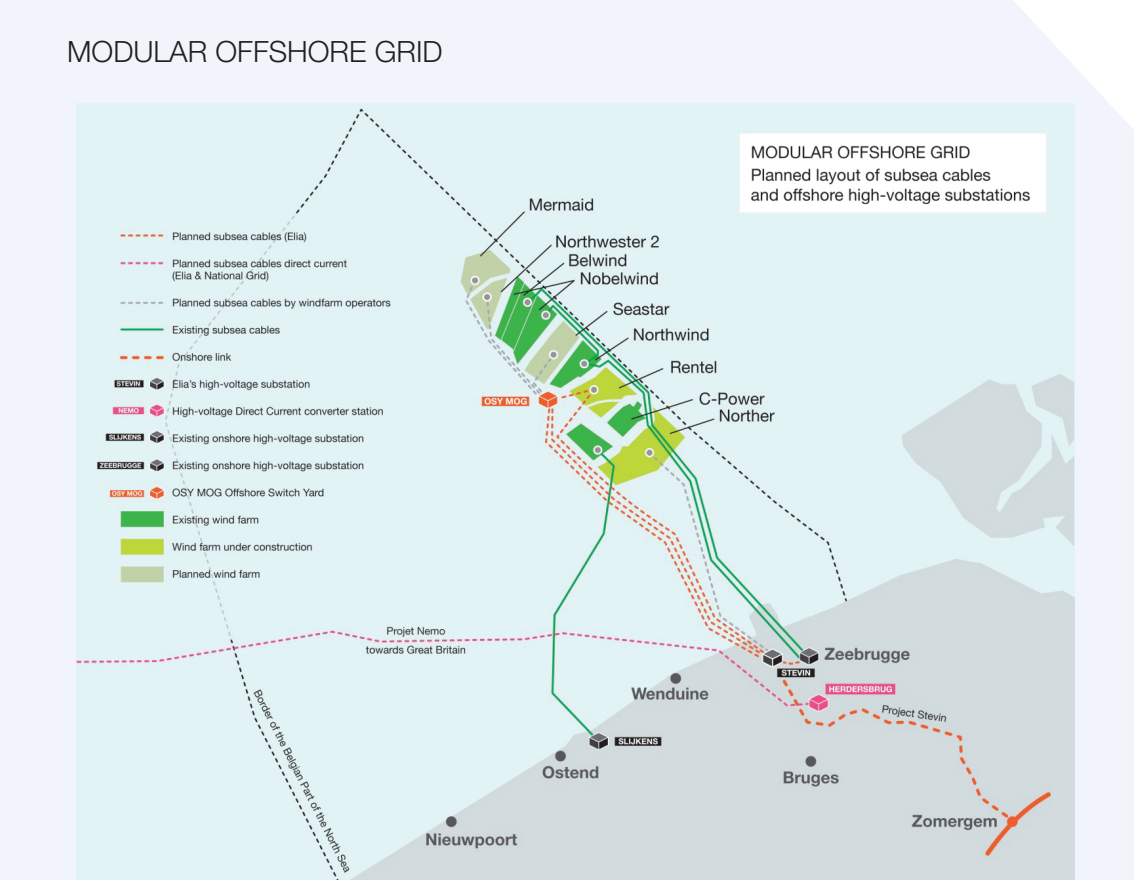

Figure 6. Spatial location of the MOG – phase I and the localisation of planned submarine cables in the BNS (Source: *Elia*).

Regulation (EU) No 347/2013). For grid integration on the Belgian side, a connection to the Stevin project is being created (*Brochure NEMO-STEVIN 2013*, *Tant 2014*, *website Elia*). The construction of the Belgian section of the Nemo link will take place in 2018, with commissioning foreseen for early 2019. The possibility of a second HVDC interconnector cable between the UK and Belgium is currently being investigated within the so called Nautilus project (*Elia*, *Volckaert and Durinck 2018*).

NORTH SEA OFFSHORE GRID

Submarine cables are also important for transnational energy and communications networks (*OSPAR QSR 2010*). In the context of the creation of an integrated European energy network (COM (2010) 677), Europe is promoting the development of a North Sea Offshore Grid between the ten neighbouring North Sea countries (*Mathys et al. 2009* (*OPTIEP-BCP project BELSPO*), *Offshore Electricity Grid Infrastructure in Europe 2011*). The intention is to integrate the Belgian offshore power grid into a European power grid with DC connections. Such connections allow to transport greater power over longer distances and ensure the supply of energy. This vision is in line with the European Commission's energy policy (see also studies *Intelligent Energy Europe*). A first initiative in this direction was the establishment of the *North Sea Countries Offshore Grid Initiative* (*NSCOGI*) wherein 10 North Sea countries concluded a Memorandum of Understanding (MoU) to evaluate the possibility of developing a coordinated offshore grid in the North Sea and associated onshore connections with a view to economic profitability and achieving the renewable energy objectives in 2020 (*Offshore Electricity Grid Infrastructure in Europe 2011*). The progress of the initiative was monitored in progress reports on the following website: *www.benelux.int/NSCOGI*. The initiative for increased regional cooperation on affordable European offshore energy is currently gaining momentum under the *North Seas Energy Cooperation*. The intention for a closer cooperation has already been consolidated in a *political declaration (2016)* and in the meantime *implementation objectives (2016)* have also been formulated. An overview of the policy framework, the technical and the economic aspects is given in the *Offshore Electricity Grid Infrastructure in Europe (2011)*.

PIPES

The transport of gaseous products to our country takes place by means of submarine pipes (*Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *Brouwers et al. 2011*):

- Zeepipe has been operational since 1993 and is operated by Gassco. The pipeline transports about 13 billion m³ of gas per year with a daily capacity of 42 million m³;
- The Franpipe pipeline (former Norfra pipeline) is operated by Gassco and has been operational since 1998, transporting 55 million m³ of gas per day between Dunkirk and the Norwegian shelf. The pipeline has a capacity of 19.6 billion m³ per year;
- The Interconnector Pipeline operated by IUK has been transporting gas between the south coast of the UK and Zeebrugge since October 1998. This pipeline is bidirectional and can therefore be used for the import/export of gas from/to the UK. In winter, imports from the United Kingdom take place with a capacity of 20 billion m³ per year (personal communications, *FPS Economy, S.M.Es, Self-employed and Energy, General Directorate Energy*) and in summer exports to England take place with a capacity of approximately 25.5 billion m³ per year.

6.6.4 Impact

The installation and exploitation of cables and pipelines has a (local) impact on the marine environment. This impact is taken into account in the EIAs that must be included to the permit applications for the cables and pipelines concerned. A number of studies and environmental impact assessments which specifically focus on the effects of cables on the environment are included in table 9.

Table 9. An overview of the environmental effects of the installation and exploitation of cables and pipelines in the BNS.

Impact	Literature
Toxic pollution from zinc-coated pipeline	*Maes et al. 2004 (MARE-DASM project BELSPO)*
Introduction of hard substrate on the seabed (pipeline) => 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 by soil particles)	*Milieueffectenrapport - 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*, *Milieueffectenrapport - NEMO LINK 2012*, *MER - Belgian Offshore Grid 2013*, *Rumes et al. 2013 – MEB NEMO*, *Rumes et al. 2014 – MEB Belgian Offshore Grid*, *Durinck 2017*
Electromagnetic field around cables	*OSPAR QSR 2010*, *Milieueffectenrapport - 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 / pipelines	*Milieueffectenrapport - 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)*, *Milieueffectenrapport - NEMO LINK 2012*, *MER - Belgian Offshore Grid 2013*, *Rumes et al. 2013 – MEB NEMO*, *Rumes et al. 2014 – MEB Belgian Offshore Grid*, *Durinck 2017*

6.6.5 Sustainable use

MEASURES IMPACTING ON THE MARINE ENVIRONMENT

At present, no common programs or measures exist at the international level to address the impact of pipes and cables on the marine environment (*OSPAR QSR 2010*). *OSPAR 2016* does list a collection of measures to mitigate the emission and impact of underwater noise caused by human activity, but for the time being cables and pipelines are not mentioned separately. At European level, however, the Marine Strategy Framework Directive (2008/56/EC) (MSFD) can be regarded as a framework to address the impact of submarine cables and pipelines. This directive comprises the following descriptors for a good environmental status (GES) of the marine environment: underwater noise and other forms of energy (*descriptor 11*), seabed integrity (*descriptor 6*) and non-indigenous species introduced by human activities (*descriptor 2*). Recently, by request of the European Commission, a baseline environmental assessment study was drafted (*BEAGINS 2017*) about the development of energy production, energy storage and power cable projects in the North Sea and Irish Sea. In addition to analysing potential risks and limitations, the study

also includes recommendations for mitigation. This to create a framework to ensure that environmental aspects are properly taken into account during the development of offshore energy systems.

At the Belgian level, the effects of power cables on the marine environment are considered in the environmental impact assessments (EIAs) and monitoring programmes of the Modular Offshore Grid and the Nemo Link connection (see table 9). Furthermore, the effects of the individual cables for wind farms are discussed in the monitoring programme of the offshore wind farms (*Degraer and Brabant 2009*, *Degraer et al. 2010*, *Degraer et al. 2011*, *Degraer et al. 2012*, *Degraer et al. 2013*) and their respective EIAs (*MUMM*). The assessment of potential environmental impacts from pipeline construction is reflected in the associated EIAs.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
Agreement on the Conservation of small cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)	1991	1994

European legislation

Title	Year	Number
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
Communication from the commission to the European Parliament, The Council, The European Economic and Social Committee, The Committee of the Regions and the European Investment Bank – Clean Energy For All Europeans	2016	860
Communication from the Commission - An Integrated Maritime Policy for the European Union	2007	575
Communication from the Commission - A European strategic energy technology plan (SET-plan) - 'Towards a low carbon future' {SEC(2007) 1508} {SEC(2007) 1509} {SEC(2007) 1510} {SEC(2007) 1511}	2007	723
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
Communication from the Commission - Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond	2008	768
Communication from the Commission: Energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network	2010	677
Communication from the Commission - Blue Growth opportunities for marine and maritime sustainable growth	2012	494
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
Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive (MSFD))	2008	56
Directive on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC	2009	28
Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (Recast)	2016	767
Regulation (EU) 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 Text with EEA relevance	2013	347

Belgian and Flemish legislation

Abbreviation	Title	File number
Decree of 8 May 2009	Decreet houdende algemene bepalingen betreffende het energiebeleid (het energiedecreet)	2009-05-08/27
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 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 17 May 2004	Koninklijk besluit tot wijziging van het koninklijk besluit van 20 december 2000 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	2004-05-17/44
RD of 28 September 2008	Koninklijk besluit tot wijziging van het koninklijk besluit van 20 december 2000 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	2008-09-28/42
RD of 3 February 2011	Koninklijk besluit tot wijziging van het koninklijk besluit van 20 december 2000 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	2011-02-03/12
RD of 11 April 2012	Koninklijk besluit tot instelling van een veiligheidszone rond de kunstmatige eilanden, installaties en inrichtingen voor de opwekking van energie uit het water, de stromen en de winden in de zeegebieden onder Belgische rechtsbevoegdheid	2012-04-11/15
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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
MD of 8 May 2008	Ministerieel besluit houdende aanstelling van ambtenaren bedoeld in artikel 25 van het koninklijk besluit van 12 maart 2002 betreffende de nadere regels voor het leggen van elektriciteitskabels 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	
MD of 16 March 2009	Ministerieel besluit houdende aanwijzing van de ambtenaren die ermee belast zijn de Minister te vertegenwoordigen en toe te zien op de toepassing van het koninklijk besluit van 20 december 2000 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	
Law of 12 April 1965	Wet betreffende het vervoer van gasachtige producten en andere door middel van leidingen	1965-04-12/30
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	1991-09-19/
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 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 31 January 2003	Wet houdende de geleidelijke uitstap uit kernenergie voor industriële elektriciteitsproductie	2003-01-31/38
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

7

Fisheries

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Polet, H., Torreele, E., Pirlet, H., Verleye, T. (2018). Fisheries. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 115-129.

In 2016 the worldwide production of fishery products, including aquaculture, amounted to 202.2 million tonnes (marine mammals not included). Sea fishery products account for 68.9% (139.4 million tonnes), of which 57.7% (80.4 million tonnes) is wild catch. In contrary to Asia (44.4% wild catch, 42.9 million tonnes), the marine wild catch in Europe still amounts to 84.7% (13.5 million tonnes) of the landing of sea fishery products. Freshwater fishery products, yet considerably limited in landing (62.8 million tonnes), have a stronger representation of aquaculture products on a global scale (81.6%; 51.2 million tonnes) (*FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

The total landing of sea fishery products (including aquaculture) from the European Union (EU) totalled 4.4% (6.1 million tonnes) of the global sea fishery production in 2016. Spain, the United Kingdom and Denmark provide almost half (44.7%) of the EU landings. The marine wild catch in the EU accounted for 6.4% (5.1 million tonnes) of the global marine wild catch. The Belgian landings in the same year represented 0.5% (24,583 tonnes) of the EU-total (*Devogel and Velghe 2017*). The number of Belgian fishing vessels (71 vessels) accounts for less than 0.1% of the total European fleet with a tonnage and engine capacity of 0.9% and 0.7% of the European total, respectively (*Devogel and Velghe 2018*, *http://ec.europa.eu/fisheries/fleet/index.cfm*).

The global or European catch by marine recreational fisheries is unknown. The number of individual boat anglers in the EU is estimated at about 9 million. Together, they spend 77.6 million days at sea and the total economic activity related to this sector is estimated to be 10.5 billion euro annually, of which 5.1 billion euro direct expenditures (*Hyder et al. 2017a*, *Hyder et al. 2017b*). Belgium is a small player in the European marine recreational fisheries context. Belgian recreational fishing vessels spend around 9,500 days at sea on a yearly basis. The landing of fishery products by the marine recreational fishing community is estimated at over 200 tonnes and the direct expenses (purchase of materials, boat maintenance, etc.) are estimated at 5.3 million euro annually (*Verleye and van Winsen 2018*).

7.1 Policy context

The management of the European fleet and the conservation of fish stocks are mainly regulated by the Common Fisheries Policy (*CFP*, Regulation (EU) No 1380/2013) as imposed in articles 38 to 44 of the Treaty on the Functioning of the European Union (*TFEU*). The EU fisheries policy is implemented by the Directorate-General Maritime Affairs and Fisheries (*DG MARE*) of the European Commission (EC) and by EU Member States (more information: *overview of European legislation concerning the CFP*). The CFP has been developed within a sustainable development context, as stated by the EU Strategy for Sustainable Development (COM (2001) 264) and *sustainable development goal 14 (SDG 14)* of the United nations. Within this context, an ecosystem approach and a sustainable exploitation of living biological resources at sea will be pursued. The European fisheries policy is based on advice from the Advisory Councils (see articles 43 to 45 and appendix III of the CFP), as well as from a number of national and international organisations and instances such as the Scientific, Technical and Economic Committee for Fisheries (STECF) of the EC and the International Council for the Exploration of the Sea (ICES) (*Adriansens 2009*, *manual for the CFP 2009*). The European fisheries management relies on scientific data, collected by the Member States based on the context of data collection (Regulation (EU) No 2017/1004 and Implementing Decision (EU) No 2016/1251) (see **7.5 Sustainable use**).

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 the crew and examination conditions for which the federal Government is still the competent authority (FPS Mobility). The Flemish Ministry of Agriculture and Fisheries is responsible for the commercial fisheries policy (*Schauvliege 2014*). The *Department of Agriculture and Fisheries* is responsible for the preparation of a policy on European and Flemish level. Within this department, the *Division Knowledge, Quality and Fishery* (AKKV) is responsible for the implementation of the European policy, the formulation of policy proposals, the development of regulations and the implementation of the fisheries policy. The *Fisheries Service* is part of the latter division and is responsible for the coordination, implementation and enforcement of the fisheries policy. This also includes the legal tasks of collecting economic data, such as landing statistics.

The implementation of the European policy for investments and actions in favour of fisheries is regulated, *inter alia*, by the European Maritime and Fisheries Fund (EMFF, Regulation (EU) No 508/2014). The Belgian *Operational Programme (EMFF) 2014-2020 "Vooruitziend en voortvarend"* (see **7.5.4 Sustainable fisheries**) creates a framework and a manual for the funds of the EMFF. 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 implementation of the fisheries policy also includes the control of fishing activities and data collection, including the reporting of the data in *annual reports*.

The policy is also supported scientifically by the Flemish Research Institute for Agriculture, Fisheries and Food (*ILVO*). The Strategic Advisory Council for Agriculture and Fisheries (*SALV*) advises the Government of Flanders and the

Flemish Parliament about agriculture and fisheries in a broad sense. The advises, as determined by stakeholders represented in the SALV, are part of a supported political decision-making process. The fisheries related advice is prepared by the Technical Commission Fisheries (TWV) of the SALV. In the past, the *Milieu- en Natuurraad van Vlaanderen* (*Minaraad*) provided advice in a number of fisheries related cases as well. 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 Belgian fisheries policy is discussed in more detail in *Vanderperren and Polet (2009)* (CLIMAR project *phase 1* and *phase 2* BELSPO), the Belgian Operational Programme (EMFF) 2014-2020 and *VIRA 2018*. An extensive overview of the legislation concerning fisheries is given in the *Codex Coastal Zone, theme Fisheries*.

The marine recreational fisheries are subject to both European, federal, Flemish and communal legislations. An overview of the relevant legislation is discussed on the website *www.recreatievezeevisserij.be*.

7.2 Spatial use

The CFP is valid in the Belgian fisheries zone (law of 10 October 1978), the borders of which correspond to the Belgian exclusive economic zone (EEZ, law of 22 April 1999). In this zone, the practicing of fishing activities is subject to Belgian jurisdiction (although fisheries are a Flemish competence, see above), taking into account the rights of foreign vessels in the context of the CFP and the relevant international regulations (article 5 and appendix I).

In the territorial waters (the zone from the baseline to 12 nautical miles (nm) offshore), fisheries are regulated by the national legislation (law of 19 August 1891). This legislation defines that only fishing boats of <221 kW are allowed to fish in the territorial sea if they use a beam trawl, while in the 0-3 nm zone, only ships of <70 GT are allowed to fish (see also **7.3.2 Belgian fishing fleet**). An extension of this zone towards 4.5 nm is included in the RD of 20 March 2014, but needs approval on European level. However, due to the veto of each impacted Member State in the formal negotiation procedure for Belgian fisheries measures (cf. CFP) this measure was not included in the final proposal of fisheries measures.

In the territorial sea, fisheries are exclusively reserved for Belgian fishermen, although French and Dutch fishermen are allowed under certain conditions as a result of multilateral conventions (*Douvere and Maes 2005*, *GAUFRE project BELSPO*) and the European legislation. The CFP (appendix I) gives the Netherlands unrestricted access to the Belgian 3-12 nm zone. The treaty revising the treaty establishing the Benelux Economic Union (2008), concluded on 3 February 1958, also gives the Netherlands the right to fish without restrictions in the 0-3 nm zone. The Belgian-French convention on *ijle haring* (herring caught between December and April) and European sprat fisheries in the French and Belgian territorial waters (1975) allows French fishing boats to catch sprat and herring in the Belgian territorial sea under certain conditions (see appendix I of the CFP).

Fishing is forbidden at the *Paardenmarkt* site, a munition dump site (*Maes et al. 2000*, RD of 20 March 2014) (see theme **Military use**). The MD of 4 October 2016 prohibits certain fishing activities around ship wrecks to protect the marine cultural heritage. Furthermore, the RD of 11 April 2012 prohibits shipping (and therefore also fisheries) in a safety zone of 500 m around wind farms (see also theme **Energy (including cables and pipes)**). The compatibility of offshore wind farms and passive gear fisheries and mariculture has been investigated extensively in the context of the MARIPAS project (*Verhaeghe et al. 2011*), the *Aquavalue project* and in the research project *EDULIS* (see theme **Marine aquaculture**).

In the marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*) measures have been proposed in four zones in the habitats directive area '*Vlaamse Banken*' (Flemish Banks) to stimulate alternative sustainable fisheries on the one hand, and to protect the environment on the other hand (see theme **Nature and environment**) (figure 1). As directed in the CFP these measures were formally aligned with the impacted Member States and had to be converted into an EU Delegated Act (*C(2018) 1194 final*). However, on 14 June 2018 this document was revoked by a resolution of the European Parliament (*2018/2614(DEA)*) because the measures were considered as insufficient. 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.

In the updated marine spatial plan (2020), which manages the use of space in the Belgian part of the North Sea (BNS) until 2026, new zones are reserved for renewable energy. Research is going on to investigate if and how aquaculture and passive gear fisheries can be allowed within the renewable energy zones without endangering safety. The pre-draft marine spatial plan 2020-2026 was approved by the Council of Ministers in April 2018 and in the summer months of 2018 a public consultation (*MSP 2020-2026, public consultation 2018*) followed.

A detailed overview of the fishing activities of the Belgian, Dutch and British vessels in the BNS, i.e. the spatial distribution of the fleet (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 limited importance for the Belgian fisheries fleet because only 9% of the total landings in 2017 originate from ICES region IVc, where the BNS is part of (*Devogel and Velghe 2018*). The Belgian coastal fishing vessels as well as the Dutch beam trawlers and pulse trawlers are quite active in the BNS.

Belgian fishermen are mainly active outside the BNS, such as in the Southern and Central North Sea, the Celtic Sea, the English Channel, the Irish Sea and the Bay of Gascogne. 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 (*VIRA 2018*). Furthermore, Belgian fishermen have access to limited quota in Norwegian waters. A detailed list of these areas is given in *VIRA 2018*.

A map with the historical fishing grounds (1929-1999) can be consulted on the website '*A century of sea fisheries in Belgium*' of Flanders Marine Institute (*VLIZ*). The historical spatial distributions of different West European marine fish species can be consulted through the Piscatorial Atlas (Olsen, 1883), which can be found on the portal *HisGISKust*.

The recreational sea anglers and trawling fisheries (beam trawl, otter trawl) are mainly active within the 3 nm zone. The recreational fishing activities from the beach (beach angling or angling from piers or breakwaters, passive nets, wading using a small shrimp net and horseback shrimp fisheries) is characterised by a strong spatial variability along the Flemish coast (*www.recreatievezeevisserij.be*).

7.3 Social interest

7.3.1 Employment

Employment in the fisheries sector has declined due to a crisis that has affected the fisheries sector (see **7.5 Sustainable use**). In 2017, the fisheries sector in Belgium consisted of 382 accredited sea fishermen (*VIRA 2018*). In 2014, Belgium had 271 fish processing companies (*Blondeel et al. 2016*, *Verlé et al. 2016*). In the 68 companies with fish processing as their main activity, approximately 1,490 people were employed (*Verlé et al. 2016*). One of the most important challenges within the sector is to promote the attractiveness of the sector and to find well trained young adults (*SALV 2015*, *SALV 2016*). Efforts are made to improve the inflow of young people into the sector, for example by means of the *Fund for young ship crew members*, in which Belgian ship owners annually deposit a mandatory contribution (for 2018: decision of the Government of Flanders of 15 December 2017). The number of young ship crew members decreased in the period between 1980 and 2017 from 222 to 55, despite the increases in the maximum age in 1988 and 2001. Furthermore, sea fishing is a dangerous profession with a relatively high amount of work related accidents (38 in 2017), even though there are many rules in place to improve working conditions on board and optimise safety (*VIRA 2018*). *Previs* is, among others, responsible to promote a preventive policy and awareness raising in the topics of safety and health on board of fishing vessels.

7.3.2 Belgian 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;
- A 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 ending 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.

The bottlenecks which inhibit the flow from the recreational fishery sector to the commercial segment are discussed in *van Winsen et al. (2016)* (LIVIS, *GIFS*). Based on these bottlenecks it is studied if the establishment of a new small scale professional fisheries segment is possible and meaningful.

In 2017, the Belgian sea fishing fleet consisted of 71 vessels with a total engine power of 45.051 kW and a gross tonnage of 13,712 GT (*Devogel and Velghe 2018*). The reported total engine power does not correspond to the

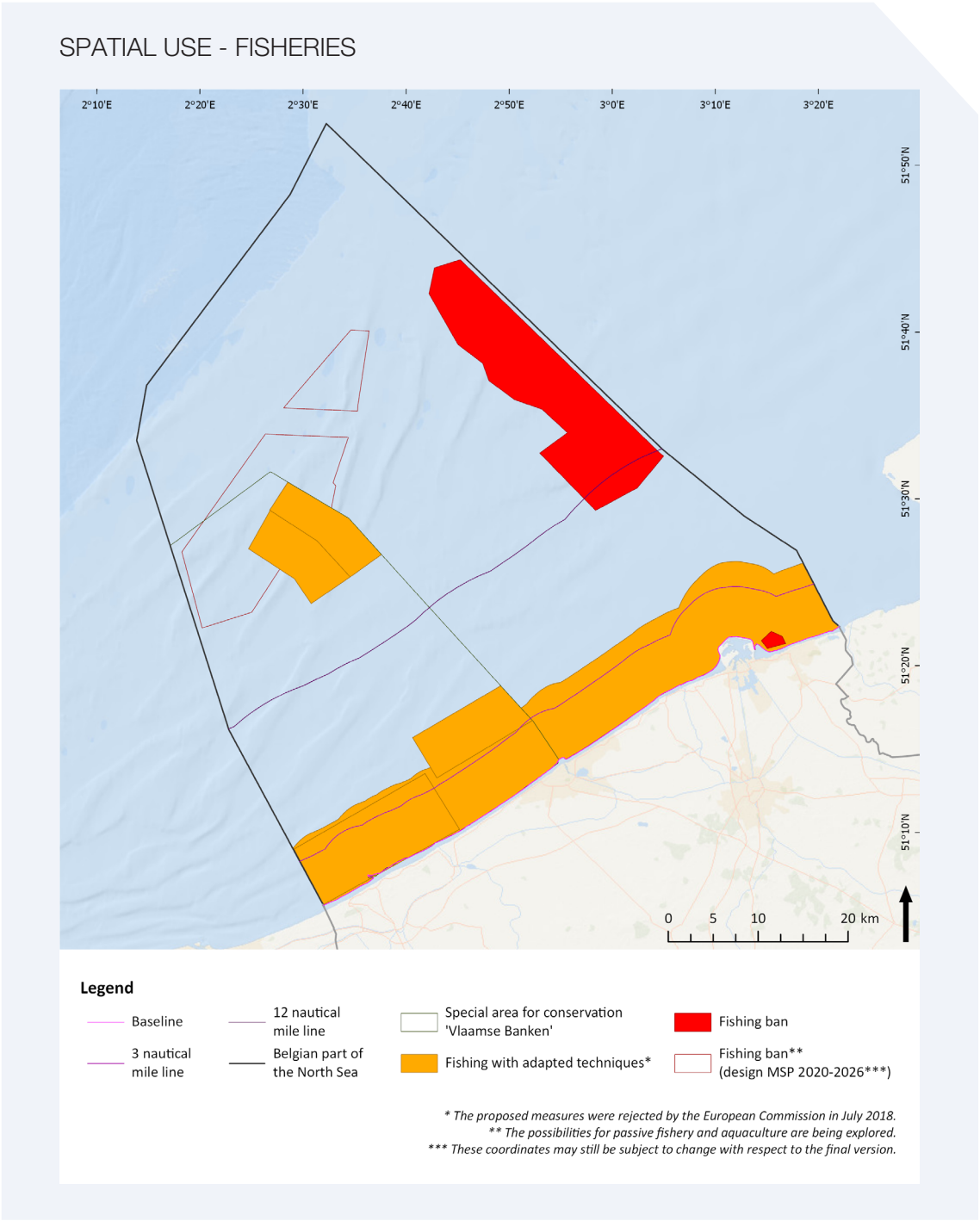

Figure 1. The delimitation of the fishery zones and locations forbidden for fishing activities in the BNS (Source: RBINS, *marineatlas.be* (based on the RD of 20 March 2014), *MSP 2020-2026, public consultation 2018*).

reported engine power in the 'Official list of Belgian fishing vessels' of the FPS Mobility because the latter does not take into account additional fictive engine power. Between 1950 (457 vessels) and 2000 (127 vessels), there was a strong decrease in the number of active fishing vessels. The total engine power capacity, however, did not reveal a comparable decrease and remained relatively stable (figure 2). This is mainly due to a trend towards larger vessels within the beam trawling section (*Rijnsdorp et al. 2008*) which was made possible by the aggregation of engine powers (*Operationeel Programma in uitvoering van het Nationaal Strategisch Plan voor de Belgische visserijsector 2007-2013*). 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 '*A century of sea fisheries in Belgium*' of Flanders Marine institute (VLIZ) and in a review article *Lescrauwaet et al. (2013)*. Recently, a reference

work on the core aspects of the broader fisheries sector during 500 years of Flemish sea fisheries was published (*Lescrauwaet et al. 2018*).

Another important challenge with regard to the development of the sector is the rejuvenation of the Belgian fishing fleet. In 2017, the average age of the hull of Belgian fishing vessels was 28 years. 77% of the vessels is 20 years or older, while 41% even exceeded 40 years of age (*VIRA 2018*). The average age of the engines is lower (15 years) since a number of vessels replaced their old engines by more efficient ones after the fuel crisis of 2008. However, the trend of engine renewal has come to a standstill. The demand for ship building (with financial support) to replace the existing vessels is increasing strongly since a couple of years (*VIRA 2018*), but the CFP does not provide financial support to build new vessels.

In the Flemish coastal marinas, 806 unique vessels were identified in 2016 which are visibly equipped to undertake recreational fishing activities at sea. The majority (88%) are angling vessels, 12% are trawling vessels (otter trawl (7%) and beam trawl (5%)). These are characterised by a strong variability in sailing frequency. The average engine power of the angling vessels is 118 kW (160 hp) while the average length is 7.36 meters (see *www.recreatievezeevisserij.be*).

7.3.3 Landings and value

The historical landings of the Belgian fishing vessels between 1929 and 1999 have been collected for each species and for each fishing area on the website '*A century of sea fisheries in Belgium*' of VLIZ. Landings peaked after the Second World War, when over 70,000 tonnes of fish were landed in the Belgian ports each year. The landings subsequently decreased gradually until 2009 (19,175 tonnes), while in 2017 the landings amounted 22,142 tonnes (*Devogel and Velghe 2018*). The long-lasting decrease of the landings until 2009 can largely be explained by a change in the species composition of the catch (*VIRA 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 **7.5 Sustainable use**). In 2017, 16,728 tonnes were landed in Belgian ports against 5,414 tonnes in foreign ports. The port of Zeebrugge covered 64.1% of the landings in Belgian ports, Ostend 34.1% and Nieuwpoort 1.8%. Plaice, sole, gurnards, cuttlefish and rays were the most important species in terms of landing volume (*Devogel and Velghe 2018*).

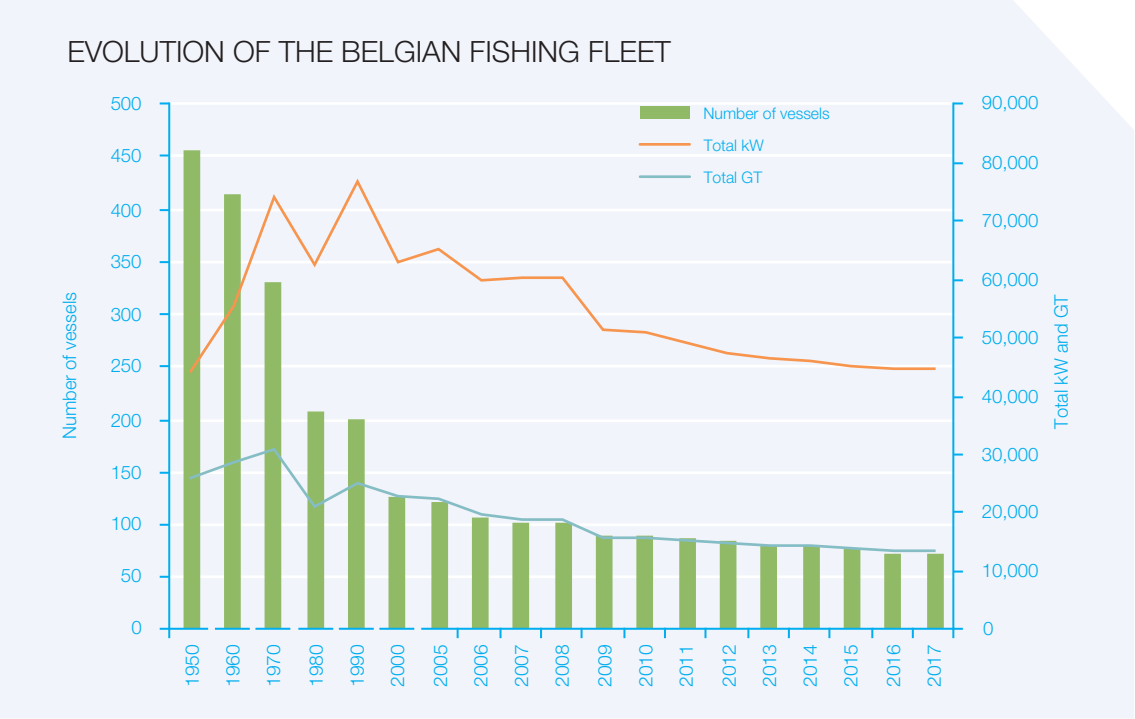

Figure 2. Evolution of the Belgian fishing fleet, number of vessels and capacity (GT and kW) on 31 December of the year, 1950-2017 (*Devogel and Velghe 2018*).

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 the Second World War 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 (website '*A century of sea fisheries in Belgium*', VLIZ). This was followed by a decrease to 68.367 million euro in 2009, followed by an increase to 88.183 million euro in 2017. Sole remains the most important fish species for Belgian fisheries with 27.8% of the value of landings in 2017 (*Devogel and Velghe 2018*). The value of landings of each species between 1929 and 1999 is available on the website '*A century of sea fisheries in Belgium*' (VLIZ). The recent value of landings for each species can be found on the *website* of the Department of Agriculture and Fisheries.

The first estimate of the total landing (i.e. retained fish) from the recreational sea fisheries sector for the period May 2017 until May 2018 amounted to over 200 tonnes. The angling vessels account for half of the catches with whiting, dab, cod, mackerel and sole as the main caught species. The trawling vessels account for the landing of 56.6 tonnes of which 56.3 tonnes of shrimp. The various fishing activities from the beach account for a total retained catch of 55 tonnes, with whiting and shrimp as the main species caught. Notwithstanding the prohibition on the commercialisation of the catch, the recreational fisheries sector has an economic importance in the sense of direct expenditures (5.3 million euro) and indirect value creation (e.g. tourism, job creation (no figures available)) (*Verleye and van Winsen 2018*).

7.3.4 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* auction. The average prices of fish caught by Belgian fishing vessels have increased almost constantly after the Second World War with a peak of 4.48 euro per kilo in 2006. In 2017, the average price of fish in Belgian ports amounted 4.02 euro per kilo (*Devogel and Velghe 2018*).

Figures from the *GfK Panel Services* Benelux for VLAM reveal that in 2017, Belgians bought on average 8.4 kg of fish, molluscs and crustaceans per capita, for a total amount of 106 euro. The degree of self-sufficiency for fish, molluscs and crustaceans in Belgium and Luxembourg from fisheries and aquaculture amounted to 14.6% in 2008 (*VLAM*). In 2017, the value of imported fish products amounted to 2 billion euro, of which 62% originated from EU Member States, with the Netherlands as the main EU-supplier (41%). The export value totalled 1.1 billion euro (97% within the EU) with France (33%), the Netherlands (27%) and Germany (15%) being the most important selling markets (*VIRA 2018*).

7.3.5 Fishing communities

The social dimension of the fisheries sector (training, employment, wellbeing, safety, etc.) is discussed in detail in *VIRA 2018*. In the context of the SALV analysis about the socio-economic aspects of the fisheries sector (*SALV 2016*), the problems surrounding the absence of local fishing communities were raised. The impact of the CFP on the social and economic aspects of fishing communities was investigated in a European study: '*Regional social and economic impacts of change in fisheries-dependent communities 2011*' including a case study in Ostend (*Delaney et al. 2010*). The *GIFS project* investigated the socio-economic and cultural importance of inshore fisheries for coastal communities. Within ILVO, the *VISEO group* aims to gather knowledge about techniques, ecosystem and society by means of specific and integrated social scientific research, meeting the needs of the fisheries sector as well as the policy. The research topics include business economics research, supply chain research, international market research and research on the impact of the policy on the competitiveness of the sector and the environment.

Complementary to the *FAO Code of Conduct for Responsible Fisheries (1995)*, the FAO published *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (2015)*. These guidelines aim to contribute to the visibility, recognition and strengthening of the already important role of the small-scale fisheries, to promote the international efforts concerning the fight against famine and poverty, but also to stimulate responsible fisheries and a sustainable socio-economic development. Furthermore, the possible role of small-scale fisheries in the context of 'Blue Growth', including the potential impact on coastal communities concerning economic growth, employment and innovation, is discussed in *Stobberup et al. (2017)*. FAO also published technical guidelines concerning a sustainable and socially responsible management of the recreational fisheries in *FAO Technical Guidelines for Responsible Fisheries – Recreational Fisheries (2012)*.

The size of the Belgian recreational fishing community is estimated at more than 2,000 individuals (*Verleye and van Winsen 2018*), of which 32% is a member of one of the many sea fisheries associations. The average age is

55 years, 98% of the sector are men and 70% is living in the province West Flanders (*www.recreatievezeevisserij.be*). In the context of recreational sea fishing 16 horseback shrimp fishermen (licensed as UNESCO heritage) and three associations of manual shrimp fishermen (in the intertidal zone with a shrimp net – in Dutch: *kruiers*) are active in Oostduinkerke. In the first place, they can be considered as a folklore tradition (see *www.paardevissers.be* and *provincie West-Vlaanderen 2008*, see theme **Maritime and coastal heritage**).

7.4 Impact

Fishing activities have an effect on the (marine) ecosystem, but the precise impact is still being discussed. Besides killing, displacing, influencing and extracting organisms from the sea, some fishing techniques also have a certain impact on the seabed integrity (*Depestele et al. 2014*, *Teal et al. 2014*, *Depestele et al. 2016*). This causes changes in the natural equilibrium after fishing. Furthermore, other factors such as the energy use by ships, which consists almost exclusively out of fossil fuels, and waste production impact the environment (i.e. *VIRA 2014*). An overview of the impact of fishing activities is given in *Polet and Depestele (2010)* and *Strategische Milieubeoordeling (SMB) van het Nationaal Operationeel Programma voor de Belgische visserijsector 2014 - 2020*. The latter Strategic Environmental Assessment (SEA) is required by the RD of 18 May 2008. A few of these effects will be further elaborated below.

7.4.1 Overfishing and illegal, unreported and unregulated fisheries

A structural lack of equilibrium between the capture capacity of a (mostly international) fishing fleet and the biological potential of the exploited fish stocks, will lead to the overfishing of these fish stocks. The *national fleet reports* in execution of article 22(2) of the CFP describe the equilibrium of the fishing capacity and the fishing opportunities and are delivered at the STECF. In the Belgian context ILVO will set up an action plan with measures to restore the equilibrium in case of a disequilibrium. Especially when overfishing causes a reduced reproductive capacity, this will often result in the collapse of the concerned fish stocks. Furthermore, fisheries may cause irreversible changes in the population structure and the food web (*Pauly et al. 1998*, *Polet et al. 2008*, *OSPAR QSR 2010*, *OSPAR IA 2017*). Quota overviews and additional quota measures are published on the *website* of the Fisheries Service. Belgian quota overruns are rather exceptional. The legal basis for eventual measures in case of not respecting the imposed quota is formed by Regulation (EU) No 1224/2009 and article 16 of the decision of the Government of Flanders of 16 December 2005.

The effect on the marine biological communities is exacerbated by illegal, unreported and unregulated (IUU) fisheries (*handbook on IUU Regulation 2010*, *website Sea Fisheries Service*, *website DG MARE*) and by discarding non-target or low-valued species (called bycatch). Some other illegal practices will also negatively impact the environment, such as high-grading, i.e. maximising the value of the catch by discarding smaller individuals of a certain species in favour of the larger ones (more information: *Vandendriessche et al. 2008*, *handleiding voor het GVB 2009*). In *Pauly and Zeller 2016* ('Global Atlas of Marine Fisheries') fishery data of 273 countries is reported based on independent reports and not based on the reports of Member States of the Food and Agriculture Organization (FAO). An estimation of the unreported catch and bycatch of the Belgian sea fisheries between 1929 and 2010 is given in *Lescrauwaet et al. (2013)*. In 2010, *ICES* introduced the principle of maximum sustainable yield (MSY) as a basis for their advice. A healthy MSY status means biomass levels of the concerned stocks have to be high enough and the fishing mortality has to be low enough to ensure a permanent maximum sustainable yield (*VIRA 2018*). A review of the North Sea fish stocks of sole, plaice and cod to the MSY context by *Nimmegeers et al. (2018)* suggests an increase in the reproductive biomass of the three fish stocks since 2007 and only cod is still fluctuating around the MSY limit (*ICES 2017a*, *ICES 2017b*, *ICES 2017c*). The fishing mortality is characterised by a decrease since the last 20 years, in which sole and cod are still just above the MSY reference level, and plaice is more or less at the MSY level.

7.4.2 Impact of fishing gear

The impact of fisheries on the ecosystem and the biological communities strongly depends on the fishing gear used and the time and place of fishing, although some other factors such as the mesh width of the nets and the expertise of the fishermen also play an important role. The *BENTHIS project (2012-2017)* has assembled all knowledge about seabed disturbance. It gives a thorough insight into the issue of seabed disturbance and proposes a method to quantify seabed disturbance based on the fishing gear characteristics and the habitat. One case study focused on the North Sea. The results indicated a more nuanced view on seabed disturbance and associated benthic mortality, mainly because the scientific insight improved with the availability of high resolution data on the spatial and temporal distribution of fishing effort (*Teal et al. 2014*, *Eigaard et al. 2016*). In table 1, an overview of the impact of the most abundant types of fishing gear in the Belgian fisheries is given. The current Belgian research to 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 being discussed in *Polet and Van Peteghem (2010)*.

Table 1. An overview of the impact of the most abundant types of fishing gear in the Belgian fisheries.

Fishing gear	Impact on the ecosystem	Literature
Beam trawls	Seabed disturbance and associated effect on benthos and habitat	*Lindeboom and de Groot 1998*, *Houziaux et al. 2008 (Project BELSPO)*, *Polet et al. 2008*, *Rabaut et al. 2008*, *Depestele et al. 2008*, *Polet et al. 2010*, *Polet and 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*
	Bycatch and discards	*Depestele et al. 2008*, *Vandendriessche et al. 2008*, *Polet et al. 2010*, *Polet and 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 and Verschueren 2015*, *Operationeel Programma EFMZV 2014-2020*, *Uhlmann et al. 2016*, *Verschueren and Lenoir 2016*, *van Marlen et al. 2016*
	Shifts in the food chain caused by discards	*Sotillo et al. 2012*, *Depestele et al. 2014 (BENTHIS)*, *Sotillo et al. 2014*, *Depestele 2015*, *Depestele et al. 2016*
	Use of fuels and resources	*Depestele et al. 2007*, *Polet et al. 2008*, *Polet et al. 2010*, *Polet and Van Peteghem 2010*, *Polet and Depestele 2010*, *Operationeel Programma EFMZV 2014-2020*
	Litter	*Bekaert et al. 2015 (SPEKVIS)*
Otter trawl	Seabed disturbance and associated effect on benthos and habitat	*Buhl-Mortensen et al. 2016*, *Gislason et al. 2017*
	Sediment resuspension	*Mengual et al. 2016*
Entangling nets (a type of gill net)	Bycatch of seabirds and marine mammals	*Haelters and Kerckhof 2004*, *Depestele et al. 2006*, *Depestele et al. 2008*, *Haelters and Camphuysen 2009*, *Depestele et al. 2012 (WAKO-II project BELSPO)*, *Depestele et al. 2014 (WAKO-II project BELSPO)*
	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)*
	Bycatch and discards	*Depestele et al. 2012 (WAKO-II project BELSPO)*, *Depestele et al. 2014 (WAKO-II project BELSPO)*

Sys et al. (2016) studied whether or not the variations in landings by Belgian fishing vessels in the Southern Bight of the North Sea are subject to competitive interaction with the Dutch beam trawl/electric pulse fishing. Further research is being done to investigate the possible negative ecosystem effects of electric 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*). An overview of the scientific findings can be found on the site *www.pulsefishing.eu*. This fishing technique is used frequently by Dutch vessels in the Belgian part of the North Sea. In Belgium this is only done in the context of research and the number of licenses is limited to two.

7.4.3 Impact on other users

The spatial impact of fishing activities on other users of the sea is discussed in the *GAUFRE project (BELSPO)*. In *Maes et al. (2004)* (*MARE-DASM project BELSPO*) a bottleneck analysis of commercial fisheries was conducted. The compatibility with other users in the BNS is also addressed in the marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*). On the other hand, other human activities on the BNS also impact fisheries (spatial use, changes in fish stocks, etc.), these effects are discussed in the respective theme chapters.

7.4.4 Recreational fisheries

With the exception of passive gear fisheries using fixed nets, recreational fisheries do not need a license in the Belgian marine waters. It was therefore not easy to quantify fishing effort and landings by recreational fishermen. For the first time, the large-scale *Belgian monitoring programme* (VLIZ, ILVO, FPS Environment), which focuses on cooperation with the recreational fishing community, generates extensive insights into recreational fish catches, fishing effort, the number of fishermen and the economic impact of the sector (*Verleye and van Winsen 2018*). A historical framework is provided in *Lescrauwaet et al. (2013)* where an estimate is made of, *inter alia*, the size of the recreational sea fisheries from 1929 to 2010.

7.5 Sustainable use

7.5.1 Common Fisheries Policy (CFP)

The CFP (Regulation (EU) No 1380/2013) includes a set of rules for managing the European fishing fleets and aims for a sustainable exploitation of marine resources as well as the creation of jobs and growth in coastal areas (see also *Facts and figures on the Common Fisheries Policy 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. An overview of all European legislation related to the CFP is given on this *website*.

The EC strives towards long-term management, and will draft multiannual plans that will contribute to a sustainable exploitation of the concerned fish stocks and the protection of the marine ecosystems. The multiannual management plan for demersal fish stocks in the North Sea (Regulation (EU) No 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. The plan is to make a multiannual management plan for the Northern and South-Western waters as well. A proposal for this, made by the EC, has been transferred to the European Parliament and Council.

A few elements included in the CFP are the gradual implementation of a landing obligation (ban on discards), the achievement of MSY for the fish stocks by 2020 and the focus on regional management by new advisory councils (*website DG MARE*). The ecological, economic, social and governance impacts which are foreseen by this policy were investigated in *Agnew et al (2010)*.

In order to achieve the goals of the CFP, the EU has introduced 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 are available on the *website of the Fisheries Service*. An overview of the quota and its utilisation can be found on the *website* of the *Redercentrale*. The quota can be swapped among the Member States. During the *World Summit on Sustainable Development Johannesburg (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*, *manual for the CFP 2009*). At this moment, the MSY is determined for the important commercial species for which data is available. For certain species such as rays, the MSY cannot be determined yet. *ICES* gives quantitative TAC advice to Europe based on all available information for all fish stocks without a management plan or MSY value. The current Belgian fleet mainly focuses on typical mixed fisheries, catching species from sustainable fish stocks as well as non-target species. 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 Advice for the North Sea (*WGMIXFISH*). On the other hand, attention is paid to the effects of excessive selective fishing and balanced harvesting of fish stocks in accordance with their natural occurrence is advocated (*Garcia et al. 2012*);
- 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 capacities for every EU Member State in kilowatts (kW) and gross tonnage (GT). For fleet segments with overcapacity, the Member States can take measures. The efficiency of the EU measures dealing with the overcapacity of the fishing fleet was critically reviewed in the following study: *Study of the European Court of Auditors (2011)*.

The European Maritime and Fisheries Fund (EMFF; Regulation (EU) No 508/2014) was established to support the implementation of the operational programmes of the EU Member States which include the measures mentioned above as well as further elaboration of the EU priorities as discussed in the EMFF regulation (see also **7.5.4 Sustainable fisheries**). The EMFF wants the fisheries and aquaculture sectors to become competitive, ecologically sustainable, economically viable and socially responsible (*VIRA 2014*). Over the period 2014-2020, 41.746 million euro will be reserved for Belgium, representing 0.73% of the total EMFF budget (5.749 billion euro) (see also *website*). To optimise the implementation of the EMFF an *ex post evaluation of the European fisheries fund (2007-2013)* (SWD (2017) 274) was executed with a focus on the degree of use of the financial measures and the effectivity and efficiency of the operational programme.

Since 1 January 2010, the control system for ensuring compliance with the CFP has been settled by Regulation (EC) No. 1224/2009, which refers to Regulation (EC) No. 1005/2008 (see also *Verleye et al. 2018*) in order to prevent and eliminate IUU-fisheries (see **7.4.1 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 (the so-called vessel monitoring system). Moreover, 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 (*VIRA 2012*, *website DG MARE*). The European Fisheries Control Agency (EFCA) was established in Vigo in 2006 to organise the collaboration and coordination between the Member States with regard to the control and inspection of fisheries.

7.5.2 Marine Strategy Framework Directive

Besides the CFP, the Marine Strategy Framework Directive (MSFD, *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 theme **Nature and environment**). Examples are the descriptors 1 (biodiversity; *Cochrane et al. 2010*), 3 (populations of commercially exploited species; *Piet et al. 2010*), 4 (elements of the marine food chain; *Rogers et al. 2010*), 6 (integrity of the seabed; *Rice et al. 2010*), 9 (polluting substances in marine organisms for human consumption; *Swartenbroux et al. 2010*) and 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 *Programme of measures for the Belgian marine waters (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, public consultation*) was published in which the specific environmental targets for fisheries were evaluated. Despite the fact that a positive evaluation was observed concerning descriptor 3, fisheries in Belgian waters still have a high negative impact on the benthic habitat quality (*IA2017 Condition of Benthic Habitat Communities: Subtidal Habitats of the Southern North Sea*) whereby the soft substrate was assessed as inadequate and the good environmental status (GES) was not achieved.

7.5.3 Data collection in Europe and Belgium

In-depth research and scientific information are essential to underpin the CFP. On an European level, the fisheries research is regulated by Implementing Decision (EU) 2016/1251 establishing a multiannual programme for the collection, management and use of data in the fisheries and aquaculture sector for the period 2017-2019. Since 2014, the financing of the data collection is covered by the EMFF. Advice to the CFP on the basis of scientific information is provided through different bodies (more information: *manual for the CFP 2009*):

- The International Council for the Exploration of the Sea (*ICES*) provides biological advice for EU fisheries management through international cooperation of fisheries biologists. The conclusions of the working groups within ICES dealing with stock assessment are taken into account in the deliberations of the ICES Advisory Committee (*ACOM*);
- STECF is the EC's regular fisheries advisory body. This body was set up in 1993 (Decision 93/619/EC), renewed in 2005 (Decision 2005/629/EC) and renewed in early 2016 under the new CFP (Decision EU 2016/C 74/05). The STECF consists of a group of independent scientists, established in order to advise the EC on all aspects of the fisheries policy.

In Belgium, the ILVO Fisheries Biology research group gives advice on the condition and management of Belgian and European fisheries. The group also conducts research on fisheries biology, stock assessment methods, the dynamics of marine ecosystems and the potential impact of fisheries management on fish stocks and fisheries in se. To achieve these general objectives, research activities mainly focus on data collection concerning the size of fish stocks and the exploitation patterns of commercially important species. This results in scientific advice supporting the development and implementation of the CFP.

Furthermore, socio-economic data from fisheries (including marine recreational fisheries), the fish processing industry and aquaculture are inventoried and studied by ILVO. This results in both scientific and (socio-)economic advice which supports the development and implementation of the CFP.

The few important challenges include: the evolution from a 'single-species' towards a 'multi-species' approach, a fisheries oriented perspective in the context of the ecosystem approach, encourage the cooperation of the fisheries sector and the scientists by means of fisheries-science partnerships (VWP), the Brexit, socio-economic impact of policy changes, the evolution towards an integrated chain policy and the landing obligation.

Implementing Decision (EU) 2016/1251 provides an obligation to collect biological data from recreational catches. For the North Sea, data (catch and discard) should be collected for the following species: cod, sea bass, pollack, *Elasmobranchii*, salmon and eel. The *monitoring programme* for marine recreational fishing (VLIZ, ILVO, FPS Environment), as included in the national programme of measures under the MSFD (FPS Environment), provides in the collection of catch data (all species) and an initial economic impact analysis (*Verleye and van Winsen 2018*).

7.5.4 Sustainable fisheries

The fisheries sector has gone through several years of crisis. The government has tried to respond to this crisis with specific measures. Hence, there is a movement towards a more sustainable Flemish fisheries sector, *inter alia* by means of investments in higher profitability, energy-saving techniques in a broad sense (engine, auxiliary engine, fishing gear, equipment, etc.), alternative, environmentally friendly or more selective fishing techniques, scrapping programmes to balance the catch capacity of the fleet and quota, emphasis on other target species, changes in landing volumes, improvement of the quality of fish products, improved working conditions and safety of the crew and the development of a sustainable aquaculture sector in Flanders (e.g. *VIRA 2012*). An overview of the current problems within the fisheries sector that may hinder the further existence of the sector under its current form on medium-term is discussed in *SALV (2016)*.

In order to deal with the profitability problems of the fishing fleet the Flemish authorities drew up an *overall action and restructuring plan (Fisheries Task Force 2006)*, aiming towards sustainable Flemish fisheries by means of structural measures. More specifically, the following restructuring operations were carried out:

- Adapted fleet policy: This plan is part of the European Regulation (EC) No. 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, see **7.3.2 Belgian fishing fleet**). 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 **7.3.2 Belgian fishing fleet**);
- Adjusted quota policy: The adjusted Flemish quota policy (in force since 1 February 2006) should 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.

Within the context of the EMFF, every Member State needs to develop an *Operational Programme (EMFF) 2014-2020* (see also *Department of Agriculture and Fisheries 2016*) and a Strategic Environmental Assessment (SEA) of the Operational Programme (*Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische Visserijsector 2014-2020*) (see RD of 18 May 2008). For the Belgian fisheries sector, a SWOT-analysis and an elaboration of the strategy have been carried out for five of the six priorities of the EMFF:

- Union priority 1: Promoting environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based fisheries;
- Union priority 2: Fostering environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture;
- Union priority 3: Fostering the implementation of the CFP;
- Union priority 5: Fostering marketing and processing;
- Union priority 6: Fostering the implementation of the integrated maritime policy.

Union priority 4 (Territorial cohesion) will not be implemented in Belgium as Belgium has no fishing communities or outlying fishing grounds.

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 *societal covenant for sustainable fisheries* (2011) that has been developed by the fisheries sector. This covenant has resulted in the report *Vistraject* (*De Snijder et al. 2015*), which identifies seven main goals concerning the transition of the sector towards sustainable Flemish fisheries. The three main principles are profitability, environmental care and the social aspect of fisheries. In June 2015, a societal covenant for the implementation of the goals of the *Vistraject*-project was signed. The covenant consists of a task force, a guidance committee and four working groups, i.e. WG Fisheries, WG Policy, WG Innovation and WG Coast.

ILVO conducts research on sustainable fishing techniques. In this context, the design of the beam trawl has been modified to increase selectivity and to reduce seabed disturbance and towing resistance in order to increase fuel efficiency (*Depestele et al. 2007*, *Stouten et al. 2007*). Experimental modifications of the fishing gear have been tested to decrease discards of undersized fish and non-commercial organisms. It is expected that research with regard to a better species and length selection will remain necessary due to the discard ban (e.g. *Depestele et al. 2011*). In addition, research is conducted on alternative fishing techniques such as handline fishing, gillnets, flyshooting and shrimp pulse trawls (Hovercran) (e.g. *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*).

Many research projects aim to make fishing more sustainable. One of the most striking projects with practical results is the *VALDUVIS project*. The *VALDUVIS* method uses indicators under the three pillars of sustainability to determine the sustainability score at the level of each individual fish box landed. The *MaViTrans project* concerns the 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 on 11 June 2018). The *Combituig project* aims to reduce the catch of bottleneck species and other bycatches in the beam trawl fishery and to improve their survival by means of innovative technical net developments. The *VALOREVIS project* (2014-2015) in turn aimed at identifying the waste streams in the fisheries sector that are on the one hand most interesting to valorise and on the other hand at facilitating and creating new industrial activities and cooperation in Flanders based on valorisation. The *SPEKVIS project* (2013-2014) aimed at identifying alternative materials for the polyethylene dolly ropes (loose ropes that protect the bottom trawling nets against wear and tear). The release of plastics into the sea and their fragmentation into so-called microplastics can lead to the uptake of these particles by marine organisms and therefore constitutes an important research topic with a focus on the quality of fish products (*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 2017*). Subsequently, in the autumn of 2018, the FPS Environment and VLIZ started a test project on the use of lead alternative fishing weights and sinkers in collaboration with the marine recreational fishing community.

The *Geovis* project gathers the available information (both scientific and from the fishermen) about Belgian fishing grounds into an online platform, accessible to the sector and the policymakers. The aim is to help 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) within which the future of Belgian fisheries will have to develop are determined by the CFP, as well as numerous other directives such as the Habitats Directive (HD), the MSFD, the European Framework Directive for Maritime Spatial Planning, 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 at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries (2016/C 74/05)	2016	74/05
Communication from the Commission (COM): A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development	2001	264
Green Paper (COM): Reform of the Common Fisheries Policy	2009	163
Communication from the Commission (COM): Reform of the Common Fisheries Policy	2011	417
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 concerning 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
Council Regulation (EC) No 744/2008 of 24 July 2008 instituting a temporary specific action aiming to promote the restructuring of the European Community fishing fleets affected by the economic crisis	2008	744
Council Regulation (EC) No 1005/2008 of 29 September 2008 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
Council Regulation (EC) No 1224/2009 of 20 November 2009 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 .../.... Regulation (EC) No 811/2004, (EC) No 768/2005, (EC) No 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) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 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) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing 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 (European Maritime and Fisheries Fund)	2014	508
Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 establishing a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sector for the period 2017-2019	2016	1251

Belgian and Flemish legislation

Abbreviation	Title	File number
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 Februari 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 15 December 2017	Besluit van de Vlaamse regering houdende de vaststelling van de verplichte bijdrage van de reders van Belgische vissersvaartuigen voor het jaar 2018 aan het Fonds voor Scheepsjongeren	2017-12-15/28
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
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 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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 14 December 2017	Ministerieel besluit houdende tijdelijke aanvullende maatregelen voor het jaar 2018 tot het behoud van de visbestanden in zee	2017-12-14/04
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

8

Marine aquaculture

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Bossier, P., Delbare, D., Drouillon, M., Nevejan, N., Wille, M., Verleye, T. (2018). Marine aquaculture. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 131-141.

In 2016, the worldwide production of fishery products (including aquatic plants) amounted to 202.2 million tonnes. Aquaculture accounted for 54.5% (110 million tonnes) of the total production (figure 1), while in 1990 and 2000 it only accounted for 13.4% and 25.7% of the total production, respectively. As a result, aquaculture is globally the fastest growing food production sector with an average annual increase of 7.3% since 1990 (figure 1) (*FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

In the following, the term aquaculture includes the cultivation of aquatic organisms (in fresh, salt or brackish water). Mariculture or marine aquaculture is a specialised branch of aquaculture and includes the cultivation of marine species at sea and on land.

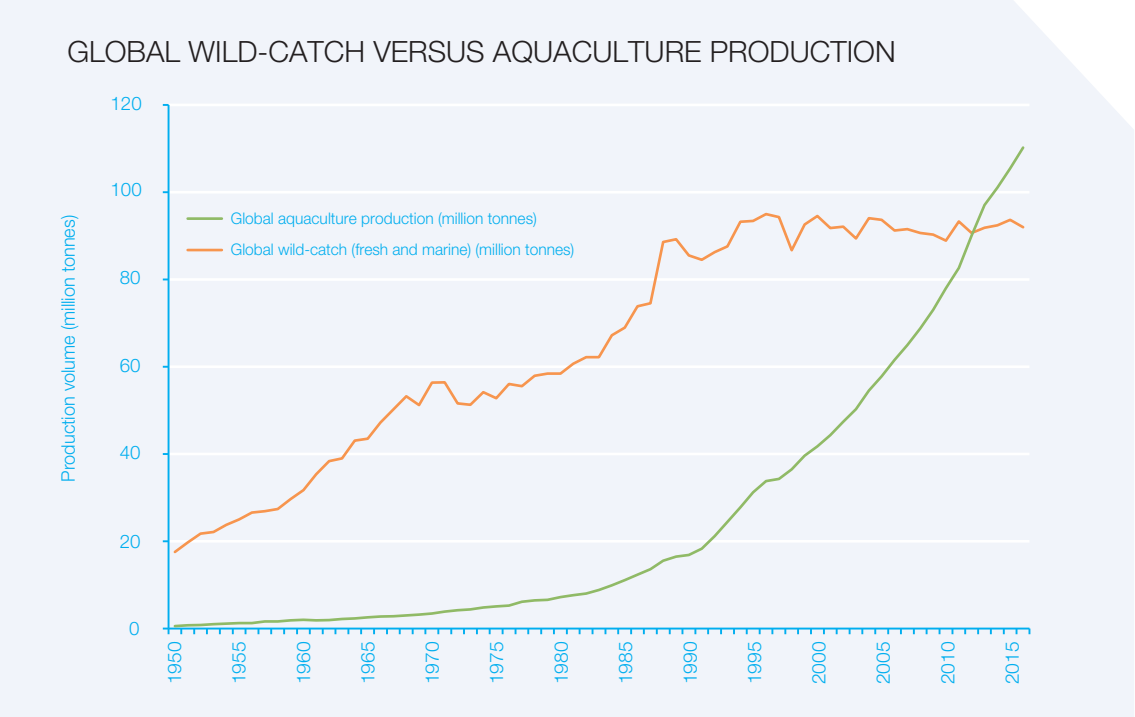

Figure 1. Aquatic production (global wild-catch and aquaculture production) between 1950 and 2016 (fresh, brackish and marine) (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

Global mariculture production amounted to 58.9 million tonnes in 2016, representing a total production value of 101.5 billion US dollars. The European Union (EU) accounted for 0.99 million tonnes (1.7%), while Europe produced a total of 2.44 million tonnes (4.1%). The main European mariculture producer is Norway (mainly salmon) with a total volume of 1.3 million tonnes, representing 54% of the European total. Noteworthy is the stagnation of marine aquaculture production within the EU over the last two decades (figure 2), while Norway shows a tripling of its marine production over the same period. In 2016, Belgium had no commercial mariculture activities cf. the FAO statistics. The importance of freshwater aquaculture was also limited to a production volume of only 44 tonnes (see also figure 4) (*FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

8.1 Policy context

At the European level, the policy concerning aquaculture (including mariculture) is included in the Common Fisheries Policy (CFP, Regulation (EC) No 1380/2013). Communication COM (2009) 162 includes a strategy for the sustainable development of European aquaculture. The Communication COM (2013) 229 comprises strategic guidelines presenting common priorities and general objectives for the sustainable development of European aquaculture: administrative simplification, coordinated spatial planning, increased competitiveness and the full exploitation of competitive advantages. Furthermore, a sustainable aquaculture is one of the main priorities of the European Maritime and Fisheries Fund (*EMFF*, Regulation (EU) No 508/2014).

On a Belgian level, mariculture, which takes place at sea, is under supervision of the federal Government (secretary of state for the North Sea /*FPS Health, Food Chain Safety and Environment*). Aquaculture or mariculture institutions on Flemish territory, however, are a Flemish competence. In this regard, the *Division Knowledge, Quality and Fishery*

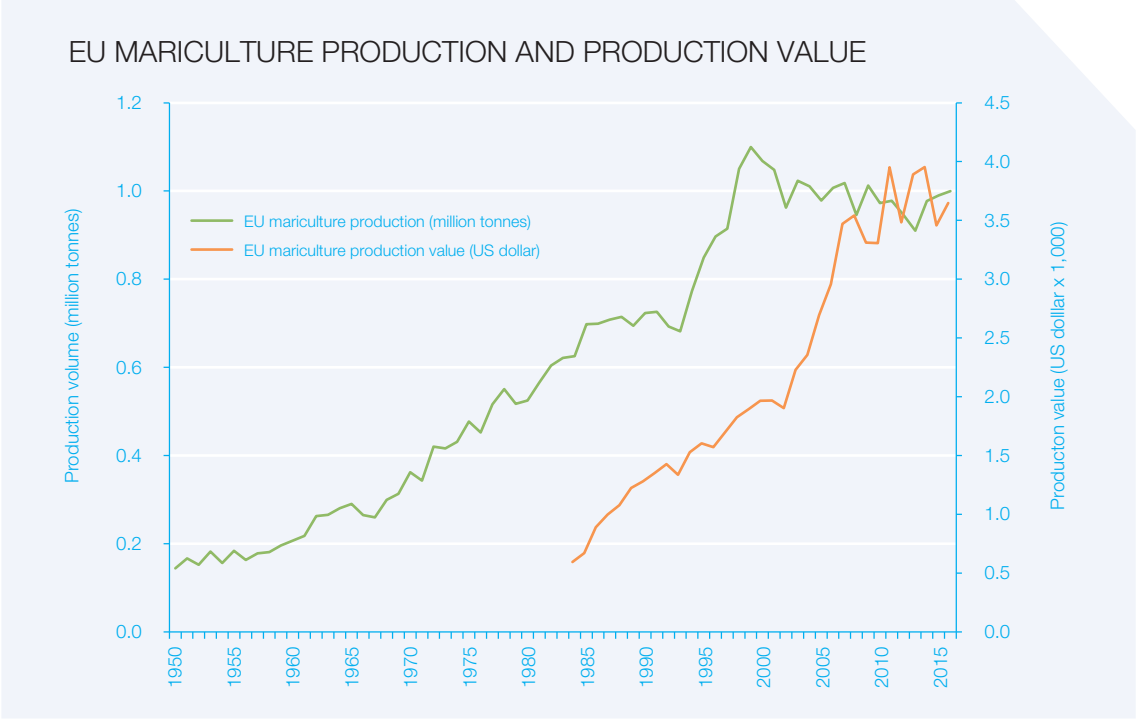

Figure 2. Mariculture production and mariculture production value in the European Union (EU) from 1950 to 2016 (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

(AKKV) of the *Department Agriculture and Fisheries* is the management authority of the *Operational Programme (EMFF) 2014-2020*, which also includes measures to support aquaculture (*summary brochure*). These measurements must be in line with the *Belgian National Strategic Plan for Aquaculture (2014-2020)*. In order to better coordinate actions to promote aquaculture, EU Member States are obliged to draw up a multiannual strategic plan on the basis of the EU guidelines presented in the Communication COM (2013) 229. In 2017, during the mid-term review of the plan, a greater emphasis was placed on mariculture. Other regulations and competent authorities for mariculture and aquaculture can be found on the website of the *Flemish Aquaculture Platform* and in the publication *Aquaculture in Flanders (2013)*.

8.2 Spatial use

8.2.1 Marine spatial plan and mariculture

The possibility of sustainable mariculture activities (under strict conditions) in the Belwind I and C-Power wind farms has been included in the marine spatial plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014*) for the Belgian part of the North Sea (BNS). The wind farm concession holders should agree to these conditions and the mariculture activities must reduce the eutrophication level within the concession zone (figure 3). In the process to the new MSP (2020-2026), new areas for aquaculture activities are drafted. The existing zone for renewable energy is designated as a development area for aquaculture where concessions will be delivered under strict conditions. Within the new renewable energy zones, it is still being examined whether and how aquaculture can be allowed without compromising safety (*MSP 2020-2026, public consultation 2018*).

A coordinated spatial plan on EU level is considered necessary to ensure the sustainable development and growth in aquaculture by reducing uncertainties, facilitating investments and tackling the lack of space (COM (2013) 229). The compatibility of mariculture and passive gear fisheries in the wind farms has already been investigated in the context of the MARIPAS project (*Verhaeghe et al. 2011*) and *Alver et al. (2015)*. Within the *AquaValue project*, a roadmap for integrated aquaculture at sea was developed in 2015. Four pilot projects were put forward that can provide a strong stimulus for the development of a sustainable integrated aquaculture sector in Flanders. These formed the basis for a number of concrete follow-up projects that are being implemented at sea (see **8.5 Sustainable use**).

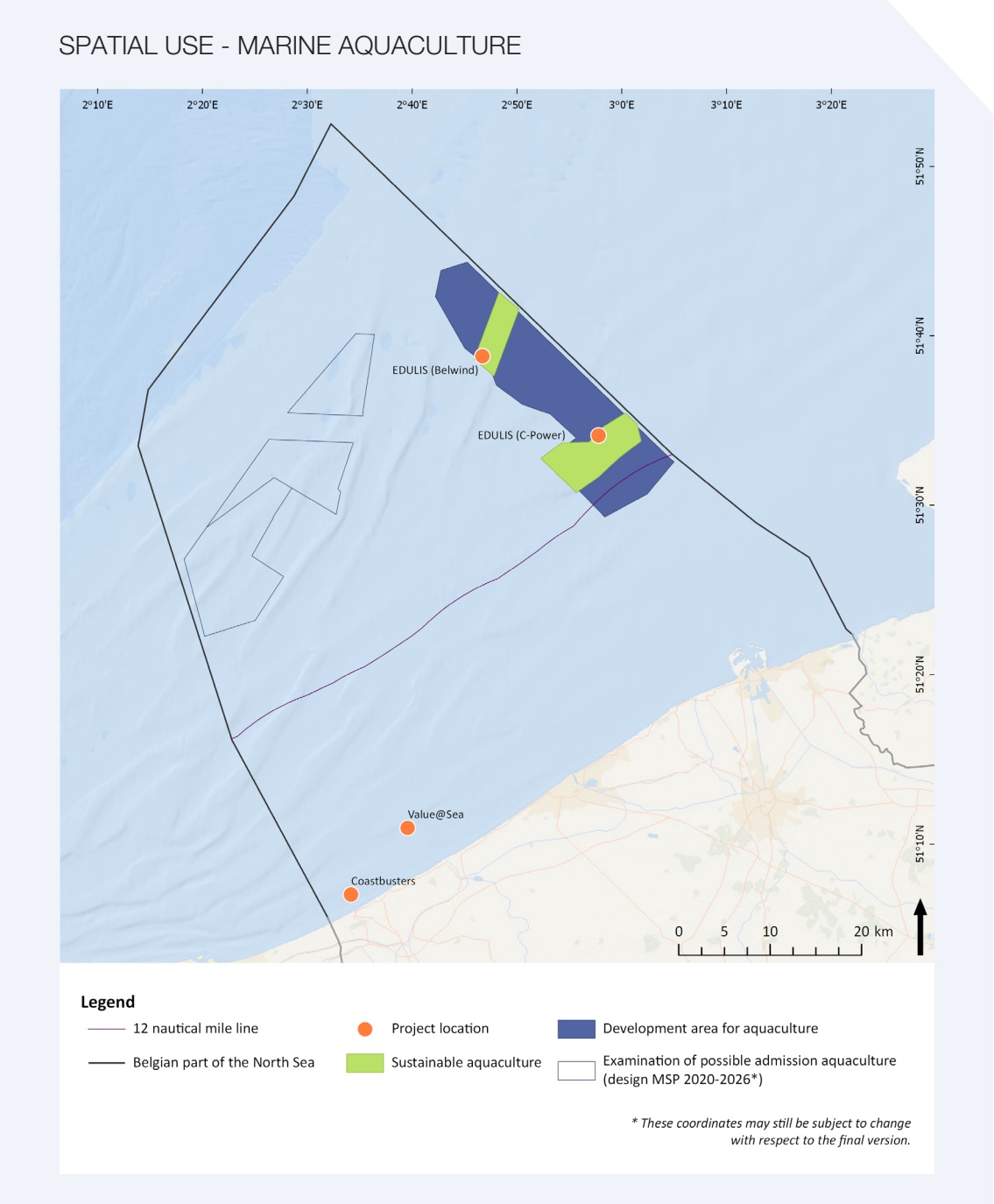

Figure 3. The locations reserved for aquaculture in the BNS (Source: RBINS, *marineatlas.be* (based on the RD of 20 March 2014, *MSP 2020-2026, public consultation 2018*, Flemish Hydrography 2013).

8.2.2 Mussel farming in the North Sea

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). From 2002 until 2006, the offshore mussel cultivation experiments were continued by private funding (José Reynaert) and were scientifically supported by CLO-DVZ (now ILVO). Independently of this private initiative, a FIOV project (*Financieringsinstrument voor de Oriëntatie van de Visserij*) 'Study on the commercialisation of Belgian offshore suspended mussel culture' was carried out between 2005 and 2008 by the Foundation for Sustainable Fishery Development (SDVO). In this project, the production of mussels by means of suspended cultivation in cages on five different areas, was evaluated (*Milieu-effectenbeoordeling Mosselcultuur 2005*, *Delbare 2005*, *Van Nieuwenhove*

2008, ICES WGMASC Report 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 stipulated a simplified procedure and a model form for the determination of the EIA. SDVO marketed the cultivated mussels under the name 'Flanders Queen Mussels', but supply volumes remained very limited (8 tonnes in 2008). This activity ended in 2010. In 2006, Reynaert and Versluys started commercial production of mussels under the name 'Belgica mussels' with a maximum landing of 300 tonnes (2010-2011), but the production ceased in 2011. In both projects, the mussel cages used were technically not resistant to the harsh weather conditions. As several studies demonstrate the potential for shellfish and seaweed farming in the Belgian part of the North Sea, the project 'North Sea Aquaculture' was recently initiated with private, FIVA (Financial Instrument for the Flemish Fisheries and Aquaculture Sector) and EMFF funding (see **8.5 Sustainable use** for more information).

8.2.3 Aquaculture in the coastal zone

In the Belgian coastal zone, aquaculture can be found in the Sluice Dock of Ostend (*Spuikom*) where the European flat oyster (*Ostrea edulis*) and the Pacific oyster (*Magallana gigas*) are farmed (e.g. Curé et al. 2000). The current aquaculture activities are distributed over two zones of 4 and 5 ha, respectively (website Oostendse Spuikom). The permits for aquaculture are granted by the Coastal Division of the Agency for Maritime Services and Coast (MD&K). The consultation platform Spuikom aims for an optimal coordination of the different users based on a consensus and provides advice to the actual administrator/owner, i.e. the Coastal Division. In 2016, the Coastbusters project (2016-2019) was launched to investigate the possibilities of using marine organisms for nature-based coastal protection (see also **8.5 Sustainable use**, and theme **Safety against flooding**).

8.3 Societal interest

In 2014, 11,865 companies in the EU Member States were active in the aquaculture sector with a total of 69,673 employees. A total of 69% of these companies (8,197), accounting for 46,954 jobs, were situated within the saltwater (bony fish) or shellfish aquaculture sectors (STECF 16-19 Economic Report of EU aquaculture sector). In terms of production volumes (tonnes), mariculture represented 78% of total EU aquaculture production in 2016, accounting for 0.99 million tonnes worth 3.6 billion US dollar (see also figure 2). This represents 1.7% of the global mariculture production volume and 3.6% of the global mariculture production value (FAO Fisheries and Aquaculture Information and Statistics Service 2018).

In Belgium, the importance of aquaculture for human consumption is limited, and in 2016 only 44 tonnes of freshwater species with a value of around 0.5 million euro were produced (figure 4) (FAO Fisheries and Aquaculture Information and Statistics Service 2018). The Belgian National Aquaculture Strategy Plan (2014-2020) aims to achieve a production volume of 1,032 tonnes in 2023, with a production value of 11.45 million euro. Employment in the primary Belgian aquaculture sector was estimated at 60 fulltime equivalents (FTEs) in 2014, while the supply sector accounted for 78 additional FTEs (VIRA 2014).

The main activities within the aquaculture sector in Belgium take place in Wallonia, where trout farming is the main activity, but will not be discussed further in this text. The Flemish Aquaculture Platform reports about 36 Flemish companies, not only producers. This list includes specialised feed companies, aquaculture product distributors and consultancy firms. The most important cultivated species are sturgeon (caviar), zander (pike-perch), prawns and jade perch (*Omegabaars*) (e.g. VIRA 2018). Marine aquaculture in the Belgian coastal area is virtually non-existent, with the exception of oyster farming in the Spuikom (Ostend), but the initiative is of limited economic importance (Verlé et al. 2016).

From a historical point of view, the cultivation of flat oysters on our coast has been of considerable commercial importance (Pirlet 2012). The 'Ostend Oyster' (*l'Ostendaise* or *Royal Ostendaise*) in particular enjoyed worldwide fame. Shortly before the First World War, oyster farming reached its peak with 26 oyster parks along the Belgian coast. Every year, 30-35 million oysters were imported from England and further cultivated in Belgian oyster farms (Halewyck and Hostyn 1978, Polk 2002). The two world wars and the increasing pollution of sea water caused a sharp drop in the number of oyster farms and ultimately resulted in the disappearance of domestic oyster farming today. An overview of these activities can be consulted on the website about the history of Belgian oyster farming.

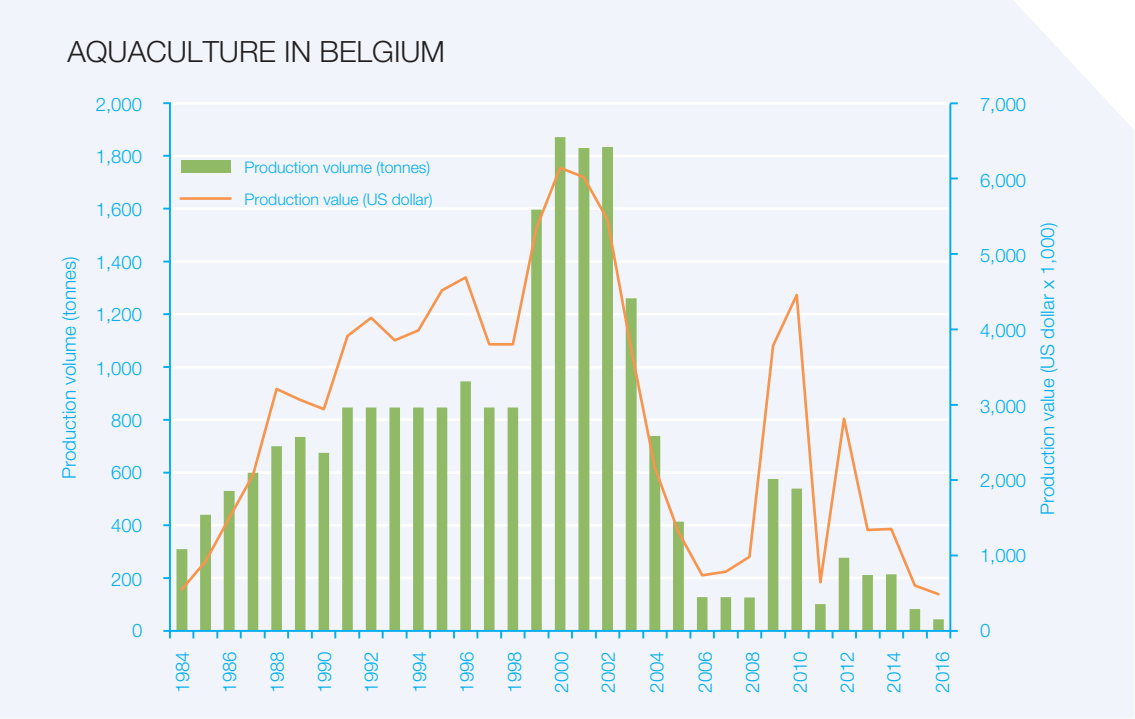

Figure 4. Annual aquaculture production and production value in Belgium (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2018*).

8.4 Impact

Mariculture has a number of positive effects on the environment and the users of the sea (e.g. *The State of World Fisheries and Aquaculture (FAO 2018)*, *Sustainable Fisheries and Aquaculture for Food Security and Nutrition (HLPE 2014)*). In addition to its contribution to global food security, aquaculture offers benefits for the common welfare, the economy and the environment such as:

- Sustainable and locally produced food;
- Healthy food;
- Infrastructure and employment (including fish processing companies) (*WorldFish 2015*, *Slater 2017*);
- Mariculture provides a remedial potential for the trophic higher level species. Bivalves are filter feeders and help maintain or improve water quality by reducing the turbidity, increasing the light penetration, reducing algal blooms, nitrogen removal (*Carmichael et al. 2012*), protecting the coastline, stabilising sediments, accelerating the nutrient cycle, sequestering nutrients and acting as habitats for other organisms. Seaweeds (or macroalgae) absorb nitrogen, phosphate and carbon from the water they use for growth, protein production and the production of energy reserve products (especially carbohydrates);
- Seaweed can be a bioresource of high quality components for human consumption;
- Seaweed can be used as raw material for the production of non-food: bio-based materials, bio-active components for cosmetics or pharmaceuticals, feed for farmed fish or cattle, and biofuels (*Buck et al. 2017*).

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 and the cultivated organisms. The possible negative effects of mariculture (fish and shellfish) are extensively discussed in international publications such as *OSPAR QSR (2010)*, *Report of the Global Conference on Aquaculture 2010 (FAO 2012)*, *Guidance on Aquaculture and Natura 2000 (2012)*, *Brenner et al. (2014)* and *The State of World Fisheries and Aquaculture (FAO 2018)*. At national level, this aspect is addressed in the *Milieu-effectenbeoordeling Mosselcultuur (2005)*, *De Wachter and Volckaert (2005) (GAUFRE project BELSPO)*, *Goffin et al. (2007)* and the *Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische Visserijsector 2014 - 2020*). A number of negative effects are:

- Modifications of the natural nutrient flux by, *inter alia*, excretion of organic nitrogen compounds;
- Organic enrichment of the underlying soil;
- Introduction of non-native species;
- Spread of diseases and parasites in farmed and wild stock;
- Genetic contamination of wild populations.

8.5 Sustainable use

8.5.1 International and European developments

Several FAO publications point to the need to shift from land-based and nearshore aquaculture production to sustainable offshore production systems in order to meet the growing demand for food and the competition for space and clean water (*Lovatelli et al. 2013*, *Kapetsky et al. 2013*). In these documents, the importance of integrated multitrophic mariculture (e.g. *Bollengier 2016*) as a mitigation approach against the excess generation of nutrients and organic matter caused by intensive mariculture activities (e.g. *Soto 2009*, *Report of the Global Conference on Aquaculture 2010 (FAO 2012)*, *Sorgeloos 2013*, *Buck et al. 2017*) is also highlighted. By cultivating species of lower trophic levels and optimising food and nutrition strategies, the impact on the ecosystem is minimised and long-term sustainability is pursued. Recommendations regarding offshore aquaculture, fish feed and aquaculture technologies were formulated in the 2012 (*Part I*, *Part II*) and 2013 (*Part I*, *Part II*) Bremerhaven Declarations.

The scientific advisory report (EC) *Food from the Oceans (2017)* provides a framework on how more food (biomass) can be extracted from the ocean in a sustainable way, and also formulates a number of policy recommendations for this purpose. The report is in line with the aforementioned FAO publications and targets aquaculture with a focus on lower trophic levels. It also identifies mariculture as the sector with the greatest potential to meet the growing food demand. It is recommended to focus on herbivorous filter feeders (e.g. mussels) for direct human consumption or, in combination with cultivated algae, as a more ecologically efficient food source for cultured marine omnivorous or carnivorous organisms (e.g. bony fish, shrimps).

In the Communications COM (2009) 162 and COM (2013) 229, the EC has committed itself to guarantee an environmentally friendly aquaculture. The EC has promised to emphasise the importance of an ecologically sustainable aquaculture development in its policies and measures. Furthermore, Europe has imposed directives for an aquaculture-friendly environment in order to guarantee the health of the aquatic animals and the safety and quality of the aquaculture products. The European legislation that is relevant in this context is listed in table 1 (not exhaustive).

Table 1. The main European legislation on sustainable aquaculture.

European legislation	Subject
Directive 91/676/EEC	Nitrates Directive – The protection of water against contamination caused by nitrates from agricultural sources.
Directive 92/43/EEC	Habitats Directive – The conservation of natural habitats and of wild fauna and flora.
Directive 2000/60/EC	Water Framework Directive – Establishing a framework for Community action in the field or water policy.
Directive 2006/88/EC	Animal health requirements for aquaculture animals and products thereof, and the prevention and control of certain diseases in aquatic animals.
Regulation (EC) No 708/2007	The use of alien and locally absent species in aquaculture.
Regulation (EC) No 762/2008	The submission by Member States of statistics on aquaculture.
Directive 2008/56/EC	Marine Strategy Framework Directive – A framework for community action in the field of marine environmental policy.
Directive 2009/147/EC	Birds Directive – The conservation of wild birds.
Directive 2010/75/EU	Integrated pollution prevention and control.

Furthermore, Europe has published guidelines dealing with the relation between aquaculture and Natura 2000 areas: *Guidance on Aquaculture and Natura 2000 (2012)*. These guidelines aim to (1) give a clear view on the conservation objectives, (2) promote good practices and (3) indicate how sustainable aquaculture and nature protection are compatible.
The sustainable development and deployment of aquaculture facilities at sea and in the coastal zone are also addressed in the framework of the Integrated Maritime Policy (COM (2007) 575). In order to unlock the potential of EU aquaculture and counteract stagnation, the COM (2013) 229 identifies four priority areas for action:

- Simplify administrative procedures;
- Coordinated spatial planning to reduce uncertainties and facilitate investments;
- Enhancing the competitiveness of the EU aquaculture sector;
- Ensure a level playing field for EU market operators by fully exploiting their competitive advantages (e.g. strict environmental regulation, food safety, consumer protection standards).

Strengthening competitiveness in the EU should be achieved through better market organisation and the full use of the EMFF (see also theme **Fisheries**) for production and marketing plans and for strengthening the links between Research and Development (R&D) on the one hand and the aquaculture sector on the other. Within the EMFF, 'Union Priority 2' aims to promote ecologically sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture.

8.5.2 Federal and Flemish developments

At the Belgian level, the mariculture activities have to comply with the law of 22 April 1999 (EEZ law) 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 to the organisation of marine spatial planning in the maritime areas under the jurisdiction of Belgium (see also theme **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 the marine strategy and the RD of 23 June 2010 on achieving good surface water status. The RD of 18 May 2008 stipulates that the National Operational Plan requires an environmental impact assessment with regard to mariculture in the maritime areas under the jurisdiction of Belgium. A simplified procedure is in force for certain activities at sea, such as the production of live bivalve molluscs using suspended cultivation (MD of 8 July 2005). A list of the Belgian/Flemish regulations to minimise the impact of aquaculture and mariculture facilities on the environment is given in *Coppens and Stoop (2003)*, *European and Belgian legal regulations for aquaculture establishments (2008)*, *Aquaculture in Flanders (2013)* and the *Flemish Aquaculture Platform*.

In the *Operational Program 2014-2020* (see also *Department of Agriculture and Fisheries 2016*), Union Priority 2 aims to promote environmental sustainability, resource efficiency, innovation, competitiveness as well as knowledge-based aquaculture. The basis for the realisation of this union priority is the *National Strategic Plan for Aquaculture* (NSPA 2017). The Operational Programme provides for a SWOT analysis and an initiation to policy priorities for the Belgian aquaculture sector. The *strategy* includes the following aspects:

- Stimulating technological development, innovation and knowledge transfer;
- Promote the competitiveness and viability of aquaculture companies, including the improvement of safety and working conditions;
- Protection and restoration of aquatic biodiversity and promotion of aquaculture related ecosystems and promotion of 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.

The *Flemish Aquaculture Platform* aims to stimulate and facilitate the development of the Flemish aquaculture sector, to map the aquaculture landscape (trends and developments) in Flanders and to present itself as the main information channel on aquaculture for entrepreneurs and researchers. In 2012, the *Strategic Aquaculture Steering Group* (SSAQ) was established under the umbrella of the Flemish Aquaculture Platform. It brings together all levels of the aquaculture industry to further develop and adjust the strategic choices and provides an aquaculture consultant to guide concrete projects and promote networking. At the Flemish level, a bottleneck analysis and recommendations to facilitate sector development have been published by the Court of Audit (*het Rekenhof*): *Aquaculture in Flanders (2013)*.

Various research and scientific institutes and companies are conducting research into the sustainable development of aquaculture within Flanders and in the BNS (see *Flemish Aquaculture Platform*, *Flemish Seaweed Platform*, etc.). A first example of this is the MARIPAS project, which investigated the integration of mariculture and offshore wind farms (*Verhaeghe et al. 2011*). The *AquaValue project* (2014-2015) developed a roadmap for aquaculture in Flanders. In addition to research on the integration of aquaculture with other offshore activities (see also **8.2 Spatial use**), special attention was paid to a multitrophic approach with additional species along the food chain. The subsequent research project 'North Sea Aquaculture' has a threefold objective: innovation in 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' comprises two separate projects / test sites: (1) the Value@Sea project (2017-2019) near the coast of Nieuwpoort and (2) the *EDULIS project* (2016-2018) in the Belgian wind farms (C-Power and Belwind). The Coastbusters pilot project (2016-2019) off the coast of De Panne also resulted from the AquaValue project, but is not part of 'North Sea Aquaculture'.

Value@Sea aims to test the technical, ecological and economic feasibility of the integrated cultivation of extractive aquaculture species such as the flat oyster, scallop and sugar kelp. The EDULIS project aims to investigate the economic and ecological feasibility of mussel farming in offshore wind farms and also analyses the forces acting

on a mussel longline. In both projects, a life cycle analysis and a business case will be developed to investigate the economic feasibility of offshore mussel farming and coastal shellfish and seaweed cultivation. The economic feasibility of local seaweed farming was studied in the *SeaConomy* desktop project (2016-2018), a multidisciplinary consortium of companies, sector organisations and government agencies. There is also *the Blauwe Keten* (Interreg Flanders - the Netherlands, 2015-2018), which focuses on the development of a complete supply chain, from cultivation to market product, for the salt water algae *Spirulina*. The Coastbusters pilot project explores the use of innovative biostabilisation methods as a coastal protection mechanism, with the aim of achieving the natural accretion of sand and strengthening the foreshores against coastal erosion (see also theme **Safety against flooding**). Three concepts will be tested, each with the potential to form a natural biogenic reef, namely the use of sand mason worms (*Lanice conchilega*), seaweed and bivalves (mussels).

The concept of biogenic reefs for the protection of the coastal area and the possibilities with regard to sea ranching and multi-species hatcheries will also be investigated in the context of the *Blue Cluster*, a spearhead cluster of the Government of Flanders for sustainable and innovative economic developments at the BNS.

The R&D *Zeebes project* (2017-2019) is conducting research into a pilot process for the (re)production of tunicates and into the technology and analyses for obtaining an economically feasible method of processing and drying these organisms for bulk applications in aquaculture feeds. In addition, the presence of interesting bioactive substances for pharmaceutical and nutraceutical applications will also be investigated.

Furthermore, the European Interreg IV project *Aquavlan* (2009-2014) aimed to build the foundations for an economically, socially and ecologically sustainable aquaculture sector within the Flemish-Dutch border region. It specifically focused on the sustainable cultivation of shellfish, fish and the harvesting of saline vegetables. The current Interreg V project *Aquavlan2* (2016-2019) supports companies in the aquaculture and horticulture sector in the border region with technical innovation.

In 2018, two aquaculture related *EMFF projects* with Belgian partners were pre-selected for funding by the European Commission. The AlgaeDemo project aims to demonstrate the sustainable, large-scale industrial cultivation of selected seaweed species at open sea, with automated seeding, harvesting and monitoring; and the AQUA-LIT project will develop a toolbox of innovative ideas and methodologies to prevent marine littering from aquaculture activities and to remove litter from aquaculture facilities.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
Communication from the Commission (COM): An integrated maritime policy for the European Union	2007	575
Communication from the Commission (COM): Building a sustainable future for aquaculture - A new impetus for the Strategy for the Sustainable Development of European Aquaculture	2009	162
Communication from the Commission (COM): Strategic guidelines for the sustainable development of aquaculture in the EU	2013	229
Directive on the protection of waters against pollution caused by nitrates from agricultural sources (Nitrate Directive)	1991	676
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals	2006	88
Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive on the conservation of wild birds (Birds Directive)	2009	147
Directive on industrial emissions (integrated pollution prevention and control)	2010	75
Regulation concerning use of alien and locally absent species in aquaculture	2007	708
Regulation on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96	2008	762
Commission Regulation (EC) No 1251/2008 of 12 December 2008 implementing Council Directive 2006/88/EC concerning the conditions and certification requirements for the placing on the market and the import into the Community of aquaculture animals and products thereof and laying down a list of vector species	2008	1251
Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 1048/2010	2013	1379
Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 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	2013	1380
Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing 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	2014	508

Belgian and Flemish legislation

Abbreviation	Title	File number
MD of 8 July 2005	Ministerieel besluit betreffende de bepaling van een activiteit van publicitaire en commerciële ondernemingen onderworpen aan de vereenvoudigde procedure en de vaststelling van het modelformulier voor de opstelling van het milieueffectenrapport	2005-07-08/31
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	
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 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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

9

Agriculture

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van Bogaert, T., Platteau, J., De Waegemaeker, J., Vanderheiden, Dauwe, S., Pirlet, H. (2018). Agriculture. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 143-153.

A high population pressure (due to urbanisation) and various space claims put increased pressure on agriculture, resulting into a gradual loss of agricultural land (*Kerselaers 2012*, *Rogge and Kerselaers 2013*, *Bergen et al. 2014*). Belgium is following the European trend in this respect, although in recent years (2006-2012), the decline has slowed down to some extent (*Landscapes in transition, EEA 2017*, *BE-landcover 2012, EEA 2017B*). This trend is also visible in the coastal zone[1], although with a differentiation in pressure between coastal and hinterland municipalities. Agriculture however, as an integral part of the agro-nutritional system, remains of an important economic value, with a slight increase in Flanders in the final production value over the last 10 years (*LARA/VIRA 2016*, *Vrind 2017*) and an agricultural trade surplus of 6.2 billion euro in 2016 (*Vrind 2017*). Agriculture in the coastal area is also economically important and, from a historical perspective, lies at the basis of the land reclamations and the creation of valuable agricultural landscapes (cultural-historical as well as ecological, for example the historical permanent grasslands) that result from this. In addition, agriculture also has a significant impact on the marine environment through, for example, the supply of nutrients such as nitrogen and phosphorus which can lead to eutrophication of the coastal waters (60% of the effluent nitrate and 31% of the effluent phosphate derives from agriculture (*OSPAR QSR 2010*)). Eutrophication especially constitutes a problem in the Southern North Sea and English Channel (*OSPAR Commission 2017*), despite a decrease in nutrient concentrations compared to 1990. However, these nutrients originate from all over the country and not only from agriculture in the coastal zone. Measurements by the Flemish Environment Agency (*VMM*, *MAP-Meetnet*, *Nutriënten in oppervlaktewater in landbouwgebied 2017*) show no improvement in the concentration of nitrates and phosphates in surface water in recent years, hence the eutrophication status of our coastal waters remains problematic (*OSPAR Commission 2017*). A further reduction of nitrates and phosphates from all sources is therefore still important for achieving a good status for the ground water, surface water and coastal waters (see theme **Nature and environment**) (*Ferreira et al. 2010*, *Voortgangsrapport Mestbank 2013*, *Mestrapport 2017*). By contrast, marine influences can also put pressure on coastal agriculture, in particular through salinisation of the soil (see **9.4.3 Salinisation of the coastal area**). In addition to these mainly negative interactions, it should also be noted that agriculture in the coastal zone provides many ecosystem services (e.g. protection against erosion, enhanced biodiversity, water regulation, etc.), but because of the marine focus of the Compendium for Coast and Sea, these won't be discussed further in this chapter.

9.1 Policy context

An important part of the agricultural policy is determined at the European level by the Common Agricultural Policy (CAP) of the *Directorate-General for Agriculture and Rural Development* of the European Commission (for more information: *The European Union in brief: Agriculture 2017*). For the period 2014-2020, the CAP is much more integrated into the overall *EU 2020 strategy*[2]. As in the previous period, the European agricultural policy is still embodied at the Flemish level by two so-called cornerstones: direct support with a focus on financial income support and rural development programmes that address broader themes such as landscape development, nature value and social cohesion (*LARA 2014*, *Investeren in landbouw in België: 2014-2020 (2016)*).

At the Flemish level, the agricultural policy is developed by the Flemish minister of Agriculture and Fisheries (see also *Policy memorandum 2014-2019. Agriculture and Fisheries*). The *Agriculture and Fisheries Department* is responsible for the preparation, implementation and evaluation of the policy. The policy is supported by the Research Institute for Agriculture, Fisheries and Food (*ILVO*), Flanders' Agricultural Marketing Board (*VLAM*) and the Strategic Advisory Council for Agriculture and Fisheries (*SALV*).

By means of research and information centers, the provinces play an important role in the councelling, education, short chain and innovation with regard to agriculture. The provincial authorities also have 'indirect competences' concerning the permit policy, spatial planning and the maintenance of non-navigable waters of the 2nd category (*website province West Flanders*, *Provincie West-Vlaanderen, Meerjarenplan 2014-2019*). Furthermore, the agricultural policy is linked to other policy domains and authorities such as the Flemish environment and spatial policy and the federal Agency for the Safety of the Food Chain (*FASFC*). The developments in the international/European and Flemish agricultural policy are discussed in detail in the following publications: *LARA (2014)* and *Investeren in landbouw in België: 2014-2020 (2016)*. A broader overview of the legal context with regard to agriculture is provided in the *Codex Coastal Zone, theme Agriculture*.

[1] Unless stated otherwise, coastal zone refers to the 10 coastal communities ((Blankenberge, Bruges, Knokke-Heist, Bredene, De Haan, Middelkerke, Ostend, De Panne, Koksijde en Nieuwpoort) and the 9 hinterland communities (Damme, Jabbeke, Zuienkerke, Diksmuide, Lo-Reninge, Gistel, Oudenburg, Alveringem en Veurne).

[2] Constitutes the EU agenda with key issues the EU wants to address by 2020. The EU 2020 strategy's core objective is to address the structural weaknesses in the European economy by aiming for sustainable, structural and inclusive growth. The EU's objectives are translated at national level.

9.2 Spatial use

In Flanders, the areas reserved for agricultural purposes are registered in the Flemish spatial structure plan (*RSV*) as the 'agricultural structure'. 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. Regional plans were reaffirmed when a consensus between the nature, forest and agriculture sector was present (*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 10 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-oriented consultation in drawing up the plans to implement the zoning changes (SIPs). Despite the fact that the deadlines have passed, the *Department Environment* continuous 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* (*ruimtelijke visie*) was drafted which indicates 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 region (*Danckaert 2013*). The regional spatial implementation plans (RSIPs) for agriculture, nature and forest in this region can be consulted on the website of the RSV (*ruimtelijk structuurplan Vlaanderen*). Besides the further implementation of the Flemish spatial structure plan, the Government of Flanders is also preparing a new *Beleidsplan Ruimte Vlaanderen* with new planning concepts on themes as 'the productive landscape' in which, *inter alia*, attention is paid to food production (see also *Groenboek. Vlaanderen in 2050: mensenmaat in een metropool? Beleidsplan ruimte Vlaanderen 2012*, *Witboek Beleidsplan Ruimte Vlaanderen*).

Within the framework of a new spatial development policy, the *Department Environment* of the Government of Flanders provides area-specific 'Territorial Development Programmes' with the aim of bringing together relevant stakeholders and realising short and medium term achievements on the basis of common objectives. In this capacity, the province of West Flanders has a cooperation agreement with the Department Environment within the so-called *T.OP. Coastal Zone* (see a.o. theme **Safety against flooding**).

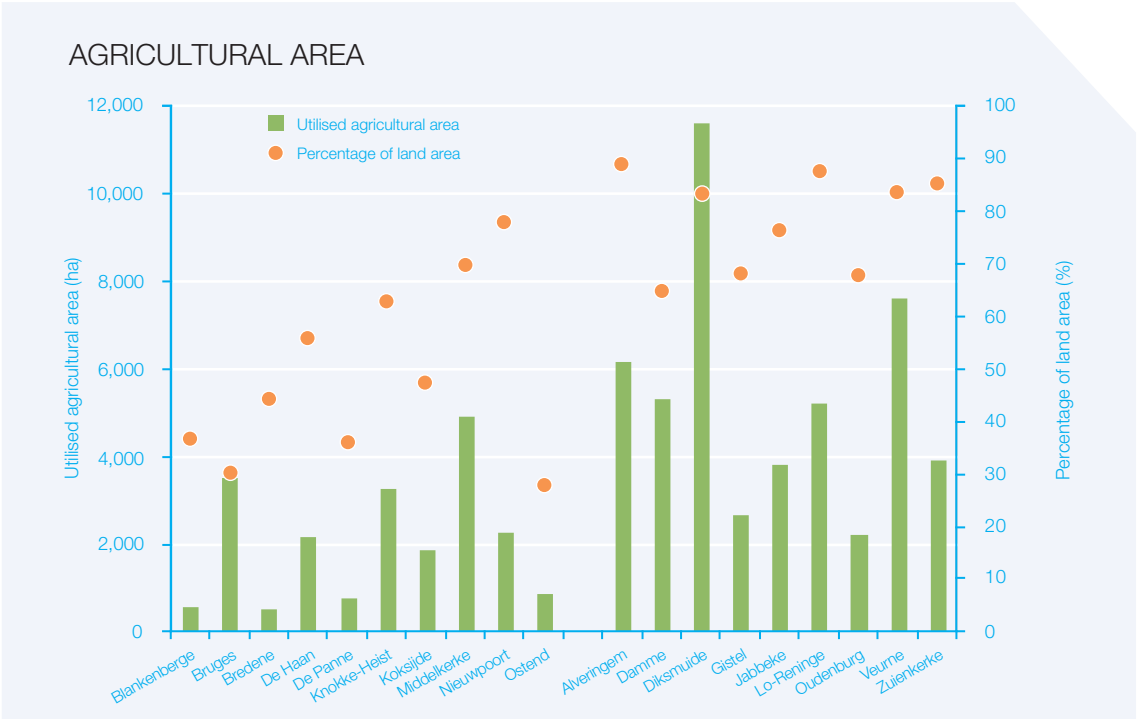


Figure 1. Utilised agricultural area in the coastal and hinterland municipalities in ha in 2017 and the percentage of the agricultural area relative to total area of the municipalities (Source: *Agriculture and Fisheries Department based on FPS Economy – Statbel*).

Areas of the agricultural structure are described in the spatial structure plan of the province of West Flanders (*PRS-WV*). For our focus area, the eastern and western polder area (parts of the spatial structure in the PRS-WV) are important for the agricultural structure. Few agricultural activities are still present in the coastal zone (subarea *Kustruimte, Westkustruimte, Oostendse ruimte* and a part of *Brugse ruimte*) due to strong urban pressure, economic developments (e.g. harbour of Zeebrugge) and increased nature protection.

The instrument of land exchange consolidation has been developed to achieve a solid agricultural structure, as described in the spatial planning (see above). In Flanders, the Flemish Land Agency (*VLM*) is responsible for these land exchange consolidation projects. The purpose of this instrument is to improve the economic exploitation of the agricultural enterprises as well as to improve the areas for nature and recreational purposes. An overview of all development projects (general projects, rural projects, land planning projects, land exchange consolidation projects and nature development projects) is given in the *project database* of the VLM-website.

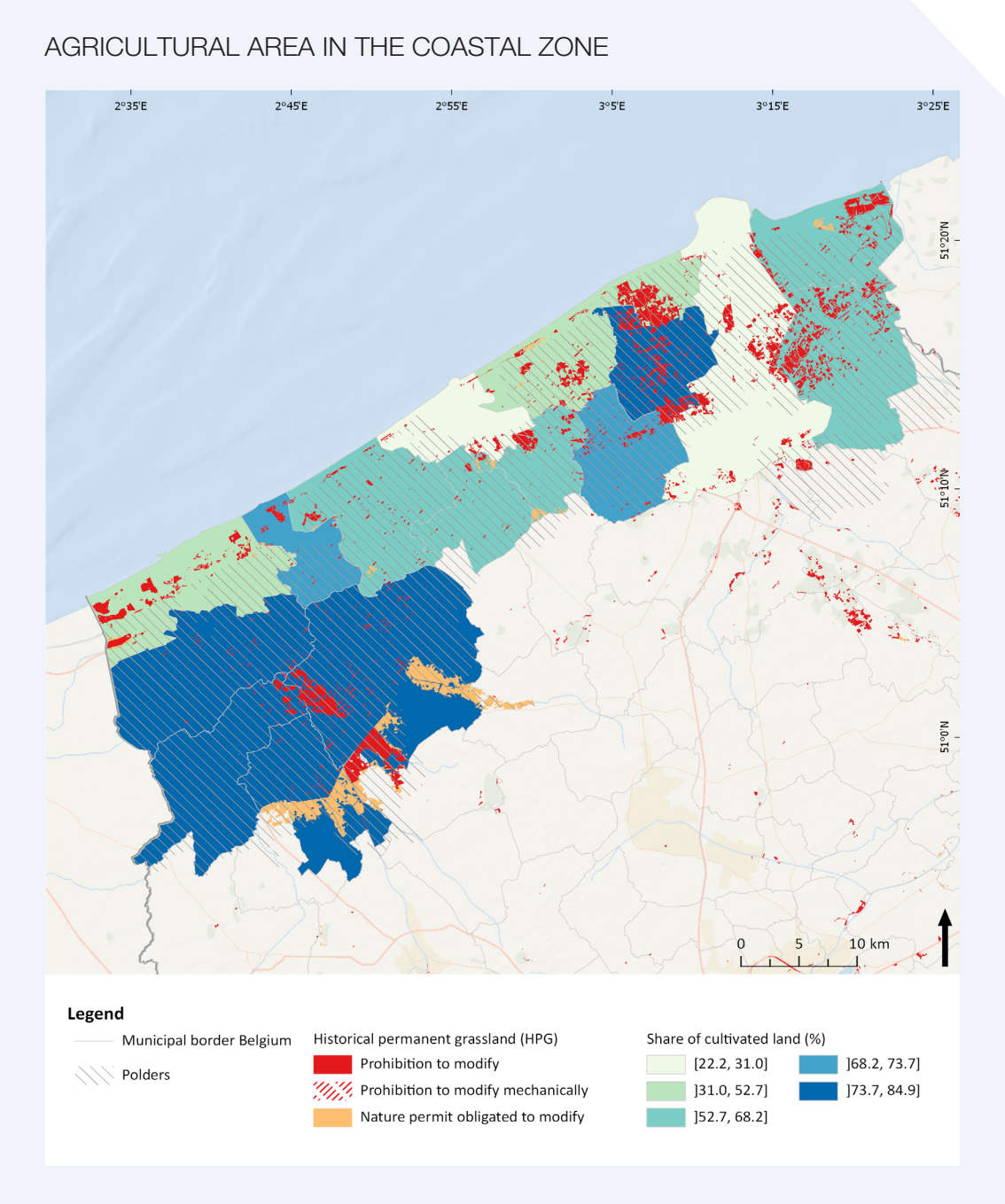


Figure 2. The agricultural area in the coastal zone (Source: VMM (GDI-Vlaanderen), Agency for Nature and Forest, Statbel 2017).

Table 1. Summary of the number of farms in the coastal zone (2017) and the total agricultural surface area (ha) at the municipal level.

Municipality	Number of farms in the coastal zone (2017)	Agricultural area (ha)
Blankenberge	17	550
Bruges	127	3,520
Damme	174	5,328
Jabbeke	120	3,828
Zuienkerke	82	3,902
Knokke-Heist	89	3,245
Diksmuide	353	11,635
Lo-Reninge	1569	5,273
Bredene	8	516
Gistel	80	2,677
Middelkerke	153	4,936
Ostend	23	852
Oudenburg	74	2,223
De Haan	54	2,127
Alveringem	206	6,711
De Panne	18	743
Koksijde	48	1,860
Nieuwpoort	52	2,266
Veurne	192	7,613
Total municipalities	**2,026**	**69,188**

The agricultural area in the coastal zone constitutes a total surface area of about 69,188 ha (figure 1 and table 1). This corresponds with 11.3% of the agricultural area in Flanders (Source: *Agriculture and Fisheries Department based on FPS Economy – Statbel*).

All parcels registered by the Agriculture and Fisheries Department, and their cultivation can be downloaded in GIS format from the Geopunt website (*www.geopunt.be*). The spatial layout of the agricultural areas in the coastal zone is shown in figure 2.

9.3 Societal interest

In the coastal and hinterland municipalities, 2,026 agricultural and horticultural enterprises were active in 2017 employing 3,880 people (2015 figures). This corresponds to 8.7% of all agricultural enterprises in Flanders and 7% of employees in agriculture. Within the coastal region, agriculture represents approximately 2.2% of the workforce (*RESOC 2017*, *Agriculture and Fisheries Department based on FPS Economy – Statbel*). The majority of both the enterprises and the employment in the coastal zone are located in the hinterland municipalities (figure 3). The specialisation of these companies, based on the standard output (more info: *Danckaert et al. 2009*), concerns primarily the production of crops and the rearing of cattle, pigs and poultry (see table 2) (Source: *Agriculture and Fisheries Department based on FPS Economy – Statbel*), see also the specific theme agriculture and horticulture in (*West-Vlaanderen Ontcijferd, 2016*).

The agricultural enterprises in the coastal zone account for 137,287 cows, 642,997 pigs, 6,483 sheep (2016), 2,254 goats (2016) and 3,093,184 heads of poultry (Source: *Agriculture and Fisheries Departments based on FPS Economy – Statbel*).

An as yet small but strongly growing sector in the coastal zone is that of organic farming. In 2017 the area used for organic farming (including land in conversion) amounts to 473 ha, an increase of 114% relative to 2012. If we consider the total agricultural area in the coastal zone, this currently amounts to a modest 2.8% (figures requested from the *Agriculture and Fisheries Department* based on *TÜV Nord Integra* and *Quality Partner*).

In addition to an economic importance, agriculture provides various ecosystem services with a productive, regulatory and cultural function. Producing ecosystem services include the production of food and feed, energy and fibre. In terms of regulatory services, there are benefits in terms of climate regulation, water quality and erosion control. The cultural ecosystem services are mainly situated within the conservation of open space (see a.o. theme **Nature and environment**) and agricultural tourism. More information on agriculture and ecosystem services, see *Van Gossum et al. (2016)* and *Dumez et al. (2017)*.

For other figures on agriculture, please visit the *website* of the Agriculture and Fisheries Department.

Table 2. Number of enterprises in the coastal area in 2017, broken down by specialisation (Source: *Agriculture and Fisheries Department based on FPS Economy – Statbel*).

Specialisation	Number of enterprise in the coastal zone (2017)
Agriculture	523
Horticulture	78
Milk production	240
Beef production	255
Mixed cattle breeding	182
Other grazing livestock (sheep, etc.)	81
Pigs and poultry	259
Mixed enterprises	408
Total of enterprises	**2,026**

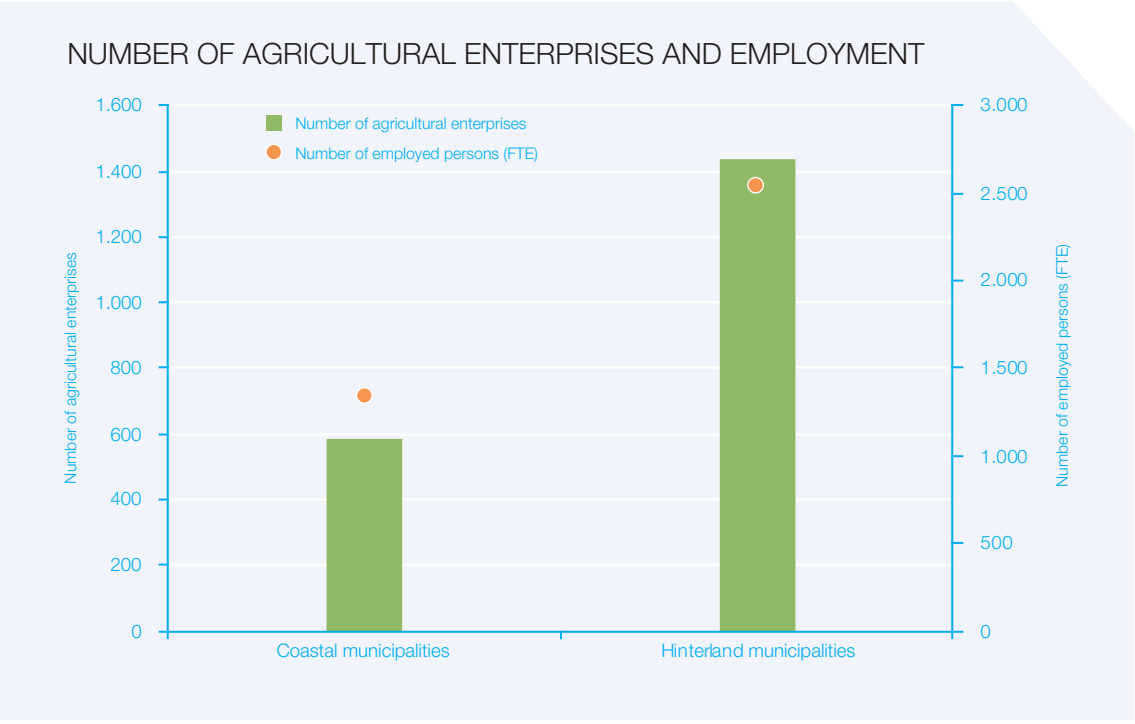


Figure 3. Number of agricultural and horticultural enterprises (2017) and employed persons in the coastal and hinterland municipalities in 2015 (Source: *RESOC 2017*, *Agriculture and Fisheries Department based on FPS Economy – Statbel*).

9.4 Impact

In the section 'impact', the (general) effects of agricultural activities on the ecosystem are discussed, as well as the indirect effects of these activities on the marine environment (eutrophication). In addition, the phenomenon of salinisation is discussed. Although salinisation is primarily caused by other human activities, it has a considerable effect on the agricultural activities in the coastal zone with a potentially more prominent role in the near future due to climate change.

9.4.1 Effects on the ecosystem

The different effects of the agricultural activities on the environment in Flanders (not specific for the coastal area) are listed in *Wustenberghs et al. (2007)*, *LARA (2014)*, *Vlaams Regionaal Indicatorenrapport (VRIND 2017)* and *MIRA systeembalans (2017)*. A description of the ecosystem of the polder area is discussed in the theme **Nature and environment**. The effects on the ecosystem include, *inter alia*:

- The use of chemical products for crop protection (more information: *Lenders et al. 2013*, *Van Esch et al. 2012*);
- The use of water (more information: see **9.4.3 Salinisation of the coastal area**, e.g. *Lenders et al. 2013*);
- The use of energy (more information: *Lenders et al. 2013*);
- The impact on soil quality (e.g. compaction resulting in salinisation) and erosion sensitivity (*Erosie in Vlaanderen 2015*);
- Eutrophying emissions (more information: see **9.4.2 Eutrophication of the coastal waters**, *Overloop et al. 2011*, *Overloop 2013*, *Voortgangsrapport Mestbank 2013*, *Mestrapport 2017*);
- Acidifying emissions;
- The emission of greenhouse gasses;
- The emission of particulates;
- Waste production;
- The impact on spatial use;
- The reduction in biodiversity.

A summary of the most recent facts and figures can be found on the *VMM* website with interesting publications from the *Agriculture and Fisheries Department*.

9.4.2 Eutrophication of the coastal waters

The use of fertiliser in agriculture which reach the coastal waters through watercourses has, along with a number of other actors, played an important role in the increase of nutrient concentrations (nitrogen (N), phosphorus (P)) in aquatic ecosystems (*State of Europe's seas 2015*). An excessive nutrient supply or 'eutrophication' amplifies phytoplankton production potentially leading to changes in ecosystem structure, habitat destruction and biodiversity loss (*André et al. 2010*). The issue of eutrophication is covered by descriptor 5 of the MSFD and is described in *Ferreira et al. (2010)*, which also outlines the conditions for a good environmental status.

A clear downward trend was observable in the 1990s, however during the last few years (2006-2014), a stagnation can be observed in the amount of dissolved N and P in our coastal waters (*OSPAR IA 2017*). A trend confirmed by land-based measurements (*Mestrapport 2017*, *Fysisch-chemische kwaliteit oppervlaktewater 2016*, *Nutriënten in oppervlaktewater in landbouwgebied 2017*, *VMM* MAP-Meetnet). Furthermore, in addition to river transport of nutrients, atmospheric inputs also cause concern (*OSPAR QSR 2010*, *OSPAR Commission 2017*). The eutrophication of coastal waters was studied in detail in the *AMORE* (*AMORE project BELSPO*), *AMORE II* (*AMORE II project BELSPO*) and *AMORE III projects* (AMORE III project *phase 1* and *phase 2 BELSPO*) (more information: *Lancelot and Rousseau 2004*, *Rousseau et al. 2006*, *Lancelot et al. 2007*, *Lancelot et al. 2009*). A centralisation of knowledge and information on eutrophication in the southern part of the North Sea took place in 2014 as part of the *ISECA project*. The *NewSTHEPS* project (2014-2019) (*NewSTHEPS project BELSPO*) is carrying out concentration measurements under the MSFD on chemical pollutants, including N and P, in our coastal zone.

9.4.3 Salinisation of the coastal area

Salinisation, the process of brackish or salt ground water penetrating the soil root layer, has a considerable impact on agriculture in the coastal area. As a result, salt accumulates in the soil (*Peeters 2013a*, *Peeters 2013b*), which has a detrimental effect on the crops. Naturally, a distribution of fresh and saline / brackish groundwater occurs in

the coastal area. In the zone of phreatic groundwater, a freshwater lens lies above a layer of salt / brackish water which allows for traditional agriculture in the polder area. From an agricultural perspective it is important to have a freshwater lens that is sufficiently thick, but without the soils becoming too watery. This freshwater lens acts as a buffer to the intrusion of saltwater in the hinterland (*Van den Eynde et al. 2011* (CLIMAR project *phase 1* and *phase 2* BELSPO) and the *CLIWAT project*), but it contains interruptions along the coast. The current 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 and agriculture, large-scale infrastructure works (e.g. land reclamation, harbour expansion, tunnels, drainage, etc.) and interventions in water management (e.g. water level management, drainage systems, etc.), play an important role. Hydrological interventions in the coastal zone may thus in the short term lead to changes in the fresh-salt water distributions and in the long term possibly to salinisation (*Vanleberghe and Vanhoutte 2001*, *Vandenbohede et al. 2009*, *Vandenbohede et al. 2010*, *Vandenbohede et al. 2012*, *Stroomgebiedbeheerplan voor de Schelde 2016-2021*). In the future, sea level rise and extreme droughts caused by global warming may also increase the salt pressure towards shallow ground and surface water (*Vandenbohede et al. 2012*, *Vandenbohede and Lebbe 2012*, *Zwaenepoel et al. 2016*).

This led, *inter alia*, to a revision of the salinisation maps (*dov.vlaanderen.be*) of De Breuck (1974 and 1989) that were based on measurements from the 1960s and 1970s with the aim of accurately determining the current salinisation status and identifying potential bottleneck zones. This happened in 2010 (CliWat project) for the central coastal area (Nieuwpoort-Zeebrugge) (*Vandenbohede et al. 2010*), within the framework of the *ScaldWIN project* (*Lebbe et al. 2012*) and in 2014 for the eastern coastal area (*VMM 2016*). Based on these studies, it can be concluded that the freshwater balance is currently fairly stable (*Vandenbohede et al. 2010*, *Zwaenepoel et al. 2016*, *VMM 2016*). Nevertheless, in the exceptionally dry summer of 2017, water shortages occurred in the agricultural land of the coastal region along with related salinisation problems (*Droogterapport 2017*). Furthermore, recent studies place salinisation within the context of climate change (e.g. *De Waegemaeker et al. 2013*), which highlights the need for a long-term perspective on the hydrology of the coastal region. A detailed determination of the fresh-saltwater balance for the entire coast and polder region was recently carried out as part of the *Topsoil project* (phase 1).

9.5 Sustainable use

The implemented policy at international and European level (Treaty of Lisbon, the EU 2020 strategy, CAP, etc.) to achieve a sustainable agriculture is described in detail in the *LARA (2014)*. In the report, several interlinked sustainability themes in agriculture are discussed such as water management, manure management plan (*mestactieplan*), biodiversity, bio-economy, etc. Furthermore, recommendations and measures to reduce or avoid the environmental impact of agriculture in Flanders are listed in *Wustenberghs et al. (2009)*, *Van Steertegem (2009)*, *Zwaenepoel et al. (2016)* and *MIRA systeembalans (2017)*. *Gobin et al. (2008)* and *Maertens et al. (2016)* discuss the adaptation possibilities and mitigation strategies of Flemish agriculture to climate change in more detail, and in *Mathijs et al. (2012)*, *LARA/VIRA 2016* and *MIRA systeembalans 2017* there is a broader focus on the sustainability of both food production and consumption from a transition perspective. Various studies which focus on sustainable agriculture are also being carried out by the engineering department of the Agriculture and Fisheries Department (website of the *Agriculture and Fisheries Department*). These include *inter alia*: *Bergen (2013)* (Agro-ecology), *Danckaert et al. (2013)* (Food Footprint), *Dumez et al. (2014)* (New perspectives for agriculture and policy) and *Bergen et al. (2014)* (Challenges for Flemish agriculture).

The sustainable compatibility of several user functions in coastal areas (housing, tourism, recreation, agriculture, industry, nature, etc.) is discussed within the European recommendation for Integrated Coastal Zone Management (IC(Z)M) (COM (2002) 413). The compatibility of different sectors in the polders on the coast is discussed in a case study of the *Uitkerkse Polder* (Blankenberge) (*Bogaert et al. 2002*).

Measures and regulations for certain effects linked to agricultural activities that are of specific importance to the coastal zone are discussed below.

9.5.1 Measures against eutrophication

In the North-East Atlantic Ocean, OSPAR has created a *common procedure (2013)* for the identification of the eutrophication status (*OSPAR IA 2017*). In cases where this classification results in so-called problem areas, the OSPAR environmental strategy requires that contracting parties, individually or jointly, take measures to reduce or eliminate the anthropogenic causes of eutrophication. This procedure serves as a framework to identify the actions described in *OSPAR Strategy (2010-2020) (2010)* with the aim of achieving and maintaining a healthy marine environment free from eutrophication by 2020 within the OSPAR region. The uniform monitoring and classification

strategy is described in the '*eutrophication monitoring programme (2005 – updated 2013)*' (see also *OSPAR website*). At the European level, the issue of eutrophication is covered by various directives within the Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD). The Nitrates Directive (91/676/EC) is an integral part of the Water Framework Directive (WFD, 2000/60/EC) which, *inter alia*, imposes an obligation to achieve a good surface and groundwater quality by 2015. It includes substances that contribute to eutrophication, such as N and P, in its list of main pollutants. The Nitrates Directive more specifically aims to reduce the leaching of nitrates from agriculture (*Goffin et al. 2007*). Other directives under the umbrella of the WFD also have a link to eutrophication, such as Directive 91/271/EC on urban waste water and Directive 2008/1/EC concerning integrated pollution prevention and control.

In the Marine Strategy Framework Directive (MSFD) (2008/56/EC), eutrophication is included as descriptor 5 for determining the environmental status in the marine environment. The criteria and methodological standards for the determination of a good environmental status with regard to eutrophication as currently applied by OSPAR are described in *Ferreira et al. (2010)*. In addition, the MSFD is incorporated into Belgian legislation by the RD of 23 June 2010 on the marine strategy for the BNS.

The WFD is translated at the Flemish level into the decree on integrated water management (decree of 18 July 2003) (for implementing decisions and amendments see *website Coordination Committee on Integrated Water Policy*) and partially at the federal level into the RD of 23 June 2010 concerning the establishment of a framework for achieving good surface water status (see also *FPS Public Health, Safety of the Food Chain and Environment 2009*). In addition, the MSFD was incorporated into Belgian legislation by the RD of 23 June 2010 on the marine strategy for the BNS.

At the Flemish level, the Nitrates Directive is translated into the Manure decree, which deals with the quality status with regard to diffuse pollution of groundwater and surface water by agriculture and horticulture. The decree was adopted on 23 January 1991 and has since been substantially modified on a number of occasions. The new Manure decree of 22 December 2006) has been in force since 1 January 2007, with the fifth Manure Management Plan (MAP-V) applying to 2015-2018 (for implementing decisions and amendments see *VLM website*). This renewed manure management plan aims to break the current stagnation in water quality (Management Programme for the implementation of the Nitrate Directive, *Mestrapport 2017*). Since 2011, the Government of Flanders, in cooperation with ILVO, has been providing a so-called 'research platform for sustainable fertilisation' to accompany the Manure Management Plans. The aim of this forum is to bring together stakeholders from policy, research and practical organisations and to facilitate and coordinate research on sustainable nutrient use in agriculture. An overview of the recently completed and current studies can be found on the website of the *VLM* and in the *Mestrapport 2017*. Furthermore, nutrient limiting agricultural practices also come up in the *PDPOIII* in the context of a sustainable CAP (see **9.1 Policy context**) and in the *MIRA systeembalans 2017*. An up-to-date overview of the manure legislation can be found on the *VLM* website.

On 23 April 2014, the Government of Flanders decided to establish a Programmatic Approach to address atmospheric nitrogen deposition (*PAS*). The PAS programme (2014-2031) aims to tackle the problem of eutrophying and acidifying atmospheric deposition of nitrogen, of which about two-thirds comes from the agricultural sector, in special areas of conservation under the European Habitats Directive (Directive 92/43/EC) by means of source-oriented (at the emission side) and effect-oriented measures. A number of steps are anticipated in the implementation of this programme: a transition phase (2014-2015), a provisional PAS (2015-2019) and a final PAS (from 2019 onwards).

The *VMM* disposes of a monitoring network for the water quality, which has been expanded since 1999 to include specific monitoring points for agriculture (see the water quality *geoportal*). In *Lancelot et al. (2011)* the costs and ecological efficiency of measures in *inter alia* agriculture to prevent eutrophication in the Southern Bight of the North Sea were modelled (see also AMORE III project *phase 1* and *phase 2* BELSPO, and *TIMOTHY project* BELSPO).

9.5.2 Measures against salinisation

The European Communication COM (2012) 46 provides an overview of the implementation of the Thematic Strategy for Soil Protection since its establishment in COM (2006) 231. This includes *inter alia* soil degradation through salinisation. Furthermore, intrusions of salt water were also included in the WFD (2000/60/EC) and the Groundwater Directive (2006/18/EC) as parameters for the quantitative and qualitative status of groundwater (see also *VMM 2008*).

The WFD has been translated into Flemish legislation by the decree of 18 July 2003 concerning integrated water management (*website Coordination Committee on Integrated Water Policy*). 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[3] that describe a collection of groundwater body specific actions to combat groundwater salinisation. A detailed overview of all actions can be consulted on the website *integraalwaterbeleid.be*. Furthermore, the WFD is also partly incorporated into Belgian legislation by the RD of 23 June 2010 concerning the establishment of a framework for achieving good status of surface waters. The management and monitoring (*VMM MAP-meetnet*) of the quality of ground and surface water is a core task of *VMM* (operational water management department). More information: *Vandenbohede et al. 2010* and the legislation listed in the *Codex Coastal Zone, theme Groundwater extraction*.

'*Climate Change in the Polders - Choosing fresh or salt?*' (*Zwaenepoel et al. 2016*) provides an overview of several solution strategies based on domestic and foreign research projects (with a focus on the Dutch context). Also discussed are the challenges posed by a changing hydrology and the current knowledge gaps in the field of agriculture in the Flemish polder region. In addition, two research projects were recently launched on new agricultural strategies in the context of water scarcity and salinisation of the Flemish polders. For example, phase two of the Interreg *Topsoil* project tries to develop local pilot projects with the help of stakeholder participation in order to improve freshwater availability for farmers. In addition, the Interreg North Sea Region project *SalFar* is developing innovative farming methods for growing crops on saline soils by using test sites in different regions. In Flanders, the research focuses on the socio-economic barriers to saline agriculture and also the salinification problem along with the potential of saline agriculture in the Flemish coastal region through stakeholder participation is investigated.

The Agriculture and Fisheries Department also provides support for sustainable water use in agriculture in the form of a *praktijkgids water in de land- en tuinbouw* on sustainable and efficient agricultural methods and techniques.

In the study *ontwerpopgaven van Metropolitaan Kustlandschap 2100*, two different development scenarios were proposed for the water management in the coastal polder, being one integrated water system or compartmentalisation[4] (*De Waegemaeker et al. 2012*). In this context, the adaptation of agriculture to an increasing saline seepage that may occur in the future is discussed. A second study by LABO RUIMTE, '*Stedelijk Systeem Kust*', with clear interfaces to MKL2100 investigates challenges and opportunities in urban space (and undeveloped space) to guarantee a sustainable coastal area in the future. One of the elements discussed is the achievement of sustainable water management in the polders.

9.5.3 Protection of historical permanent grasslands (HPGs)

In the coastal polders, historical permanent grasslands (HPGs) are present which are used for agricultural purposes but are valuable from an ecological point of view as well. The HPGs are defined in the 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 mentioned above 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.

In order to achieve an effective protection of the grasslands, an inventory has been made with the exact location of the HPGs (*De Saeger et al. 2013*). In the Flemish coalition agreement (2014-2019), the government has committed itself to initiate a protection programme based on a map subsequent to a public inquiry. In 2015, the Government of Flanders decided to protect 8,000 of the 12,000 acres of grasslands. A part will be protected by means of nature legislation whereas another part will be covered by the European agricultural policy. For example, the CAP (*Investeren in landbouw in België 2014-2020 (2016)*) provides for a financial reward for farmers who pay attention to natural resources such as HPGs in the form of bonuses.

[3] The three measure groups: Protected and water-rich areas – part ground water, Quantity ground water, Contamination of ground water.
[4] Building on coastal design research within the CcASPAR project: Climate Change and Changes in Spatial Structures Research Project.

Legislation reference list

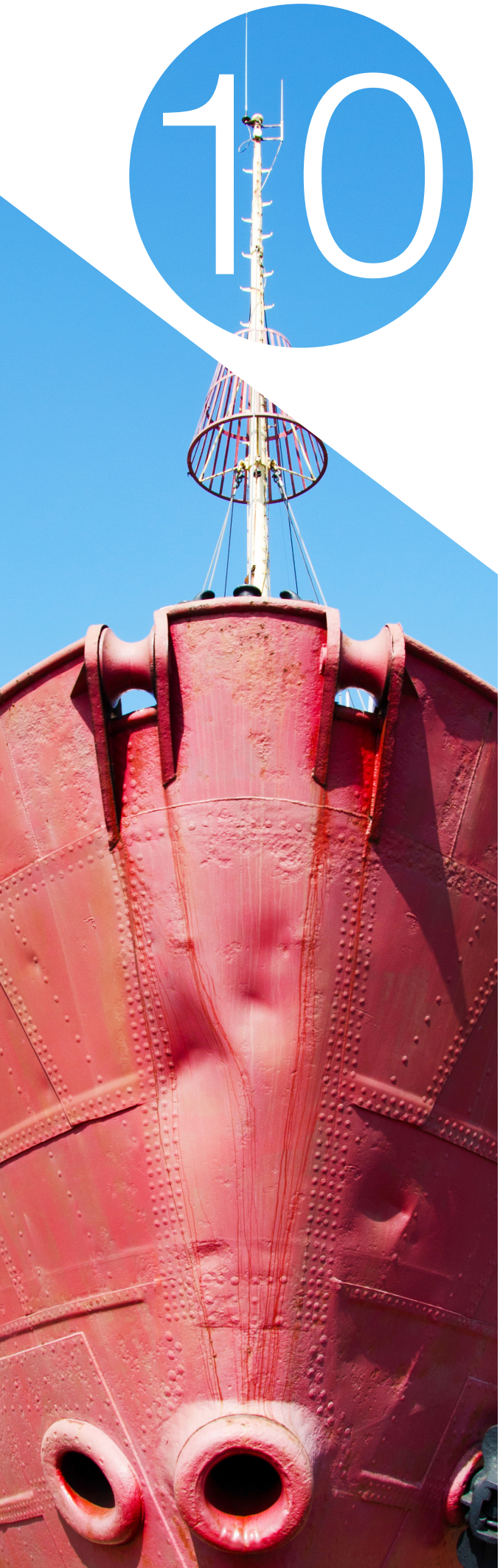
Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
COM: Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe	2002	413
COM: Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Thematic Strategy for Soil Protection	2006	231
COM: Report of the Commission (COM): The implementation of the soil thematic strategy and ongoing activities	2012	46
Council Directive concerning urban waste-water treatment	1991	271
Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural source (Nitrate Directive)	1991	676
Council Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive 2000/60/EC establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration (Groundwater Directive)	2006	18
Directive concerning integrated pollution prevention and control	2008	1
Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Treaty of Lisbon	2007	

Belgian and Flemish legislation

Abbreviation	Title	File number
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
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



10

Maritime and coastal heritage

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Pieters, M., Van Dijck, M., Missiaen, T., Van Haelst, S., Pirlet, H., Devriese, L. (2018). Maritime and coastal heritage. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 155-167.

Maritime and coastal heritage covers a very wide range of aspects. It includes maritime archaeological heritage in the sea as well as on the land, historical fleet, architectural heritage which is typical of the coastal zone, coastal landscapes with heritage value, maritime movable heritage and intangible maritime heritage. 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. Moreover, reviews that deal with a particular aspect of maritime heritage in an integrated way, beyond artificial and variable limits (legal, physical or disciplinary), are not available either.

Addressing maritime and coastal heritage in an integrated way offers benefits with regard to the understanding of relationships and elucidating the wider context. Furthermore, the various types of borders have also changed significantly over time. In the Roman period, for example, the coastline was located further seaward compared to the present situation, even though there were several tidal channels which penetrated into the hinterland (evolution coastline from 16th century see *HisGISKust*). This is why archaeological heritage that was originally formed on land, may nowadays be situated below sea level. It goes without saying that this heritage, if still available, should be seen in conjunction with the archaeological heritage situated in the current coastal plain.

10.1 Current situation

10.1.1 Maritime[1] archaeology

The concept of maritime archaeological heritage covers a wide range of aspects. The most important elements are:

- Shipwrecks and other wrecks (e.g. airplanes) as well as parts thereof, regardless of where they are found (in the sea, in rivers or former rivers or recycled anywhere on land). The expansion to sites on land only applies to shipwrecks and parts thereof (e.g. *Pieters et al. 2015*);
- Settlements or other traces or remains of human activity in seas, rivers or other bodies of water and their palaeoenvironmental context (e.g. *Missiaen 2012*, *Missiaen et al. 2017*). An important category in this regard can be linked to the theme of sea level rise after the cold phases of the ice ages;
- Archaeological sites and traces situated on land and their palaeoenvironmental context, which were entirely focused on the sea or the water for their former operations such as lighthouses, fishing villages, shipyards, seawalls, peat extraction, salt extraction, quays, drainage canals, etc.;
- Archaeological remains of sea fish that are found far inland during archaeological research (e.g. *Van Neer and Ervynck 2006*, *Van Neer and Ervynck 2016*);
- Palaeontological bones of terrestrial fauna found at sea (for the Belgian part of the North Sea (BNS) and adjacent beaches, see *Vermeersch et al. 2015*).

There is no restriction with regard to the age of the investigated archaeological heritage. A shipwreck from WWII deserves an appropriate archaeological treatment, which will obviously differ from the treatment of a shipwreck from the Bronze Age.

Since 2003, systematic research has been performed on maritime archaeological heritage by *Flanders Heritage Agency* and its precursors (Institute for the Archaeological Heritage (IAP), Flemish Institute for Immovable Heritage (VIOE)). From 2017, focus has been on inland waterways in particular (rivers, docks, the Zwin, etc.) and the intertidal area adjacent to the territorial sea.

For the entire spectrum of maritime archaeological heritage, as outlined above, a number of (partial) overviews are available for Flanders and the BNS:

- The database of Flanders Heritage agency (*www.maritieme-archeologie.be*) 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) which are present in the North Sea and in Flanders, artefacts from the sea, and maritime sites such as fishing villages and lighthouses.

In addition, there are two more databases that provide valuable information about parts of the above described heritage, namely shipwrecks, without having an archaeological perspective:

- The wreck database of the Flemish Hydrography (*www.afdelingkust.be/nl/wrakkendatabank*) has been developed from a perspective of safe shipping. The information in this database formed the basis for a book about shipwrecks in the North Sea which inventoried 277 wreck sites (*Termote and Termote 2009*);
- The online database (*www.wrecksite.eu*; private initiative), which has become an internationally respected and consulted database on shipwrecks and their positions.

[1] Maritime Archaeology – Nautical Archaeology – Marine Archaeology – Underwater Archaeology are all related concepts. In the heritage sector, the term 'maritime archaeology' is increasingly used as the umbrella term for former mentioned categories.

In addition to the three databases mentioned above, a number of reviews are available that cover part of the maritime archaeological spectrum. The website of the so-called *Onderzoeksbalans* of Flanders Heritage Agency consists of two main parts: *Onderzoeksbalans Onroerend Erfgoed Vlaanderen* and *Bibliografie Onroerend Erfgoed Vlaanderen*. Two digital summary documents are available on *maritime archaeology*:

- An overview of the archaeological research in the BNS below the high water line (including the beach) (published in adapted format in *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 a recent overview article on medieval ships (*Van de Moortel 2011*).

For the study of the maritime archaeological heritage of WWI, an overview work exists about the War under Water (*Termote 2014*). It offers a structural insight of the activities of the *Unterseeboot Flottille Flandern* during 1915-1918.

For the study of shipwrecks found on land, the research on the medieval shipwrecks in Doel is important in an international context (e.g. *www.onroerenderfgoed.be/nl/actueel/projecten/de-kogge*, *Haneca and Daly 2014*, *Vermeersch and Haneca 2015*, *Vermeersch et al. 2015*). In recent decades, extensive research has been conducted in Flanders on the archaeological heritage of late medieval and early modern fishermen, focusing on the medieval fishing community of Walraversijde. A large part of the study of the archaeological research in Raversijde has been published in *Pieters et al. (2013)*. With regard to the maritime landscapes of the Belgian coastal plains, there are a number of studies conducted by the Vrije Universiteit Brussel (e.g. *Tys 2004*, *Tys 2013*, *Tys 2017*). Recently, Ghent University, in close cooperation with the Flanders Marine Institute (VLIZ), took the first steps in structured research into the drowned (pre)historical landscapes off the Belgian coast (*Missiaen et al. 2017b*, *De Clercq 2018*).

Within the IWT project 'Archaeological research in the North Sea: development of an efficient evaluation methodology and proposal for sustainable management in Belgium (*SeArch*)' (2013-2016), methodologies were provided for the existing knowledge gaps with regard to buried shipwrecks and prehistorical relics in the North Sea (*Van Haelst et al. 2016a*, *2016b*, *2016c*, *Missiaen et al. 2016*). In addition, the project aims to provide guidelines for the different users of the North Sea, including the legal framework relating to the maritime archaeological heritage. The legal framework should ensure sound management of valuable heritage, but cannot stand in the way of appointed economic exploitation of the North Sea (*Missiaen et al. 2016*, *Missiaen et al. 2017*).

At the end of 2016, the 'Zeebrugge project', commissioned by MOW – Maritime Access Division, started. It concerns a unique geological and archaeological study of Zeebrugge (offshore), including the study of palaeolandscapes. The study is part of the *Complex Project Coastal Vision* (formerly Flemish Bays Project). Final results are expected by the end of 2018 – beginning of 2019.

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

10.1.2 Historical fleet

The historical fleet policy has been created relatively recently by two parallel developments. Firstly, since the 1980s, increased attention was paid to the vessel types that were in danger of disappearing or had already disappeared. This led to attempts to preserve ships, to restore them or to build replicas of ships that were already gone. The organisation of 'Ostend at Anchor' can be framed within this societal development. Secondly, from the beginning of the 1990s onwards, the focus on the historical fleet grew from the Industrial Heritage Cell within the former Department of Monuments and Landscapes (the current Flanders Heritage Agency). The link between the historical fleet and industrial heritage is obvious. The ships were built using materials which were also used in other economic sectors. Initially, wood was the preferred material for ships. Depending on the vessel type, the switchover to steel, the key product of industrial revolution, was made sooner or later. Since the 1960s, synthetic materials were increasingly used for recreational boating. The propulsion of the ships evolved from sails to steam engines, and subsequently to diesel engines. The historical fleet is inventoried in a database by Flanders Heritage Agency (*https://inventaris.onroerenderfgoed.be/ivm/varend/zoeken*). The database was adopted on 16 June 2017, which means that the government or other parties (such as ports) may attach certain legal effects and benefits to the database of the historical fleet. The Flanders Heritage Agency has published an extensive brochure with information on the inventory (database), the establishment and the protection of the Historical Heritage (see also *Brochure Heritage – Historical*

Fleet 2016). Immovable heritage also gives an overview of the literature through the website of the *Onderzoeksbalans – Bouwkundig Erfgoed*.

Two types of vessels are of great importance for the coast specifically: fishing boats and sail yachts. An overview of the fishing boats since 1929 can be found in the *database of the Belgian fishing fleet* of the Flanders Marine Institute (VLIZ) (see also theme **Fisheries**).

The Panesi project took a closer look at the construction of fishing vessels on the coast based on the archives of the Panesi shipyard (*Van Dijck and Daems 2015*). The study outlines the history of shipbuilding on the coast and describes the development of the fishing boats build between 1870 and 1970.

The Mercator ship is a special case which was protected as a monument in 1996 and was considered as historical fleet 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. Since 1961, it has been open to the public as a museum (*Vanden Bosch 2001*). Finally, the West-Hinder Light Ships (1950, Belliard yard, Ostend; *Janssens 1997*, *De Graaf 2012*, *VLIZ Wetenschatten 2015b*) must be mentioned. These floating lighthouses warned ships for shallow sandbanks and were replaced by unmanned light platforms in 1993.

10.1.3 Architectural heritage along the coast

The interest in the preservation of architectural heritage in Belgium goes back to the 19th century. The architectural heritage along the coast includes many components which are specifically maritime-related: hotels and other residential accommodation, tourist and recreational facilities and infrastructure (see also theme **Tourism and recreation**), coastal defence (civil and military) (see also theme **Safety against flooding** and theme **Military use**), lighthouses, sluices, all kinds of maritime business infrastructure, etc. The first two groups of architectural heritage on the coast 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 shows architectural accomplishments that originated on the coast between 1870 and 1914.

The architectural heritage of the coastal zone has been gradually inventoried since 1977 (*Maelfait et al. 2012*). And since, the vulnerable coastal heritage received more attention (*Cornilly 2005*). The results of the inventory are available online for the public: *https://inventaris.onroerenderfgoed.be*. Specifically, for the province of West Flanders, there is *Monumentaal West-Vlaanderen*, an illustrated overview in three parts of all protected monuments and sites in the province on 1 January 2011. The coastal area is mainly covered in Volume III, published in 2005 (*Cornilly 2005*). The update for the province of West Flanders after 1 January 2001 was discussed in the heritage magazine '*In de Steigers*'. In view of the redistribution of competences since January 2018, the province of West Flanders will no longer issue new numbers. An overview of the spatial distribution of the protected architectural heritage along the coast and additional information can be consulted on the geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be*).

For certain groups of architectural heritage such as lighthouses (*Warzée 1999*), military heritage on the coast from WWI (*Deseyne 2007*, *Vernier 2012*), the Atlantic Wall (*Philippart et al. 2004*, *Philippart 2014*), tourism-related heritage (*Cornilly 2006*), and modern architecture (*Cornilly 2007*), thematic overview publications exist as well, although they are not exhaustive.

The industrial archaeological heritage is increasingly addressed in the context of heritage conservation. This industrial heritage includes typical maritime components such as shipyards, port infrastructure and fish processing companies (*Onderzoeksbalans – Bouwkundig erfgoed*). Because of its maritime location, Flanders hosted a fairly large number of shipyards that built both wooden and metal vessels for inland, coastal and maritime navigation until the 20th century. The study of the industrial heritage of shipbuilding in Flanders remains limited to a few case studies, such as the Van Praet and Van Damme shipyards in Baasrode (*Segers 1994*) and a first major 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 (e.g. *Himler 1993*, *Asaert et al. 1993* and *Himler and Moorthamers 1982*). The other Flemish ports have been far less studied. Also 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 for the period 1850-1950 is available (e.g. *De Clerck 2006*, *De Clerck 2007*). An overview of the history of Belgian oyster farming is given by *Polk (2000)*, *Halewyck and Hostyn (1978)*, *Pirlet (2012)*, *Steevens and Van Moerbeke (2015)* and *Pirlet (2016)* as well as on the following website: *www.vliz.be/wiki/Historiek_van_de_Belgische_oesterkweek* (see also theme **Marine aquaculture**).

10.1.4 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 quite a natural appearance (*Cornilly 2005*). The protected landscapes in the coastal zone include very diverse areas ranging from creek areas (*Lapscheure*, *De Grote Keignaard* in Zandvoorde), backlands (*Lampernisse*), dune regions (*Westhoekduinen, Houtsaegerduinen* 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.

An overview of the spatial distribution of the known landscape heritage can be found in the *inventory of landscapes with heritage value* and on the geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be*). Anchor sites, or in other words very valuable landscape ensembles from a heritage perspective, are represented in the *landscape atlas*. An overview of the protected landscapes in West Flanders on 1 January 2001 can be found in '*Monumentaal West-Vlaanderen*' (*Cornilly 2005*). The situation after 1 January 2001 is recorded in the heritage magazine '*In de Steigers*', in the *inventory of landscapes with heritage value*, in the *geoportal* of Flanders Heritage Agency, and via the website *Monumentenwacht Vlaanderen*.

10.1.5 Movable and intangible heritage[3]

The term 'movable heritage' covers historically valuable objects which are usually to be found in museum collections, archives or heritage libraries. Museums 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 zone[4], some of which focus specifically on the coast (see *www.erfgoedinzicht.be* for the digital disclosure to the collection of these museums). Furthermore, several libraries are located along the coast. Some of them have publications with historical value in their collection. An overview of these collections is given on the website '*collectiewijzer*' of the Flemish heritage library. The *VLIZ library* of the Flanders Marine Institute exclusively collects publications about the sea and coast. *The library and documentation centre of the National Fisheries Museum (NAVIGO)* focuses on the history of fisheries in the broadest sense.

Furthermore, the archives of the various levels of government are often important sources of movable heritage and '*the Archiefbank Vlaanderen*' contains overviews of private archives that are important for maritime heritage (e.g. from the free fisheries schools). The State Archives of Belgium preserve many documents related to coastal municipalities. An overview of the latter archives can be found in the online *database*. The provincial archive has its own database, *Probat*, where in addition to the archives of the province of West Flanders, various municipal archives can be searched as well (e.g. De Haan, Koksijde, Middelkerke, Blankenberge). The archive of Ostend has its own *website*. In addition, the various image databases should also be mentioned for their role in the disclosure of historical imagery. The *provincial image bank* contains photographs of many coastal municipalities. The municipalities of De Panne, Koksijde and Nieuwpoort are included in the image bank *Westhoek verbeeldt* of the *Erfgoedcel CO7*. Ostend has its own *image bank*, which was recently integrated in the image bank (*beeldbank*) *Kusterfgoed*. De '*beeldbank Kusterfgoed*' collects mainly the heritage collections of the municipalities Middelkerke, Ostend, De Haan and Blankenberge, and also focuses on the collections that belong to local heritage players and private persons. The initiative '*a century of sea fisheries in Belgium*' of VLIZ collects historical data about the landings and legislation of the Belgian fisheries (see also theme **Fisheries**). Recently, a reference work on the core aspects of the broader fisheries sector during 500 years of Flemish sea fisheries was published (*Lescrauwaet et al. 2018*). This work is based on archive, data and literature research, and the information is provided via the central online platform '*History of Belgian sea fisheries*'. Finally, the local historical societies also preserve a lot of interesting materials. An overview of all societies on the coast is available on the following website: *Heemkunde Vlaanderen*.

Comparable to the protection of buildings, valuable (sub-)collections or documents can also be protected by decree (*Topstukkendecreet*). The list of valuable objects and collections (*topstukkenlijst*) provides an overview of the protected movable heritage. Some objects from the collections of the NAVIGO museum and *Museum aan de Stroom* (*MAS*) are also included in the Dutch initiative *Maritiem Digitaal*, a searchable collection system of the maritime world. In addition, items from the NAVIGO museum collection are made digitally accessible by *Lukas-Art Vlaanderen*.

[2] Research into the genesis and significance of the maritime landscape (drowned palaeolandscapes) has been included in maritime archaeology.
[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 zone also have interesting collections on maritime and coastal heritage.

Intangible cultural heritage represents traditions, customs, knowledge and practices inherited or historically developed by a group of people - simply 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 the *Platform for intangible heritage in Flanders*. An overview of intangible heritage is offered in the *inventory of intangible heritage*. Individuals or organisations must submit an application themselves to be included in the inventory. This inclusion is a prerequisite to apply for UNESCO recognition. Some examples of intangible heritage on the coast are the horseback shrimp fishermen in Oostduinkerke and the carnival of Blankenberge.

The typical coastal intangible heritage is currently threatened by several factors. The fisheries heritage as well as the fisheries sector are under pressure. Rising fuel prices, increasing regulation and decreasing catches cause the professional reorientation of many fishermen. Because of this, the movable and intangible heritage related to fisheries has an increasingly smaller source of supply. A museum such as *NAVIGO museum* 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. As well as *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.

10.2 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* for full list of UNESCO 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 for it. 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 *inter alia* promotes the Convention of 2001. Furthermore, Belgium is also involved as member of the Advisory Council at the organisation '*European Maritime Heritage*'.

The main legal framework for activities at sea is the UN 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 has only recently recognised immovable heritage (landscapes, architectural heritage and archaeological heritage) as part of the cultural heritage. The Commission proposes a new 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 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 is the EU year of cultural heritage, in which there will be intensive cooperation with major European heritage organisations such as Europa Nostra and Nemo. In addition, the *Council of Europe (culture, heritage and diversity)* plays a very important part in heritage conventions, such as the *Convention for the Protection of the Architectural Heritage of Europe* (Granada 1985), *Convention for the Protection of the Archaeological Heritage of Europe* (revised) (Valletta 1992), *European Landscape Convention* (Firenze 2000) and the *Convention on the Value of Cultural Heritage for Society* (Faro 2005) (see *website* 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 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 in the BNS and the associated royal decree are of importance (see website *www.vondsteninzee.be* for more information). This law (the so-called 'OCE law') implements the Belgian ratification of the UNESCO Convention for the Protection of the Underwater Cultural Heritage (2013) to a considerable extent. Under the OCE law, discoveries younger than 100

years old can be recognised as cultural heritage under water, which is not possible through the UNESCO Convention. According to the OCE law, every discovery at sea must be reported to the Governor of West Flanders. He serves as 'receiver of the cultural heritage under water' and is not only responsible for the registration and the announcement of discoveries, but also offers advice to the competent secretary of state for the North Sea concerning a discovery's possible heritage status. On 21 September 2016, a RD was assigned imposing measures concerning in situ protected under water heritage, and several ministerial decisions (MD of 4 October 2016) were adopted for the protection of underwater cultural heritage, in which measures for protection of 9 of the 11 already affirmed wreckages in the Belgian North Sea are included (see *measures of enactment of the law of 4 April 2014*, see further **10.3.1. Maritime archaeology**). Concerning the shipwreck sites UB-29 and *HMS Wakeful*, these measures where not necessary because of their location within a fairway. These sites are therefore indirectly protected.

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*). In addition, a 'best practice' brochure was developed with recommendations about how to implement the underwater heritage best in the schedule and performance of works at sea, as well as with different protocols on alerting archaeologic discoveries (download everything through *www.sea-arch.be/en/results*).

In Flanders, the competences with regard to immovable, movable and intangible heritage are covered by different bodies:

- *Flanders Heritage Agency*, part of the Environment Department (*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 Efgoed – Samen de zorg voor onroerend erfgoed vanzelfsprekend maken 2017*). The agency carries out these tasks in an integrated way since 1 January 2013. The *OMG Inspection Agency* of the Environment Department 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 (*www.kunstenenerfgoed.be*). The Flemish Interface Centre for Cultural Heritage (*FARO*) plays an intermediary role between the cultural heritage field (movable and intangible heritage) and the government, supports cultural heritage organisations, local and provincial governments and managers of cultural heritage, and promotes the development of the cultural heritage field. In addition, the organisation *Herita vzw* supports and unites everyone involved in heritage. *Herita vzw* also manages several heritage sites and organises activities related to heritage (e.g. Open Monumentendag);
- The policy notes on immovable heritage (*beleidsnota onroerend erfgoed (2014-2019)*) and culture (*beleidsnota cultuur (2014-2019)*) contain the strategic lines of the heritage and cultural policy in Flanders, which are concretised and prioritised in annual policy letters;
- Since 1 January 2015, a new decree on immovable heritage has been in place (see *Brochure Onroerend Erfgoed – De Regelgeving 2014*, *Brochure Onroerend Erfgoed – Een toelichting 2014*) that replaces three preceding decrees (Monument decree of 1976, Archaeology decree of 1993 and Landscape decree of 1996) and a law on the preservation of monuments and landscapes (1931). All the maritime immovable heritage present in the coastal zone, including the beach up to the average low water mark at springtide, is included in this new decree;
- 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 (*Provincie West-Vlaanderen 2008*) and the Cultural Heritage decree of 6 July 2012 with regard to cultural heritage (decree of 6 July 2012 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 (*Strategische Visienota*) 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 November 2015 (see also *Brochure Onroerend Erfgoed – Varend Erfgoed in Vlaanderen*).

The Government of Flanders has positioned the depot policy on the agenda in 2008 by appointing the regional depot policy to the five provinces and the Flemish Community Committee. The *province of West Flanders* is responsible for the 'depot policy' and invests in maritime heritage by developing projects in which coastal actors can participate (see *De Provincie aan de Kust. Beleidsbrief Kust 2011*). Equally as important in this context is the establishment of the heritage cell *Kusterfgoed* (*www.kusterfgoed.be*) in 2015, at which four coastal municipalities (Middelkerke, Ostend, De Haan and Blankenberge) work together around movable and intangible heritage at the coast. Since 1 January 2018, the Government of Flanders, and no longer the municipalities themselves, determines the beacons of this regional depot policy (see further **10.5.5 Movable and intangible heritage**; website *depotwijzer.be*).

10.3 Spatial Use

10.3.1 Maritime archaeology

The geographic position of the maritime heritage in marine areas is included in a number of databases. These also play an important role in the 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 has been developed.

As far as the BNS concerns, there are three databases that offer structured information: *www.maritieme-archeologie.be*, *wreck database* (and *map viewer*) and *www.wrecksite.eu*. Within the *SeArch project*, an interactive geoportal concerning the underwater heritage (including prehistorical discoveries) was developed in the BNS (*www.sea-arch.ugent.be*).

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 which are recognised as cultural heritage underwater by the law of 4 April 2014 are listed in a register on the following website: *www.vondsteninzee.be*.

Since 2014, underwater cultural heritage has indeed received a spatial translation by the recent recognition and protection of eight ship wreck sites (the lightship *West-Hinder*, de *HMS Wakeful*, a 19th century *wooden sailing ship* that perished in front of 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*) and the MD of 6 April 2018 recognised 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).

In annex to the RD of 20 March 2014 concerning the marine spatial plan (MSP), the cultural and ecological importance of the more than 215 (ship)wrecks that lay in the BNS is acknowledged (*Maes and Seys 2014*). In a new MSP (*MSP 2020-2026, public consultation 2018*), the respect of underwater cultural heritage in the BNS plays an important purpose, wherein:

- the most valuable cultural heritage under water is in situ protected according to a legal procedure;
- the acknowledged wrecks for which protection measures apply 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.

10.3.2 Architectural heritage along the coast

The new geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be*) provides an overview of the geographic location 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 dispose of an *Action Plan Architectural Heritage* to protect, preserve, manage and evaluate future developments.

10.3.3 Landscapes with heritage value

The geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be*) provides an overview of the geographic location of the architectural heritage in the coastal area (see also the inventory *landscapes with heritage value*).

10.4 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. Flanders is mostly associated with heritage, art

and artists, beer, and good food and beverages, according to a *Reputatieonderzoek (2017)* by Tourism Flanders (*Toerisme Vlaanderen*). Furthermore, the report of the project *Cultural Heritage Counts for Europe* discusses the value of cultural heritage and its impact on Europe's economy, culture, society and the environment. In general, marine and maritime cultural heritage are underappreciated (*Pieters 2017*). The social and economic advantages that this heritage entails are often unknown.

With regard to the coastal zone, primarily the economic benefits related to coastal tourism are known (see also theme **Tourism and recreation**). According to *De Baerdemaeker et al. (2011)*, 189,229 (or 10% of) overnight stays in hotels on the coast were related to the presence of immovable heritage in 2009. Along with day trippers and recreationists, heritage tourism expenditure amounts for more than 2 million visitors annually, whereas the total heritage-related

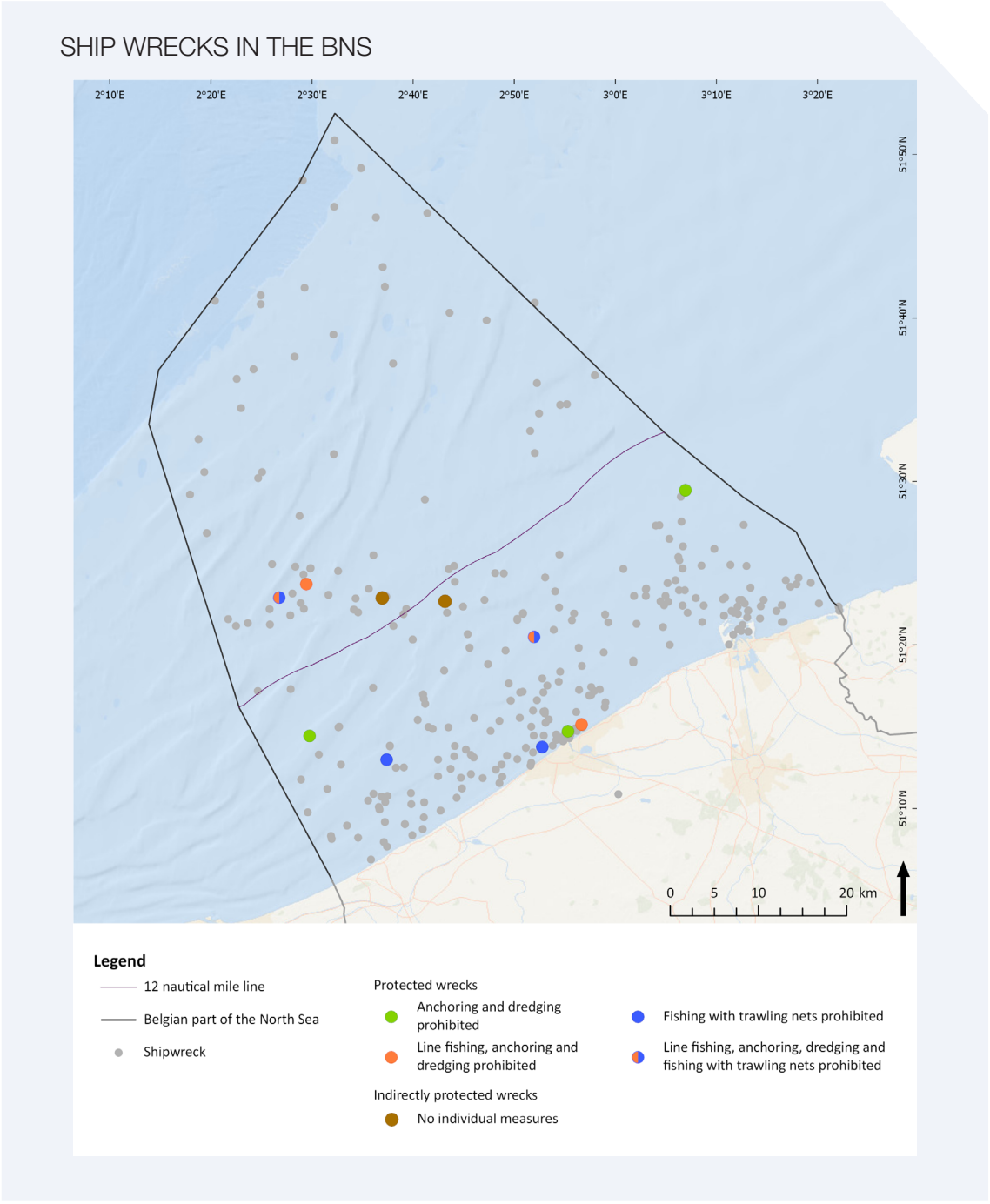

Figure 1. Ship wreck sites in the BNS. The individual protective measures are displayed for the 11 recognised ship wreck sites (Source: Flanders Heritage Agency, MD of 4 October 2016).

tourism expenditure amounts to almost 60 million euro. In the publication *Trendrapport Kust (2015-2016)*, numbers on the cultural attractions are available (see also theme **Tourism and recreation**). According to Maes et al. (2005) (*GAUFRE project BELSPO*), many shipwrecks in the BNS create a tourism revenue. However, this kind of revenue is rather diffuse and difficult to quantify.

The other aspects of the societal importance of cultural heritage in the coastal zone are less known and only some fragmented figures and information exist:

- According to *Maelfait et al. (2012)*, more than 4 million euro of grants were allocated between 2008 – 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), the house would get 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*);
- In a number of historic shipyards, social employment projects are developed;
- Museums are also associated with education. However, there are no data available regarding their impact;
- The recent 'Zeebrugge project' is a good example of how an economic driven project (Complex Project Coastal Vision) can happen in synergy with research into drowned landscapes and underwater heritage. The broad media attention for the recent discoveries of fossil bone material in the '*Scheur*' near Zeebrugge confirms this great social relevance.

10.5 Sustainable use

10.5.1 Maritime archaeology

Until recently, underwater heritage was barely taken into account, mainly because of the ignorance about it. In 2014, however, a new law on the protection of underwater cultural heritage in the BNS entered into force (law of 4 April 2014). This law introduces 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 finds on the beach should be reported to the *Flanders Heritage Agency* (see also *Van Haelst et al. 2016b*, *De Blauwe 2017*). The law falls within the scope of the Belgian ratification (2013) of the UNESCO Convention (Paris 2001) on the protection of the underwater cultural heritage. At the end of 2016, five new shipwrecks in the North Sea were recognised as cultural heritage on the basis of this law. 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 HMS Wakeful and the UB-29) (MD of 4 October 2016). Furthermore, 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 the annex to this maritime spatial plan (RD of 20 March 2014) (*Maes and Seys 2014*). There is no 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 use of certain marine areas. In the *Nemo Link project*, which aims at connecting transmission networks of the United Kingdom and Belgium, is strived towards maximal evasion of known or newly detected heritage sites to reduce the effect on the maritime cultural heritage to a minimum (see also theme **Energy (including cables and pipes)**). Knowledge about the heritage sites and their position along the cable route is crucial herein.

10.5.2 Historical fleet

Since 29 March 2002, there has been a decree that regulates the protection of the historical fleet (i.e. *Varenderfgoeddecreet*). This decree was modified on 9 May 2014 and has, together with the accompanying decision on the historical fleet 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 historical fleet policy is implemented by Flanders Heritage Agency. A separate section of the Royal Commission for Monuments and Sites has been created to advise the minister on the historical fleet. On 1 January 2015, this commission was changed to the Flemish Commission for Historical Fleet (VCVE). In order to achieve a responsible conservation policy, an inventory of the historical fleet has been developed (*https://inventaris.onroerenderfgoed.be/ivm/varend/zoeken*).

In the beginning of 2018, 28 vessels were already protected under the historical fleet policy (see *inventory*). Not all of the protected and inventoried vessels are linked to the coast. Other sectors, such as inland shipping, are included in these numbers as well.

10.5.3 Architectural heritage along the coast

Due to the 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 and replaces three preceding decrees (Monument decree of 1976, Archaeology decree of 1993 and the Landscape decree of 1996) and the law of 1931 on the conservation of monuments and landscapes. Since 2009, the architectural heritage has been 'established' in the inventory (*https://inventaris.onroerenderfgoed.be*), 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://beschermingen.onroerenderfgoed.be*.

10.5.4 Landscapes with heritage value

The scarcity of open space on the coast also applies to landscapes with heritage value. In addition to the protected landscapes with heritage value, which usually have an important ecological value as well, the immovable heritage sector is currently mainly working with 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 Plan - *Ruimtelijk Structuurplan Vlaanderen*). An anchorage area is a valuable landscape with a series of heritage elements (landscape, architectural, archaeological, maritime). An anchorage area is described in the landscape atlas (see *https://geo.onroerenderfgoed.be*).

In the past, these anchorage areas only received a legal status after the 'designation'. From then on, the local government is obliged to take it into account when developing a Spatial Implementation Plan (SIP) (*Landschappen: een kennismaking 2013*). The decree on immovable heritage (*Onroerenderfgoeddecreet*) no longer allows such a 'designation'. In order to preserve the immovable heritage, items from the landscape atlas can be determined in the *'established' landscape atlas*. 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 'established' landscape atlas and with a heritage plan (*onroerenderfgoedrichtplan*).

10.5.5 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), KMSKA (Antwerp), and MSK Ghent. 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).

A great deal of movable heritage has not been included in the list of pieces with an exceptional value. Therefore, the province of West Flanders has developed a so-called *depot policy* with the support of the Government of Flanders (more information: *Steen and Van den Nieuwenhof 2008*). On 27 May 2016, the Government of Flanders reached an agreement on slimming down the provinces including the discontinuation of provincial tasks regarding cultural heritage policy. As from 1 January 2018, the Government of Flanders itself will determine this regional depot policy. Since 2008, this policy focuses on two lines including the registration of movable heritage possessed by museums, local heritage 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 *inventory* of intangible heritage currently contains 53 elements, two of them are specific to the coast: the carnival of Blankenberge and horseback shrimp fishing in Oostduinkerke. The inventory is established according to the bottom-up principle. Organisations or individuals must submit an application 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, the annexation 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*. In 2013, horseback shrimp fishing in Oostduinkerke was recognised by UNESCO as intangible heritage.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex,* the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
World Heritage Convention	1972	1996
United Nations Convention on the law of the sea (UNCLOS)	1982	1994
Convention on the protection of the underwater cultural heritage	2001	2009 (ratified by Belgium in 2013)
Convention for the safeguarding of the intangible cultural heritage	2003	2006

European legislation

Title	Year	Number
Convention for the protection of the architectural heritage of Europe	1985	1987
Convention for the protection of the archaeological heritage of Europe (revised)	1992	1995 (ratified by Belgium in 2010)
European Landscape Convention of the Council of Europe	2000	2004
Convention on the value of cultural heritage for society	2005	2011

Belgian and Flemish legislation

Abbreviation	Title	File number
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
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
RD of 25 April 2014	Koninklijk besluitbetreffende de bescherming van het cultureel erfgoed onder water	2014-04-25/21
RD of 21 September 2016	Koninklijk besluit betreffende de reglementaire maatregelen ter bescherming van het cultureel erfgoed onder water	2016-09-21/12
MD of 4 October 2016	Ministerieel besluit betreffende individuele maatregelen ter bescherming van het cultureel erfgoed onder water	2016-10-04/03
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 4 April 2014	Wet betreffende bescherming van het cultureel erfgoed onder water	2014-04-04/07

11

Social and economic environment

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Europe's coastal zones are characterised by a rapidly growing population and a population density that is on average 10% higher than in the hinterland areas. Moreover, these regions are also subject to an increasing development of infrastructure and economic activities (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*, *Eurostat 2017*). Hence, coastal zones are regions with a unique identity and specific challenges. However, the coastal area itself is not homogeneous. On the one hand, there is the distinction between coastal municipalities and hinterland municipalities. But also within the coastal municipalities, there's a distinction between the coastal belt (districts located against the sea) and the more remote districts. While the districts along the coastal belt have a metropolitan character, the more remote districts more often have the characteristics of the hinterland municipalities within the coastal area.

The Belgian coast is characterised by a typical social environment with, *inter alia*, an increased population density, a large ageing population and a high number of second residences. Real estate prices can vary considerably between coastal municipalities, but also within the same coastal municipality between the coastal belt and the areas with a more rural character (*Stedelijk systeem kust 2017*). In addition, from an economic point of view, the coast is also a specific region with, on the one hand, large economic gates (two seaports and an international airport) and, on the other hand, increased unemployment, seasonal employment and a limited number of high-quality jobs for the higher educated (*Breyne et al. 2007*, *Maelfait et al. 2012*). In this theme text, the Belgian coastal area is compared in the first place to the province of West Flanders. In the publications mentioned below, the figures are also benchmarked within larger geographic areas such as the Flemish Region.

11.1 Policy context

In Belgium, policy on the economic environment involves both federal and Flemish actors. At the federal level, there are the federal public services *FPS Employment, Labour and Social Dialogue* and *FPS Economy, SMEs, Self-Employed and Energy* (see the federal policy statements *Werk 2014* and *Economie en consumenten 2014*). In addition, there are the Flemish policy domains of *Work and Social Economy* and *Economy, Science and Innovation* (see the Flemish policy memorandums *Sociale economie 2014-2019* and *Werk, Economie, Wetenschap en Innovatie 2014-2019*).

At the Flemish level, housing policy and spatial planning belong to the policy domain Town and Country Planning, Housing Policy and Immovable Heritage (*RWO*) (see the Flemish policy documents *Omgeving 2014-2019* and *Wonen 2014-2019*). Since 1 April 2017, the policy domains of Environment, Nature and Energy (LNE) and Spatial Planning, Housing Policy and Immovable Heritage (RWO) have formed a new policy domain: the Environment Department (*OMG*). Other Flemish policy domains 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.

The province of West Flanders (e.g. *Streekhuis Kust*, *De Provincie aan de Kust. Beleidsbrief Kust 2011*) and the municipalities are involved with the conversion of economic policy, housing policy and spatial planning (see below). The legal framework for spatial planning can be found in the *Codex Coastal Zone, theme Spatial Planning*. In addition, local legislation for coastal residents is also listed (*Codex Coastal Zone, theme Local legislation*).

The Environment Department has launched a territorial development programme (*T.OP*) for the coastal area and has signed a cooperation agreement with the province of West Flanders, with the aim for an action-oriented programme for the spatial development of the coastal area in the short and medium term for themes such as urban reconversion, salinisation and spatial quality. On the basis of stakeholder consultation, the core team continues to work on 4 sites that apply to the coastal area: 'Seawall and urban areas, 'The dune belt', 'The polders' and 'The accessible Westhoek'. Each of the sites has a central theme and focuses on solid projects or on knowledge gathering and sharing. Within the 'Seawall and urban areas' site, the general focus is on densification in accessible places and on providing a range of residential options for different types of inhabitants (families, the elderly, etc.). The site will also look at how the built-up area can contribute to robust coastal protection (see also theme **Safety against flooding**). The 'dune belt' site, on the other hand, focuses on the possible optimisation of the connectivity between the different dune areas (mainly western coastal area). In the 'polders' site, particular attention is paid to the role and place of water in the landscape and in all possible forms of use. In 'accessible Westhoek', it is examined how spatial development can be linked to the mobility policy.

11.2 Spatial use

The current spatial use has been and still is determined by the regional plans drafted by the federal government. A regional spatial plan corresponded approximately to one or more districts, where the space was arranged into

areas where housing and facilities could grow further, where (commercial) activity could be accommodated, where camping sites were provided in recreational areas, where areas were protected as nature reserves, as well as where agricultural areas were given their place. A destination 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, there are currently differences between the various coastal municipalities concerning the actual implementation, such as the heights and densities of apartment blocks.

The planning system was changed by the new Flemish decree on town and country planning (decree of 18 May 1999). The destinations in a regional plan remain valid until they are replaced by a new destination via a spatial implementation plan (SIP). Such SIPs can be elaborated up by municipalities, provinces or the Flemish Region. The establishment of a SIP is the implementation of a spatial vision, which is described in a spatial structure plan. There are three spatial structure plans: the Spatial Structure Plan for Flanders (*RSV*), the West Flanders Spatial Structure Plan (*PRS-WV*) and the municipal structural plans. These spatial visions determine the future of the use of space. The Regional Plans, SIPs and BPAs can be consulted on the following website: *www.giswest.be/gewestplan-rups-internet*. In 2016, the communication and participation process took place following the revision of the PRS-WV.

In the *RSV*, the coast is indicated as an urban network and a tourist-recreational network. This means that a coherent urban policy must be pursued for the coast, with opportunities for further tourism-recreational activities. This will give the regional urban area of Ostend (consisting of parts of Middelkerke, Ostend, Bredene and Oudenburg) the role to meet new housing and business needs. In addition, Ostend and Zeebrugge have been designated as economic gateways, allowing further development of the ports of Zeebrugge and Ostend, as well as Ostend-Bruges International Airport. The development of these gates is laid down in regional spatial implementation plans (RSIPs). The Flemish Region also anchors the large, contiguous nature areas in RSIPs such as the Zwin, the beaches between seaside resorts on the west coast, etc. The *RSV* and the RSIPs can be consulted at: *www.ruimtelijkeordening.be*. Parallel to the further implementation of the Spatial Structure Plan, the Government of Flanders approved the 'White Paper Policy Plan for Spatial Planning' in Flanders on 30 November 2016 (*Witboek Beleidsplan Ruimte Vlaanderen 2017*). In the White Paper, the Government of Flanders formulates objectives, spatial development principles and activities that will form the basis for transforming Flanders' space. A draft BRV (*Beleidsplan Ruimte Vlaanderen*) is currently being prepared. Once the draft BRV has been approved, a public consultation is planned.

The *PRS-WV* refines the spatial planning in the coastal area, giving each coastal municipality opportunities for further development. This needs to be concretised by the municipalities in municipal structural plans and translated into municipal spatial implementation plans. The province determines the possibilities regarding constructions on the beach and dike by means of provincial spatial implementation plans. The PRS and SIPs are available at *www.west-vlaanderen.be/ruimtelijkeordening*.

11.3 Current state

11.3.1 Social environment

THE COAST AND ITS INHABITANTS

On 1 January 2017, the coastal region[1] numbered 423,146 inhabitants (coastal municipalities: 337,199; hinterland municipalities: 85,947). This is 35.6% of the total population in West Flanders (Source: rijksregister 2017, processed by the province of West Flanders). In the period 2002-2017, the population in the coastal area increased by 4.5% (figure 1), an increase comparable to the increase in the surrounding coastal areas around the North Sea (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*).

Both coastal and hinterland municipalities are experiencing a population increase. This increase is more pronounced in coastal municipalities, but from 2015 onwards the hinterland municipalities catch up strongly with the coastal municipalities (figure 1). The population increase in the coastal area is slightly higher than the average in West Flanders, due to the higher population increase in the coastal municipalities (Source: rijksregister on 1 January 2017, processed by the province of West Flanders).

Statistics Flanders presented new population projections at the beginning of 2018 (figure 2). The projections suggest a further population increase in the coastal area, although rather limited, +2% in the coastal municipalities and +1% in the hinterland municipalities.

[1] The coastal area comprises 10 coastal municipalities (Blankenberge, Bruges, Knokke-Heist, Bredene, De Haan, Middelkerke, Ostend, De Panne, Koksijde and Nieuwpoort) and 9 hinterland municipalities (Damme, Jabbeke, Zuienkerke, Diksmuide, Lo-Reninge, Gistel, Oudenburg, Alveringem and Veurne).

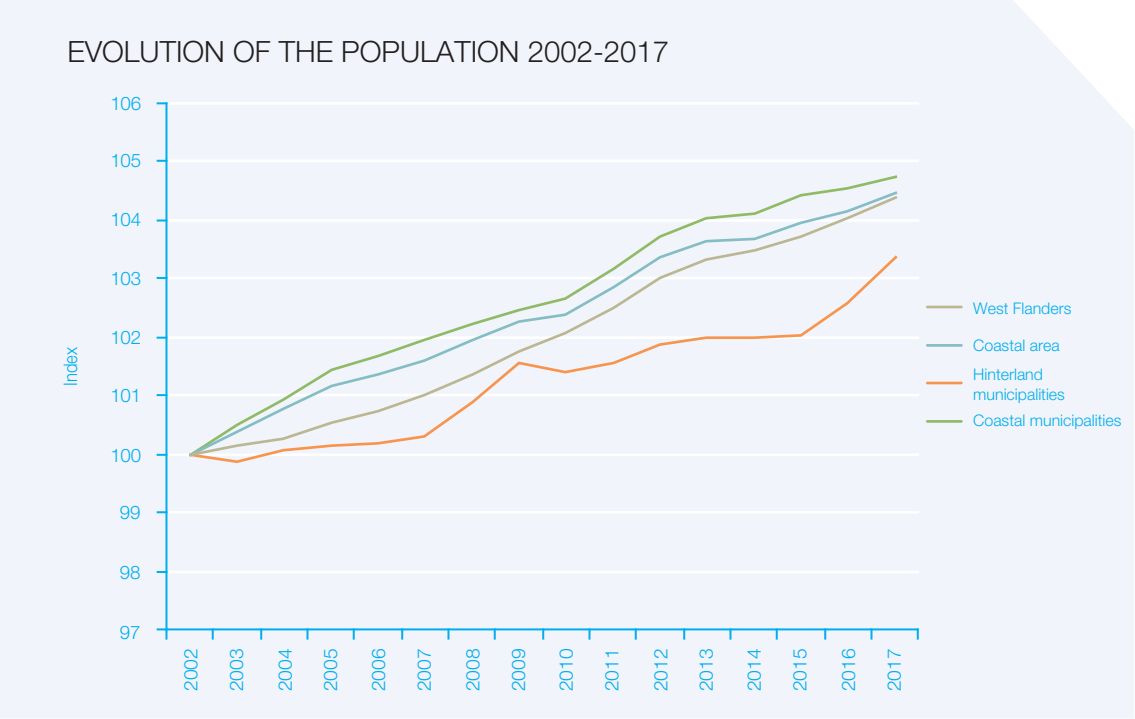

Figure 1. Evolution of the population in the coastal area (coastal and hinterland municipalities) and the province of West Flanders in the period 2002-2017 (Source: rijksregister, processed by the province of West Flanders).

The Belgian coast as well as the Dutch and parts of the Northern French Coast constitute the North Sea coastal area with the highest population density (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*). In the coastal zones of the Netherlands and Belgium, even regions with more than 1,000 inhabitants per km² are recorded (*North Sea Region climate change assessment 2016*). The average population density in the Flemish coastal area is 369 inhabitants per km². This average hides a certain variety: the population density of the coastal municipalities is 699 inhabitants per km², the population density of the hinterland municipalities is 129 inhabitants per km² (Source: *RESOC dataset 2016* at *www.pomwvl.be*). 80% of the inhabitants of the coastal area live in a coastal municipality (Source: national register on 01.01.2017, processed by the province of West Flanders).

The coastal population has a number of typical characteristics. According to the publication *Grensoverschrijdende atlas: Van Berck tot Brugge, één grens, twee gebieden, één gezamenlijke horizon (2006)*, the occupancy profile of the Belgian coast is very similar to that of the French Côte d'Azur. The dejuvenation and ageing population are more pronounced in the Belgian coastal area than in the rest of Flanders and West Flanders (Coudenys 2012 in *Maelfait et al. 2012, De Klerck 2011*). The age groups under 55 years decrease proportionally, the age groups older than 55 years increase proportionally (figure 3). Furthermore, the structural coefficients tell us something about the composition of the population (see the demographics table 1). In general, the coastal area can be divided into two realities, in which hinterland municipalities are following the province's trend and coastal municipalities show a different trend.

In West Flanders, for every 100 persons between 0 to 19 years of age, there are 146 people aged over 60. For coastal municipalities, this ratio rises to 213. The so-called 'grey pressure' in the coastal municipalities is 75: per 100 persons in the professionally active age range (20-59 years), there are 75 people over the age of 60. The internal ageing (the share of people aged 80+ within the group of 60+) amounts to 23 in the coastal municipalities. This means that the coastal municipalities score slightly lower than the hinterland municipalities and West Flanders. On 01.08.2017, 8 out of 10 coastal municipalities appeared on the list of 20 Belgian municipalities with the oldest population (Source: rijksregister). Only the municipalities of Bruges and Bredene were not included in this list.

On 1 January 2017, there were 143,808 persons aged 60+ in the coastal area (Source: rijksregister, processed by the province of West Flanders). The increase in the number of people aged over 60 between 2002 and 2017 amounts to 35%. During the same period, the number of young people under 20 in the coastal area decreased by 12% (from 85,152 in 2002 to 74,350 in 2017) (Source: rijksregister (population including waiting register, processed by the province of West Flanders)).

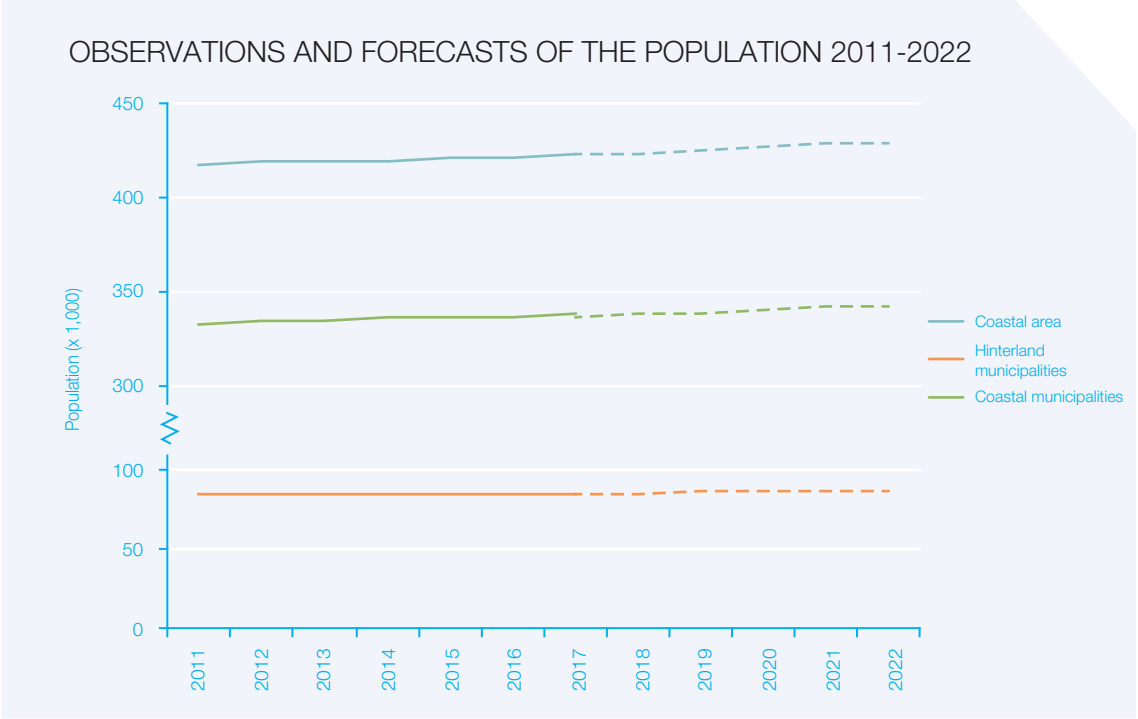

Figure 2. Observations and forecasts of the evolution of the population in coastal municipalities, hinterland municipalities and the coastal area (Source: Studiedienst Vlaamse Regering – SVR).

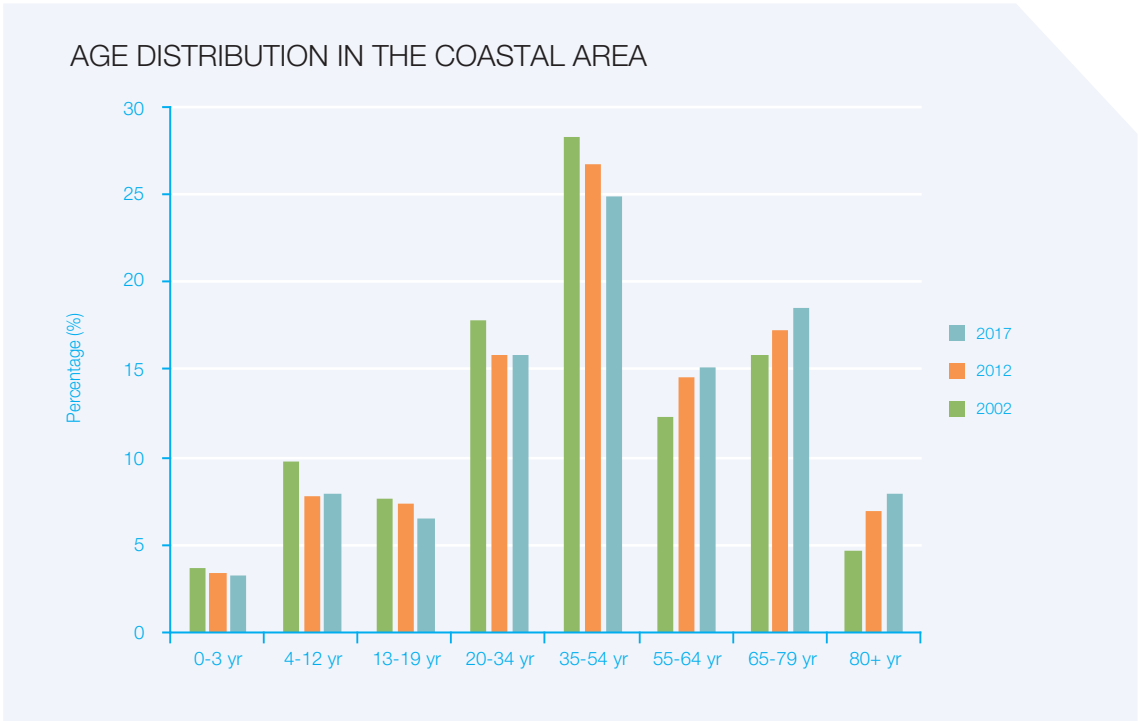

Figure 3. The evolution of the age distribution of the population in the coastal area between 2002 and 2017 (Source: rijksregister, processed by of the province of West Flanders).

Table 1. The structural coefficients in the coastal area (coastal municipalities + hinterland municipalities) and the province of West Flanders on 1 January 2017 (Source: rijksregister, processed by the province of West Flanders).

	Structural coefficients			
	Coastal municipalities	Hinterland municipalities	Coastal area	West Flanders
Ageing degree (60+/0-19 year)	213	133	193	146
Grey pressure (60+/20-59 year)	75	53	70	58
Internal ageing (80+/60+)	23	24	23	24
Family care index (80+/50-59 year)	55	44	52	48
Juvenile pressure (0-19 year/20-59 year)	35	40	36	40

On 1 January 2017, 199,857 households lived in the coastal region (Source: rijksregister 2017, processed by the province of West Flanders). In the period between 2002 and 2017, the number of households increased by 12.6%. The increase in the number of households is higher than the increase in the number of inhabitants. Over the past 12 years, the coast has therefore been characterised by a further reduction in family size, with average households becoming smaller. The average family size in the coastal area is 2.09. The municipalities in the hinterland have an average family size of 2.35, while the average family size in the coastal municipalities is 2.02 (*https://provincies.incijfers.be/dashboard*).

When the characteristics of the households are examined in more detail, a distinction can first be made according to the family composition. A household is made up either of a single person or of several adults living together, without children under the age of 20 (family without child), or of one or more adults living with one or more children under the age of 20 (family with children) (figure 4). The latter category also includes single-parent families. Of all households in the coastal area, 38% are singles, 41% have no children and 21% have children (figure 4). The coastal municipalities have on average more single people and fewer families with children than the hinterland municipalities and West Flanders (Source: rijksregister on 01/01/2017, processed by the province of West Flanders).

A distinguishing feature of the coastal municipalities is the large proportion of single people (figure 4). This group has increased strongly over the past 12 years (+28% in the coastal area, +32% in West Flanders) (see above: family dilution) (figure 5). The largest increase in the proportion of people living alone can be observed in the hinterland municipalities (+41%).

When we observe the population characteristics, a few indicators reveal the urban character of coastal municipalities: an older population, many people living alone and a higher population density. This urban profile first appeared in the deprivation atlases (*Kesteloot et al. 1996*, *Kesteloot and Meys 2008*) which contained an analysis at neighbourhood level. The neighbourhoods located along the coast show a very different profile than the neighbourhoods behind the coastal strip. The demarcation line between more and less deprived neighbourhoods does not manifest itself at the municipal level. In order to determine the urban profile of the coastal strip and the associated problems, an analysis at the neighbourhood level is necessary.

The deprivation atlas of the province of West Flanders (West Flanders Provincial Council, Data & Analysis Centre, *West Flanders Deprivation Atlas 2017*) confirms the urban character of the coastal municipalities and also notes that coastal towns are confronted with a higher than average deprivation (*West Flanders Deprivation Atlas 2017*). The most deprived neighbourhoods in West Flanders are found in the municipality of Ostend (20) (figure 6). In the coastal area, 19.7% of all households live in a deprived neighbourhood, which is higher than the average of West Flanders (14.35%). On average, 23% of the families living in coastal municipalities live in deprived neighbourhoods. In the hinterland municipalities, 4% of the families are affected (*West Flanders Deprivation Atlas 2017*, see also the *Municipal Index Cards – Deprivation*).

THE COAST AND ITS INHABITATION

The total surface area of the coastal area is 1,183 km². The coastal municipalities account for 42% of this area, the hinterland municipalities take up 58% (Source: FPS Economy, General Directorate of Statistics and Economic Information, based on the land register).

The Belgian coastal area has by far the highest share of built-up surface area of all European countries (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*, *Eurostat 2017*). In the

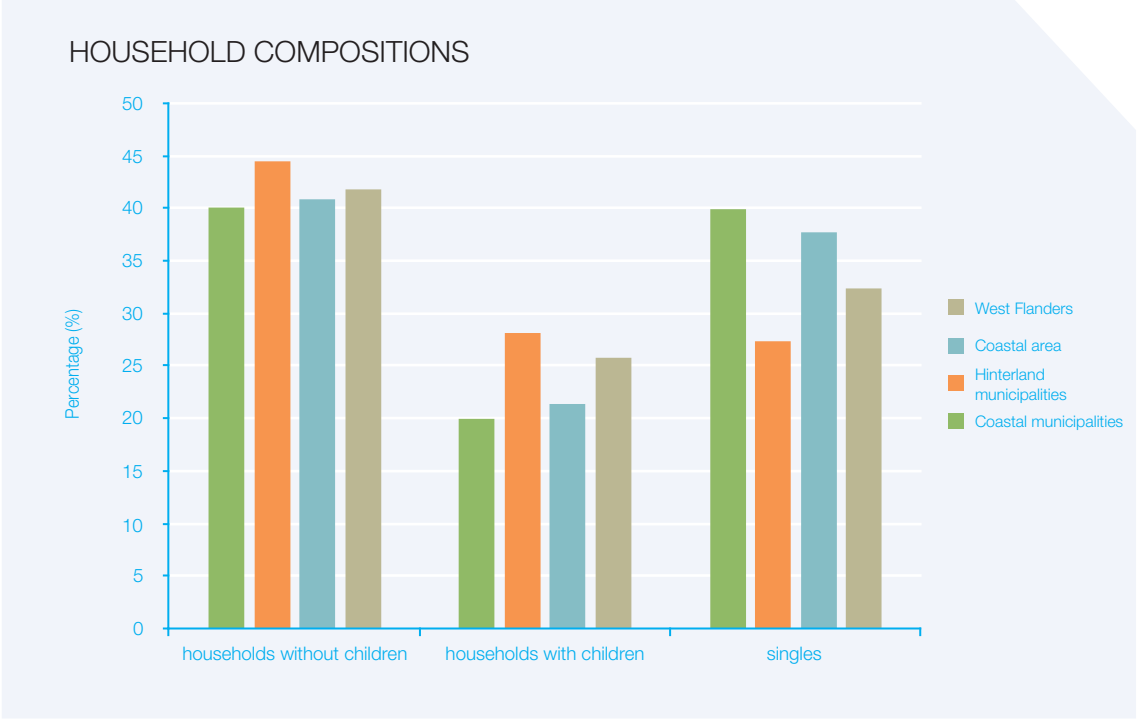

Figure 4. Overview of families without children, with children, and single persons in the coastal area (coastal municipalities + hinterland municipalities) and the province of West Flanders on 1 January 2017 (Source: rijksregister, processed by the province of West Flanders).

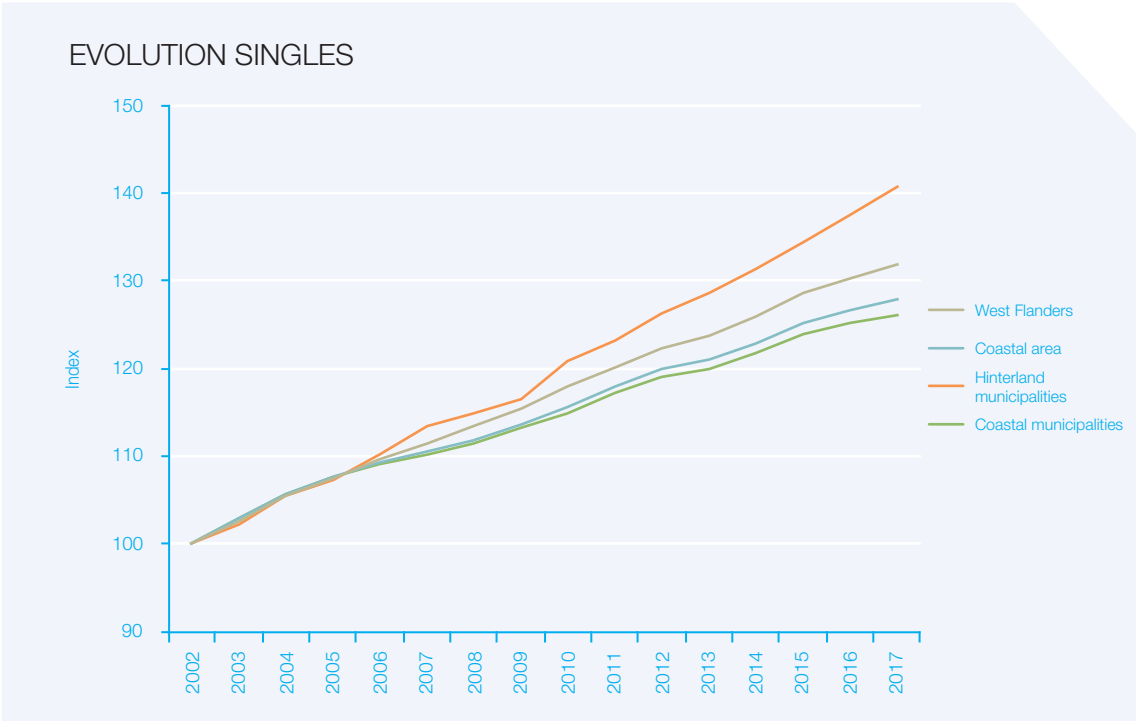

Figure 5. The evolution of singles in the coastal area (coastal municipalities and hinterland municipalities) and in the province of West Flanders in the period between 2002 and 2017 (Source: rijksregister, population on 1 January of the year, processed by the province of West Flanders).

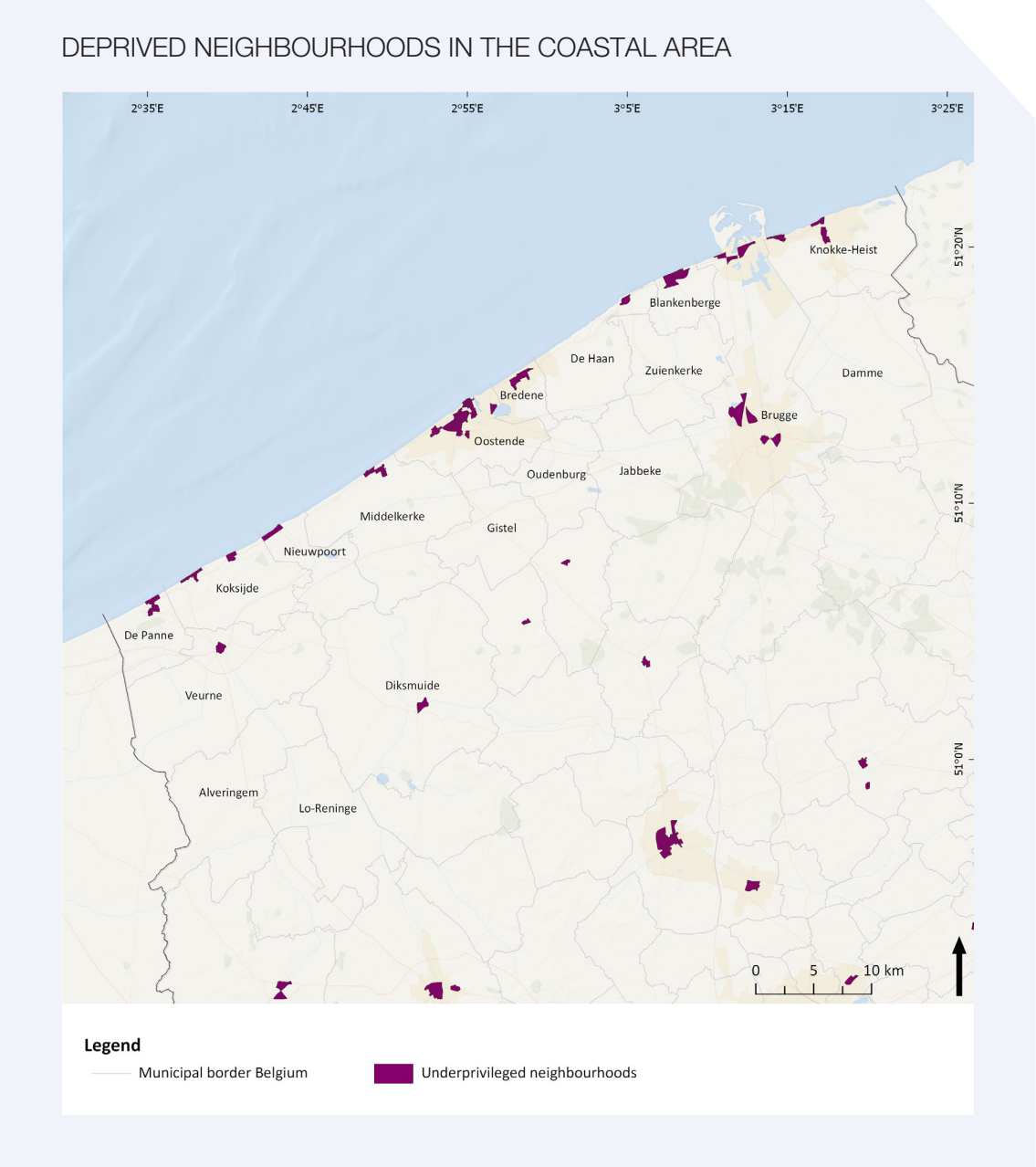

Figure 6. Location of the deprived neighbourhoods in the coastal area (Source: *West Flanders Deprivation Atlas 2017*).

publication: *Grensoverschrijdende atlas: Van Berck tot Brugge, één grens, twee gebieden, één gezamenlijke horizon (2006)* a comparison between the habitation of the Belgian coast and the northern French Côte d'Opale is discussed in more detail. The built-up area in the Belgian coastal area amounts to 239 km². 7% of the built-up area in the coastal area is used for residential purposes. For coastal municipalities, the built-up area as a function of housing amounts to 35% of the built-up area, whereas in hinterland municipalities this is only 4% (Source: FPS Economy, General Directorate of Statistics and Economic Information, based on the land register).

On 1 January 2016, the coastal area had 314,575 housing facilities (table 2). However, there is a big difference in the type of housing. In the coastal municipalities, 55% of the houses are situated in an apartment (block) while in the hinterland municipalities this concerns only 9% of the number of housing units. In the hinterland municipalities, 86% of the housing facilities are ordinary houses (*Kadasterkubus* of the province of West Flanders).

The total number of housing facilities in the coastal municipalities is considerably higher than the number of homes needed for housing its inhabitants. On average, 38% of the housing facilities in the coastal area is not used as a permanent home (figure 7). In other words, housing facilities often serve other functions, such as a second residence, some sort of business activity, and sometimes they remain tenantless houses (Coudenys 2012 in Maelfait et al. 2012).

Table 2. An overview of the housing facilities in the coastal area, divided by hinterland and coastal municipalities (Source: province of West Flanders, *Kadasterkubus*, situation on 1 January 2016).

	Coastal area		Hinterland municipalities		Coastal municipalities	
Total number housing facilities	**314,575**	***100%***	**39,120**	***100%***	**275,455**	***100%***
Residential houses	149,422	*47%*	33,743	*86%*	115,679	*42%*
Commercial premises	9,469	*3%*	1,666	*4%*	7,803	*3%*
Apartments and buildings	155,684	*49%*	3,711	*9%*	151,973	*55%*

The use of housing facilities for purposes other than permanent habitation might have negative consequences for society, such as an increased sense of insecurity and a lack of social cohesion. On the other hand, a large supply of second homes on the coast is one of the basic conditions for the tourism industry (see theme **Tourism and recreation**). Figure 7 clearly shows that a large housing surplus is mainly a coastal phenomenon. The hinterland municipalities have on average only 12% of housing facilities which are used for purposes other than permanent residence.

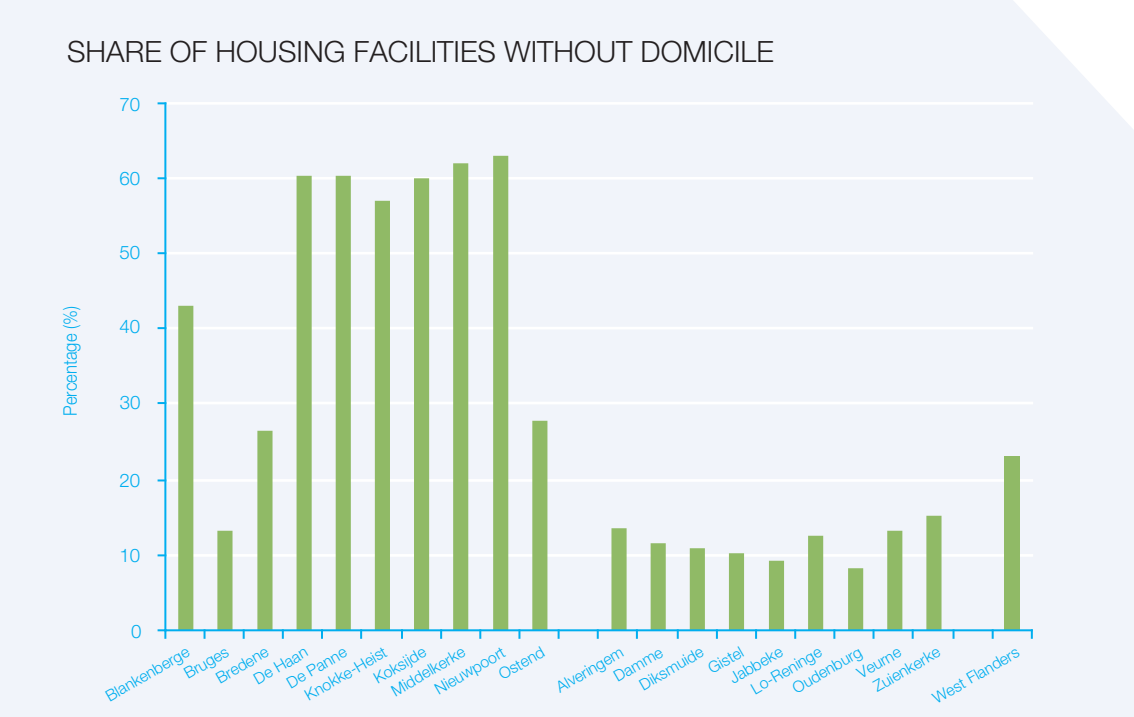

Figure 7. The share of housing facilities without domicile in the coastal area (Source: *Kadasterkubus* of the province of West Flanders, situation on 1 January 2016).

11.3.2 Economic environment

THE COAST AND ITS LABOUR MARKET

In 2015 there were 167,940 professionally employed (employees, self-employed and helpers) people between the age of 18 and 64 in the coastal area. As a result, the coastal area reached a share of 33.1% of the total number of employed people in West Flanders. At the end of 2015, the coastal municipalities counted 120,963 employees whereas the hinterland municipalities counted 21,315 which comes down to 34.5% of the total in West Flanders. In addition, 27,928 self-employed and helpers (excluding those working on a secondary basis) were also active in coastal municipalities and 9,792 in hinterland municipalities, accounting for 35.3% of the total of self-employees in West Flanders (Source: *RESOC dataset 2017* at *www.pomwvl.be*).

The coastal region is characterised by a very weak industrial base. The industry's share of salaried employment was only 9.0% in coastal municipalities at the end of 2015, compared to 19.6% in West Flanders. In the coastal municipalities no less than 86.3% of the salaried employment is in trade and services, of which tourism and catering constitute a major part. In these sectors, a large proportion of the jobs are seasonal employment. In West Flanders, 73.3% of all employees are active in trade and services (Source: *RESOC dataset 2017* at *www.pomwvl.be*).

In 2015, 141,732 inhabitants of the coastal municipalities and 40,231 inhabitants of the hinterland municipalities belonged to the professionally active population (working people and non-working jobseekers) aged between 18 and 64. This means that the coastal region accounts for 33.6% of the total figure for West Flanders. The degree of activity – the ratio of the professionally active population to the total population aged between 18 and 64 – was 73.0% in coastal municipalities and 78.2% in hinterland municipalities (2015). The degree of activity in coastal municipalities is somewhat lower than in West Flanders (76.8%). The employment rate – the ratio of the number of working people to the total population aged between 18 and 64 – is also lower in the coastal area (68.4%) than in West Flanders (72.0%) (figure 8; 2015). With an unemployment rate – the number of non-working jobseekers compared to the professionally active population aged between 18 and 64 – of 7.7%, the coastal region did worse than average in West Flanders (6.2%). This is mainly due to coastal municipalities (8.5%); in hinterland municipalities, the unemployment rate (4.9%) was significantly lower (Source: *RESOC dataset 2017* at *www.pomwvl.be*).

In 2016, there were 13,480 non-working jobseekers in the coastal area, or 42.5% of the total in West Flanders. In addition, there were 1,737 older unemployed people in the coastal region; this is 47.6% of the total in West Flanders (Source: *RESOC dataset 2017* at *www.pomwvl.be*). The unemployment pressure – the ratio of the number of non-working and older unemployed people to the current professional active population (18-64 years) – is clearly higher in coastal municipalities (6.8%) than in hinterland municipalities (3.9%) and West Flanders (5.0%) (figure 9) (Source: VDAB and RVA in *RESOC dataset 2017*). The highest unemployment pressure was observed in 2016 in Ostend (9.8%).

In 2014, there were only four coastal municipalities (Bruges, Knokke-Heist, Ostend and Nieuwpoort) with a positive commuting balance among employees. In these municipalities, the number of employees coming to work, but residing outside the municipality, exceeds the number of inhabitants working outside of the municipality (Source: at *www.pomwvl.be*).

In the following information sources: *West-Vlaanderen Ontcijferd editie 2016*, the *Gemeentelijke Steekkaarten* and the *RESOC dataset*, statistics about the labour market are available at the level of municipalities, districts and the province of West Flanders.

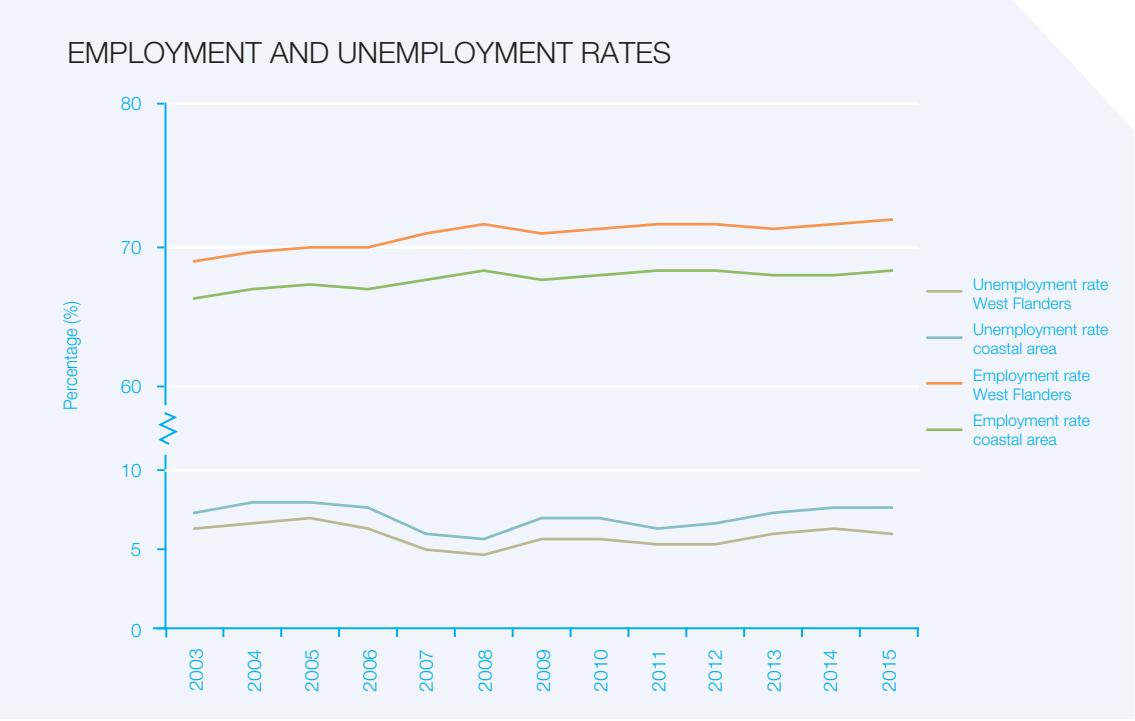

Figure 8. Evolution of the employment and unemployment rate in the coastal area and the province of West Flanders, 2003-2015 (Source: Steunpunt WSE, Processing: Department of DSA POM West Flanders).

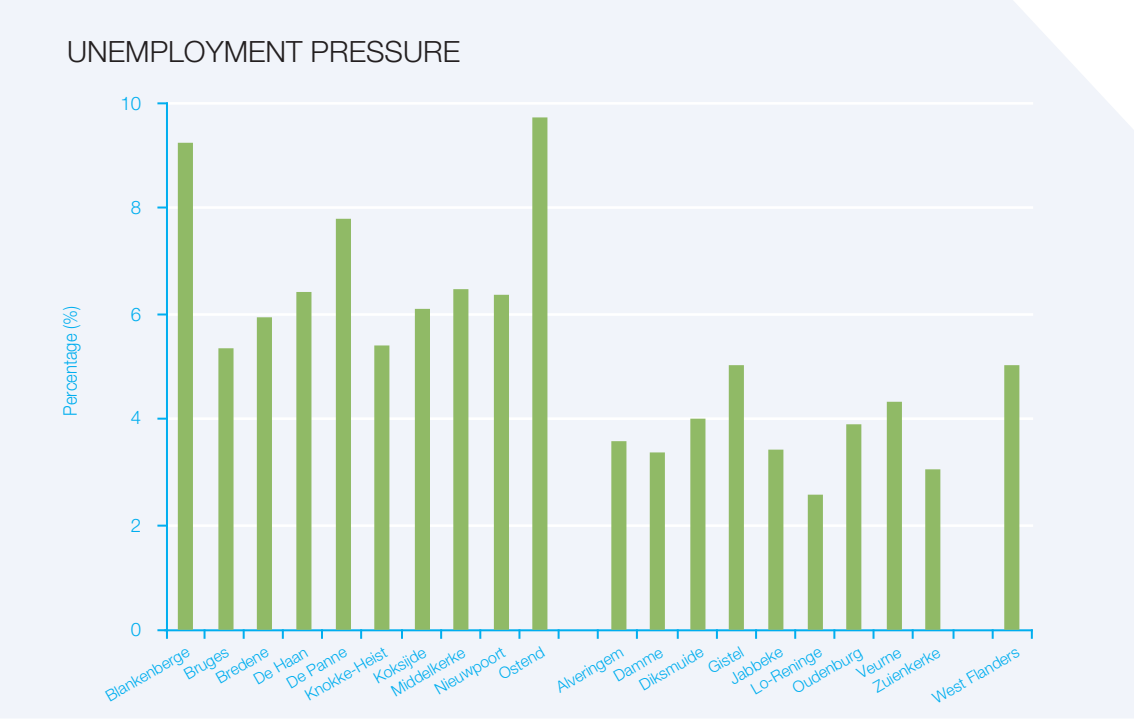

Figure 9. Unemployment pressure in the coastal area, 2016 (Source: *RESOC dataset 2017* at *www.pomwvl.be*, processing: DSA Department, POM West Flanders).

ENTREPRENEURSHIP AT THE COAST

In 2015, the produced wealth measured on the basis of the gross domestic product (GDP[2]) per capita, was lower in West Flanders (35,447) than in the Flemish Region (37,243) or Belgium (36,513). Bruges (36,595) is the only coastal region with a GDP per inhabitant higher than the average of West Flanders (source: NBB in *RESOC dataset 2017*). The GDP per capita increased on average 2.1% per annum over the period 2006-2015 in West Flanders, with the strongest gain made in the Ypres district (3.0%) and the weakest in the Tielt district (1.1%) (Source: NBB in *RESOC dataset 2017*). Because GDP per inhabitant grew more strongly in the period 2006-2015 than in Belgium, West Flanders was able to narrow the gap with Belgium where the gap to Flanders remained just as large. The available income per capita grew faster in West Flanders than in Flanders and Belgium. Here, West Flanders made a catch-up compared to the Flemish Region and widened its gap with Belgium.

With regard to the realised gross value added (GVA)[3], the district of Bruges ranks second, after Kortrijk, with a share of 24.5% in the GVA realised in West Flanders in 2015. The remaining coastal districts of Ostend and Veurne account for 10.5% and 4.9% respectively of the total GVA. In 2015, the GVA per employee in West Flanders amounted to 90,824 euro. This means that the province of West Flanders remains well below the Flemish average of 97,377 euro. The coastal districts of Veurne (101,232) and Ostend (97,377) have a GVA per employee that exceeds that of the Flemish average (Source: NBB in *RESOC dataset 2017*).

In 2016, the companies with a registered office in West Flanders generated a combined turnover of 89.5 billion euro; this represents 15.2% of the Flemish total (Source: *Conjunctuurnota POM West-Vlaanderen*). In 2016, there were 38,995 active enterprises in the coastal area, which represents 33.9% of the total in West Flanders. 29,253 of these active enterprises are located in coastal municipalities, 9,742 in hinterland municipalities. In the coastal area, 69.3% of active enterprises can be found in the tertiary[4] sector and 7.9% in the quaternary[5] sector. In West Flanders, the share of active companies in these sectors is lower (63.6% in the tertiary sector and 6.4% in the quaternary sector). The share of founded and disappeared enterprises in the tertiary and quaternary sectors is also remarkably higher in the coastal area compared to West Flanders. The economic dynamics of the coastal area are relatively large. Both the foundation ratio (ratio of the number of foundations to the number of active enterprises) (coastal area:

[2] The GDP is the market value of all officially recognised final goods and services produces within a country in a given period of time. The GDP per capita is often considered an indicator of a country's standard of living.
[3] GVA: the difference between the marketable value of production and the purchased primary resources.
[4] Service sector: the economic sector in which enterprises want to make profit by selling their goods or services.
[5] The non-commercial services: e.g. governmental services and services with government funding.

9.7%, coastal municipalities: 10.3%, hinterland municipalities: 8.2%) and the retirement ratio (ratio of the number of shutdowns and bankruptcies to the number of active enterprises) (coastal area: 5.7%, coastal municipalities: 6.0%, hinterland municipalities: 4.8%) were larger in the coastal region than in West Flanders as a whole in 2016. The turbulence ratio (sum of foundation and retirement ratios) is therefore considerably higher in the coastal municipalities (coastal area 15.4%, coastal municipalities 16.2%, hinterland municipalities 13.0%) than in the West Flanders figure (13.9%) (Source: FPS Economy (ASDEI) in *RESOC dataset 2017*). These findings can be attributed entirely to coastal municipalities since the ratios in the hinterland municipalities are always below the total figure for West Flanders. Urban centres tend to record more foundations and also more shutdowns. This is inherent to the possibilities offered by such centres. The higher turbulence on the coast can also be partly explained by the nature of the activities present. Among the pioneers of the start-ups and bankruptcies is after all the hotel and catering industry, which is much more strongly represented in the coastal area than on average in West Flanders. In 2016, for example, there were 4,197 active enterprises in the hotel and catering industry in the coastal area (coastal municipalities: 3,567 active enterprises, hinterland municipalities: 630 active enterprises), accounting for 51.0% of the province of West Flanders. The coastal municipalities alone account for 43.4% of the number of hotel and catering businesses in West Flanders. The number of active enterprises in the hotel and catering industry in relation to all active enterprises accounts for 12.2% in coastal municipalities, 6.5% in hinterland municipalities, 10.8% in the coastal area and 7.2% in West Flanders. In addition, in 2016 there were 4,596 active enterprises in the retail trade in the coastal area (coastal municipalities: 3,709 active enterprises; hinterland municipalities: 887 active enterprises), accounting for 39.7% of the province of West Flanders. The coastal municipalities themselves make up 32.0% of the number of retail businesses in West Flanders (Source: FPS Economy (ADSEI), processing: Department DSA, POM West Flanders).

The coastal area covers 36.2% of the total surface area of West Flanders. On 1 January 2016, the coastal area only constituted 22.4% of the total area used for business activities in West Flanders. In West Flanders 17.7% of the built-up area is used for business activities; in the coastal area this percentage is 14.2%. In coastal municipalities, the proportion of the built-up area that is used for activities is greater than in hinterland municipalities (15.9% compared to 11.5%) (Source: *RESOC dataset 2017* at *www.pomwvl.be*).

In 2015, the spatial productivity in the coastal area equalled 43.1. This means that in the coastal area there were 43.1 persons working per hectare of economically occupied land. In the coastal municipalities this number amounted to 54.7, compared to 21.4 in the hinterland municipalities and 31.5 in West Flanders as a whole. These differences are caused by the different morphology and economic structure of these regions. Economic use of space is completely different in urban regions because of a different sectoral structure: on the one hand, relatively less industry and fewer users of large space, and on the other hand, more trade and services with offices and high-rise buildings, as well as more employees per unit of land area. Until 2008, spatial productivity in West Flanders remained at the same level, after which the indicator showed a declining trend. In the other regions, spatial productivity has been on a declining trend since 2006. These decreases are the effect of a growing spatial dispersion of living and working. Commercial sub-urbanisation or migration from the city towards the surrounding countryside, following on the residential sub-urbanisation, has increased sharply in recent years. The Flemish spatial structure plan RSV has not yet been able to curb this trend (Source: *RESOC dataset 2017* at *www.pomwvl.be*).

In the following information sources: *West-Vlaanderen Ontcijferd editie 2016*, the *Gemeentelijke Steekkaarten* and the *RESOC dataset*, statistics on entrepreneurship are available at municipal, districts and the province of West Flanders.

11.4 Sustainable use

11.4.1 Sustainable living at the coast

On the coast, there are few ingredients present for a balanced, sociologically healthy social environment. The strong aging and growing increase of 80+, the many single people, the numerous relocations and the strong pressure from tourists and second homes create an unbalanced social and demographic situation. This disrupted social climate appears mostly in the neighbourhoods close to the coast (*Meire and Bracke 2005*, rijksregister, Coudenys 2012 in *Maelfait et al. 2012*).

The ageing of the coastal population creates a skewed demographic mix, which causes a different society model. On the coast, there are proportionally much more elderly people compared to the rest of Flanders. This effect is amplified by the second home owners, of which most are over the age of 45 without children under the age of 18 living at home. 75% of the second home owners are at least 55 years old and live together with their partner. More than half of the owners are (pre-)retired. This means that the ageing population is further increased by approximately 124,500 second home owners aged over 50 who reside for approximately 82 nights a year in their second home (WES 2008, second homes at the coast, *part 1* and *part 2*). During the last 10 years, 20,000 inhabitants over 56 years of age settled at the

coast (*province of West Flanders 2015*). Research commissioned by the province of West Flanders shows that in the next 15 years the coast will reside more individuals over the age of 60; and in 2030 there will be 117,777 inhabitants (51.72%) older than 56. According to the most recent SVR-projections (2015-2030; *Studiedienst Vlaamse Regering*), the ageing population and the increase in the number of people aged 65 to 79 and the over-80s on the coast will continue until at least 2030 (*Government of Flanders 2016*). In addition, it appears that approximately 40% of the number of homes on the coast are second homes, accounting for approximately 86,000 homes (*province of West Flanders 2015*).

The province of West Flanders is actively investing in the coastal ageing programme (*programma Vergrijzing aan de kust*), whereby the coast can be regarded as a laboratory for the future ageing of the population in Flanders. For example, the policy document '*Vergrijzing aan de Kust: Lust of last (2012)*' (province of West Flanders) outlines the situation of the ageing population on the coast, formulating a number of bottlenecks and challenges. The '*Ruimte voor ouderen (2017)*' inspiration guide provides an overview of the various forms of housing for the elderly and tries to respond to the housing needs of coastal residents in West Flanders. Furthermore, in *Vandekerckhove et al. (2015)*, commissioned by the province of West Flanders, the relocation movements of people older than 80 were analysed for the coast, including the consequences for the housing market and the healthcare sector in the coastal area. The study reveals a number of trends: the retired migrant is insufficiently prepared for ageing, a social network is important and the housing supply on the coast has not been adapted. 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.), focus on adapted and self-reliant housing and awareness-raising (see also *De Klerck 2011*).

The importance of a personal social network is also discussed in *Meire and Bracke (2005)*. For the many singles and retired migrants at the coast, who have left their social environment, social isolation is a realistic prospect. It is therefore essential to restore and strengthen this social network as much as possible. A study about the livability at the coast *(Meire and Bracke 2005*) has revealed that the mutual involvement of residents scores poorly along the coast, especially in the neighbourhoods close to the sea.

A good physical environment and good living conditions are also essential for a sustainable living environment and for the well-being of the residents. The urban profile and the high level of deprivation indicate the many challenges of the coastal area (*Maelfait et al. 2012*). In addition, ageing also offers economic opportunities, for example in the care economy or the experience economy (see also: *website POM West Flanders*).

11.4.2 Economic development at the coast

In *West Deal*, the strategic lines of the economic policy of the province of West Flanders were outlined for the period 2013-2018. A number of policy lines are specifically relevant for the coastal area, such as the potential of Ostend as an industrial port for offshore developments, the expansion of the port of Zeebrugge, tourism-related opportunities for the Ostend-Bruges International Airport, etc. 'Factories for the Future' (*Fabrieken voor de Toekomst*) is also a concrete application of West Deal, in which the blue energy cluster focuses on wind, wave and tidal energy. In the study *West-Vlaanderen Groeit – Ambitie 2030*, a study was conducted into the situation of the West Flanders economy and its future prospects. Five future visions and five specific construction sites for West Flanders are formulated, including the economy in the coastal area (blue energy, ports, coastal care economy, etc.).

Via the '*detailhandel Vlaanderen*' website of the Knowledge Network Retail Trade, information can be requested for each municipality (including a municipal fact sheet) about the retail trade in Flanders. Also, the new data portal *provincies.incijfers.be* can also be used to compile figures, tables, graphs and maps for each selected area classification (e.g. coastal area).

With regard to retail trade, the coastal municipalities have a higher number of commercial buildings in relation to the population compared to the hinterland municipalities. The highest number of commercial properties (per 1,000 inhabitants) is registered in Knokke-Heist (49.76), De Panne (48.83) and Nieuwpoort (47.57) (figure 10). The largest vacancy (unoccupied commercial properties compared to all commercial properties) was found in Bredene (14.0%), De Panne (13.3%) and Blankenberge (13.0%) (figure 10).

In the context 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 completed in 2012 (*Belgian State 2012*, *Börger et al. 2016*), and an update of this socio-economic analysis was published in 2018 (*Volckaert and Rommens 2018*). These studies partly deal with socio-economic developments on the coast, paying attention to the accommodation for tourists on the coast and their expenses (see also themes **Tourism and recreation** and **Nature and environment**).

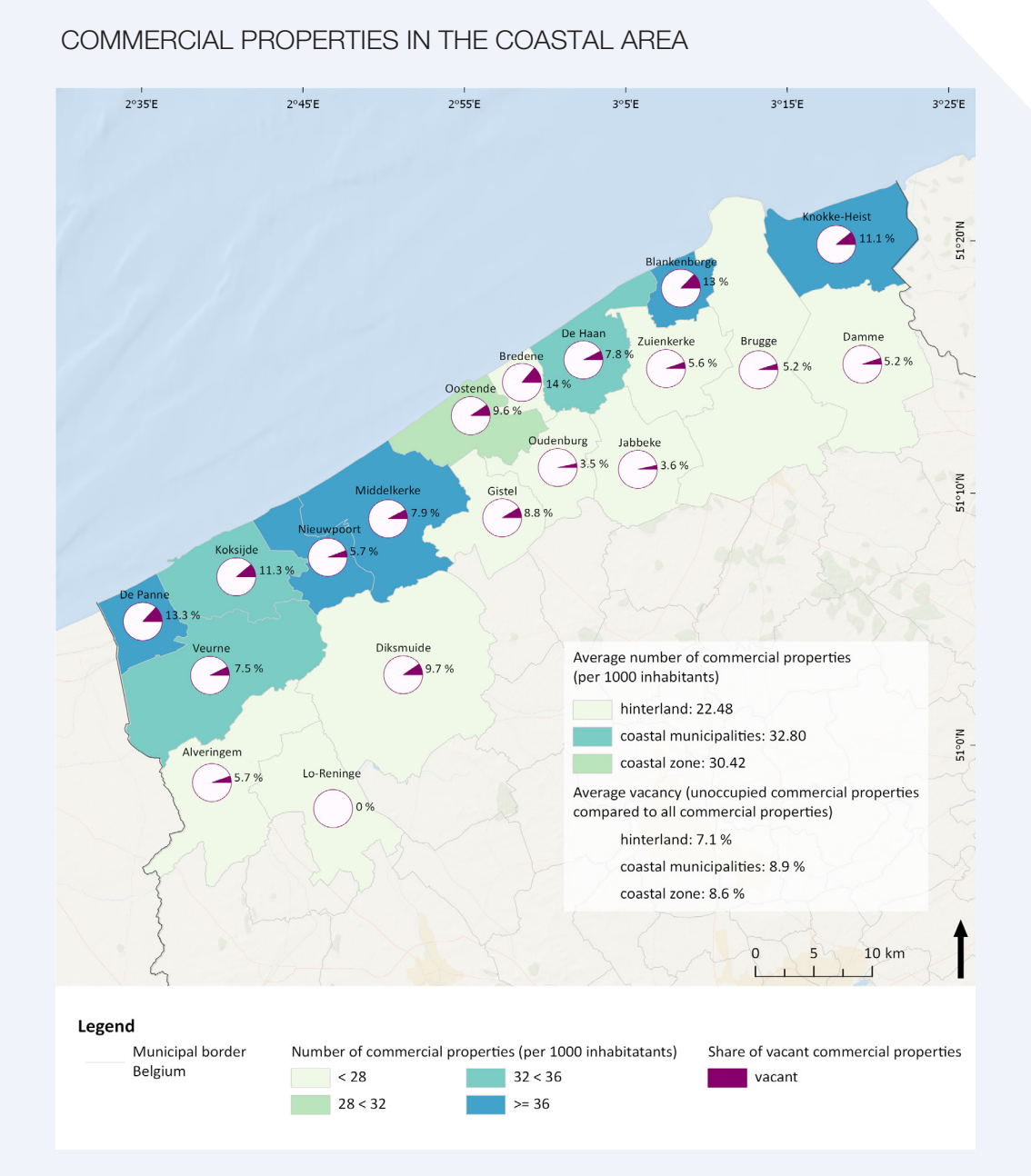

Figure 10. The number of commercial properties per 1,000 inhabitants for each municipality in the coastal area in 2017 and the number of vacant commercial properties compared to all commercial properties per municipality in 2017 (Source: *provincies.incijfers.be* via province of West Flanders).

11.4.3 Urban vision development on the coast

In order to be able to respond to the future challenges of the coastal area, a 'reconversion' of the current urban system is being considered. '*Stedelijk Systeem Kust*' is a design-based research project into transformations of the built environment in the coastal area, in order to obtain a robust urban system (*Stedelijk Systeem Kust 2017*). The research is a collaboration between the Team *Vlaams Bouwmeester*, Department Environment (*Ruimte Vlaanderen*), OVAM and the province of West Flanders and forms part of *LABO RUIMTE*, a platform for designing research into spatial-societal issues. For example, apartment buildings along the coast can also provide a sustainable response to the needs of a growing group of senior citizens. With the Integrated Territorial Investment (GTI) *Health Care Accelerator*, local authorities, healthcare institutions, companies and knowledge institutions are working together to meet this challenge.

The coastal area is a dynamic zone with major challenges in terms of e.g. housing, mobility and work. In the designing study *Metropolitaan Kustlandschap 2100* about the development possibilities for the coast up to 2100 in the context of a changing climate and socio-economic context, the coastal area was considered as one functionally coherent area, one urban metabolism (*Geldof and De Bock 2014*). The Territorial Development Programme (T.OP) for the coastal area was set up in November 2015 within *Ruimte Vlaanderen* (Department Environment) with the aim of tackling large-scale spatial challenges in the coastal area in cooperation with the province of West Flanders and the municipalities. Urban development issues are elaborated into a supported vision or master plan by a team of experts. This will enable the municipality to put this into practice by means of a spatial implementation plan or by issuing permits. These projects are currently being carried out and the implications for the coast are not yet apparent. In Knokke-Heist, for example, it was investigated how an older district near Heist station could be renovated with an additional package of new houses, without restricting the open character and spacious park structure. In Veurne, research was conducted into how the old station, the square in front of it and the surrounding area can be renovated so that this can remain a well-functioning public transport hub, but at the same time can also offer more quality to local residents. The results of this research will only become visible on the site in the coming years. Similar research is also planned in Middelkerke, Blankenberge and Koksijde in 2018-2019.

There are also vision developments or planning processes that focus partly or entirely on the sea side, such as the *Complex Project Coastal Vision* (development of sustainable measures for long-term coastal protection) and the marine spatial plan (MSP) for the Belgian part of the North Sea (see also themes **Safety against flooding**, **Nature and environment** and **Integrated ocean policy**).

Legislation reference list

Overview of the relevant legislation at the federal and Flemish level. For the consolidated national legislation we refer to the *Belgisch staatsblad* and the *Justel-databanken*.

Belgian and Flemish legislation		
Abbreviation	**Title**	**File number**
Decree of 18 May 1999	Decreet houdende de organisatie van ruimtelijke ordening	1999-05-18/33
RD of 23 June 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05

12

Tourism and recreation

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Europe is the most visited tourist[1] region in the world with the highest number of international visitors. Moreover, about half of the tourist overnight stays are booked in coastal areas (*Eurostat Regional Yearbook 2017* and COM (2014) 86), making coastal and maritime tourism (including the cruise sector) the biggest maritime sector in Europe in regard to added value and employment (*Ecorys 2013*). Furthermore, European coastal tourism provides jobs for 3.2 million people, generating over 183 billion euro of added value a year (*DG MARE*).

The Belgian coast is a popular holiday destination as well. Residential tourism accounted for more than 5 million arrivals and 30 million overnight stays in 2016. The number of day trippers varies between 16 and 19 million annually. The total spending of coastal tourists amounts to approximately 2.9 billion euro (*Dagtoerisme naar de kust 2017*, *Dagtoerisme naar de kust 2017*, *Toerisme in cijfers XL 2017*).

Besides coastal tourism, tourism in the hinterland also accounts for a considerable number of arrivals and overnight stays. The tourist and recreational regions of Bruges Woodland and Westhoek area accounted for more than 500,000 arrivals and nearly 1.1 million overnight stays in 2016 (*Westtoer, Trendrapport Brugse Ommeland 2015-2016*, *Westtoer, Trendrapport Westhoek 2015-2016*). Furthermore, the Westhoek region welcomes through its war history a large number of commemorative tourists with a peak of 800,000 war tourists in 2014 during the centennial commemoration of the Great War (figures *Westtoer*). It should be noted, that the borders of these regions extend beyond the hinterland communities (the strategic policy plans for tourism and recreation in *het Brugse Ommeland 2013-2018* and *De Westhoek 2018-2024*).

12.1 Policy context

At the European level, the policy relating to tourism is stipulated by *DG GROW* of the European commission. However, coastal and maritime tourism is included in the so-called 'Blue Growth' policy (COM (2012) 494) established by *DG MARE*. In this context, a strategy was developed to increase growth and employment in sustainable coastal and maritime tourism (COM (2014) 86), with a strong focus on cooperation between EU Member States.

Considering that the coast constitutes a 'macro product' within Flemish tourism but is completely located in the province of West Flanders, it has been decided to have a policy plan (*Strategisch beleidsplan voor toerisme en recreatie aan de kust 2015-2020*) drafted jointly by 'Tourism Flanders' (*Toerisme Vlaanderen*), under the supervision of the Flemish minister for Tourism (Flemish level, *beleidsnota toerisme 2014-2019*), and *Westtoer* (provincial level). Every year, the Flemish Parliament also issues 'tourism policy letters' (*beleidsbrieven toerisme*) (*Weyts 2016*) which formulate strategic and operational objectives with a thematic or regional emphasis. The policy of the Westhoek area and the Bruges Woodland region has been defined on a provincial level by *Westtoer* in the strategic policy plans for tourism and recreation of the Bruges Woodland (*het Brugse Ommeland 2013-2018*) and the Westhoek (*de Westhoek 2018-2024*).

In the past, the Government of Flanders and the minister for Tourism provided funding in the framework of the Coastal Action Plan I (*Kustactieplan*) (1997-2002), II (2000-2004) and III (2005-2009) and the 'Flemish Coastal Impulse Programme' (*Impulsprogramma Vlaamse Kust*) (2010-2014) to invest in certain coastal-related projects. Since 2015, the impulse programmes focus on tourism leverage projects (*toeristische hefboomprojecten*) and cycling and walking network projects that apply to the whole of Flanders. A first thematic call for subsidies, the 'Everyone deserves a holiday' (*Iedereen verdient vakantie*) impulse programme, was launched in the spring of 2017. Furthermore, a permanent measurement and monitoring system has been developed which provides numbers on coastal tourism twice a year. These statistics are annually compiled in a trend report (*Westtoer, Trendrapport Kust 2015-2016*) and a key figures overview (*Kerncijfers toerisme kust 2016*). More information on the sectoral legislation on tourism can be found on the website of Tourism Flanders (*Toerisme Vlaanderen*) and the *Codex Coastal Zone, theme Tourism and recreation*.

For water recreation on the coast, the RD of 4 August 1981 regarding the police and shipping regulations for the Belgian territorial sea, coastal ports and beaches is of interest (more information: *website FPS Mobility and Transport, oplijsting vaarregels*). Furthermore, the law of 20 January 1999 and the associated royal decrees stipulate a number of restrictions for recreational activities in marine protected areas. The regulation with regard to boating and water recreation on the fairways has been developed by *DG Shipping* (FPS Mobility and Transport) and is discussed in the following documents: *Vademecum van de pleziervaart in België (2017)*, *De pleziervaart op de bevaarbare waterwegen in Vlaanderen (2017)* and *Wijzer op het water (2010)*. The FPS Mobility and Transport, in cooperation with the secretary of state for the North Sea and the minister for Mobility, is currently working on a revision of the current legislation on recreational boats.

[1] Here we follow the statistical definition of 'tourism', which includes not only private visits but also business visits.

With regard to bathing along the coast, the European directive concerning the management of bathing water quality (2006/7/EC) is of importance as it stipulates the bathing water quality standards (more information: *De nieuwe zwemwaterrichtlijn, VMM 2006* and the *website kwaliteit zwemwater*).

The policy concerning outdoor recreation is described in the strategic policy plan for outdoor recreation for the province of West Flanders 2009-2018 (*Strategisch beleidsplan openluchtrecreatie voor de Provincie West-Vlaanderen 2009-2018*). The legislative framework of recreation and sport activities along the coast has been extensively elaborated in the *Codex Coastal Zone* (themes *Tourism and recreation*, *Coastal Zone Management* and *Local legislation*) and is also discussed by *Derous (2005)* and *De Wachter and Volckaert (2005)* (*GAUFRE project BELSPO*).

12.2 Spatial use

The areas for tourism and recreation are primarily steered by spatial planning (see theme **Social and economic environment**). Instruments such as the spatial structure plans, spatial implementation plans (SIPs) and regulations, on a Flemish, provincial and municipal level, indicate the possibilities for future tourist-recreational developments in a specific area.

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 *inter alia* developed within the framework of initiatives and studies such as the Masterplan for Coastal Safety (*Masterplan Kustveiligheid*), Ecosystem vision for the Flemish coast (Ecosysteemvisie Kust, 2017) (part *1*, *2*), Complex Project Coastal Vision (*Complex Project Kustvisie*, previously Flemish Bays (*Masterplan Vlaamse Baaien 2014*)) and Metropolitaan Kustlandschap 2100 (*phase 1*/ *phase 2*/ phase 3 part *1*, *2* and *3*) (see theme **Safety against flooding**), where phase 1 describes the historical context of coastal tourism. Furthermore, the designation of Ostend and Bruges as regional urban areas (*regionaal stedelijke gebieden*) and Blankenberge and Knokke-Heist as local urban areas (*kleinstedelijke gebieden*) in the *RSV* is important for the tourism sector as this designation has consequences for the potential 'highly dynamic functions' that may be developed in the coastal region. Tourism Flanders drafted a study on the spatial use of tourism and recreation in Flanders (*Ruimte voor Toerisme en Recreatie in Vlaanderen (WES 2007)*) (RuiTER) where the question concerning space for the different aspects of tourism was raised in order to provide input for the large reconsideration of the *RSV* of 2011. In addition to the RSV, the regional spatial implementation plans (RSIPs) can be consulted on *www.ruimtelijkeordening.be*. Besides the further implementation of the Flemish spatial structure plan, the Government of Flanders is preparing a new *spatial policy plan* (see *Groenboek. Vlaanderen in 2050: mensenmaat in een metropool? Beleidsplan ruimte Vlaanderen (2012)*, *Witboek Beleidsplan Ruimte Vlaanderen*). Within this new spatial policy plan, a Territorial Development Programme for the coastal zone (*T.OP Kustzone*) has been developed. In this programme, the Environment Department of the Government of Flanders cooperates with the province of West Flanders and local authorities on short- and medium-term spatial development projects. T.OP Kustzone builds on the revised spatial structure plan of the province of West Flanders (*Provinciaal Ruimtelijk Structuurplan-WV*), local partner consultations and studies such as *CCaSPAR*, *MKL2100*, *Complex project coastal vision*, *STADSMonitor*, etc.

The Government of Flanders is the owner of almost all beaches along the Belgian coast (with the exception of the military base (beach) at Lombardsijde). The Coastal Division grants concessions for the development, maintenance and exploitation of the marinas for water recreation and sports along the Flemish Coast (*website Coastal Division*). Furthermore, the Coastal Division is responsible for providing safe coastal protection measures (see also theme **Safety against flooding**) and an integrated sustainable coastal management and is in the position to grant beach and sea dike concessions for private use in consultation with municipal authorities, other public authorities, utility companies, contractors, private individuals, etc. (*website Coastal Division*).

Important regional policies for the coast have been formulated in the spatial structure plan of the province of West Flanders (*PRS-WV*). In the PRS-WV, several coastal municipalities have been selected as population centres (*woonkernen*) with opportunities for development under specific conditions. The PRS-WV has also defined outdoor recreational green areas, amusement parks and tourism-recreational linear elements (watercourses, railway beds, dykes and road infrastructure). In addition, a number of strategic project areas were selected where tourism and recreation should be given an important place (*PRS-WV*, *Strategisch beleidsplan voor toerisme en recreatie aan de Kust 2015-2020*). These are the Yser Estuary in Nieuwpoort, the area to the east of Blankenberge, the area to the south of the station in Knokke, the military base of Koksijde and the east bank of Ostend. Furthermore, the *provincial spatial implementation plans* (in particular the provincial SIPs (PSIPs) for beach and dike) are of significant importance for organising the tourist-recreational functioning of each coastal zone area because of the zoning that outlines a number of preconditions for future developments. Our coastal zone, for example, already has a well-developed cycling and hiking network and development zones have been designated for the construction of cycle 'highways' between the seaside towns.

At municipal level, processes are under development that create new opportunities for tourism and recreation within the municipal structural plans. These possibilities are elaborated in more detail for the possible spatial developments for tourism and recreation on a local level in the implementation plans. As a guideline, one can call on research by *Gruijthuijsen (2015)* into the needs and wishes of tourists in Belgian and Dutch seaside resorts, in which, among other things, the demand for a modernisation of the public space was recorded.

12.3 Societal interest

12.3.1 Coastal tourism

The tourist-recreational sector is crucial for the coastal economy. In 2016, there were 5,474,233 arrivals at the coast in the residential tourism sector, representing a total of 30,032,221 overnight stays (figure 1). Commercial accommodation constitutes 40.8% of these stays and second home tourism 59.2%. In addition, 17,618,000 day-trippers arrived at the coast in 2016 (*Westtoer, Trendrapport Kust 2015-2016*, *Dagtoerisme naar de kust 2017*), more information: study *Vakantieganger in commercieel logies Kust (2017)*. The presence of the International Airport of Ostend - Bruges and the seaports of Ostend and Zeebrugge are also important for the inflow of foreign tourists to the Belgian coastal area. Figures on the number of passengers in the aforementioned ports are available on the website of the *Vlaamse Havencommissie*. Traffic figures for Ostend-Bruges International Airport are available on the following web page *www.ostendbruges-airport.com/figures*.

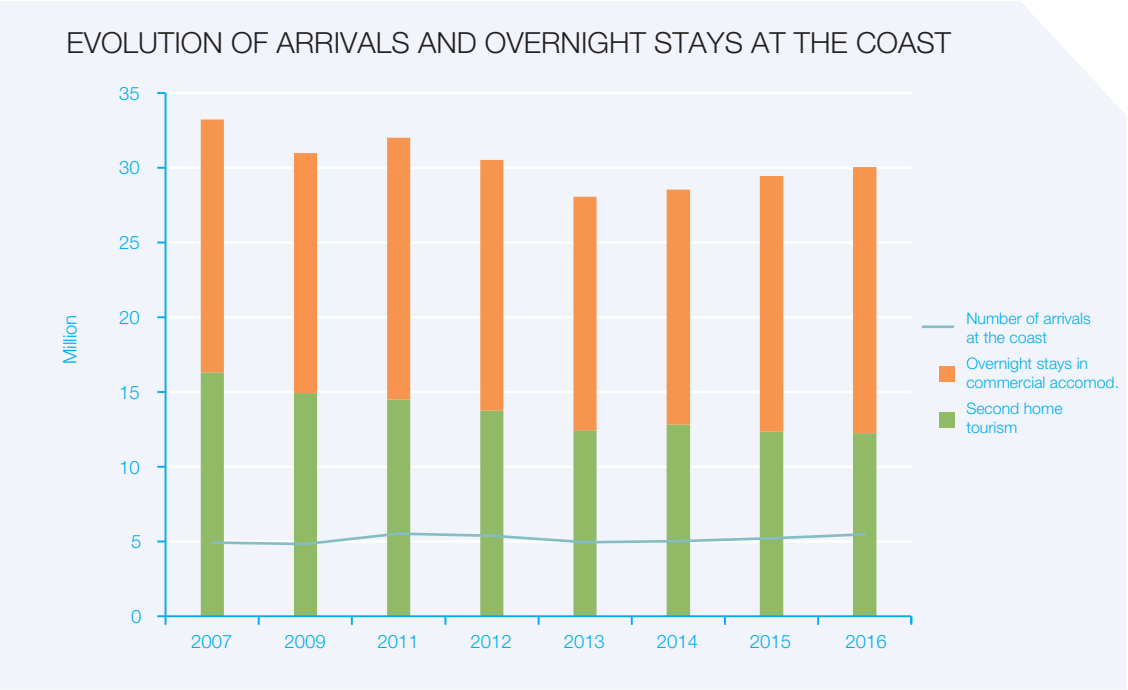

Figure 1. Evolution of the overnight stays in commercial accommodation, second home tourism and arrivals at the coast (*Westtoer, Trendrapport Kust 2012-2013*, *Westtoer, Trendrapport Kust 2015-2016*).

The total direct spending generated by residential tourism (commercial accommodation, second home tourism and mooring in marinas) and day trippers amounted to almost 2.9 billion euro in 2016 (table 1 and figure 2). Overnight tourism represented 2.1 billion euro in direct spending and day tourism 682.8 million euro (*Westtoer, Trendrapport Kust 2015-2016*, more information: *Vakantieganger in commercieel logies kust 2017*). When visiting the coast, the average day tripper spends approximately 39 euro a day, a resident in commercial accommodation 66 euro a night and a second home owner in a holiday house 42 euro a night (*Westtoer, Trendrapport Kust 2015-2016*, *Vakantieganger in commercieel logies kust 2017*). Direct turnover in the construction sector due to the construction of second homes amounted to 367 million euro in 2007 (*IDEA consult 2009*). Recent research on the meeting industry at the coast reveals that this sector generates a turnover of 60 million euro (2013) (*Westtoer, onderzoek Meeting aan Zee 2015*, *Westtoer, Trendrapport Kust 2015-2016*).

Table 1. Direct expenditures from coastal tourism by type of tourism in 2016 (*Westtoer, Trendrapport Kust 2015-2016*).

Type of Tourism	Direct spending of tourists in million euro	Percentage
Commercial accomodation	797.1	27.6
Second home tourism	1.328.9	46.0
Mooring in marinas	22.1	0.8
Day trippers	682.8	23.6
Meeting Industry	60.0	2.1
Total	**2,890.9**	**100**

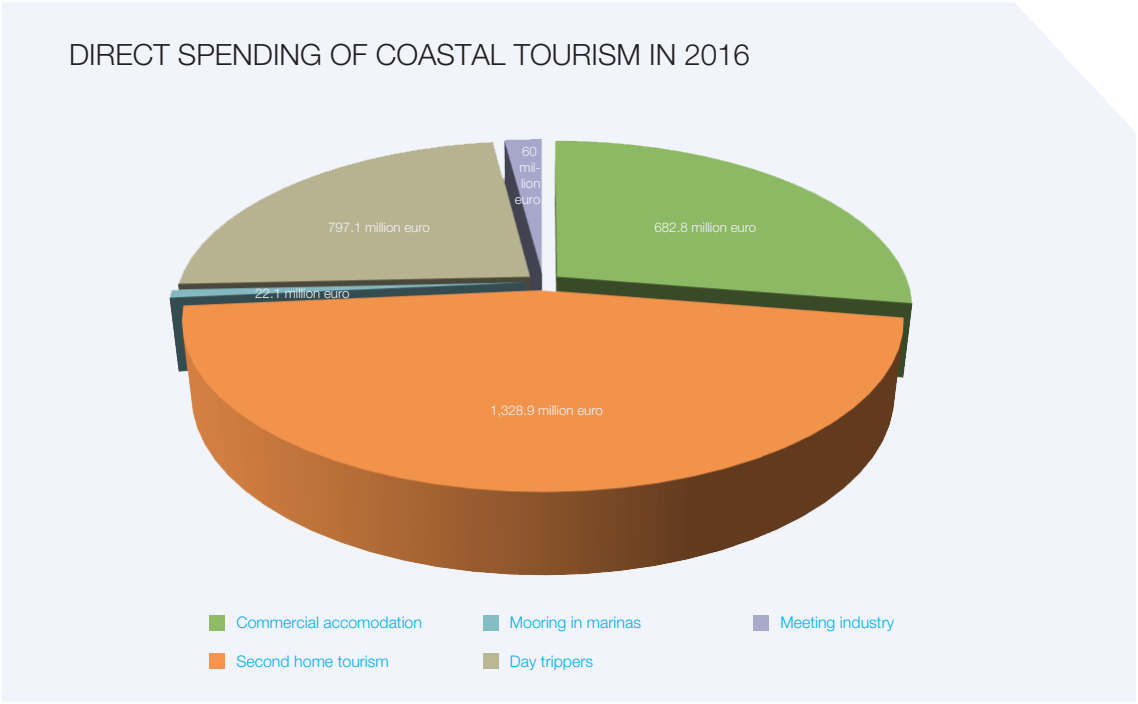

Figure 2. The total direct spending of coastal tourism per type of tourism in 2016 (*Westtoer, Trendrapport Kust 2015-2016*).

The activities of the Belgians during day trips (including to the coast) have been examined in detail in *pilootonderzoek naar daguitstappen van de Belg (2010-2011)* and more recently in *Vakantieganger in commercieel logies kust (2017)*. These reports show that over 80% of the tourists mainly get to the coast by car and that the main reason for a visit is to relax (48%) and enjoy the healthy sea air (45%). In terms of activities, strolling on the dike (70%), visiting cafes, tearooms, terraces (57%) and visiting restaurants (44%) are very popular. According to the *Trendrapport Kust 2015-2016*, there were 27 water sports clubs and 13 yacht clubs (3,553 berths) active along the coast in 2016, with spending in marinas amounting to 22.1 million euro. The economic benefits of sports and recreation activities along the coast (without indirect effects) are also listed by *De Wachter and Volckaert (2005)* (*GAUFRE project BELSPO*). The *Seaconomics project* (2010-2014) further investigated the economic importance of the marinas (*Westtoer, onderzoek gebruikers kustjachthavens 2013*). Based on this research, the average annual turnover generated by all users of the Flemish yacht clubs is estimated at 25.3 million euro.

According to statistics of the research department of the Government of Flanders (based on data from the National Social Security Office (NSSO) and the National Institute for the Social Security of the Self-Employed (NISSE)), the total employment of employees in the tourism industry at the coast in 2010 amounted to 11,253 jobs. The employment of the self-employed and helpers at the coast totaled 2,286 jobs (*Weekers 2013*). According to another calculation, the direct employment resulting from coastal tourism in 2016 is estimated at nearly 29,000 fulltime equivalents (assuming 1 fulltime equivalent direct employment per 100,000 euros of direct spending) (*Westtoer, Trendrapport Kust 2015-2016*) with a total employment (direct and indirect) of 43,364 full-time equivalents. Employment in the construction sector as a result of second home tourism was estimated at 1,814 jobs in 2007 (*IDEA consult 2009*).

12.3.2 Hinterland tourism

In addition to coastal tourism, tourism in the Westhoek area, Bruges Woodland and Bruges is of significant importance. Bruges Woodland accounted for 123,856 visitors and 258,887 overnight stays in 2016 (*Westtoer, Trendrapport Brugse Ommeland 2015-2016*). The arrivals and overnight stays in the Westhoek area amounted to 384,816 and 835,997 respectively (*Westtoer, Trendrapport Westhoek 2015-2016*). Bruges accounted for 1.01 million arrivals and 1.75 million overnight stays in 2016. These are arrivals and overnight stays in commercial accommodations (excl. second home tourism) (*Westtoer, Kerncijfers Toerisme West-Vlaanderen 2016*). In these trend reports, spending and employment are discussed as well.

12.4 Impact

As mentioned above, coastal tourism has a significant economic and societal value and creates a number of facilities such as the coastal tram and marinas. However, tourism in the coastal area also has a number of effects on the social and ecological environment. On the social level, the amount of second homes has an impact on the quality of life along the coast: higher real estate prices, weakened social cohesion, mobility problems, etc. (Coudenys 2012 and Keunen and Hoornaert 2012 in *Maelfait et al. 2012*, *Meire and Bracke 2005*, *Goffin et al. 2007*, *De West-Vlaamse kansarmoedeatlas, 2017* (see theme **Social and economic environment**)).

The large amount of second homes also affects the cultural heritage at the coast (*IDEA consult 2009*) (see theme **Maritime and coastal heritage**), although clear synergies between tourism and the coastal heritage are present, such as the touristic function of cultural-historical buildings along the coast (*De Baerdemaeker et al. 2011*).

On an ecological level, the rise of mass tourism towards the coast since the 1930s with the massive construction of tourist-recreational accommodation (holiday homes, camping grounds, holiday parks, second homes, etc.), has played an important role in the urbanisation of coastal areas, fragmentation of valuable open space and the disappearance of habitats (*PRS-WV*, *Goffin et al. 2007*, Boone 2012 in *Maelfait et al. 2012*, *Henkens et al. 2012*, *Provoost et al. 2014*). Especially the dune area underwent a strong fragmentation, *inter alia* caused by spatial planning (*Welkom in de duinen 2008*) (see theme **Nature and environment**). Furthermore, the high concentration of tourists and residents in the coastal area during the peak season has some direct and indirect ecological effects (see table 2).

Table 2. An overview of the direct and indirect ecological effects caused by the high concentration of tourists and residents in the coastal area.

Impact	Literature
Increased consumption of energy and water	*Vanlerberghe and Vanhoutte 2001*, *Goffin et al. 2007* (see theme **Agriculture, salinisation**), *Lenders et al. 2013*
Problems with waste processing	*Goffin et al. 2007*, *De Groof in Maelfait et al. 2012*, *Kustactieplan OVAM*, *Actieplan Marien Zwerfvuil 2017*
Litter on the beach	*Lescrauwaet et al. 2006*, *Goffin et al. 2007*, *Maelfait 2008*, *Doomen et al. 2009*, *André et al. 2010*, *Claessens et al. 2013*, *Devriese and Janssen 2017* (for marine litter, see theme **Maritime transport, shipping and ports** and theme **Nature and environment**)
Mechanical cleaning of the beaches	*Belpaeme 2003*, *Dominguez 2006*, *Goffin et al. 2007*, *Doomen et al. 2009*, *Vanhooren et al. 2011*
Contribution of coastal tourism to the eutrophication of the coastal waters	*Maes et al. 2004 (MARE-DASM project BELSPO)* (see theme **Agriculture**)
Pollution caused by traffic	*Goffin et al. 2007*
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*, *Goffin et al. 2007*, *Derous 2005 (GAUFRE project BELSPO)*, *Welkom in de duinen 2008* (see theme **Nature and environment**), *Krijgsveld et al. 2008*
Pollution by recreational boating	*Maes et al. 2004 (MARE-DASM project BELSPO)*, *De Wachter en Volckaert 2005 (GAUFRE project BELSPO)*, *Lescrauwaet et al. 2006*, *Goffin et al. 2007*
Sport fisheries	See theme **Fisheries**

12.5 Sustainable use

12.5.1 Sustainable development of coastal tourism

In order to ensure the protection of coastal ecosystems, the *Natura 2000 network* of marine protected areas was established by Europe under the Habitats Directive (92/43/EC). The *management plans* for the BNS for the period 2018-2023 are already adopted (see the theme **Nature and environment**). At European level, the sustainable integration of the different users and sectors (including tourism and recreation) of the coastal zones is included in the European Recommendation on the implementation of Integrated Coastal Zone Management (ICZM, 2002/413/EC). More recently, as part of the European Commission's Blue Growth strategy, fourteen actions have been identified to promote jobs and develop the European marine and maritime tourism sector within a sustainable framework (COM (2014) 86). Europe also provides a series of funding channels for this (*Guide on EU funding for the tourism sector 2014-2020*). Some specific applications for Belgium are the expansion of the Zwinvlakte, the *Life+ natuurproject FLANDRE* and the *Interreg project Vedette*, which carry out nature restoration in the coastal dunes with attention to the different target groups, and the *EMAS Easy MOVE-IT! project* that helps small and medium-sized enterprises in the tourism sector in terms of efficiency and sustainability.

Maelfait et al. (2012) published, in the context of ICZM, a number of indicators and measures have been proposed that promote the sustainable development of tourism and recreation at the coast. The relation between tourism and the social and economic aspects of the coast is discussed in more detail in the theme **Social and economic environment**.

In the strategic policy plan for coastal tourism (*Strategisch beleidsplan voor toerisme en recreatie aan de kust 2015-2020)*, *Tourism Flanders* and *Westtoer* have formulated 12 strategic objectives in order to further develop tourism at the Belgian coast:

- Strategic projects in light of the international potential (leverage projects and strategic project areas);
- Further investments in basic infrastructure and public space;
- Weather independent facilities in view of a four-season destination;
- Space for recreation;
- An accessible coast;
- The development of tailor-made vacations with integrated customer service;
- Innovation and differentiation in the accommodation sector;
- Enforcement and competiveness in the hospitality industry;
- A modern welcoming policy in the context of a broad hospitality;
- An integrated marketing policy;
- Knowledge-driven coastal tourism;
- Policy and organisation.

For the implementation of some of the strategic guidelines mentioned above, tourism leverage projects (*toeristische hefboomprojecten*) can be used within the impulse programmes (see **12.1 Policy context**). It should be mentioned that these projects apply to Flanders (and not only the coastal region). The further development of tourism at the coast is also strongly steered by spatial planning (see **12.2 Spatial use**). *Vanden Eede et al. (2014)* developed biological valuation maps for the Belgian coastal zone, which can be used as a decision-making tool by local policymakers in orienting spatial projects and allowing tourism activities.

In addition, there are a number of policy initiatives and studies (table 3) which address the issue of working towards sustainable coastal tourism in Belgium, e.g. Metropolitaan Kustlandschap 2100 (*phase 1*/ *phase 2*/ phase 3 part *1*, *2* and *3*), *T.OP Kustzone*, Masterplan Coastal Safety *(Masterplan Kustveiligheid)*, *CLIMAR project BELSPO*, Long-term vision North Sea 2050 (*Langetermijnvisie Noordzee 2050*) , Ecosystem vision for the Flemish Coast (part *1*, *2*) (*Ecosysteemvisie Kust*), Complex Project Coastal Vision (*Complex Project Kustvisie*) (previously Masterplan Flemish Bays 2014), *the Blue Cluster* (see also theme **Safety against flooding**).

In addition, various labels (e.g. *Blue Flag* of Bond Beter Leefmilieu, *the Q-label* for tourism entrepreneurs, *green key*, *the accessibility label* of the non-profit association *vzw inter*, etc. (more information: *website Toerisme Vlaanderen*)) are trying to contribute to sustainable (coastal) tourism.

Table 3. Overview of a number of studies that address sustainable coastal tourism.

Stustainable coastal tourism	
Child-friendliness on the Flemish coast (*Kindvriendelijkheid aan de Vlaamse Kust*)	Study on how to make the Flemish coast more attractive for families with children.
Interreg project 120 km Coastal quality (*Interreg project 120 km Kustkwaliteit*) (2008-2012)	Project to develop a sustainable beach and coastal management. See, *inter alia*, studies of *van Meenen 2009*, *Pijpers 2009*, *kansen aan de kust 2009*
Climate change as an incentive for renewed coastal tourism? (*De Waegemaeker 2012*)	Examines the impact of a compartmentalised coast (*CcASPAR*) on coastal tourism

12.5.2 Tourism and nature

In *Goffin et al. (2007)*, *Maelfait et al. (2012)* and *Strategisch beleidsplan voor toerisme en recreatie aan de kust 2015-2020* measures have been formulated in order to achieve a balance between the maintenance of the natural system and the needs of recreationists and tourists. In this regard, policy instruments such as the decree of the Dunes and spatial planning play an important role and are discussed in more detail in the theme **Nature and environment**. The compatibility of recreation and nature is also discussed in publications such as *Belpaeme (2003)*, *Zwaenepoel et al. (2005)*, *De Uitkerkse polder, een recreatieve meerwaarde voor de Vlaamse kust (2007)*, *Welkom in de duinen (2008)*, *Doomen et al. (2009)*, *Henkens et al. (2012)*, *Cosyns et al. (2014)* and *Provoost et al. (2014)*.

The (bathing) water quality of the coastal zone (within 1 nautical mile) is managed on the European level within the Water Framework Directive (2000/60/EC) by Directive 91/271/EC concerning urban waste-water treatment and Directive 2006/7/EC concerning the bathing water quality. On the federal level, these European measures are implemented by the RD of 23 June 2010 concerning the status of surface waters. On the Flemish level, the following decrees are important: the decree of 18 July 2003 (integrated water policy) (more information: *website Coordination Committee on Integrated Water Policy (CIW)*) and the decree of 8 December 1998 concerning the bathing water quality.

The quality of the bathing water of the coast is frequently sampled by the Flemish Environment Agency (*VMM* and the *website kwaliteit zwemwater*) (*Goffin et al. 2007*, Pelicaen 2012 in *Maelfait et al. 2012*, *VMM 2017*). The *Flemish Agency for Care and Health* is competent for the health aspect of the bathing water quality. The eutrophication of the coastal waters and the problem of salinisation are discussed in more detail in the theme **Agriculture**.

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex,* the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
COM: Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe	2002	413
COM: Communication from the Commission (COM): Blue Growth opportunities for marine and maritime sustainable growth	2012	494
COM: Communication from the Commission (COM): A European strategy for more growth and jobs in coastal and maritime tourism	2014	86
Council Directive concerning urban waste-water treatment	1991	271
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive concerning the management of bathing water quality and repealing Directive 76/160/EEC (Bathing Water Directive)	2006	7

Belgian and Flemish legislation

Abbreviation	Title	File number
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
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
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
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

13 Safety against flooding

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Verwaest, T., Thoon, D., Mertens, T., Monbaliu, J., Van Besien, P., Mostaert, F., Devriese, L., Pirlet, H. (2018). Safety against flooding. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 195-207.

In the 20th century, the average sea level on earth increased by 1.7 mm annually. Since the 1950s, a significant acceleration of the global sea level rise has been observed. Currently, the annual sea level increase has already reached 3.4 mm per year (global average), and thus exceeds the sustainability goal of a maximum increase of 2 cm each decennium (*Brouwers et al. 2015*). There is also increasing and explicit indication that man-made climate change is at the root of that acceleration. Thermal expansion of seawater and melting of ice sheets and glaciers accounted for 75% of sea level rise since 1971 (Source: *https://en.milieurapport.be*).

The statistical analysis of the measurements at the Belgian coast is not straightforward, given that the sea level is not only influenced by climate change but also by natural fluctuations. Nevertheless, the values show that the annual average sea level in 2017 was significantly higher than at the start of the measurements. In Ostend the trend line increased by 129 mm between 1951 and 2017 (figure 1) (Source: *www.milieurapport.be*). Significant increases have been recorded in Zeebrugge and Nieuwpoort as well. However, this increase does not seem to have continued in recent years (*Brouwers et al. 2015*). An approximate linear increase in flood levels of 20 cm per 100 years has been observed, with no significant acceleration or weakening of this long-term trend over the measurement period from 1925 to 2014 (*Willems 2015*). A study of the extreme high waters in Ostend shows that the storm surge – apart from the rise in the annual average sea level – does not show any separate or additional upward trend (*Willems 2015*). Climate change and the associated sea level rise also result in more intense erosion of coastal areas and a higher frequency of storm surges (*EEA Technical Report 2010a*, *Balancing the future of Europe's coasts, EEA 2013*), although no increase in the storm frequency in the Belgian part of the North Sea (BNS) has been observed so far (*Van den Eynde et al. 2011*, *CLIMAR project BELSPO*, *Hossen and Akhter 2015*). Neither has an increased erosion for the Belgian coast been demonstrated (see also *CREST project*). *Brouwers et al. (2015)* also provides an overview of the available scenarios with regard to sea level rise and storm surges off the Belgian coast.

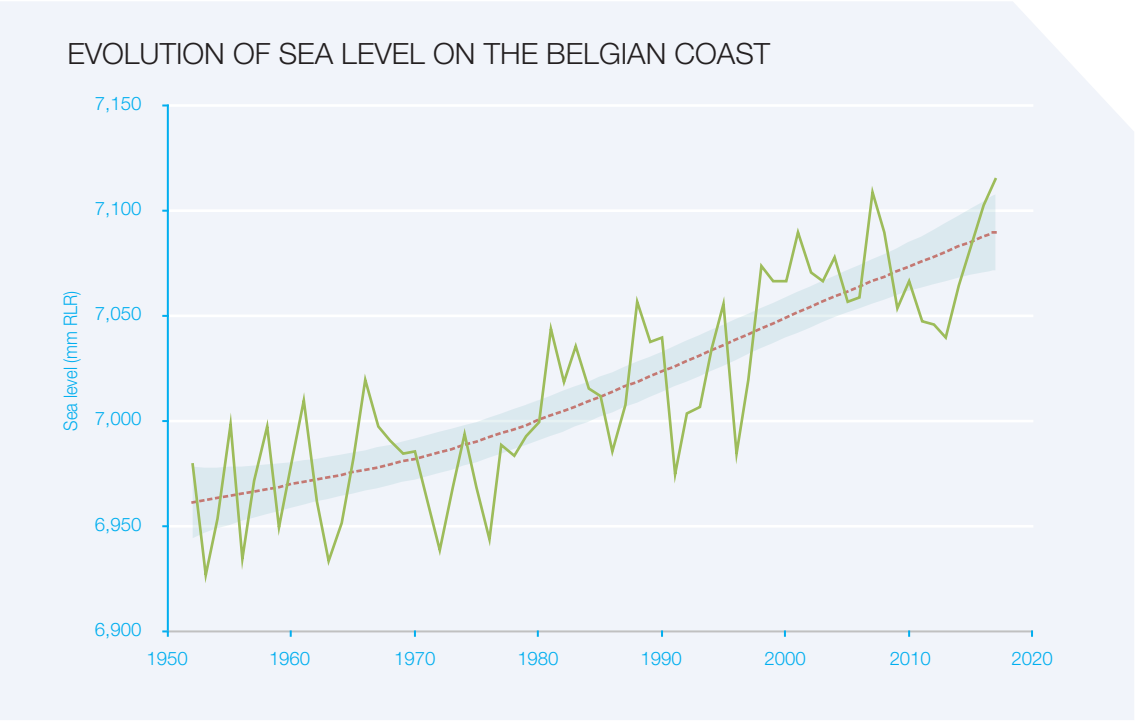

Figure 1. Evolution of sea level[1] on the Belgian coast (Ostend, 1951-2017) (Source: *www.milieurapport.be*).

The factors mentioned above increase the risk of flooding in low-lying coastal areas. A third of the EU citizens lives within 50 km of the coast. It is therefore estimated that coastal floods could impact up to 3.65 million people every year in Europe by 2100 (*Vousdoukas et al. 2018*). The regions with the highest risk of flooding driven by sea level rise and storm surges are the North Sea coasts of Belgium, the Netherlands and Germany, but also the Mediterranean coastal region of northern Italy (*EEA Report 2017*). The Netherlands and Belgium are among the most vulnerable

[1] Sea level is expressed in millimetres RLR (*Revised Local Reference*). The data from a local reference (for the Belgian coast it is the TAW or 'Tweede Algemene Waterpassing' (Second General Water Adjustment)) have been converted to the international reference level. Further on in the document, the usual TAW value is used, whereby instead of the average sea level at low tide in Ostend being used as the zero point, a 'fundamental point' was chosen, namely the point or reference mark GIKMN located in the Royal Observatory of Belgium in Ukkel. Since the RLR reference is an arbitrary agreement based on a fixed level, it is mainly used in time series as shown in this figure.

countries in the European Union, as more than 85% of the Belgian and Dutch coastal areas (zone up to 10 km inland) is below the level of an annual storm surge (+5 m TAW) (*EEA Report 2006*, *Eurosion*, *Balancing the future of Europe's coasts, EEA 2013*, *EEA Report 2017*). In Flanders, 15% of the surface area is less than 5 metres above the average sea level. Moreover, the Belgian coastline is the most built-up area in Europe: in 2000, over 30% of the coastal strip (up to 10 km inland) and almost 50% of the area up to 1 km inland was built-up. In West Flanders, 33% of the population live in low-lying polder areas that are prone to flooding caused by the sea (*Brouwers et al. 2015*). In addition to housing, the coastal zones of the Netherlands and Belgium are also home to important economic activities, partly due to the presence of seaports. As a result, in the event of a flooding, the loss of human life and property damage can be very high (*The European environment: state and outlook 2010. Adapting to climate change 2010*, *Kellens 2011*, *The Ports of Flanders 2017*, *EEA Report 2017*, *Coppens et al. 2018*).

The North Sea coast of Belgium is characterised by coastal dunes, sandy beaches and naturally soft foreshores (*North Sea Region Climate Change Assessment 2016*). A review of the Flemish coastal protection measures in 2007 and 2008 showed that approximately one third of the straight coast[2] and coastal ports needed additional protection against the impact of severe storm surges. Reference is made to design storms with water levels with a return period of 1/1,000 (*Brouwers et al. 2015*). The term 'superstorm' is sometimes used for super extreme storm surges (water level of +8 m TAW, from the NW, return period 1/17,000) (*Reyns et al. 2010*). The *Masterplan Coastal Safety* (approved by the Government of Flanders on 10 June 2011) describes the measures to be taken to ensure adequate protection of the coastline and the adjacent low-lying polders against a storm surge with a return period of 1,000 years with a time horizon[3] of 2050. Both 'soft' (beach nourishment, dune nourishment, etc.) and 'hard' coastal protection measures (storm walls, wave-damping extension of the seawall, etc.) will be realised.

In the meantime, the implementation of the *Masterplan Coastal Safety* is well advanced (see **13.5.2 An integrated approach to coastal protection**).

- Some of the most vulnerable zones, namely De Panne, Koksijde, Ostend (East Bank, Centre, Mariakerke, Raversijde), Middelkerke and Westende, and De Haan-Wenduine were already provided with beach nourishments.
- The seawall of De Haan-Wenduine was renovated and fitted with flood protection measures;
- In Blankenberge and Knokke-Heist, a pre-take of the beach nourishment as provided for in the *Masterplan Coastal Safety* has already been carried out;
- In 2014, the first phase of the flood protection measures was carried out in the port of Ostend;
- In June 2018, the first phase of the construction of a storm wall in the port of Blankenberge was completed and, in February 2018, preparatory works for the construction of the storm surge barrier were started in Nieuwpoort;
- In the near future, the security of the vulnerable zone Ostend-Raversijde-Mariakerke will be supplemented by a storm wall (Source: *website Coastal Division*);
- The adjustments to the seawall in Middelkerke-Westende and further flood protection measures in the ports of Ostend, Blankenberge and Zeebrugge are in the design stage.

The most recent review (situation 2015) has shown that approximately 10% of the straight coast does not meet the requirements set out in the *Masterplan Coastal Safety*. This is partly due to the fact that this Masterplan Coastal Safety has not yet been fully implemented and partly due to the need for maintenance of the nourishments provided. A maintenance programme for sandy coastal protection measures was therefore drawn up based on the recent assessment.

Flooding of low-lying polders due to heavy rainfall also occurs in the coastal area, but is not restricted to this zone. Nevertheless, it is important to take this kind of floods into account, especially given that by 2100, the change of rainfall may be 10% higher in the coastal area compared to the hinterland (*Van Steertegem 2009*). Due to the sharp increase in extreme, short-term rain showers, sewerage and other drainage systems will be placed under additional pressure 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) on the one hand and from the sea on the other (e.g. *Willems 2013*). However, this theme text largely excludes flooding of the hinterland.

Parallel to the drafting of the *Masterplan Coastal Safety* in 2009 an innovative vision was presented on the future development of the Flemish Coast, called 'Flemish Bays 2100' (*Projectgroep Vlaamse Baaien 2012*) through a new collaboration between a number of Flemish consultancy firms and entrepreneurs. Because of its innovative and sustainable character, several subprojects were considered by the Government of Flanders in an independent trajectory that culminated in the *Masterplan Vlaamse Baaien 2014* (see **13.5.2 An integrated approach to coastal protection**). In December 2017, the Government of Flanders initiated the Complex Project Coastal Vision, which aims

[2] Straight coast: the whole of the beaches, foreshore, dunes and seawalls.
[3] At present, the water level at sea is approximately 7 m TAW during a 1,000-year storm surge. The water level will rise as a result of sea level rise. The Masterplan Coastal Safety uses the following assumptions about sea level rise: + 30 cm by 2050, + 80 cm by 2100 (compared to the year 2000).

to develop a long-term approach for the protection of the Flemish coast, with a time horizon of 2100. It is important to note that even after 2050 the average annual sea level and the level of a 1,000-year storm surge will continue to rise under the influence of global climate change.

In cooperation with the Coastal Department, VMM has drawn up the '*Flanders Climate Portal*' in which the state of the climate is mapped out using maps, key figures and graphs. In this portal, the current climate situation (temperature, precipitation, etc.), the effects (flooding, heat, drought) and the impact (victims, costs) of climate change can be consulted, but also climate scenarios up to 2100 can be framed. Comprehensive long-term climate scenarios are published by the Intergovernmental Panel on Climate Change (*IPCC*). Such estimates provide a deeper insight into the social importance of coastal protection measures and safety against flooding in general.

13.1 Policy context

In 2007, the *High Waters- or Floods Directive* (2007/60/EC) was adopted in response to concerns about the harmful effects of floods 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 waterways. Furthermore, since 2013, Europe has a strategy for adapting to climate change (COM (2013) 216, *website Climate Adapt*) which includes the impact on coastal areas. The opinion of the European Committee of the Regions (*2017/C 207/18*) makes policy recommendations based on the mid-term evaluation of the LIFE programme on a European strategy for climate change adaptation.

Since 1980, the policy concerning water management has been a competence of the regions (law of 8 August 1980). The most important legislative instrument within this policy concerns the *decree on integrated water management* of 18 July 2003, amended in 19 July 2013, which since 2010 provides for the Flemish transportation of the European Floods Directive. The *Coordination Commission Integrated Water Policy* hosts the deliberation in Flanders between the various policy domains and administrative levels involved in water policy. The policy context and the division of competences in Belgium and Flanders with regard to water policy is discussed in detail in the river basin management plan for the Scheldt and the Maas (*Programme of measures for the River Basin Management Plans for Scheldt and Maas 2016-2021*, *River basin management plans for Scheldt and Maas 2016-2021*), and a river basin management plan for the Belgian coastal waters (2016-2021) (*River basin management plan Belgian coastal waters 2016-2021*) (see also themes **Nature and environment** and **Scheldt Estuary**).

In Belgium, almost all coastal policy is regulated at the Flemish level. Although the federal government is competent seaward from the baseline (low-water line), the Government of Flanders also has some powers with an impact beyond the baseline, e.g. coastal protection measures (coastal safety) and the maintenance of the navigation channels to the four Flemish seaports. Specifically for floods from the sea, the *Coastal Division* (part of the Maritime Services and Coastal Agency – MDK, which falls under the Flemish policy area of Mobility and Public Works - *MOW*) is responsible for the safety of the Flemish coast against flooding. A policy is followed whereby the coastal protection measures are subjected to a safety test every six years. For this test, basic safety must be guaranteed in all coastal zones, namely protection against a storm surge with a statistical return period of 1,000 years. Within the framework of the *Masterplan Coastal Safety*, *Flanders Hydraulics*, in collaboration with the Coastal Division, also has drawn up flood maps and associated estimates of casualties and damage to the coastal area in the event of a storm surge (see also: the *geoloket* of waterinfo.be). These flood risk calculations will be updated on a regular basis. The most recent results have been determined for the situation in 2015 (*Ruiz Parrado et al. 2017*, *Vanneste et al. 2018*). The Masterplan Coastal Safety with time horizon 2050 and the *Complex Project Coastal Vision* (partly building on the project 'Vlaamse Baaien', which was initiated by a number of market parties but later adopted in the policy domain Mobility and Public Works) with time horizon 2100 of the Government of Flanders are elaborated in more detail in the section **13.5 Sustainable use**. In addition, the *Sigmaplan* of the Government of Flanders should also be mentioned. This plan regulates flood protection from the Scheldt and its tributaries, and runs until 2030, but is not discussed in detail here (see also theme **Scheldt Estuary**, *ScheldeMonitor* and the *VNSC* website).

Belgium and Flanders, each within their own competences, are committed to both mitigation and adaptation to climate change. This involves adaptation of natural and human systems to the current and expected consequences of climate change and is translated into the Flemish Adaptation Plan (FAP), part of the Flemish Climate Policy Plan (VKP) (*Voortgangsrapport 2015 Vlaams Klimaatbeleidsplan 2013-2020*). In order to realise all coastal protection measures, the environmental legislation needs to be respected by the drafting of Environmental Impact Assessments (EIA). Moreover, building permits must also be granted for the implementation of hard measures. This means close cooperation with, in particular, the Royal Belgian Institute of Natural Sciences (RBINS), the Agency for Nature and Forest (*ANB*), which falls under the Flemish policy domain Environment, and the Environment Department (*Omgeving*) with regard to the issue of building permits.

Since 100% safety can never be guaranteed, emergency plans are still needed. All coastal municipalities have to develop a municipal emergency plan against flooding from the sea (Special Emergency and Intervention Plan for flooding, in short 'BNIP floods'). If the (expected) impact of a storm surge exceeds the municipal level, the emergency planning is scaled up to the provincial level or even to the national level if this is no longer possible within the provincial emergency planning. The *province of West Flanders* is competent for the format and coordination of a provincial BNIP floods. The Crisis Centre of the FPS Home Affairs can take over the coordination by e.g. deploying the National Emergency Plan for 'Floods and High Water'.

13.2 Spatial use

The *Masterplan Coastal Safety* discusses the demarcation of areas of particular attention along the Flemish coast, as well as the necessary protection measures for each of these zones (see **13.5.2 An integrated approach to coastal protection**). The status of the works in these zones can be found on the following website: *www.afdelingkust.be*. The spatial distribution of the flood hazard (the physical characteristics of floods such as extent and depth) and the flood risks (potential negative consequences for humans, environment, heritage, etc.) are available for Flanders on the *geoportal* of waterinfo.be. For the Complex Project Coastal Vision, the use of space is elaborated in the alternative study (AON – Alternatives Research Note).

The protection of the coast is also discussed in the marine spatial plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014*). This vision paper stipulates certain spatial policy choices with regard to coastal safety (the raising and widening of beaches, raising of sandbanks off the coast). In the context of the implementation and support of the Masterplan Coastal Safety, sufficient sand and gravel extraction areas are demarcated in function of soft coastal protection (see also theme **Sand and gravel extraction**). In addition, a zone has been demarcated for the study of wave propagation in shallow coastal areas in the proximity of the Broers Bank in cooperation with the Coastal Division (*studieproject Meetnet Vlaamse Kust – Broersbank*). In consultation with the Flemish minister responsible for Coastal Safety, the new MSP for the period 2020-2026 will also include provisions to support the guarantee of safety against flooding of the coastal zone in the longer term. One of the provisions anticipates an area intended for the construction of a pilot island for coastal protection (*MSP 2020-2026, public consultation 2018*). As the plan is not yet final, changes may still occur.

13.3 Societal interest

13.3.1 Damage and casualties in case of floods

A study has been conducted to determine the protection measures of the *Masterplan Coastal Safety*. In addition to the safety tests of the sea barrier, flood risk calculations have been executed. In these calculations, the number of casualties and economic damage to be expected in 2006 for a range of (super)storms were examined (*Meire et al. 2011*). In 2015, the 2006 calculations were updated (*Vanneste et al. 2018*). Table 1 summarises the updated calculation results for a range of extreme storm surge levels. It is noteworthy that direct economic damage in absolute terms is higher than previously reported figures. This is due, on the one hand, to improvements in the LATIS software (developed by the department of Mobility and Public Works of the Government of Flanders and Ghent University) and, on the other hand, to an update of the monetary value of the buildings and infrastructure on the coastal protection measures and the coastal plain. The ongoing spatial developments in the coastal region further increase the potential economic and human losses. The damage that a storm with a certain probability of occurrence can cause is becoming ever greater (*Plan-MER for the Integrated Coastal Safety Plan: notification 2009*, *Kellens 2011*). However, compared to the previous calculation in 2006, a decrease in the damage and the number of victims is observed for the situation in 2015, if the same (monetary) basic data are used as input in the calculations. This is due to the measures already implemented in the framework of the Masterplan Coastal Safety.

The return period indicates the repeat period of an event (storm, storm surge). A return period of 100 years means that there is an average of 1 chance out of 100 that a certain event will occur in the coming year. It is interesting to note that with an additional sea level rise of about 50 cm, the current return period for a level of + 7.5 m TAW will shift from 1 change of 1,000 to 1 change of 100 per year (table 1).

In the context of the Masterplan Coastal Safety a map has been drafted with the distribution of the inundated area during a 1,000-year storm surge under the conditions present in 2015 (figure 2). The largest damage risk is situated in the four ports, which are also the weakest areas in terms of coastal safety. Prior to the implementation of the Masterplan Coastal Safety, the seaside resorts scored badly in the areas of Ostend centre, Ostend-Raversijde, Ostend-Mariakerke, Ostend-Wellington and De Haan-Wenduine. Also, the damage risk in Middelkerke-Westende was

Table 1. An overview of the flood risks in 2015 in the Belgian coastal area for different storm surge levels and return periods, with the associated deaths and the direct economic damage (*Vanneste et al. 2018*). (These figures 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**	**Deaths**	**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

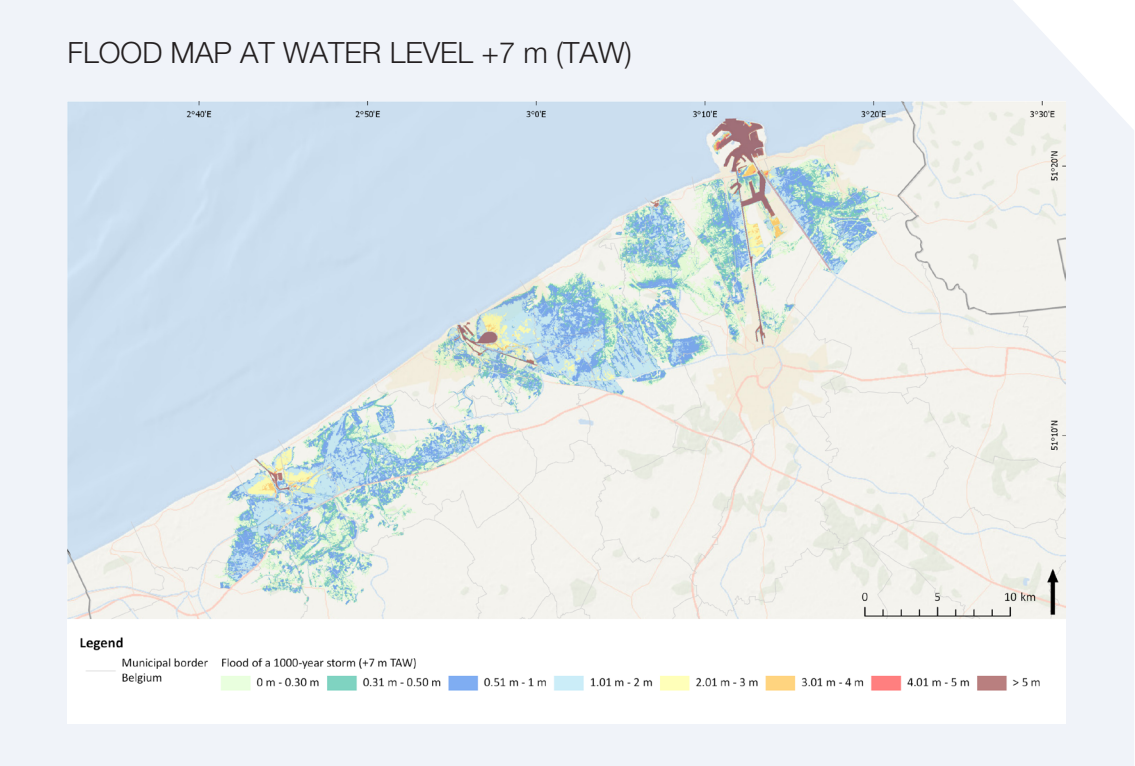

Figure 2. Calculation of the spread of flooding during a 1,000-year storm surge (+7.0 m TAW storm) under the conditions in 2015 (*Masterplan Coastal Safety*, *Ruiz Parrado et al. 2017*).

relatively high and the expected number of casualties in these zones was not socially acceptable. In the meantime, the risk has been reduced in the seaside resorts by carrying out the nourishments provided for in the Masterplan Coastal Safety.

The LATIS software was developed in Flanders, which calculates both risk and damage for the Flemish region. This instrument allows to determine the economic and human losses in case of a flood. The software is currently being extended with new modules that make it possible to chart the ecological, social and cultural impact of floods (LATIS version 4) (*Beullens et al. 2017*).

The potential economic loss and economic risks in the event of flooding can be consulted for the Flemish region using the following *geoportal* on waterinfo.be.

13.3.2 Investments in coastal safety

In Europe, it has been estimated that a total of 15.8 billion euro will have been invested between 1998 and 2015 in order to protect the coastline against floods and erosion (*Balancing the future of Europe's coasts, EEA 2013*). In the *ClimateCost* project (2009-2011), the associated costs have been calculated using different future scenarios (*Brown*

et al. 2011). Other European projects dealing with this issue include *Theseus* (2009-2013), *CLAMER* (2010-2011), *ANCORIM* (2009-2012), *COASTANCE* (2007-2013), *CoastAdapt* (2009-2011) and *SCAPE* (2016-2020).

The total cost of the investment of the *Masterplan Coastal Safety* is estimated to be more than 300 million euro. The renovation and reinforcement of sea locks, weirs and other constructions in the ports constitute a considerable share of this estimate.

The estimated volume of sand for maintaining the new beaches amounts to an annual average of 600,000 to 700,000 m³. Prior to the Masterplan Coastal Safety, the Flemish beaches were replenished with an annual average of 550,000 m³ of sand (both by means of pressure pipes and trucks) (figure 3) (*Maelfait and Belpaeme 2007*, *Vandewalle et al. 2008*, *Masterplan Coastal Safety*). Figure 3 shows the annual volumes of sand supplied for beach and foreshore nourishment. Beach nourishment contributes directly to coastal safety, foreshore nourishments rather indirectly as a possible method of beach maintenance. An important reason for the large quantities of sand supplied in 2014 and 2017 is the emergency nourishment after major storms (e.g. *Sinterklaasstorm* in December 2013, storm Dieter in January 2017) (see also theme **Sand and gravel extraction**). The foreshore nourishment in 2014 was constructed in Ostend-Mariakerke and is a pilot project in which the Coastal Department and Flanders Hydraulics wish to assess the effectiveness of a foreshore nourishment as an 'alternate feeding method' for the beaches. The data and results of this research project also serve to build up further knowledge about coastal morphology. In 2017, a foreshore nourishment was erected to the east of the port of Nieuwpoort, as nature compensation for works in and around the port of Ostend. This foreshore supplementation is also being monitored in the context of the research into 'alternative feeding methods' for the beaches.

In addition, the Government of Flanders is investing in research into how to incorporate coastal safety in the spatial development of the coastal zone in a sustainable and cost-effective manner. This is done, for example, in the *CREST project* (SBO programme, *Innovation and Business Agency 'VLAIO'*) (see also **13.5 Sustainable Use**; *Status Crest Research 2017*).

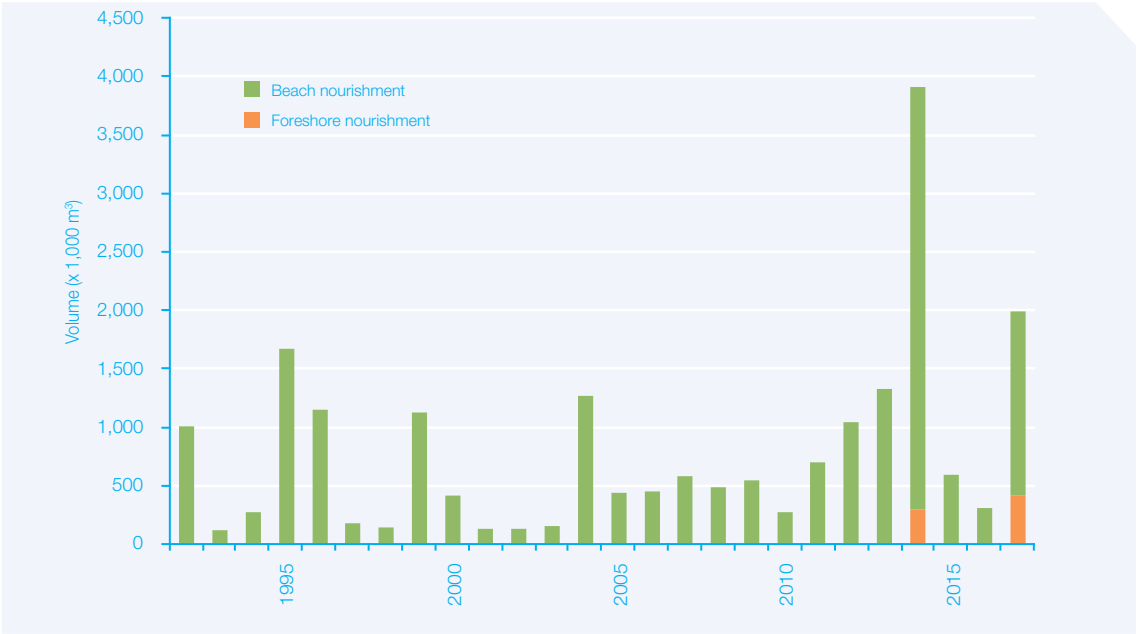

Figure 3. Evolution of the annual volumes of sand supplied for beach and foreshore nourishment (Source: Coastal Department). In the case of beach nourishment, sea sand is applied via dredgers above the low-water line. For pre-shore nourishment, the sand is applied below the low-water line.

13.4 Impact

The coastal protection works and infrastructure along the Flemish coast have, depending on the technique used, an impact on certain environmental aspects. The hard and the soft protection works are therefore subject to the European *EIA Directive* (2014/52/EU), which implies that an environmental impact assessment (EIA) report needs to be drafted prior to the granting of any environmental permit.

In general, the EIA studies of the *Masterplan Coastal Safety* estimate the environmental impact that may appear during the construction, subsequent to the execution and during the maintenance works. The effects need to be considered as potential effects, which depend on the section of the coast. The impact of the extraction of the necessary raw materials (e.g. offshore sand extraction) has been included in separate EIAs. Table 2 provides an overview of the potential effects which need to be considered during the assessment of coastal protection measures, as well as the associated literature which deals with these effects. A more detailed description is given in 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 EIA plan that maps out the environmental effects of the protection measures of the *Masterplan Coastal Safety* as a whole, a project-EIA may be needed to evaluate the local effects of the individual projects. In 2016, for example, the project-EIA for the storm surge barrier in Nieuwpoort was approved (*Environment, Nature and Energy Department 2016*). However, in most cases an exemption from the project-EIA can be requested.

Table 2. An overview of the potential effects that have to be taken into account when evaluating coastal protection measures, as well as the related literature.

Discipline	Potential effects	Literature
Water	-Turbidity of the water column -Modification of the flow pattern and the currents of the sea water -Hydrological effects – changing groundwater levels in the dunes and adjacent areas -Changes in the groundwater quality (depending on the quality of the replenished sand)	*Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende 2007*, *Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting 2009*, *Lebbe 2011*
Sea	Impact on the present seabed, beach, dune and polder soils (degree of soil disturbance) and the effect on the 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 (QUEST4D project BELSPO)*, *Houthuys et al. 2014*, *Colson et al., 2016*, *INDI67 BELSPO project*
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 the historical geographical elements and structures -Effects on the 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 the 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 Vinckx 2011*, *Vanden Eede 2013*, *Van Tomme 2013*, *Van Tomme et al. 2013*, *Vanden Eede et al. 2014*, *Colson et al. 2016*
Mobility	Modifications in the accessibility	*Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende 2007*, *Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting 2009*
Spatial use (Human - Space)	-Modifications in the access possibilities -Modifications of the recreational area -Modification of functions -Nuisance	*Plan-MER – Plan voor kustverdediging en maritieme toegankelijkheid van Oostende 2007*, *Geïntegreerd Kustveiligheidsplan. Niet-technische samenvatting 2009*
Human – health and safety aspects	-Possible 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*

13.5 Sustainable use

13.5.1 Floods directive

In the context of the *EU Floods Directive* (2007/60/EC), the Member States monitor the river basins and associated coastal areas that are vulnerable to floods. Flood hazard maps (physical properties of a flood such as the distribution and depth) and flood risk maps (potential negative effects on humans, environment, heritage, etc.) need to be elaborated by the Member States in accordance with this directive. In the case of Flanders, these maps can be consulted on the following *geoportal* (waterinfo.be).

The Member States need to develop flood risk management plans at river basin level, and align them with the neighbouring countries. In Flanders, these flood risk management plans are integrated into the river basin management plans that have been drafted in the context of the *European Water Framework Directive* (2000/60/EC) (WFD; see theme **Nature and environment**). The flood risk management plans of the Flemish coastal area are integrated in the river basin management plan of the Scheldt river (*Programme of measures for the River Basin Management Plans for Scheldt and Maas 2016-2021*, *River basin management plans for Scheldt and Maas 2016-2021*), and a river basin management plan for Belgian coastal waters (2016-2012) (*River basin management plan Belgian coastal waters 2016-2021*) (see themes **Nature and environment** and **Scheldt Estuary**).

This thematic document largely excludes flood risks from inland waterways. In Flanders, the Coordination Committee on Integrated Water Policy (*CIW*) coordinates the procedures for the drafting of all required documents for the WFD and the Floods Directive. Furthermore, an instrument such as the *water test* (*watertoets*) also contributed preventively to the restriction of the damage caused by floods.

13.5.2 An integrated approach to coastal protection

Considering the many user functions that are active in the coastal zone, Europe formulated a recommendation on integrated coastal zone management (ICZM, *2002/413/EC*). In this context, deliberations between services with competences with regard to the coastal zone are organised by the *Coastal Territorial Cooperation* of the province of West Flanders. The following section will elaborate on policies, studies, projects and initiatives which deal with coastal safety in an integrated way.

A resilient coast can withstand influences or fluctuations in the environment and will not change substantially due to natural processes and sustainable use. Dynamic coastal protection measures were defined as a core element for a sustainable coastal ecosystem in Flanders according to the Ecosystem Vision for the Flemish Coast (2017), which provides an ecological assessment framework for further development of coastal protection measures in the long term (*Van der Biest et al. 2017a*, *Van der Biest et al. 2017b*). At the end of the 20th century, the vision of coastal safety changed from a focus on 'hard measures' (such as seawalls) to a focus on 'soft measures' (sand). The coastal protection measures most used in Flanders is sand nourishment. This has contributed to an increase in the demand for sand (see also theme **Sand and gravel extraction** and figure 3). The Ecosystem Vision for the Flemish Coast (2017) is a supporting document for new interventions in the field of flood safety.

VISION FOR AN INTEGRATED APPROACH TO COASTAL SAFETY

In 2017, the Flemish Bays Initiative was reformed into the *Complex Project Coastal Vision*. A complex project is a new process approach developed by the Government of Flanders for projects with a major social and spatial impact. The aim is to realise projects within an acceptable period of time and with the widest possible support. The process approach consists of four phases: the exploration phase, the research phase, the development phase and the implementation phase. In December 2017, the initial decision of the Complex Project Coastal Vision was approved and the research phase was started. This specific complex project focuses in the first place on coastal safety but also looks at possible economic, social and natural benefits (see also *Rondelez et al. 2018* with the East Coast as focus area). In addition, the potential of pilot projects is being investigated in order to gather knowledge. In *Rondelez et al. (2018)* an overview is provided of the scientific knowledge available for these topics in recent years (table 3).

The new Ecosystem Vision for the Flemish Coast (*Van der Biest et al. 2017a*, *Van der Biest et al. 2017b*) deals with various potential natural flood protection measures, such as shallow sandbanks, foreshores and nourishments, submerged reefs, mud flats, tidal marshes and intertidal sandbanks; and dunes. The objectives of these studies were to develop an integrated vision for the Flemish coastal region and the development of an ecological assessment

framework to assess the long-term future development of coastal protection measures in terms of its impact on the feasibility of the desired situation. The second sub-report, *Van der Biest et al. (2017b)*, describes the methodology for an ecological status assessment and a tool for ecological effect assessments. The latter is being tested in case of the construction of an artificial island off the coast of Knokke-Heist. A number of initiatives, demonstration and innovation projects for integrated coastal protection are shown below in table 3.

MASTERPLAN COASTAL SAFETY

With the *Masterplan Coastal Safety*, the Coastal Division aims to protect the coast from at least a 1,000-year storm surge, and wants to reduce the residual risk of serious economic damage and casualties, based on a cost/benefit approach. The masterplan follows an approach according to the principles of ICZM (see *Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe*). Since its approval by the Government of Flanders on 10 June 2011, the plan has been gradually implemented. The website *afdelingkust.be* gives a description of the measures for each of the attention zones along the coast, as well as the status of the implementation (table 4).

Table 3. An overview of studies, projects and initiatives in the context of integrated coastal protection.

Studies, projects and initiatives	Running time	Explanation
Kappa plan (*Kustwerkgroep Natuurpunt 2010*)	2010	Natuurpunt and the West Flanders Environmental Federation (WMF) advocate an integrated climate adaptation plan for a sustainable vision for coastal protection. In this Kappa plan, coastal protection is worked out with natural climate buffers against climate change and flooding.
CcASPAR (Climate change and changes in spatial structures in Flanders) project (*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.
Metropolitaan Kustlandschap 2100 (exploratory and methodological analysis of the Belgian Coast, design assignments and exploratory design research part 1, 2 and 3) (*Geldof and De Bock 2014*)	2012 - 2014	This initiative from LABO Ruimte (Ruimte Vlaanderen and Team Vlaams Bouwmeester)- in association with the Department Mobility and Public Works and the Agency for Maritime and Coastal Services – explores various possible future scenarios for the Flemish coast from a metropolitan perspective.
The *BELSPO project CLIMAR* (*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, implemented 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.
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.).
4shore project(Colson et al. 2016)	2013 - 2016	Over a period of 3 years, this project has mapped out the ecological changes in foreshore and beach nourishments on a temporal and spatial scale for the beach and the shallow coastal zone.
4shorebis	2014 - 2016	This subproject is part of the 4shore project and evaluates the macrobenthos and physio-chemical properties of the soil sediment at the beach of Middelkerke after a nourishment activity.
Provoost et al. 2014	2014	In this ecosystem service report of the nature report 2014, the protection against floods from the sea by means of natural sea barrier elements is elaborated.
CREST project	2015 - 2019	Since 1 November 2015, the *CREST consortium* (*Climate Resilient Coast*) has been studying the robustness of the Flemish coast under a changing climate regime. In particular, effects on coastal dynamics and impact for future safety strategies will be investigated. This innovation project will allow 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; to determine the resilience of the natural coastal system in relation to storms and wind; and to develop 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.
Meetnet Vlaamse Kust – project Broersbank (*Thoon 2016*)	2013 - 2016	This study project has built up a unique data set and model set of instruments 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 consisting of seven buoys was developed off the coast.

Coastbusters project	2017 - 2020	In the Coastbusters demonstration project, the partners are going to construct a reef of 100 m² off the coast of De Panne. The reef must hold the loose sand that would otherwise be released and washed away during heavy storms. The natural reef is made up of three parts: seaweed or sea grass, mussel reef and a reef of sand mason worms.
The BELSPO *QUEST4D project (Van Lancker et al. 2012*)	2007-2011	This project quantified erosion/ sedimentation patterns and distinguished the natural from anthropogenic induced sediment dynamics.
Blue Cluster	2018 - running	The proposal for the spearhead cluster the 'Blue Cluster' proposes an extensive innovation process for the design, development, testing and validation of the building blocks for future coastal protection projects. This process covers different aspects of coastal protection and climate change adaptation which are all interlinked, ranging from the assessment of new technologies and concepts to enhancing the resilience, sustainability and economic viability of coastal protection measures.
SCAPE project	2016 - 2020	The aim of this project is 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 are developping a joint approach deploying the landscape against the water-related consequences of climate change.
Territoriaal Ontwikkelingsprogramma (T.OP) Kustzone	2017 - running	T.OP Coastal Zone was started up by the Department of Environment 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.
The BELSPO *CORDEX.be project*	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 BELSPO *TILES project* (*Van Lancker et al. 2017*)	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. The methodology has been elaborated in *van Heteren (2015)*, *Van Lancker et al. (2017)* and *De Tré et al. (2017)*.
The BELSPO *INDI67 project*	2014-2019	Development of methods to improve the monitoring of MSFD indicators 6 (sea floor integrity) and 7 (hydrographical conditions).
ARGONAUTS	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/replenished beaches.
The BELSPO *RS4MoDy project*	2017-2020	This project aims to investigate the morphodynamics of a tidal beach from short (storm event) to long term (> 25 years). This project will allow a better understanding of the morphodynamics of the beach and will provide some implications for coastal management.
The Interreg 2 Seas project *ENDURE*	2018-2020	This project focuses 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.

Table 4. An overview of the protection measures chosen and the state of implementation per focus area in the spring of 2018 (*Masterplan Coastal Safety*). The planned quantities of sand for the nourishments originate from the Masterplan Coastal Safety.

Zone of particular attention	Selected measures	State of implementation
De Panne - section 8	Dune nourishment Planned: 22.000 m³ sand	The essential volumes of dunes will be further budgeted for in 2018. Timing of the execution depends on the results of this actualisation.
De Panne - centre (sectie 13 tot 18)	Beach nourishment with an elevated beach Planned: 85.000 m³ sand	2011: construction of beach nourishment 2017: maintenance
St. Idesbald - Koksijde-centre (section 21 to 31)	Beach nourishment with an elevated beach Planned: 248.000 m³ sand	2011: construction of 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
Port of Nieuwpoort	Construction of a storm surge barrier	2018: start of construction of the storm surge barrier; the construction works will take more than 3 years
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 construction of nourishment for a beach lower than the seawall level 2017: maintenance Future: new seawall with wave-damping extension, grass dyke and reconstruction of the zone around the planned new casino
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 of the beaches 2014: construction of nourishment 2018: maintenance Future: storm wall of about 50 cm high on the seawall of Mariakerke
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-damping expansion seawall, mobile storm walls on seawall Ostend centre)	2012: sea dyke Albert I promenade along the entire 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 Further stages in study phase. Important subprojects are: protection measures in the Montgomerydock area and protection measures in the inner port. These are carried out in several stages.
Ostend-East (section 121)	Beach nourishment in line with OW-plan, partial plan for integrated coastal zone management Oosteroever (sections 199 and 120) Planned: 85,000 m³ sand	2014: construction of nourishment
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: maintenance 2015: renovated widened seawall, equipped with waterproofing elements and storm walls
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) Further stages in the study phase: adaptation of the drainage structures in the Blankenbergse Vaart and mobile barriers
Blankenberge (section 185 to 195)	Beach nourishment with low beach Planned: 384,000 m³ sand	2014-2015: phased construction of 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 then at locks in combination with an erosion barrier around the harbour	2018: Construction of the storm walls in design
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
Zwin (section 250 to 255)	Zwin project	2016-2019: construction of 4 km long Zwindijk, in combination with the digging of canals and construction of walls for expansion Zwin
Rehabilitation of locks and weirs	Ports of Blankenberge, Ostend and Zeebrugge	These projects are carried out in several phases

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*, the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

European legislation

Title	Year	Number
COM: Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of integrated Coastal Zone Management in Europe	2002	413
COM: Communication from the commission to the European economic and social committee and the committee of the regions. An EU Strategy on adaptation to climate change	2013	216
Directive establishing a framework for Community action in the field or water policy (Water Framework Directive)	2000	60
Directive on the assessment and management of flood risks (Floods Directive)	2007	60
Directive amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive)	2014	52
Directive establishing a framework for maritime spatial planning (MSP Directive)	2014	89

Belgian and Flemish legislation

Abbreviation	Title	File number
Decree of 18 July 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Law of 8 August 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02

14

Military use

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[5] Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature)

Depoorter, P., Dujeux, S., Gonsaeles, G., Devriese, L., Pirlet, H. (2018). Military use. In: Devriese, L., Dauwe, S., Verleye, T., Pirlet, H., Mees, J. (Eds.) Knowledge Guide Coast and Sea 2018 - Compendium for Coast and Sea. p. 209-217.

Military activities and exercises regularly take place in the Belgian part of the North Sea (BNS) and in the coastal area. These include: target practice on land towards sea, target practice on sea towards floating targets, detonation exercises with practice mines and historical real mines, exercises to lay, search and sweep mines, and extensive mine exercises with several NATO countries. In addition, amphibian, rescue and fly exercises take place as well, and Defence is also involved in search and rescue operations, enforcement, pollution control, etc. in the BNS (*Maes et al. 2005*, *GAUFRE project BELSPO*, *Berichten aan Zeevarenden (BaZ) 2018 nr.1*, *website Belgian Defence*).

A World War I dump site of war munitions is located in the BNS. It is situated along the coast of Knokke-Heist on the shallow sandbank *De Paardenmarkt*. According to OSPAR, 148 dump sites are located in the North Sea and the northeastern part of the Atlantic Ocean (*OSPAR QSR 2010*).

The naval component of the Belgian Ministry of Defence is also developing activities outside the BNS. In cooperation with e.g. the Federal Public Service for Mobility, support is provided to 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 (*BaZ 2018 nr.1*, see message 1/6B). Within the framework of NATO, it is also foreseen to contribute 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 *BaZ 2018 nr.1*, see message 1/6A). In the remainder of this text, however, the first focus will be on the activities within the BNS.

The Ministry of Defence also participates in the SAR organisation (Search and Rescue), under the coordination of the Maritime Rescue and Coordination Centre (MRCC) (see theme **Maritime transport, shipping and ports**), by nautical or aeronautical vessels. The frequency depends on the incidents that occur in de BNS. Moreover, in cooperation with other authorities, Defence resources can be deployed for enforcement, pollution control and other security reasons, taking into account existing agreements and cooperation agreements as well as general emergency and intervention plans.

14.1 Policy context

The policy relating to military activities is a federal matter belonging to the Ministry of Defence (*website Belgian Defence*). An overview of the legislation with regard to the military activities (at sea) is given in the *Codex Coastal Zone, theme Military activities* and *Berichten aan Zeevarenden (BAZ) 2018 nr.1*.

14.2 Spatial use

In the marine spatial plan (RD of 20 March 2014, see also *Van de Velde et al. 2014*), a number of zones reserved for military activities are indicated on the nautical chart (figure 1). Attention is paid to the compatibility with other (potential) users, such as shipping traffic and wind farms. The coordinates of these areas are communicated in the '*Berichten aan Zeevarenden*' (*BaZ 2018 nr.1*, see messages 1/36A, 1/36B, 1/37, 1/38 and 1/39).

Also in the process to establish the new MSP (2020-2026), the objective remains that the BNS continues to provide sufficient space for conducting military exercises (including exercises with an amphibious vehicle in shallow water). The contours and use of the different legally defined zones should be discussed, in function of good coordination with other activities and customs in the BNS (e.g. compatibility between Nieuwpoort-Lombardsijde shooting exercises and nature functions) (*MSP 2020-2026, public consultation 2018*).

14.2.1 Military activities and exercises in the coastal zone and the BNS

In the BNS and the coastal zone, military activities and exercises regularly take place (*BaZ 2018 nr.1*, *Belgian Defence*). These include:

- Target practices from land towards the sea. These practices only take place during the day on the military base (beach) in Lombardsijde. Appropriate signs and announcements are provided (see also the *Ministry of Defence website*) The practice area (D07) is divided into three sectors (K-small, M-medium and G-large), depending on the weapons used (*BaZ 2018 nr.1*, see messages 1/36A and 1/36B). Every year, the practice area is available for military activities for approximately 150 days. The K-sector is used about 54 days, the M-sector 39 days, and the G-sector zero days per year. These numbers may vary depending on the operational requirements of the Belgian Defence;
- Exercises to lay, search and sweep mines. These exercises take place in two smaller areas, more precisely NB-01 (between Gootebank and Westhinder, for exercises in deep water) and NBH-10 (between Wenduine and Oostende Bank, for exercises in shallow water). For certain manoeuvres, or due to weather conditions, it may be

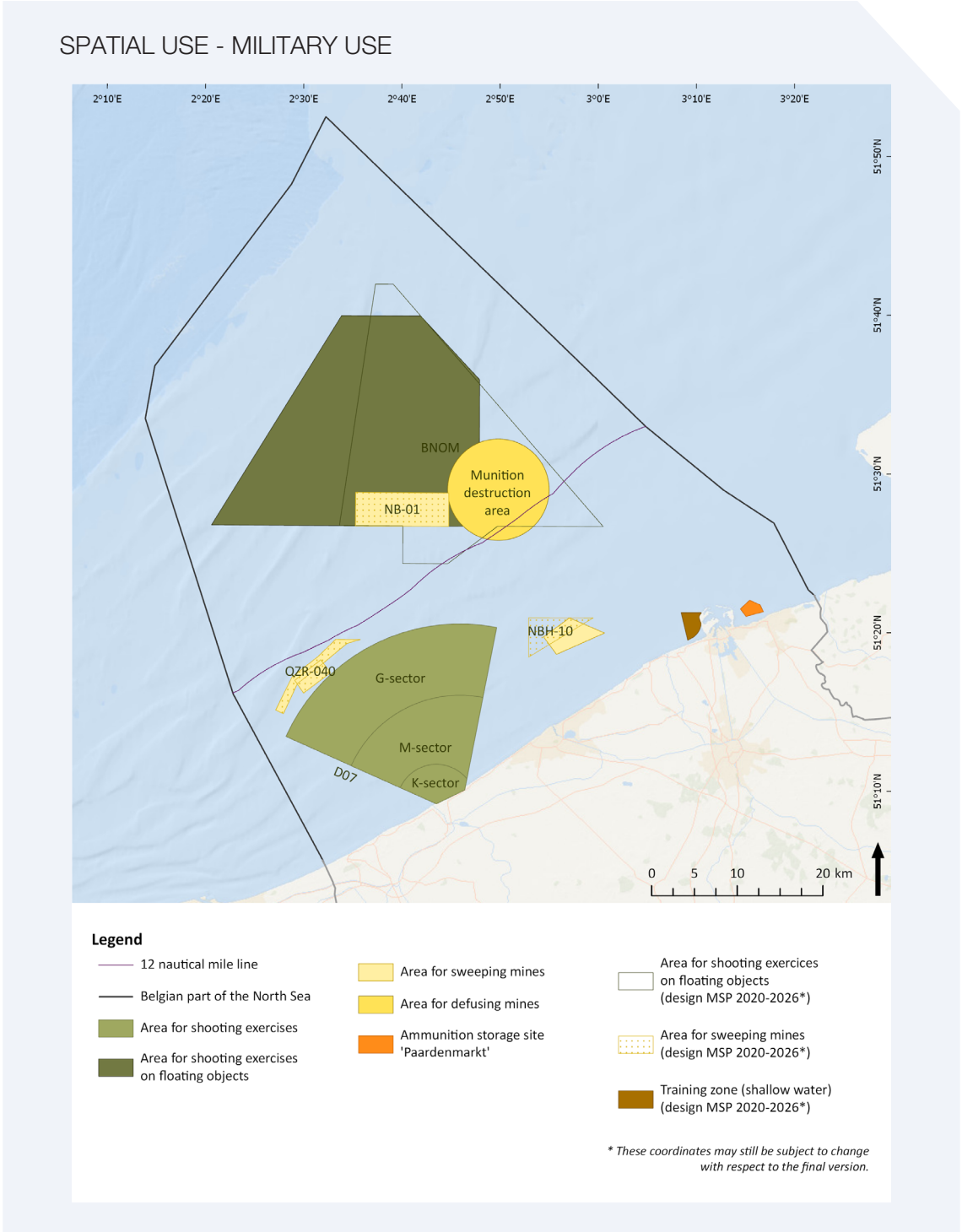

Figure 1.The demarcartion of the military training zones in the BNS (Source: RBINS, *marineatlas.be* (based on the RD of 20 March 2014), *MSP 2020-2026, public consultation 2018*).

necessary to navigate outside of these areas. The training zones can therefore be extended, if necessary, to the 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 southeastern part of the BNOM zone (zone Thornton Bank-Gootebank). After the exercises, the practice mines are removed;
- The QZR-040 zone and the zone Buiten Ratel is a practice area used by the international naval mine warfare school of Eguermin in Ostend for Naval Mine Counter Measures (NMCM) training (*BaZ 2018 nr.1*, see message 1/39);

- Detonation of historical real mines. Very occasionally, a real war mine is found by ships, fishermen or dredgers. The treatment of mines and explosives fished at sea must be carried out in accordance with *BaZ 2018 nr.1*, see message 1/10. Such mines are also detonated in the circular area, unless in case of an emergency and the munition appears to be immovable (*BaZ 2018 nr.1*, see message 1/38);
- Amphibian, rescue and fly exercises;
- Extensive mine exercises by several NATO countries. There is no set area for this kind of exercises. NATO always announces the location of the exercises beforehand. The NBH-10 zone is one of the possible training zones. Such large-scale exercises are held every two years in the BNS. Under the new MSP (*MSP 2020-2026, public consultation 2018*), a new amphibian exercise zone west of the port of Zeebrugge was requested.

Besides the different training activities, the navy vessels and resources of the Belgian Defence are used for military operations such as ensuring the Maritime Situational Awareness (MSA) for the guidance and monitoring of foreign vessels and for a large range of specific military security interventions (e.g. Maritime Security Operations – MSO).

Visits by foreign warships must be reported in advance and, if necessary, approved by diplomatic means (RD 30 December 1923). Submarines are required to navigate on the surface when passing through the territorial sea. In case of submarine accidents, a specific Distressed Submarine procedure is used (DISSUB, see *BaZ 2018 nr. 1*, message 1/9).

14.2.2 Military bases

The following military bases are located in the coastal area (*website Belgian Defence*):

- Camp Lombardsijde (Nieuwpoort/Middelkerke);
- Camp Adjutant Vlieger F. Allaeys (Koksijde);
- Bootsman Jonsen barracks (Ostend), including the naval mine warfare school;
- Naval base Zeebrugge;
- Camp LTZ V. Billet Damage Control center (Brugge).

The following military domains in the coastal zone have a management protocol with the Flemish Region (in general the Agency for Nature and Forest (*ANB*)):

- Camp Lombardsijde in Nieuwpoort/Middelkerke (54 ha);
- Camp 't Pompje in Oudenburg (62 ha).

14.2.3 Munitions dump site

After WWI, the Belgian Defence dumped German munitions on a large scale a few kilometres off the coast of Knokke-Heist on a shallow sandbank called the *Paardenmarkt*. There are at least 35,000 tonnes of munitions left on the seabed. Until recently, it was assumed that about one third consisted of toxic gas grenades. However, new indications reveal that this percentage may be significantly higher (*Missiaen 2013*). The exclusion 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 20 March 2014, see also *Van de Velde et al. 2014*). In this pentagon, bottom-disturbing activities are prohibited (RD of 20 March 2014).

14.3 Societal interest

The Belgian Defence is not only responsible for the protection of the Belgian territorial sea. In case of an emergency in the Belgian seas, the Channel or the North Sea, the Belgian army offers help and assistance and provides *inter alia* helicopters (*website airbase Koksijde*), 'ready duty ships' and divers (General Emergency and Intervention Plan (ANIP) North Sea). The commander of the province of West Flanders is competent for the deployment of additional staff, infrastructure and military resources (Source: Belgian Defence, Guidelines for Homeland Operations).

In addition, the Belgian Navy (Belgian Maritime Component) is responsible for the detection of violations in the Belgian sea zones (law of 13 June 1969, law of 20 January 1999, law of 22 April 1999). There is a collaboration with the Management Unit of the Mathematical Model of the North Sea of the Royal Belgian Institute of Natural Sciences (*RBINS-MUMM*) in the framework of detecting and combating pollution at sea. In the same way, support is provided for the identification of polluters to DG-ENV with the aid of Remoted Piloted Aerial Systems. The regent decree of 30 March 1946 grants other specific competences to the Belgian Maritime Component regarding marine and coastal demining and the surveillance of fisheries. In this context, the Belgian Navy performs checks on board fishing vessels in cooperation with the Flemish Agriculture and Fisheries Department.

Through *Maritiem Informatie Kruispunt* (*MIK*) in Zeebrugge and Ostend Radio, the Belgian Defence constitutes a part of the operational branch of the *Coast Guard* (see theme **Maritime transport, shipping and ports**). The organisation and responsibilities of MIK are stipulated in the RD of 6 February 2009. In addition to distress, emergency and safety traffic, Ostend Radio provides the notifications to shipping, both inland and at sea (Source: Admirality List of Radio Signals – Maritime Radio Stations, *BaZ 2018 nr.1*, see message 1/4). The Belgian Defence also intervenes in case of pollution in the North Sea, SAR operations and in case of the detonation of explosives at sea.

Furthermore, the Belgian Navy is responsible for the operation of the marine research vessel *Belgica*, which is managed by the Operational Directorate Natural Environment (*RBINS-OD Nature*). The Belgian Navy is also responsible for the training of foreign naval officers in the NATO naval mine warfare school in Ostend (*website Eguermin*). For this purpose, they have databases at their disposal with regard to the seabed and resources to investigate this matter. In this context, there is also collaboration with universities. In addition, the law regulating the protection of the underwater cultural heritage (law of 4 April 2014) introduced a notification obligation for finds that the discoverer may suspect to be cultural heritage (see also theme **Maritime and coastal heritage**). In consequence of this law, the Marine 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*).

EMPLOYMENT

With several bases along the coast, the Belgian Defence is responsible for significant direct and indirect employment. In 2018, direct employment in the coastal region amounted to 2,301 employees (table 1). Indirect employment derives from various maintenance companies which employ their staff at the bases (e.g. vessels maintenance), as well as from companies which perform occasional assignments for the Navy either at the naval base, or at their own shipyards. Furthermore, the suppliers of the quarters and ships should also be taken into account (Source: Belgian Defence).

Table 1. The direct employment at the army bases in the coastal zone in 2018 (Source: Belgian Defence).

Base	Employment (2018)
Zeebrugge (naval base, including crew)	1,111
Ostend (naval mine warfare school)	115
Lombardsijde (practice area + medical detachment)	318
St-Kruis (training navy, including Dutch colleagues in the context of binational activities)	437
Koksijde (airbase)	320
Total	**2,301**

14.4 Impact

14.4.1 Impact on the marine environment

MILITARY ACTIVITIES IN THE BNS AND SEAWARD TARGET PRACTICE

The impact of military activities in the BNS and seaward target practice on the marine environment is discussed in detail in *Degraer et al. (2011)*. The detection of mines and submarine exercises where sonar is used (zones NB-01 and NHB-10) may have a negative effect on marine mammals and fish (*André et al. 2010*, *Degraer et al. 2011*). Other exercises with explosions / target practices can 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 (MMM law of 20 January 1999), are discussed in **14.5 Sustainable use**.

Munitions that end up on the seabed during exercises are not cleared, except for practice mines. This may locally have a negative impact on the ecosystem due to the risk of leakage of copper and lead from munitions. 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* (*GAUFRE project BELSPO*), *Degraer et al. 2011*).

The target practices on land towards the sea take place near the the *IJzermonding* nature reserve (Yser Estuary) and near the habitats directive area 'Flemish Banks'. Furthermore, there are two marine birds directive areas (special protection area 1 and 2) and the Ramsar area 'Western Coastal Banks', which is designated for seaducks and grebes living in the vicinity of the target practices. The negative impact on fauna can be partially reduced by a proper timing taking into account the presence of marine mammals and large concentrations of susceptible seabirds and the breeding season (*Degraer et al. 2011*).

WAR MUNITIONS DUMP SITE

The release of chemicals that were used in the munitions of the *Paardenmarkt* site, such as mustard gas and Clark components (e.g. *Missiaen and Moerkerke 2002*, *Francken and Ruddick 2003*, *Francken et al. 2006*, *Francken and Ruddick 2007*, *Francken and Hafez 2009*, *Missiaen and Henriet 2010*, *Degraer et al. 2011*, *Missiaen 2013*), may lead to pollution of the sediment and the water column, and to disturbance of the food chain (*Goffin et al. 2007*, *OSPAR QSR 2010*, *Tweede Federaal Milieurapport 2015*).

Every year, divers of the Belgian Defence take part in a 'survey campaign' to collect samples from the bottom of the sea. A synthesis of the scientific research which was conducted on the impact of the munitions storage on the *Paardenmarkt* site is available on *Missiaen and Henriet (2010)*. A summary is given of the studies with regard to the topography, localisation of the munition, characterisation of the seafloor substrate, sampling and chemical monitoring, security, distribution of toxic components, biomonitoring and potential technical solutions. Furthermore, recommendations are formulated in this report for potential future research and / or actions that should be undertaken.

14.4.2 Impact on other users

Unexploded war materials constitute a potential danger for users of the sea such as fishermen and dredgers. The procedure to be followed in Belgium when mines or explosives are encountered is available in *BaZ 2018 nr.1*, see message 1/10 and in the *chart of explosives*.

In order to keep the sea, coastal waters and harbour channels free from mines, the Belgian Navy has concluded an international cooperation with the Dutch Navy: BENEFICIAL COOPERATION. In this context, they particularly address the problem of residual explosives from the First and Second World Wars. Weekly, fishermen and other vessels still encounter mines in the North Sea, which are subsequently marked and reported to the Coast Guard after which they are defused by a minehunter.

14.5 Sustainable use

14.5.1 Measures for seaward target practice

The target practices which occur in the coastal area of Nieuwpoort-Lombardsijde are subject to restrictions in order to reduce social nuisance. No target practices take place on Saturdays, Sundays, and public and school holidays, and in addition, these exercises only take place during the day. The periods when the target practices are suspended, are shown in the BaZ (*BaZ 2018 nr.1*, see messages 1/36A and 1/36B) and on the *website of Belgian Defence*. Infringements and complaints relating to the target practice rules can be submitted to the federal Police.

The target practices take place near the nature reserve the *IJzermonding* and in the marine areas of the western coastal zone which are protected by the EU Birds and Habitats Directives (see also **14.4.1 Impact on marine the 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 into account the presence of marine mammals) (*Maes et al. 2005*, *GAUFRE project BELSPO*, *Degraer et al. 2011*).

14.5.2 Measures for military activities at sea

On an international level, naval ships need to respect the rules stipulated in the United Nations Convention on the Law of the Sea (*UNCLOS 1982*). The impact of military activities on the marine environment is not covered by environmental policies and treaties, such as the international *ASCOBANS* Agreement (although the (sound)impact of military activities on small cetaceans is studied in the framework of this agreement and is called upon introducing mitigating measures in cooperation with military authorities, see e.g. *Bräger et al. 2010*) and the European Marine

Strategy Framework Directive (MSFD) (see e.g. *descriptor 11* Energy, incl. underwater noise). 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 executed in the BNS during the detonation of ammunition that ended up in the sea. Presumably, this noise will be at least of the same magnitude as pile driving for offshore wind turbines (*Belgian State 2018, public consultation*). Recent studies show that the damaging effect of the shock wave can be large and can reach very far, for example several tens of km for a 250 kg bomb (*von Benda-Beckmann et al. 2015*). There has been a plea for the consideration of the environmental effects of new military activities in the context of the Natura 2000 sites, protected by the European Birds Directive and Habitats Directive. Article 6 (section 3 and 4) of the Habitats Directive provide a balanced framework to solve potential conflicts between military activities and environmental protection at sea (*Guidelines for the establishment of the Natura 2000 network in the marine environment 2007*).

The measures protecting the marine environment (see theme **Nature and environment**) do not cover military activities (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 that case, the permission or authorisation is granted by both ministers. The law of 20 January 1999 does state 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 and preparedness of the armed forces. In *Degraer et al. (2011)* a few measures have been proposed in order to mitigate the impact of military shipping, the detonation of ammunition at sea, the use of sonar, chemical pollution, etc. In this context, the Belgian Defence investigates the frequencies of sonars and minehunters that have no influence on marine mammals, and 'pingers' are purchased to chase away the marine mammals during exercises or during the detonation of underwater ammunition (Source: *Defensie - Wapensysteem Management overleg 1e niveau – MijnenBestrijdingsVaartuigen (MBV 2018_02) -17 april 2018*).

The current trend for naval ships is to set an example on the ecological level. Within NATO, a special task force exists for this purpose (NATO Naval Armaments Group (NNAG) A/C141 - SWG12). Its aim is to promote the exchange of information between the NATO navies as well as the development of solutions, in order to meet the national and international regulations regarding the protection of the marine environment and in order to create common initiatives for building an environmentally friendly fleet. To realise these goals, NATO has adopted the principles of the *MARPOL Convention* and the London Dumping Convention and Protocol and adapted them to the specific demands of naval ships. Technically, the treaties are not applicable to military vessels, but military vessels do make the necessary efforts to respect these rules. 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 shipping 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 (Source: Belgian Defence).

Since 1966, the testing of nuclear weapons in the BNS has been forbidden by law (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 forbidden since 1973, and from 1999 onwards, this prohibition applies to the entire BNS (law of 18 August 1972, *Maes et al. 2005*, *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*).

14.5.3 Measures with regard to munitions dump sites

On an international level, the *OSPAR Convention* (1992) prohibits the dumping of all waste or other matters, including chemical waste. The dumping of chemical weapons at sea was forbidden with the ratification of the *Chemical Weapons Convention (CWC)* in 1997 (*Missiaen and Moerkerke 2002*). Subsequently, OSPAR published a recommendation for the reporting of conventional and chemical ammunitions in the OSPAR area (*OSPAR Recommendation 2010/20*).

On the European level, the Marine Strategy Framework Directive (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) concern the concentration of polluting matters: *descriptor 8* (*Law et al. 2010*) and *descriptor 9* (*Swartenbroux et al. 2010*). The revision of the initial assessment for Belgian marine waters (in the context of MSFD obligations) did not include ammunition leakage and monitoring of these chemicals (*Belgian State 2018, public consultation*). Given the fact that the dumping site at the *Paardenmarkt* sandbank is situated within the territorial waters and partly within the coastal waters, the Water Framework Directive (WFD) 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).

Due to the short distance from the coast and the shallow location, and given the fact that the dumping area is partly situated in the birds directive area (SPA-3), it is crucial to monitor the *Paardenmarkt* ammunition dump site on a regular basis (e.g. *Missiaen et al. 2002*, *Missiaen and Moerkerke 2002*, *Martens 2005*, *Missiaen and Henriet 2010*, *Missiaen 2013*). RBINS-OD Nature coordinates sampling at regular intervals on the *Paardenmarkt* with DG- ENV and Defence (divers) in order to detect any leaks of pollutants from the ammunition (*website OD Nature*). For this purpose the technique of passive samplers has been used for some time (see e.g. *Monteyne et al. 2013*, *ICES WGMS Report 2015*). The publication *Missiaen and Henriet (2010)* provides an overview of the conducted research and gives recommendations concerning further research and monitoring (e.g. geochemical monitoring) of the *Paardenmarkt* site. In *Degraer et al. (2011)* it is recommended not to intervene the *Paardenmarkt* site.

More recently, the Government of Flanders has been considering the possibility of clearing the *Paardenmarkt*. In this context, an 'innovative government contract' was set up to arrive at a pilot clearance of the ammunition dump. This assignment is drawn up by the Maritime Access Divsion (MOW Department) in cooperation with the EWI Department and forms part of the *Complex Project Coastal Vision*. The Interreg project *North Sea Wrecks* will provide tools necessary for planners, response organisations, economic actors and other stakeholders to assess and propose solutions for risk mitigation regarding wrecks and munitions in the North Sea.

14.5.4 The management of military domains

The Belgian Defence applies the federal and regional environmental legislation to the military activity, as far as this application does not obstruct the operational character or the international obligations (Source: *Bijlagenota bij het Federaal Milieucharter* (12 December 2001) and *Beleidsnota van Landsverdediging inzake Leefmilieu* (14 January 2004)). The internal environmental care within the Belgian Defence is mentioned in *André et al. (2010)*.

The *LIFE project Danah* aimed at protecting the species, protecting and expanding the heathland habitats, and preserving and restoring the nature values within Flemish military domains. This European nature restoration project did not have any applications in the coastal zone. 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 preconditions, but the often unique ecological as well as recreational/economic values are recognised and correspondingly managed (*Dumortier et al. 2009*). The environmental technical management plan concerning the dunes of the military domain 'Camp Lombardsijde' has been established in *Degezelle and Hoffmann (2002)*. The ammunition depot Zedelgem-Zuid has been fully transferred by the Defence to the Agency for Nature and Forest (ANB).

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex,* the national legislation can be consulted in the *Belgisch staatsblad* and the *Justel-databanken*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water (The Partial Test Ban Treaty (PTBT))	1963	1966
Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the seabed and the ocean floor and in the subsoil thereof (Seabed Treaty (Seabed Arms Control Treaty))	1971	1972
The convention of wetlands (Ramsar Convention)	1971	1975
International Convention for the prevention of pollution from ships and its Annexes, as amended (MARPOL Convention)	1973	1978 - 1983
United Nations Convention on the law of the sea (UNCLOS)	1982	1994
Agreement on the conservation of small cetaceans in the Baltic, North-East Atlantic, Irish and North Seas (ASCOBANS)	1991	1994
Convention for the protection of the marine environment of the North-East Atlantic (OSPAR Convention)	1992	1998
Convention on the prohibition of the development, production, stockpiling and use of chemical weapons and on their destruction (Chemical Weapons Convention, CWC)	1993	1997
Scheldt Treaty (Scheldeverdrag)	2002	

European legislation

Title	Year	Number
Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Directive on the conservation of wild birds (Birds Directive)	2009	147

Belgian and Flemish legislation

Abbreviation	Title	File number
Decision of the Regent of 30 March 1946	Besluit betreffende oprichting en organisatie van de Marine	
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 Februari 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
RD of 20 March 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
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

15

Scheldt Estuary

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The North Sea region is home to a number of important estuaries. These include the estuaries of the Seine (France), the Oder (Germany and Poland), the Elbe (Germany), the Weser (Germany), the Humber (United Kingdom), the Ems - Dollard (Germany and Holland) and the Thames - Essex (United Kingdom) (*Debergh et al. 2009*, *TIDE project*). These estuaries have a great ecological value and parts of them are designated as *Natura 2000 areas* (see also theme **Nature and environment**). On the other hand, these estuaries provide space for important economic activities such as harbour developments. Furthermore, these estuaries face common challenges such as increasing flood risks, developments in shipping (e.g. upscaling), issues regarding sediment management and the preservation of ecosystem functions. Because of 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 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 fresh - salt water gradient, with the associated tidal habitats and communities, is a unique feature in North-West Europe (*Directorate of 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.

Despite the fact that the Scheldt Estuary is a Flemish-Dutch story, this theme text focuses mainly 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*.

15.1 Policy context

15.1.1 Common policy and management

The policy and management of the Scheldt Estuary is a cross-border matter that involves both Flanders and the Netherlands. Between both countries, several treaties and memoranda of understanding (MoU) on the Scheldt Estuary have been concluded (see table 1 and *website VNSC*). Furthermore, ministerial declarations and treaties have been made in the context of integrated water management in the Scheldt Basin, which don't only involve Flanders and the Netherlands, but also the Walloon Region, the Brussels-Capital Region and France (see table 1 and website *website 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 coordination 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 about 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 aims to promote 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 response to specific policy and management questions, the official college may set up working groups to carry out specific tasks. In 2018, six working groups were active under the umbrella of the VNSC: 'Research and Monitoring', 'Development Sketch 2010', 'New Lock at Terneuzen', 'Policy and Management', 'Long-term Perspective on Nature' and 'Long-term Perspective on Accessibility'.

The cooperation between Flanders and the Netherlands includes a joint research programme and an integrated monitoring programme focusing on the functioning of the estuary (MONEOS), which will be succeeded by the permanent VNSC working group on Research and Monitoring (R&M). In 2014, 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. This report also identifies a number of priority themes towards a robust and sustainable *Agenda for the Future* for the Scheldt Estuary. This agenda started in 2014 with a comprehensive policy and management support research programme. In the meantime, initiatives have been started together with stakeholders in order to develop long-term perspectives for nature and accessibility (a.o. through the establishment of the Scheldt Council). Activities under the umbrella of the Agenda for the Future are coordinated by the permanent VNSC working group on Policy and Management, initially established for the first evaluation. In 2018, the second evaluation was launched (i.e. 5-yearly evaluation). It is expected that this report will be submitted to the Flemish and Dutch parliaments in the first half of 2019.

Table 1. Overview of cross-border treaties and memoranda for the Scheldt Estuary (Source: *VNSC*).

Flanders – The Netherlands (from 1960)	
Scheldt treaties	Memoranda of Understanding
Scheldt Council institution (2014)	MoU The Hague (2005)
Pilot Rates (2005)	Second MoU Vlissingen (2002) – mutual cooperation
Common Nautical Management (2005)	MoU Vlissingen (2002) – Safety
Common Policy and Management (2005)	MoU Kallo (2001) – Mutual cooperation
Development Sketch 2010 for the Scheldt Estuary (2005)	
Scheldt Treaty (2002)	
Widening of the Channel 48/43/38 feet (1995)	
Improvement of the Waterway at Walsoorden (1970)	
Scheldt-Rhine Connection (1963)	
Canal Ghent-Terneuzen (1960) Protocol Canal Ghent-Terneuzen (1985)	
Belgium – France – The Netherlands	
Treaties	Ministerial declarations
Treaty of Ghent (2002)	Ministerial declaration of Liège (2001)
Treaty of Charleville-Mézières (1994)	Ministerial conference in Middelburg (1998)

In addition to the system monitoring included in the MONEOS programme, specific monitoring programmes are being carried out with the aim of making the effects of certain interventions visible. The OMES programme (*Onderzoeksprogramma Milieu Effecten Sigmaplan*) monitors the effects of the different projects in the framework of the Sigmaplan, 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 developments of the *nature development projects in Zeeland*.

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, it also focuses on data and data products related to the Scheldt Estuary, with a focus on accessing and archiving data series from the MONEOS programme.

15.1.2 Common nautical management

There is also cooperation between Flanders and the Netherlands on a sectorial level. Through the Common Nautical Management (*CNM*), 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 CNM and is responsible for the safe and smooth handling of shipping traffic. The Common Nautical Authority (*CNA*) is responsible for the daily nautical control of the traffic flow. Real-time monitoring of shipping traffic on the Scheldt is carried out by the Scheldt Radar Chain (*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 Exploitation Team (*BET-SRK*).

15.1.3 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.

15.1.4 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 and Habitats Directives (Natura 2000), the WFD and the Floods Directive. This is done by setting specific targets for good ecological and chemical status (WFD) and conservation objectives (IHDs - N2000). The national and regional policy instruments then provide for the local implementation of these directives (see also theme **Nature and environment**). An overview of the policy framework for the Scheldt Estuary is available in *Debergh et al. (2009)* and on the following webpage: *www.scheldemonitor.be/en/node/67*.

15.1.5 Long Term Vision on the Scheldt Estuary

The Long Term Vision on the Scheldt Estuary (LTV, *Directorate of Zeeland and AWZ 2001*) was 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

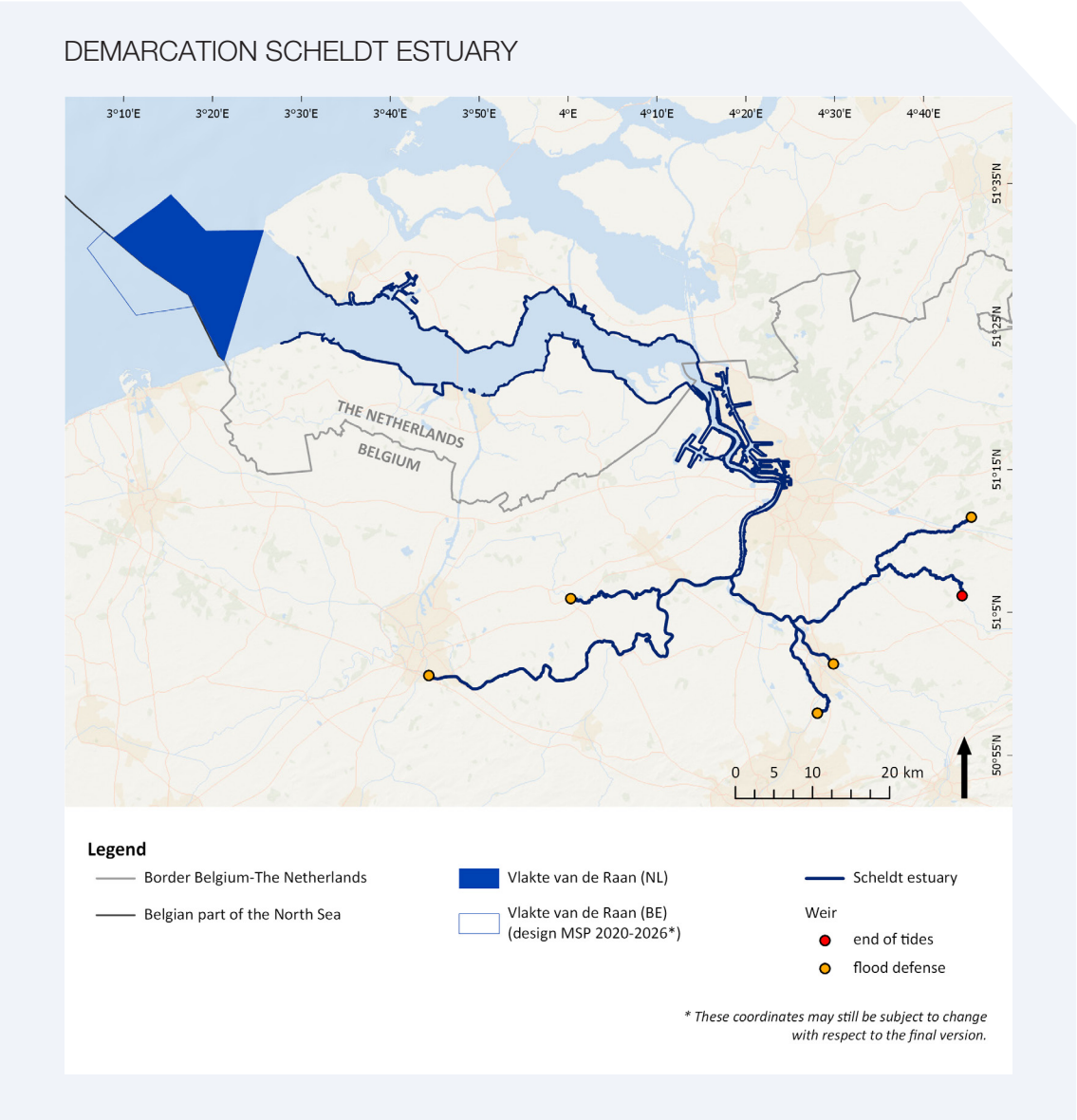

Figure 1. The area of the Scheldt Estuary, with an indication of the estuary, the Western Scheldt, the Lower Sea Scheldt and the Upper Sea Scheldt (Source: Natura 2000, *MSP 2020-2026, public consultation*, SchkeldeMonitor, Flemish Hydrography) .

focused on the themes ‘safety’, ‘accessibility’ and ‘nature’, with the development of the morphology of the estuary being central. 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 in 2030. Most of the projects have now been completed. A number of projects, such as the Westerscheldt Nature Conservation Package (with the depoldering of the Hedwige-Prosperpolder) and the realisation of the Sigmaplan, are still in progress.

In Flanders, the LTV themes of ‘safety’ and ‘nature’ are jointly implemented in the *updated Sigmaplan (2005)* approved by the Government of Flanders (2005). Under the motto ´Room for the river´, 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 wihtin a flood control area (FCA) with reduced tides (CRT)
- The renewal of dikes or depoldering;
- The development of wetlands in the valley, whether or not as a FCA.

15.2 Spatial demarcation

By definition, an estuary contains the part of a river which is subject to tidal influence (*Fairbridge 1980*). 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 LTV (*Directie 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. 2014*) 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. The shortcut channels form the mesocells (*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. 2014*):

- 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).

15.3 The ecosystem of the Scheldt Estuary

The Scheldt Estuary is an estuary in which the tidal regime along the entire salt - freshwater gradient is maintained (*Directorate Zeeland and AWZ 2001*). Because the tide penetrates 160 km inland, the Sea Scheldt has a vast freshwater tidal area with associated biotic communities (e.g. *Maris et al. 2014*). As a result, the Scheldt Estuary has a special natural value and a large range of ecosystem services (i.e. the benefits that society receives from

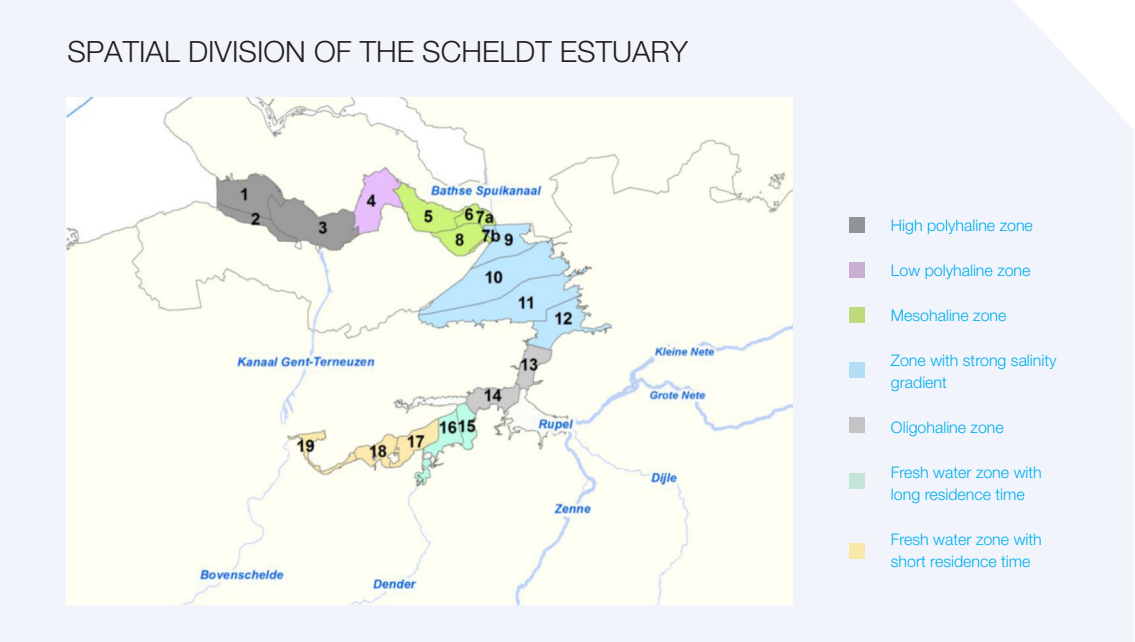

Figure 2. The spatial division of the Scheldt Estuary on level 3 and 4 according to the evaluation methodology (Source: *Maris et al. 2014*).

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 and Meire 2017*). Over the years, man has strongly influenced the Scheldt by means of reclamation and embankments, straightening, 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*) and a sharp decline in the acreage of mudflats and salt marshes as a result (e.g. *Van Braeckel et al. 2012*, *Maris et al. 2014*). The quality of the remaining habitats was also under severe pressure due to changes in hydrodynamics (e.g. current velocities, waves, duration of exposure time) 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. In this way, they are an essential habitat for economically important species such as sole (*Solea solea*) (*Maris et al. 2014*). 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*). 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 (*MER Verruiming vaargeul Beneden-Zeeschelde en Westerschelde 2007*). 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 form a refuge for, *inter alia*, the plankton in case of unfavourable conditions in the gully itself.

The ecosystem of the Scheldt Estuary provides a whole range of important ecosystem services in addition to its ecologically attractive function. For example, salt marshes play a role in the buffering of wave action (*Temmerman et al. 2015*, *Temmerman et al. 2015*) and sea level rise (*Broekx et al. 2011*, *Temmerman et al. 2013*), as a result of which they indirectly generate an economic value. The monetary valuation of (changes in) ecosystem services is already discussed in several publications (including *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 the provision of ecosystem services in the entire Scheldt delta, which includes 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 non-

native species can also be considered as a potential threat to species diversity in recent decades, some of which exhibit invasive characteristics (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*, *Vandepitte et al. 2012*, *Soors et al. 2013*, *Boets et al. 2016*, *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. 2014*).

The *ScheldeMonitor* collects the 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 list of reports on the websites of the *ScheldeMonitor* and *VNSC*).

15.4 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 (e.g. controlled flood plains), fishing, etc. The *ScheldeMonitor* website provides an overview of the available information (expertise, literature, projects, etc.), data (datasets, measured values, etc.) and data products (maps, graphs, indicators, etc.) related to these users. Certain human activities are also covered in the reports published in the framework of the R&M working group (see list of reports on the websites of the *ScheldeMonitor* and *VNSC*). Some of these activities are described in more detail below.

15.4.1 Shipping and ports

The Scheldt Estuary, particularly the area downstream of Antwerp, is characterised by a large number of shipping movements. In 2017, the number of seagoing vessels that entered the ports of Antwerp and Ghent (via Terneuzen) amounted to 17,316, or approximately 47 a day, of which 82% was accounted for by the port of Antwerp. These seagoing vessels represented a total gross tonnage of 444 million GT (92% for Antwerp), representing a total cargo traffic of 256 million tonnes (87% for Antwerp). In addition, inland navigation of goods in the port of Antwerp accounted for over 102 million tonnes (*Merckx 2018*). In 2016, the port of Antwerp also provided direct employment for 60,849 FTEs (59% of direct employment in Flemish seaports) and generated a direct added value of 10.8 billion euro (67% of Flemish seaports) (*Merckx 2018*, *Coppens et al. 2018*) (see also theme **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 *file database*, *Department Environment*).

Vlaamse Waterweg nv is working on an *integrated plan for the Upper Sea Scheldt* and wants to create a sustainable balance between all 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, so that large cargoes can be transported directly over water between Paris, Antwerp and Rotterdam. In order to prevent excessive traffic on the Ghent-Terneuzen Canal and the Western Scheldt, the Upper Sea 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.

15.4.2 Dredging and dumping

In 2017, the Government of Flanders (*Maritime Access Division*) invested 255 million euro to ensure the accessibility of Flemish ports (including the Scheldt Estuary, *Merckx 2018*) (see theme **Dredging and dumping**). This investment includes maintenance dredging at sea and on the Westerscheldt, widening of the fairway, 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 and works 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 for a tidal independent navigation of up to 13.1 m draugth and 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 aims to create new ecologically valuable habitats near a number of sandbank edges by means of targeted dumping of dredged material. In recent years, alternative dumping sites have also been explored by means of pilot dumping sites to re-dump the dredged material into the estuary (see also *VSNC website*). These new insights will be used in the optimisation of the dumping strategy.

The Maritime Access Division also has disposal permits from the provinces of East Flanders and Antwerp (Sea Scheldt) for the disposal of dredged materials from the maintenance of the Sea Scheldt and Western Scheldt, as well as the necessary extraction and dumping permits from the competent Dutch authorities (Western Scheldt).

For the Sea Scheldt, sludge management is an important point of attention (e.g. increased sludge concentration in the water column, indications of an increase in the total quantity of sludge in the estuary). The *Agenda for the Future* includes research into sludge management (*Vandenbruwaene et al. 2016*, *Vandenbruwaene et al. 2017*), with the aim of increasing system knowledge of the Scheldt Estuary and investigating the extent to which numerical models can reproduce these processes. On the basis of 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*).

The *sustainable management plan for the Upper 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 in order to keep the river navigable. The implementation of this sustainable management plan started in 2015.

15.4.3 Protection against flooding

The implementation of the *Sigmaplan* of the Government of Flanders provides protection against flooding from the Scheldt river and its tributaries, and runs until 2030 (see also **15.1 Policy context**; *ScheldeMonitor* and website *VNSC*). With research and monitoring programmes such as *OMES* (research on the environmental effects of the Sigmaplan; part of the *MONEOS* cross-border monitoring programme), Flemish water managers and scientists monitor the environmental impact of human activities in the Scheldt Estuary (*Maris and Meire 2017*). Also, since 2015, under the WFD (Directive 2000/60/EC), 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 real time at *www.waterinfo.be* and flood-sensitive areas can be searched for on the *Flanders Climate Portal* (see also theme **Safety against flooding**).

15.5 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*, *Plancke et al. 2017*, *Van Ryckegem et al. 2017*). 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 2). 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. (2014)*. 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, in which the year 2009 is considered as the

reference year (*Holzhauer et al. 2011*, *Maris et al. 2014*). *Depreiter et al. (2014)* describes the starting situation (T2009) and the trend developments until 2009 of the Scheldt Estuary. *Barneveld et al. (2018)* (T2015) evaluates the situation in the Scheldt Estuary between 2010 and 2015 and tries to identify the causes for the observed trends.

Prior to the evaluation method described above, a set of indicators has 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 *ScheldeMonitor*).

Table 2. Overview of the indicators which were selected within the evaluation methodology for the evaluation of the three principal functions of the Scheldt Estuary (Source: *ScheldeMonitor*).

Principal function	Indicator
Safety	Water movement dynamics
Accessibility	Navigability
Nature	Water quality
	Flora and Fauna
	Ecological functioning
	Habitat
	Bank-gully systems

Legislation reference list

Overview of the relevant legislation at the international, European, federal and Flemish level. For the consolidated European legislation we refer to *Eurlex*.

International agreements, treaties, conventions, etc.

Title	Year of conclusion	Year of entering into force
Canal Ghent-Terneuzen Protocol Canal Ghent-Terneuzen	1960 1985	
Scheldt-Rhine connection	1963	1998
Improvement of the Fairway at Walsoorden	1970	
Convention on wetlands of international importance, in particular as waterfowl habitat	1971	1975
Treaty of Charleville-Mézières	1994	
Widening Fairway 48/43/38 feet	1995	
Ministerial conference in Middelburg	1998	
Ministerial declaration of Liège	2001	
MoU Kallo		2001
MoU Vlissingen (2002) (2 MoUs)		2002 (2)
Scheldt Treaty	2002	
Treaty of Ghent	2002	
MoU The Hague	2005	2005
Pilot rates	2005	2008
Common nautical management	2005	2008
Common policy and management	2005	2008
Development Sketch 2010 for the Scheldt Estuary	2005	2008
Scheldt council Institution	2014	

European legislation

Title	Year	Number
Council Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	1992	43
Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)	2000	60
Directive on the assessment and management of flood risks (Floods Directive)	2007	60
Directive on the conservation of wild birds (Birds Directive)	2009	147