COMPENDIUM

COAST & SEA / KUST & ZEE

2015

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An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium

Colophon

The Compendium for Coast and Sea is an integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. The Compendium results from a collaboration between multiple academic groups, governmental authorities, civil society organisations and discussion platforms dealing with coastal and marine issues and was coordinated by Flanders Marine Institute (VLIZ).

The Compendium for Coast and Sea can be consulted online: *www.compendiumkustenzee.be*

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VLIZ

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Readers' guide to the Compendium for Coast and Sea

An integrated knowledge document about the socio-economic, environmental and institutional aspects about the coast and sea in Flanders and Belgium

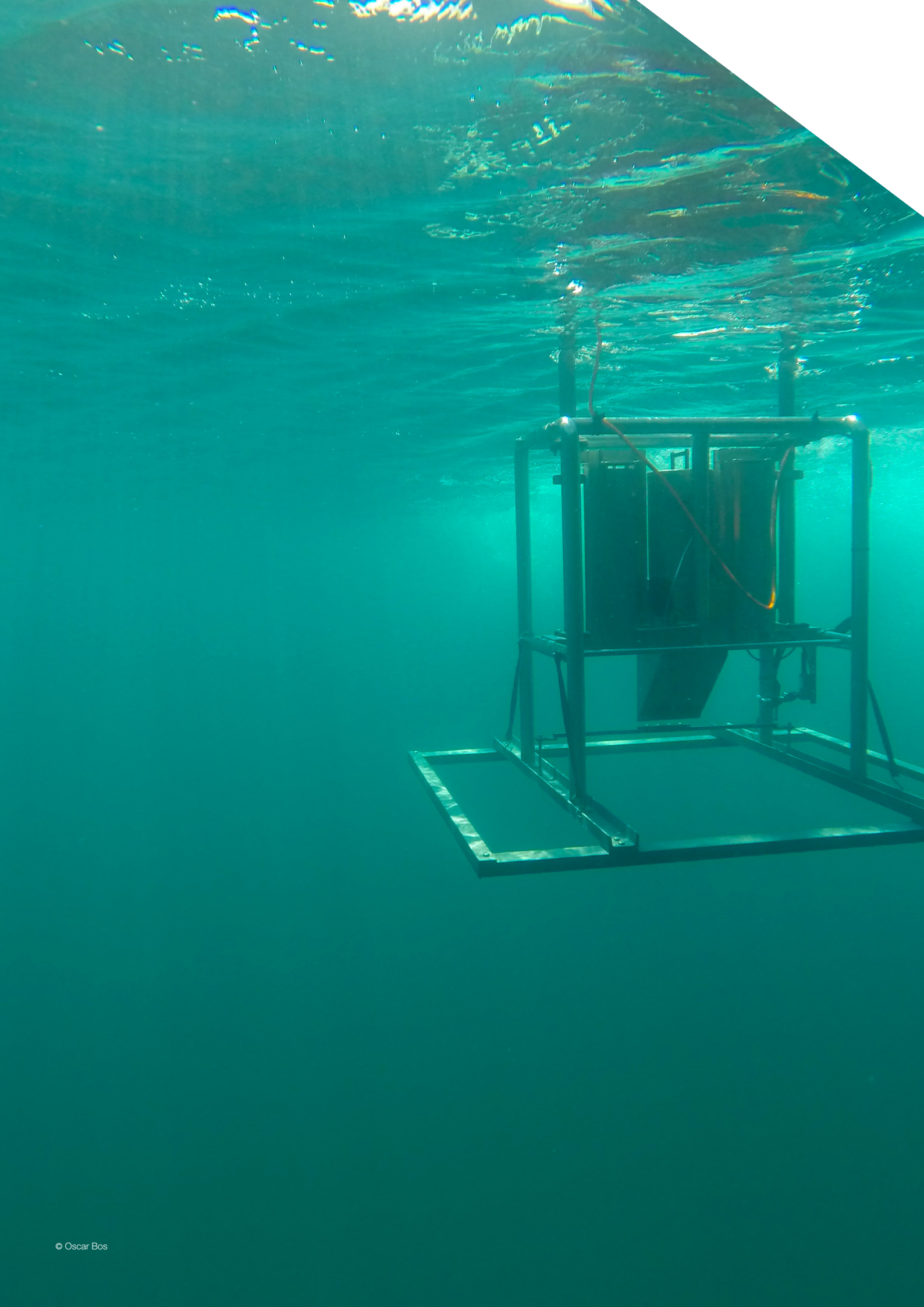
The Compendium for Coast and Sea is an initiative of the Flanders Marine Institute (*VLIZ*). The mission, goals and end products are guided by an expert group with members from the research community, government and civil society organisations. The expert group is supported by the Compendium secretariat (VLIZ) for the daily tasks and collaborates intensively with the VLIZ Scientific Board, a network of coauthors and reviewers and international experts for the realisation of the Compendium.

The disclosure of scientifically-underpinned and up-to-date information in order to respond to societal questions and challenges is of the greatest importance in the marine and maritime field. In this context, an integrated approach is necessary which addresses environmental and ecological research, as well as socio-cultural, economic and institutional aspects of the marine system. Although such information is partially available, it is generally highly fragmented, sector-specific or poorly accessible. The Compendium for Coast and Sea aims at aggregating the disperse information and data from the Flemish and Belgian marine and maritime research community and experts. In line with the Open Access policy, the cited references are made publicly available as much as possible by means of the Integrated Marine Information System (IMIS) of VLIZ. The texts of the Compendium are digitally disclosed in Dutch and English on the website of the Compendium for Coast and Sea: *www.compendiumkustenzee.be*.

The Compendium focuses on the Belgian part of the North Sea (BNS), the adjacent estuaries and the coastal area. The integrated and multidisciplinary character of the Compendium aims to increase the communication within the broad network of marine scientists and experts (from industry, policy, etc.) who are professionally involved with the coast and the sea. Furthermore, it increases the visibility and accessibility of marine research.

The Compendium for Coast and Sea includes an extensive background document which describes the marine scientific landscape (**Chapter 1**) and a summary of the knowledge on different user functions of the coast and sea, as well as an integrated theme about he Scheldt Estuary (**Chapter 2**). Furthermore, a number of derived communication products were developed which are digitally diclosed on the website:

- Brochure 'Belgian marine research - an overview' (2015) - (*Mees et al. 2015*)
- A guide to funding instruments for marine research and innovation projects (2015) - (*Pirlet et al. 2015a*)
- Catalogue 'Marine research infrastructure' (2015) - (*Pirlet et al. 2015b*)
- Vademecum 'Marine policy and legal instruments for the Belgian part of the North Sea' (2015) - (*Verleye et al. 2015*)



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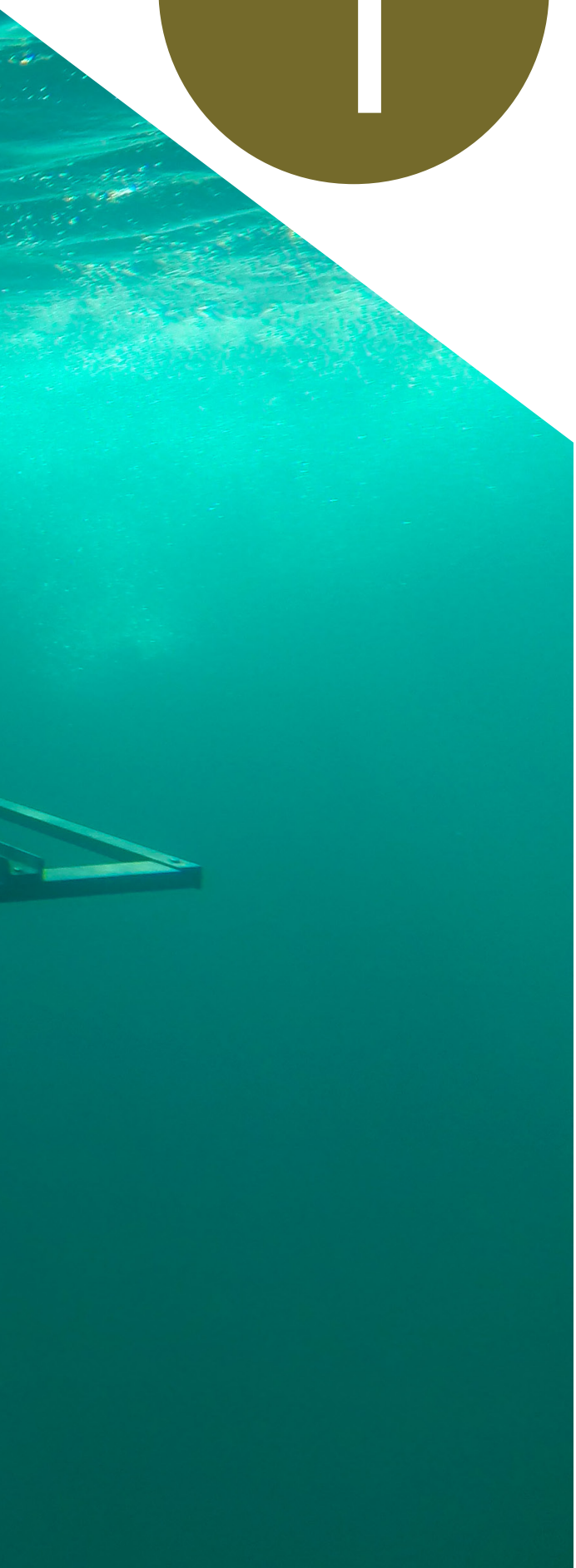

Chapter 1

Marine Research

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1. Introduction

Seas and oceans play a crucial role in the overall functioning of the earth: they absorb a large part of the atmospheric carbon dioxide, and are estimated to produce more than half of the oxygen that is available for life on earth (*Field et al. 1998*, *Behrenfeld et al. 2006*). As a storage of energy, oceans have a major impact on climate and the watercycle. Moreover, seas and oceans contain a significant part of the biological diversity on the planet (*Appeltans et al. 2012*, *WoRMS Editorial Board 2013*). In economic terms, the importance of oceans is still growing: they are a major source of food, water, energy and natural resources, generate a high economic turnover from tourism and provide the backbone of European international trade. However, our oceans are not inexhaustible or indestructible. Signs of increasing human pressures and impact on the quality of the environment are everywhere. Still, oceans remain the least explored and studied realm on earth. Multidisciplinary scientific research is crucial for understanding global processes and ecosystem functioning. This knowledge is needed for sustainable development of our growing maritime economies, and is essential for the prospective management of ecosystems towards a sustainable future. Immediate action is recommended on urgent questions such as food security, security of water and energy, climate change, and the welfare of humanity (*Rome Declaration 2014*).

This chapter provides an overview of marine research in a global, European and local context. It maps the marine research landscape in Flanders and in Belgium, building on quantitative measurements related to research capacity, research resources and knowledge output. As such, it provides a review of the expertise and diversity of the marine research community.

1.1 Marine research: global context

Oceans and seas can be considered as a single and highly connected living environment. Therefore, marine research must be approached on a global level. Several initiatives and organisations make the effort to coordinate their marine research programmes at an international level.

The Intergovernmental Oceanographic Commission (*IOC*) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) is mandated for the global coordination and execution of programmes for research and observation of the oceans, exchange of oceanographic data and information, services and training (table 1).

The *UN-OCEANS* network promotes a higher level of cooperation between UN bodies on a global level: the Convention on Biological Diversity (*CBD*), the International Maritime Organisation (*IMO*), the International Seabed Authority (*ISA*), the UN Environmental Programme (*UNEP*), the UN Development Programme (*UNDP*) and the Intergovernmental Panel on Climate Change (*IPCC*) are of particular relevance for marine and coastal research.

The UN Conference *Rio+20*, which took place 20 years after the first meeting (1992) in Rio de Janeiro (Brazil), focuses on a global agenda for sustainable development with a specific chapter on seas and oceans. In September 2015 the world leaders agreed on a set of Sustainable Development Goals (SDGs), of which *SDG 14* addresses the oceans (*Transforming our World: the 2030 Agenda for Sustainable Development*).

In the framework of the United Nations Convention on the Law of the Sea (*UNCLOS*, 1982) there are several international organisations responsible for policy making and management of activities such as shipping and fisheries and their effects on the environment. In support of these tasks, research and technological innovation are carried out. Recent developments focus on the expansion of activities such as the exploration of the Arctic waters and the deep sea, where important scientific, technological and policy challenges need to be addressed.

At the global level, a number of research networks and programmes focus on marine research (see table 2).

Table 1. Programmes for marine research, data management and training of the Intergovernmental Oceanographic Commission (*IOC*-UNESCO).

PROGRAMMES FOR MARINE RESEARCH, DATA MANAGEMENT AND TRAINING OF IOC-UNESCO		
Ocean Science Section - research coordination	Ocean acidification / ocean carbon	*Ocean Acidification* International Ocean Carbon Coordination Project (*IOCCP*)
	Climate change and adaptation	World Climate Research Programme (*WCRP*) Climate Change and Ecosystems, Coral Reefs (*GCRMN*) Climate Change and Ecosystem Dynamics (*GLOBEC*) Adaptation Climate Change in Africa (*ACC Africa*)
	Harmful algal blooms	Harmful Algal Bloom Programme (*IOC-HAB*) Global Oceanography and Ecology of Harmful Algal Blooms (*GEOHAB*)
	Marine spatial planning	Marine Spatial Planning Initiative (*IOC-MSP*)
	Integrated coastal zone management	Integrated Coastal Area Management (*ICAM*) Southeast Pacific Data and Information Network in support to Integrated Coastal Area Management (*SPINCAM*) *Integrated Coastal Research – nutrient management* and Nutrients and Coastal Impacts Research Programme (*N-CIRP*)
	Marine biodiversity	Ocean Biogeographic Information System (*OBIS*)
	Global environmental reporting	UN Regular Process (*UN Reg Process*) and Assessment of Assessments (*World Ocean Assessment*)
Operational data collection and observation of the oceans	Global Ocean Observing System (*GOOS*) Joint Technical Commission for Oceanography and Marine Meteorology (*JCOMM*, jointly with *WMO*) International Oceanographic Data and Information Exchange (*IODE*); including Ocean Biogeographic Information System (*OBIS*)	
Data networks, data portals, data centres	IODE National Oceanographic Data Centres; includes the Belgian Marine Data Centre (BMDC) (RBINS-OD Nature) and VLIZ data centre (VLIZ) in Belgium IODE Regional Ocean Data and Information Networks (*ODINs*): *ODINAFRICA*, *ODINCARSA*, *ODINCINDIO*, *ODINECET*, *ODINWESTPAC*, *ODINBLACKSEA* *IODE Ocean data Portal*, World Ocean Database 2009 (WOD09)	

Table 2. Global marine research networks and programmes.

ORGANISATION	DESCRIPTION
POGO	Partnership for Observation of the Global Oceans
WAMS	World Association of Marine Stations
CoML	Census of Marine Life
IGBP	International Geosphere-Biosphere programme, sponsor of the projects: Integrated Marine Biogeochemistry and Ecosystem Research (*IMBER*), Land-Ocean Interactions in the Coastal Zone (*LOICZ*) and International Surface Ocean - Lower Atmosphere Study (*SOLAS*)
WCRP	World Climate research Programme, sponsor of Variability and Predictability of the Ocean-Atmosphere System (*CLIVAR*)
GEOTRACES	International Study of Marine Biogeochemical Cycles of Trace Elements and their Isotopes
Future Earth Programme	*Science and Technology Alliance for Global Sustainability*; a collaborative effort of different partners including the International Council for Science (*ICSU*) and its Scientific Committee on Oceanic Research (*SCOR*); UNESCO; UNEP; WMO
DIVERSITAS	Integration of biodiversity research at the global level; participation of different UN-partners
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services; participation of different UN partners
OECD	Organisation for Economic Cooperation and Development: research on Marine Biotechnology (*OECD 2013*) and economic use of the oceans (*Future of the Ocean Economy*)

1.2 Marine research: European context

EUROPEAN POLICY FOR RESEARCH AND INNOVATION

European Commission - General science policy and organisation

The Directorate-General for Research and Innovation (*DG R&I*) of the European Commission (EC) is responsible for European research and innovation policies. Its policy goals are oriented towards the European strategy for economic growth (*Europe 2020*) and innovation (*Innovation Union*), one of the 7 initiatives within the Europe 2020 Strategy. DG R&I is also responsible for the funding and the establishment of funding instruments for research and innovation, such as the European Framework Programmes (FPs). This includes the current 'eighth Framework Programme' *Horizon 2020* (regulation (EU) 1290/2013).

The European Research Council (*ERC*) is an independent entity within the DG R&I, and funds ground-breaking research conducted by outstanding scientists. The Marie Skłodowska-Curie actions (*MSCA*) aim to increase the interdisciplinary mobility of researchers and support strategic partnerships between hosting research institutes. The European Research Executive Agency (*REA*) of the EC is a funding body responsible for managing Horizon 2020 (together with *ERC*, the Executive Agency for Small and Medium-sized Enterprises (*EASME*) and Innovation and Networks Executive Agency (*INEA*)). Independent entities conducting specific research for the EC include the Joint Research Centre (*JRC*) and the European Environment Agency (*EEA*), supported by the European Topic Centers (ETCs) and the European Environment Information and Observation Network (*Eionet*).

European Commission – Marine networks and cooperation

Research on oceans and seas inherently involves high costs and relies on research facilities that are not always accessible to all European researchers. The alignment of objectives and the pooling of available financial resources and capacities allows to address challenges in an effective and coordinated way. Moreover, 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 - COM (2010) 461).

Horizon 2020 facilitates and finances multidisciplinary research and innovation within different fields, technologies and disciplines. The agenda of this programme is strongly linked with the societal and policy context (*Pirlet et al. 2015a*, Guide to funding instruments). Horizon 2020 combines research funding with business-oriented funding for innovation measures, as well as funding coming from the European Institute of Innovation and Technology (*EIT*), to combine science, higher education and the launch of new goods and services. The seventh Framework Programme (FP7) already aimed at a strong EU leadership in the global knowledge-based economy (Europe 2020 Strategy), *inter alia* by building the European Research Area (*ERA*) to stimulate an open exchange of scientists and knowledge. The first steps in this process were the *ERA-NET projects*, a number of which were situated in the marine field, e.g. *MarinERA*, *AMPERA*, *MariFish* and *SEAS-ERA*.

Cooperation in research is also stimulated through the European Innovation Partnerships (*EIP*), Joint Technology Initiatives (*JTI*), Coordination and Support Actions (*CSA*) and the cooperation agreements on scientific research between and with member states as described in *Article 185* of the EU Convention. The European Strategic Forum for Research Infrastructure (*ESFRI*) supports a coherent and strategic approach to policies for research infrastructure in Europe. It facilitates initiatives leading to a better use and optimal development of this infrastructure at the European and international level. Three ESFRI initiatives are of particular relevance to marine research in Flanders and Belgium: the Integrated Carbon Observation System (*ICOS*) and its Ocean Thematic Centre (OTC), the E-Science European Infrastructure for Biodiversity and Ecosystem Research (*LifeWatch*), and the European Marine Biological Resource Centre (*EMBRC*). Flanders and Belgium do not take part in the other marine ESFRIs: European Multidisciplinary Seafloor and water column Observatory (*EMSO*) and *EURO-ARGO*.

Strategic research agendas and visions for the future

A number of networks and consortia with a strong representation of the European research community are oriented towards the development of a vision and preparation of strategic agendas for marine research. The European Marine Board (*EMB*) develops the interface between marine research and marine/maritime policies, and draws Position Papers on research priorities and strategies for European marine research such as *Navigating the Future IV* (figure 1).

The *EurOCEAN conferences* offer a platform for those involved in the research-policy interface, both at the European level and in the member states. These conferences allow the European research community to participate in shaping the European vision for marine research through the *Galway Declaration (2004)*, the *Aberdeen Declaration (2007)*, the *Ostend Declaration (2010)*, and the *Rome Declaration (2014)*. The *Brest Declaration (2011)* focuses on marine research infrastructure (figure 1).

In Europe, research agendas are mainly determined by the member states (for Belgium, see **Policy context for scientific research in Flanders/Belgium**). 88% of all public investments in research and development (R&D) are designed, financed and evaluated at national (and within Belgium also by the regions/communities) and local levels (*Acheson et al. 2012*). Joint Programming (JP) offers an integration and coordination platform for European member states in order to efficiently use the available national budgets and organisational resources for research; for example by drafting joint research agendas and aligning priorities for cooperation in the long term. Whereas the FPs are jointly managed at a European level, JP is characterised by a bottom-up approach with a variable geometry for participation. Since 2009, 10 Joint Programming Initiatives (JPIs) were launched, including the initiative for 'Healthy and Productive Seas and Oceans', also referred to as *JPI Oceans*, that adopted its *Strategic Research and Innovation Agenda 2015-2020* in the spring of 2015.

Other examples of partnerships between research institutes at the European level are the European Fisheries and Aquaculture Research Organisation (*EFARO*), the European Global Ocean Observing System (*EuroGOOS*), the European Network of Marine Research Institutes and Stations (*MARS*), the European Marine Research Network (*EUROMARINE*), the EU Technology Platforms *Waterborne* and *EurOcean*. Marine research is also an important component to support the operational tasks of different European and regional organisations regarding pollution, safety, dredging, etc.

DRIVERS FOR MARINE RESEARCH IN EUROPE

Different policy domains of the EC with regard to the oceans affect the European marine research in a significant way. The Integrated Maritime Policy (IMP, COM (2007) 575) is a cornerstone in these policies. The IMP aims at a more coherent approach to maritime affairs and a higher degree of coordination between the different policy domains involved. The IMP consists of a number of transversal policy instruments in the fields of Blue Growth (COM (2012) 494), Blue Innovation (COM (2014) 254), Marine Knowledge (COM (2010) 461) (see below), Maritime Spatial Planning (directive 2014/89/EU), Integrated Maritime Surveillance (COM (2009) 538) and the Regional Sea Strategies (*Verleye et al. 2015*) (figure 1). In the EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) the member states agreed to achieve a Good Environmental Status (GES) in their marine waters by 2020. The MSFD addresses the environmental aspects of the IMP and is an important driver for marine research aiming to fill the knowledge gaps. It also provides a common framework and goals for the protection and conservation of the marine environment (see also theme **Nature and environment**).

The European strategy for marine and maritime research (COM (2008) 534) was drafted within the IMP, following the *Aberdeen Declaration (2007)* (figure 1). Its aim is to provide policy makers with the necessary scientific information in support of:

- The socio-economic importance of the maritime economy;
- The increasing pressures on the marine environment as a result of human activities and climate change;
- The increasing competition for marine space.

The strategy also aims at an Integrated Marine and Maritime Research Area (*DG R&I*).

Marine Knowledge 2020 (COM (2010) 461) is an important component within the IMP. This initiative aims at centralising marine data from different sources. The aim is to provide increased efficiency to access quality-checked marine data for industry, policy makers and scientists to support the development of new or improved products and services and increase our knowledge of the oceans. At the heart of Marine Knowledge 2020 is the European Marine Observation and Data network (*EMODnet*) which integrates marine data, data products and metadata from different sources in a uniform way through a web portal.

Besides the IMP, there are a number of sectoral (marine and maritime) policy instruments that provide guidance for marine research in a European context. Evident examples are the Common Fisheries Policy (CFP, regulation (EU) 1380/2013), and the implementation of the Water Framework Directive (WFD, 2000/60/EC), the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) in marine areas and coastal zones (see also *Verleye et al. 2015*).

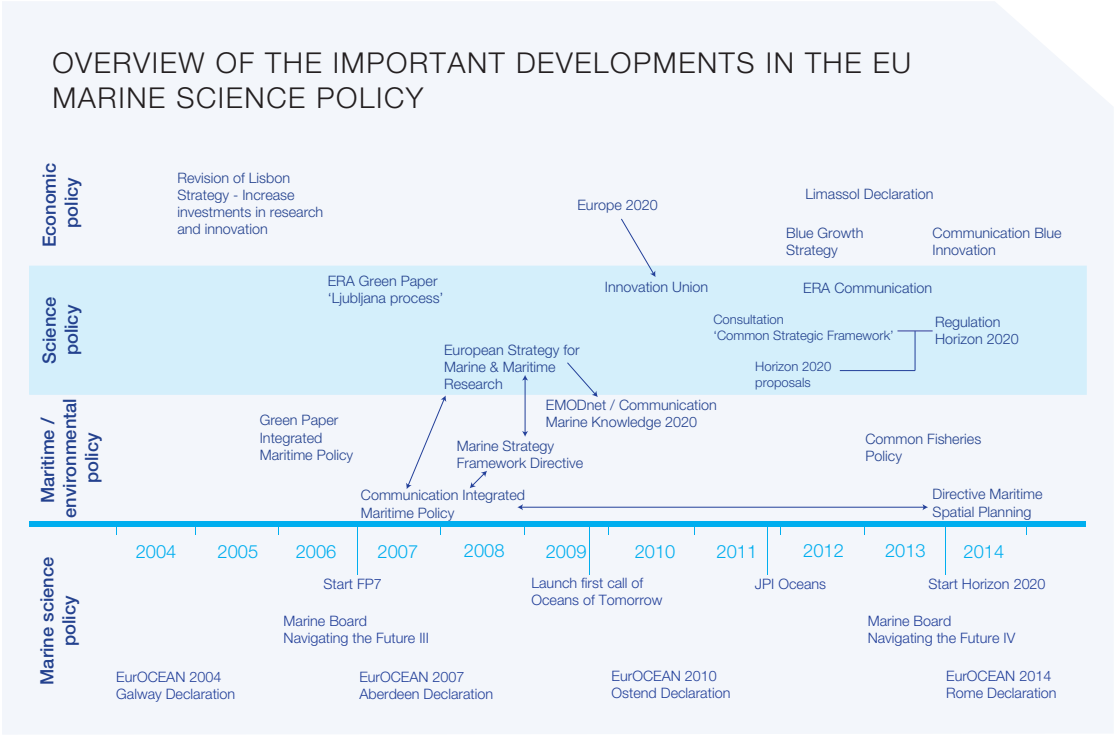

Figure 1. An overview of some of the important developments in the EU marine science policy between 2004 and 2014 (modified after *Navigating the Future IV (European Marine Board 2013)*).

Information systems in support of these policy instruments include the Data Collection Framework for the CFP (*DCF*), the Shared Environmental Information System (*SEIS*), the Water Information System for Europe (*WISE*) and WISE-marine (under construction), the Biodiversity Information System for Europe (*BISE*), the European Climate Adaptation Platform (*CLIMATE-ADAPT*) and *MyOcean*, the marine component of the COPERNICUS initiative (former GMES). The extent of what information is publicly available for researchers reveals important variations and the data policies of the different systems are evolving rapidly under the influence of the 'Open Access Movement'.

The science-policy interface within the framework of these policy instruments, as well as the actors involved, are discussed in more detail in the **Chapter 2 'Use of the sea'**.

REGIONAL SEA - THE NORTH SEA

The European Commission (EC) and the member states have established 'Regional Sea Basin Strategies' (in the framework of the EU regional policy, and/or of the Integrated Maritime Policy) for the Baltic Sea, Black Sea, Danube River Basin, Mediterranean Sea, Atlantic Ocean and the Arctic Ocean. In the framework of such strategic agendas, specific actions are agreed upon that provide guidelines to the entities involved for the implementation of their policy instruments. Hence, this will help them to reach their common goals more effectively. In the case of the North Sea no common strategy has been developed yet between the EC and the member states.

For the adjacent area of the Northeast Atlantic Ocean a maritime regional strategy (COM (2013) 279) was established by the following countries: Portugal, Spain, France, Ireland and the UK. In May 2013, during the Irish EU presidency, the EU, the USA and Canada jointly signed the *Galway Statement on Atlantic Ocean Cooperation (2013)* in order to launch a Transatlantic Ocean Research Alliance. The goal is to increase the collaboration and streamline the efforts of the partners in topics of ocean observation in the Atlantic Ocean, including the effects from the nearby Arctic Ocean. The cooperation also focuses on the marine research activities that are needed to underpin sustainable growth of the economic activities in the Atlantic. Furthermore, the action plan addresses the processes in the Atlantic Ocean which influence the climate.

Conventions at the level of regional seas exist, with the main focus on the protection of the marine environment (table 3).

Table 3. Conventions and declarations for the protection of the marine environment at the scale of regional seas.

CONVENTION / DECLARATION	REGION / REGIONAL SEA	TOPIC
OSPAR Convention (1992)	Northeast Atlantic Ocean, incl. North Sea (OSPAR-Region II)	Protection of the marine environment
Helsinki Convention (*HELCOM*, 2000)	Baltic Sea	Protection of the marine environment
Barcelona Convention (UNEP-MAP, 1978)	Mediterranean Sea	Protection of the marine environment
Bucharest Convention (Black Sea Commission) (1992)	Black Sea	Protection of the marine environment
Bonn Agreement (1969)	North Sea	Protection of the marine environment
ASCOBANS (1994)	Baltic Sea, Northeast Atlantic Ocean, Irish Sea, North Sea	Research and protection of small cetaceans and their living environment
Ministerial declarations and statements (1984-2006)	North Sea	Collaborative research on the environmental conditions and targets for marine pollution

The International Council for the Exploration of the Sea (*ICES*) is of great importance for the broader North Sea. ICES is a cooperation of 19 countries bordering the North Atlantic Ocean and adjacent seas with the aim to exchange scientific information, as well as to provide expert advice to governments and commissions of the European Union (EU) and Regional Sea Conventions OSPAR and HELCOM.

The *BONUS programme*, based on Article 185 of the EU Convention (TFEU), is a programme for research and development specially designed for the Baltic Sea, and jointly funded by the EU and the involved countries. In 2015 the potential expansion of BONUS towards the North Sea is under consideration.

EUROPEAN FUNDING INSTRUMENTS FOR MARINE RESEARCH

Overview and history of European funding instruments for research

The EU offers several instruments for the funding of research, depending on the goals, partnerships, structural embedding, budget requirements, etc. Currently the most important financial mechanisms include:

- *Horizon 2020* (2014-2020);
- The *Structural Funds*, including the European Regional Development Fund (*ERDF*) that finances the INTERREG programme (III, IV, 2 Seas);
- The European Maritime and Fisheries Fund (*EMFF*) (2014-2020) to support the CFP and IMP;
- The Programme for the Competitiveness of Enterprises and SMEs (*COSME*) (2014-2020).

Besides the aforementioned funding instruments, there are other mechanisms within the community programmes such as the Financial Instrument for the Environment (*LIFE*), the *EUREKA network*, *EUROCORES*, the European Cooperation in Science and Technology (*COST*), and *Regions of Knowledge*. An overview of the European funding instruments is available in the 'Guide to funding instruments for marine research and innovation projects' (*Pirlet et al. 2015a*).

Europe and the EC have conducted an active policy for international cooperation in research since the treaty that established the European Coal and Steel Community (ECSC) in 1952 (figure 2). Article 130f of the *Treaty for the European Union* calls for a reinforcement of science and technology as one of the foundations of the European industry. The FPs (figure 2, from 1984) were implemented according to the founding principles of the Treaty, aiming for an increased competitiveness at the international level and highlighting the need for research to underpin other EU policy goals.

Since FP1 (1984), the available EU budgets for research (FPs and other EU-financed programmes) have gradually increased in comparison to dedicated national resources for research and development (source: *DG R&I*). In the 1980s, the EU budgets for research and development (R&D) amounted to an average of 8% in comparison to the national budgets for R&D in member states. In the 2002-2005, the EU share in research funding slowly increased to

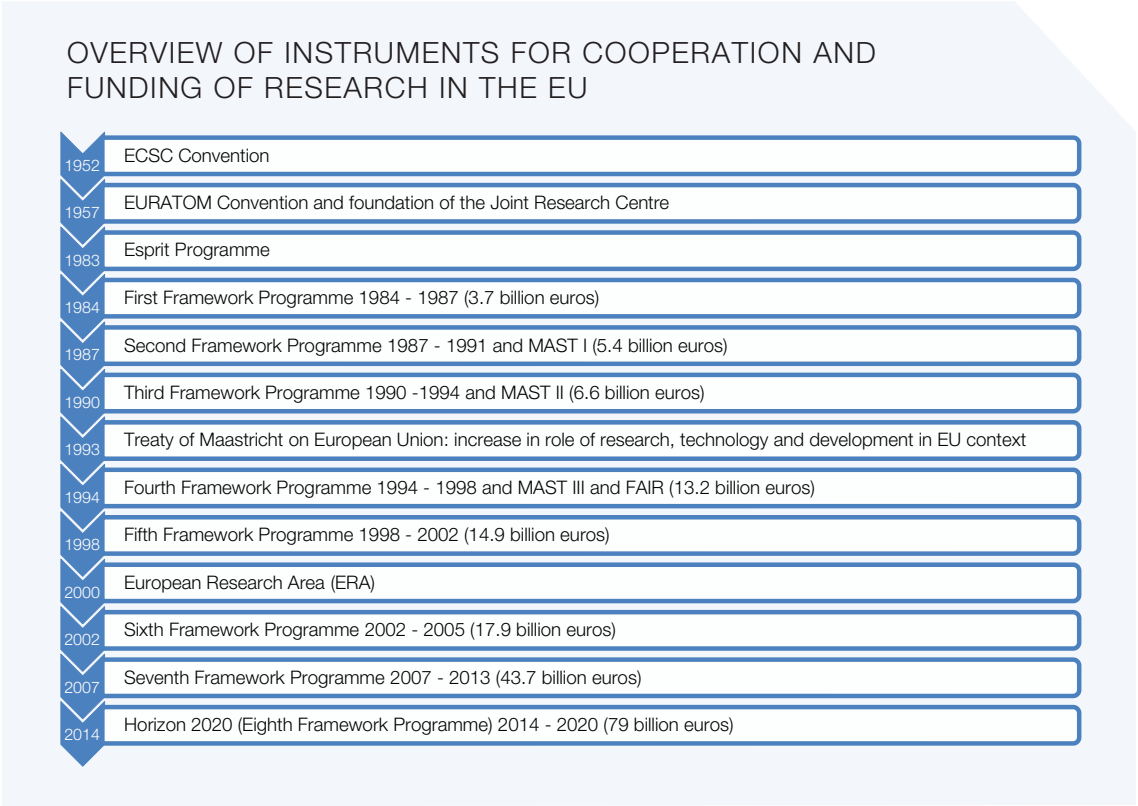

Figure 2. Chronological overview of instruments for collaboration and funding of research in the EU, with an indication of the available budget (Source: DG R&I).

an average of 15.3% compared to national research budgets (*Acheson et al. 2012*). *Horizon 2020* (regulation (EU) 1290/2013) runs from 2014 to 2020 with an approved budget of approximately 79 billion euros.

Relative importance of marine research in the European funding instruments

Depending on their research objectives, marine researchers can apply for different funding sources for the financing of their research projects and network activities. Although the FPs are the best known funding instruments, they do not necessarily have dedicated budget lines for marine research. FP2 contained a first dedicated Marine Science and Technology Programme (MAST I), continued as MAST II and MAST III. FP5, FP6 and FP7 did not include specific budgets for marine research, although an *ex-post* analysis of the share of marine-related projects is available. During FP7 there was a dedicated marine call, The Ocean of Tomorrow (total budget 124 million euro in 2010-2012 and 55 million euro in 2013) which funded multidisciplinary projects addressing the great challenges for marine research (figure 3). Horizon 2020 includes marine research as a crosscutting activity (source: *EUROCEAN Marine Knowledge Gate*, *Santos et al. 2007*, *Jagot et al. 2012*).

In comparison with the total budget available in the FPs, the share of funding for marine related projects increased from approximately 1% at the start of the FPs (1987-1991) to 3.2% during FP6 (2002-2006). During FP7 (2007-2013) this 'marine share' increased to 6.1% of the total FP7 budget and represented 1,250 projects with a total budget of 2.66 billion euro. The largest share (21%) of this budget addressed the theme 'Environment' (0.56 billion euro; 111 projects) (source: *EurOcean Marine Knowledge Gate*; figure 3).

Funding of data collection and data management

In the context of the initiative Marine Knowledge 2020 (COM (2010) 461), it is estimated that the cost of the in situ collection of marine data by public institutes of the EU member states is more than 1 billion euros a year. The cost for remote sensing of the European Seas is estimated at 400 million euros per annum. Besides financing marine/

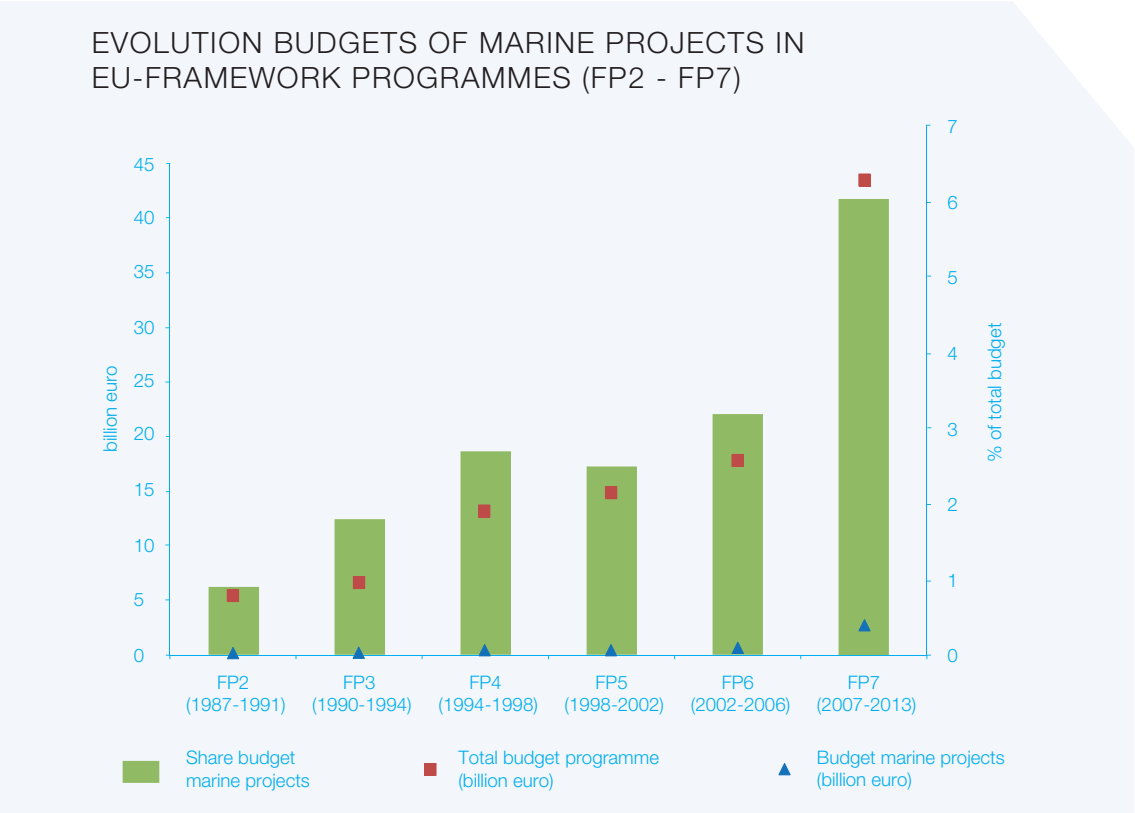

Figure 3. Marine project budgets funded by EU Framework Progammes FP2 - FP7 (billion euro) and share (%) of the total FP budgets (Source: CORDIS database, adapted by *EurOcean Marine Knowledge Gate*, data September 2015).

maritime components and initiatives in the European research programmes, an additional amount of 40 million euros is provided each year for the data collection programmes in fisheries management (DCF). A specific additional annual effort of 18.5 million euros between 2011 and 2013 focused on data collection and data integration in regional seas to support requirements of the MSFD (*COWI; Ernst&Young 2013*).

The EC increased the *EMODnet* budget within the EMFF because of the estimated benefits to be achieved by an enhanced accessibility of marine data with higher resolution, for a series of user groups. Creating additional value due to a higher efficiency in the organisation of marine observation and data management at the European scale, is an important step towards increasing cost-efficient production in science.

2. Marine research in Flanders and Belgium

2.1 Policy context for scientific research in Flanders and Belgium

DIVISION OF COMPETENCES

The division of competences for scientific research and innovation in Belgium was established in the Special law on Institutional Reforms (law of 8 August 1980). Article 6bis of this law stipulates that the federal government, the communities and the regions are responsible for scientific research within the framework of their competences, including research in pursuit of international or supranational conventions and treaties. The primary responsibility for research and innovation lies with the communities and regions. The communities are responsible for all personal matters, cultural affairs and education and training. Regional matters in the fields of economy, energy, public works, environment and transport are competences of the regions. Unlike the other regions, Flanders has chosen to join its community and regional competences (see **Flemish policy context for science and innovation**)

In the Federation Wallonia-Brussels (formerly French community), it is the *Direction de la recherche scientifique* (DGENORS) which is responsible for science policy and *inter alia* for the financing of universities. The *FNRS* is the

administration that organises the funding of research programmes, infrastructures and operations for the French-speaking universities. Since 2007-2008, the French-speaking universities in Belgium have merged into three 'Académies Universitaires', as a results of the revised subsidy regulations in this community (figure 4). *Innoviris* (formerly IWOIB) is the institute for the promotion of research and innovation for the Region of Brussels.

The federal government is responsible for: the implementation and organisation of networks for the exchange of data between scientific institutions at national and international level; space research in the framework of international or supranational institutions, agreements or instruments; federal scientific and cultural institutes; programmes and actions requiring a uniform implementation at national or international level; and for keeping a permanent inventory of the science capacity of the country. The harmonisation and coordination of the cooperation between the different levels is provided by the Interministerial Conference for Science Policy (*IMCWB*) (figure 4).

FEDERAL SCIENCE POLICY

The Federal Public Planning Service Belgian Science Policy Office (*BELSPO*) is responsible for the science policy of the federal government (figure 4).

BELSPO manages the *research programmes* in support of the policy with regard to sustainable development, actions to address climate change, biodiversity, energy, health, mobility and the information society. Of particular importance for the marine research field, is the research programme 'Belgian Research Action through Interdisciplinary Networks' (*BRAIN-be*). In addition, marine research is funded by multidisciplinary programmes such as the Interuniversitary Attraction Poles (*IUAP*). The implementation of IUAP is based on a cooperation agreement between the federal state and the communities.

In the field of biodiversity, BELSPO coordinates the services with regard to the collection of biological cultures used in scientific research (see website Belgian Coordinated Collections of Micro-organisms, *BCMM*). The *Belgian Biodiversity Platform* is the information and communication platform for scientific research on biodiversity in Belgium. BELSPO is also responsible for the Belgian contribution to the European Space Agency (*ESA*). The department consists of 10 federal scientific institutes, of which the Royal Belgian Institute for Natural Sciences (*RBINS*) and the Royal Museum for Central Africa (*RMCA*) are of particular importance with regard to marine research (figure 4).

More detail is provided on the Belgian Portal for Research and Innovation (*BRSITI*). An overview of research funded by BELSPO is available from the *FEDRA database*. The *INVENT database* keeps a permanent inventory of the Belgian research capacity (research units, research projects and research staff).

FLEMISH POLICY FRAMEWORK FOR RESEARCH AND INNOVATION

In Flanders, the Science, Technology and Innovation (EWI) policy domain is responsible for the management of science and innovation policies. In addition, other policy domains may take initiatives in the field of science and innovation to support and develop their policies (albeit to a much lesser extent). The EWI policy domain includes the EWI department, as well as several government agencies. In 2015 there was a call for restructuring. It is intended that the new structure will be in place in 2016 with the following entities:

- The Science, Technology and Innovation department (*EWI*) is responsible for the preparation, monitoring and evaluation of specific action plans, policy research and regulations in the policy fields of economics, science and innovation;
- A number of agencies are responsible for the policy implementation, including:
    - A new Agency for Innovation and Entrepreneurship (AIO), as a results of the merging of Enterprise Flanders (AO) and the business-oriented services of the Agency for Innovation by Science and Technology (IWT). The AIO will act as the front office of the Flemish government for entrepreneurs.
    - A renewed Research Foundation - Flanders (*FWO*), as a results of the merging of FWO, the Hercules Foundation (*Herculesstichting*) and the more long-term oriented programmes of IWT. FWO has the task of promoting and supporting fundamental research at the universities of the Flemish Community, including partnerships between the Flemish universities and other research institutes. The Hercules Foundation was founded by the Flemish government for the financing of medium- and large-scale infrastructures for fundamental and strategic research.

- In addition, there are investment agencies such as the Participation Company for Flanders (PMV).

- The Flemish Council for Science and Innovation (*VRWI*) is the strategic advisory board for science and innovation.

The Information Guide for Entrepreneurship and Innovation (*EWI 2015*) provides an overview of all actors in the Flemish research landscape and is available on the *website of the EWI department*.

Figure 4. Overview of the competences and the policy context for research and technological development (R&D) in Belgium, the communities and the regions (non-exhaustive overview).

SCIENCE AND INNOVATION: KEY INSTITUTES IN FLANDERS

In the first place, the research is conducted by the five universities (*KU Leuven University*, *Ghent University*, *Antwerp University*, *Vrije Universiteit Brussel*, *Hasselt University*) and Flemish university colleges (*VLHORA*), the Strategic Research Centres (SOC) (*VITO*, *IMEC*, *VIB*, *iMinds*, *Flanders Make*), the Flemish scientific institutes (*INBO*, *ILVO*, *KMSK*, *Flanders Heritage Agency*) and other research institutes (*ITG*, *KMDA*, *Botanic Garden Meise*, management schools) (figure 4). Flanders Marine Institute (*VLIZ*) is the coordination and information platform for marine research in Flanders. Flanders Hydraulics Research (*WatLab*) is a division of the technical support services of the Mobility and Public Works department of the Flemish government. An overview of the policies and authorities involved with regard to the coast and sea is provided in **Chapter 2 'Use of the sea'**.

The Flemish Interuniversity Council (*VLIR*) is an autonomous advisory platform aiming to improve the communication and cooperation between the Flemish universities. The VLIR secretariat for university development cooperation (*VLIR-UOS*) supports partnerships between Flemish universities and colleges in Flanders and the South. The Flemish university colleges are also organised in the umbrella organisation of the Flemish University Colleges (*VLHORA*). The Flemish Council for Universities and Colleges (*VLUHR*) ensures coordination between all actors involved in higher education in Flanders (VLIR, VLHORA, university associations, etc.).

MARINE RESEARCH IN FLANDERS AND BELGIUM: GENERAL POLICY CONTEXT

Marine research in Flanders and Belgium is mainly guided and funded within the framework of the science policy of the communities and the federal and regional governments (see **Divisions of competences**). Because of the growing importance of marine science in response to the societal challenges, there is an expansion of the research to other policy domains and applications as well as to a broader range of authorities. These include the fields of fisheries and aquaculture, sand and gravel extraction, dredging and dumping, shipping and ports, offshore energy, nature and environment, as well as tourism, culture and heritage. An overview of competences and authorities in the coastal zone, marine areas and adjacent estuaries is provided in **Chapter 2 'Use of the sea'**.

2.2 History of marine research in Flanders and Belgium

PIONEERS AND GROUND-BREAKING RESEARCHERS

Prior to the introduction of a more systematic approach to marine research in the early 20th century, research was conducted by scientists individually. Within this early marine research, it is *Pierre-Joseph Van Beneden* (1809-1894) who is considered as the founding father of marine sciences in Belgium. Together with his son *Edouard Van Beneden* (1846-1910), *Alphonse Renard* (1842-1903) and *Gustave Gilson* (1859-1944), he turned marine research into an essential component of sciences in Belgium. The life and work of these pioneers and groundbreaking marine scientists can be explored on the website *Wetenschatten* ('Science Treasures', a series of informative fact sheets called 'Historical personalities in Belgian marine research', VLIZ) (figure 5).

A FIRST MARINE STATION IN OSTEND

In 1843, *Pierre-Joseph Van Beneden* opened a modest laboratory called *Laboratoire des Dunes* (Dune Laboratory) on the east bank of the Ostend harbour. This marine station entirely relied on his own resources. Since other renowned European marine stations were established several years later, Van Beneden was ahead of his time. After 3 decades of research the laboratory was closed in 1870. The history of the first marine station and subsequent initiatives of *Edouard Van Beneden* and *Gustave Gilson* are described in detail in *Breyne et al. (2010)* and *VLIZ Wetenschatten 2015a*.

THE START OF THE SYSTEMATIC MARINE RESEARCH WITH AN INTERNATIONAL DIMENSION

At the turn of the century, marine science in Belgium led to several important breakthroughs. The *Antarctica expedition of the Belgica in 1897-1899* (see also *VLIZ Wetenschatten 2015b*) achieved great innovations at times when *Gustave Gilson* initiated systematic research on the North Sea. Between 1898 and 1939 he collected 14,000 marine samples, which nowadays are used as reference material for current studies in the BNS.

In 1927, the Marine Research Institute (*Zeewetenschappelijk Instituut (ZWI)*) was founded on the initiative of Gustave Gilson, with Gilson as its first director. The institute's research focus was mainly on fisheries, inventorying the fauna and flora of coastal waters, and statistical data collection of sea fisheries. Gilson was also the driving force behind the 'First International Congress of the Sea' which took place in Ostend in 1926. Together with his assistant Charles Gillis, he played a role in the establishment of the international programme for data collection for sea fisheries in the North Atlantic Region and the North Sea, through *ICES*. From 1947 onwards, Eugène Leloup was director of ZWI. The institute was closed in 1967 due to a persistent lack of financial resources (*VLIZ Wetenschatten 2015a*).

From 1963 the fisheries research performed by ZWI, was taken over by the Experimental Station for Sea Fisheries (*Proefstation voor de Zeevisserij*), later known as the National Station for Sea Fisheries (*Rijksstation voor Zeevisserij*) which is now part of the Institute for Agricultural and Fisheries Research (*Instituut voor Landbouw en Zeevisserij* (*ILVO*)) of the Flemish government. Meanwhile, several marine research groups at the Flemish universities changed their research focus towards the BNS and the Southern North Sea. In October 1970, these academic groups were at the basis of the establishment of the Institute for Marine Research (*Instituut voor Zeewetenschappelijk Onderzoek (IZWO)*). The main goals of IZWO were to support, coordinate and disclose marine research in Belgium. When IZWO was dissolved in 1999, its tasks, staff and infrastructure were assigned to the newly established Flanders Marine Institute (*VLIZ*) (*VLIZ Wetenschatten 2015a*). VLIZ is a platform for marine and coastal research in Flanders, and due to the involvement in several projects and networks, the institute supports and promotes the international visibility of Flemish marine research and international marine education.

RESEARCH PROGRAMMES FOR THE NORTH SEA

In 1970, the Belgian government initiated *Project Zee* (Project Sea) within the scope of the research programme Environment/Water. This was the *first phase of the programmatic research of the North Sea* (the former department for Programmatic Science Policy (DPWB), later DWTC, now BELSPO). Between 1971 and 1976, 200 researchers from 40 university laboratories and scientific institutes and from multiple disciplines, cooperated in the project. The goal of Project Sea was the collection of scientific data and the development of modelling techniques to simulate the impact of natural phenomena and anthropogenic effects on the marine environment. At the end of Project Sea, a unit was founded to manage the Mathematical Model of the North Sea and the Scheldt Estuary (*MUMM*), which today exists under the Operational Directorate Natural Environment (*OD Nature*) of the RBINS. Since Project Sea, there have been 7 consecutive phases in the research programme for the North Sea (see also *Pirlet et al. 2015a*, Guide to funding instruments).

RESEARCH VESSELS

As early as 1914, *Gustave Gilson* highlighted the importance of a national oceanographic research vessel. However, the introduction of the first Belgian oceanographic research vessel RV Belgica only followed a few decades later. An overview of the different Belgian marine research vessels that operated prior to the launching of the RV Belgica is presented in *Pirlet et al. (2015c)*.

It was not until 1984 that the federal research vessel *RV A962 Belgica* was introduced. The Opertional Directorate Natural Environment (RBINS) is responsible for the management of the ship and its scientific equipment, as well as the planning and organisation of the scientific campaigns at sea. The Belgian Navy provides the crew, the operational support and services from the home port of the Belgica in Zeebrugge (*website RV Belgica OD Nature*).

Between 2000 and 2012, the Flemish government provided the RV Zeeleeuw, a converted pilot boat, in support of the marine research community. In 2012 the RV Zeeleeuw was replaced by a new research ship: the *RV Simon Stevin*. The operation and crew of this ship are provided by *VLOOT*, the shipowner of the Flemish government. VLIZ coordinates the scientific programme and manages ship time as well as the research infrastructure and equipment (*website VLIZ*).

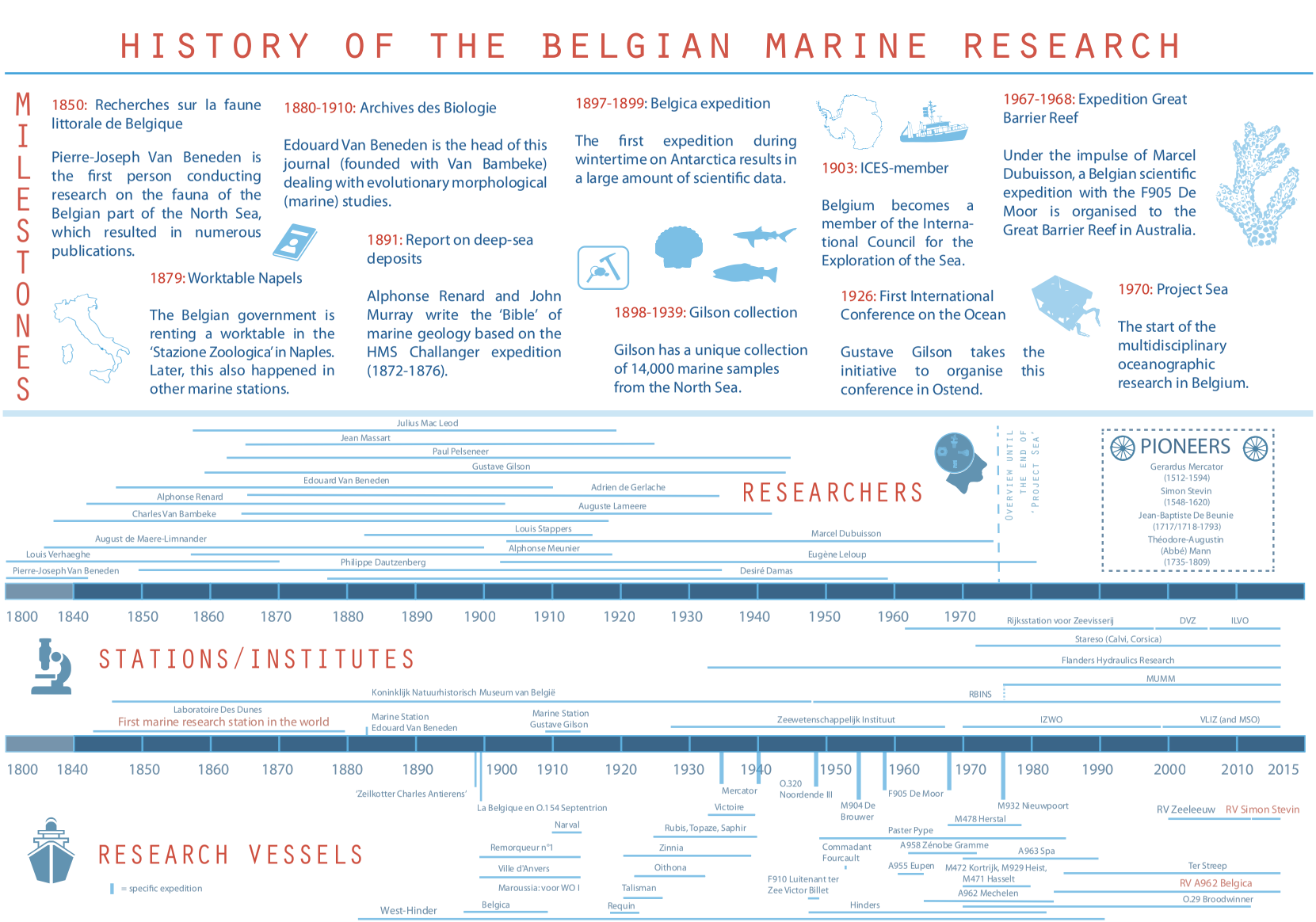

Figure 5. An overview of the history of Belgian marine research (Copyright: Scigrades – Graphical design for scientists and research institutions, torrez.pieter@gmail.com).

2.3 Marine research in Flanders and Belgium: inventory of the present research landscape

As commissioned by the Flemish government (EWI department)[1], the marine research landscape in Flanders and Belgium is mapped by VLIZ. This overview aims to make an inventory of the marine research landscape in an objective and coherent way, and provides annual updates concerning the research capacity (staff, infrastructure and resources) and knowledge output (publications and projects output). The inventory focuses on research groups affiliated with both Flemish universities and graduate schools as well as those of the Wallonia-Brussels Federation, and with Flemish and federal scientific institutes. The marine research includes the marine, maritime, coastal and/or estuarine research activities these groups perform in various research areas (*VLIZ 2014*).

METHODOLOGY

The present inventory addresses the 2008-2014 period. In order to compare and monitor evolutions in the long term, clear definitions, preconditions and replicable methods are used (*VLIZ 2014*). A crucial concept in this methodology is the definition of a Marine Research Group (MRG) (table 4).

Table 4. Definition of a Marine Research Group (MRG).

DEFINITION MARINE RESEARCH GROUP (MRG)	
An MRG simultaneously meets 4 criteria	The research group is located in Flanders or Belgium.
	The research group periodically receives government funding or subsidies embedded in policy agreements, covenants, or other legal agreements.
	Groups which do not belong to a university association are included in the list of institutes recognised for scientific research, as established in the royal decree of 22 August 2006 and the subsequent modifications of this royal decree.
	The research group focuses on marine research, or research which is relevant for this topic. In case of doubt, the measurable marine research output of the group is checked over the last 5 years. This output is defined as 'more than one peer-reviewed or VABB publication the first author of which is affiliated to the research group'.

The methodology of the inventory relies on the content of the Integrated Marine Information System (*IMIS*, VLIZ), supplemented by an annual systematic survey of literature databases. In the present inventory, these databases are Web of Science (through ISI-Web of Knowledge) and the Flemish Academic Bibliographic Database for the Social Sciences and Humanities (*VABB-SHW*). The selection of publications from these databases are checked on their marine focus and affiliation with a Belgian research group. Next, the publications are added to the collection of the Belgian Marine Bibliography (BMB) in IMIS, and a link is made between the publication, the institute and the author(s). Based on these links, new or additional MRGs are identified, provided they have published more than one marine peer-reviewed or VABB publication as a first author in the past 5 years. Since 2013, the inventory and the antecedent survey of the literature databases are conducted annually for the previous five years, on a fixed benchmark date in July. The benchmark date for the present inventory was 13 July 2015. The relationships that are established in IMIS between the publication, the institute and the author(s), allow quantitative measurement regarding the marine publications and the authors of the MRGs. However, the inventory of the staff of the MRGs is based on a direct survey of the research community. Every MRG, as well as the researchers, authors and publications affiliated with the MRG, are linked to one or more research domains and disciplines. To enable benchmarking at an international level, the definition of research domains and the further division into research disciplines, are based on the international available typology.

The conditions and the limitations associated with this methodology are described in detail in the annual report (*VLIZ 2014*). Important boundary conditions are:

- The inventory addresses MRGs at universities, graduate schools and scientific institutes in Flanders and Belgium. Marine research performed outside of these institutions is not included in the present inventory.

[1] Covenant between the Flemish Government and the Flanders Marine Institute, established by decree in Article 42 of the BS 07/28/2010.

- The results of this inventory are mainly focused on peer-reviewed publications and publications included in the Flemish Academic Bibliographic Database for the Social Sciences and Humanities (*VABB-SHW*). However, a significant part of the scientific output is available in other types of publications (e.g. theses, books, scientific advices, project reports, etc.) that are disclosed and described in IMIS, but have not yet been included in the current inventory.
- The collection of publications included in the inventory is largely determined by the surveyed databases (Web of Science and VABB-SHW), in which certain scientific fields are less represented. This implies a potential incompleteness or underestimation of the scientific output of the MRGs. In the future, the inventory may be expanded to new information sources, citable data sets and other scientific knowledge outputs (project deliverables, maps, models, etc.).
- In literature databases, new publications are included and described with a certain delay, meaning that the statistics for publications from 2014 are incomplete in the current inventory.

MARINE RESEARCH CAPACITY IN FLANDERS AND BELGIUM

Number of Marine Research Groups (MRGs)

A total of 99 MRGs were identified in Belgium on the benchmark date (July 2015). 60 groups of these MRGs are affiliated with Flemish university associations (figure 6). Scientific institutes are counted on an institute level, whereas university groups are inventoried on the level of a laboratory, unit or research group. An overview of the MRGs is available in *Mees et al. (2015)* and can also be consulted in an interactive manner on *http://www.vliz.be/en/institutes* and *www.compendiumkustenzee.be*.

The increase in the number of MRGs compared to the benchmark in 2013 (82 MRGs), can be mainly attributed to the Flemish university associations (+12 MRGs) and the universities and graduate schools of the Wallonia-Brussels Federation (+4 MRGs). These 'new' MRGs are mostly existing research groups that have recently expanded their expertise to marine research fields and applications.

The largest share of MRGs is situated in Ghent (32%) and Brussels (23%), while an important percentage of groups are also located in Liège, Antwerp and Leuven. The MRGs affiliated with scientific institutes are mainly located in Brussels and Ostend (figure 7).

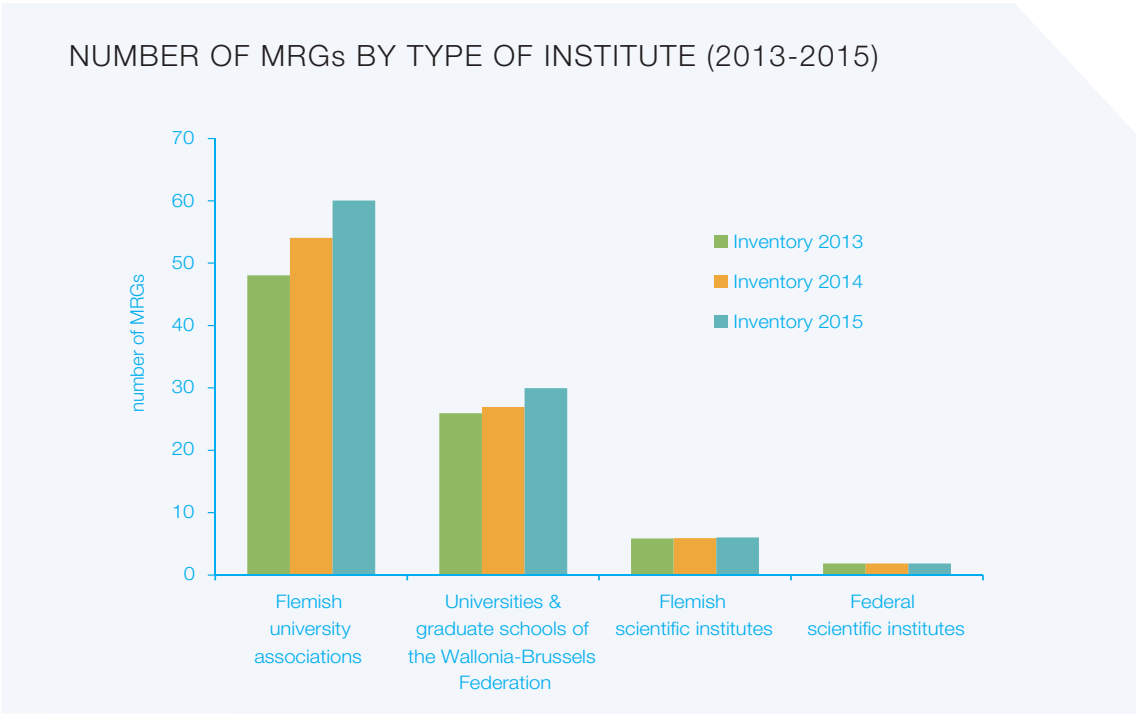

Figure 6. Number of MRGs, by type of institute (inventory 2013-2014-2015).

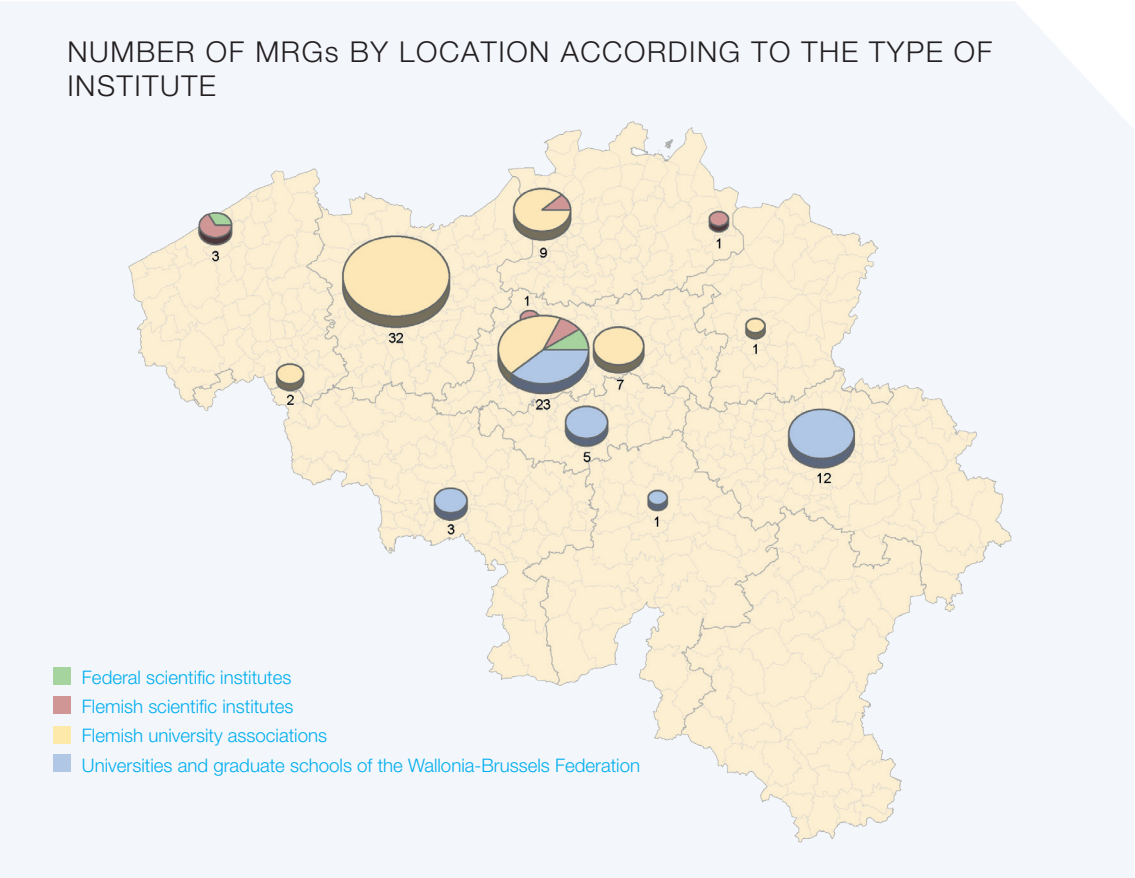

Figure 7. Number of MRGs, according to the type of institute and location (2015).

Number of marine researchers

The number of staff active in marine research provides a better insight in the actual research capacity than the number of groups. On the benchmark date of 2015, 1,373 persons were counted who were affiliated with an MRG and were active in marine research on a full- or part-time basis. This number is 30% higher compared to the benchmark of 2013 (1,075 persons). This increase is partly due to the increase in the number of groups concentrating on marine research themes, but is mainly the result of the improved response of the MRGs to the survey. The figures of 2013 can therefore be considered as an underestimation. The Flemish university associations employ 680 staff members, which represent about half of the marine research and specialised personnel in Belgium. Next in line are the Flemish scientific institutes (307 marine staff members) and the universities and graduate schools of the Wallonia-Brussels Federation (288 marine staff members), followed by the federal scientific institutes (98 marine staff members) (figure 8).

The 1,373 staff members wo are actively involved in marine research in 2015, can be further categorised in professors and heads of department (223 staff members), researchers in PhD programmes or continued research (826) and specialised, research-supporting employees (324). It should be noted that not all personnel is employed as a full-time equivalent (FTE) and/or focusses entirely on marine research topics.

Based on figures from 2013 (*Debackere & Veugelers 2015*), the Flemish MRGs (987 staff members) are responsible for 6.3% of the R&D-personnel employed in higher education and the public sector in Flanders.

The majority of the marine staff is male (63.7% versus 36.3% women). The percentage of women in marine research amounts to 46.3% in the category ‘specialised personnel’, but drops to 36.4% among marine scientist ((post)docs and PhD students) and even to 21% among heads of department and professors. For comparison: the percentage

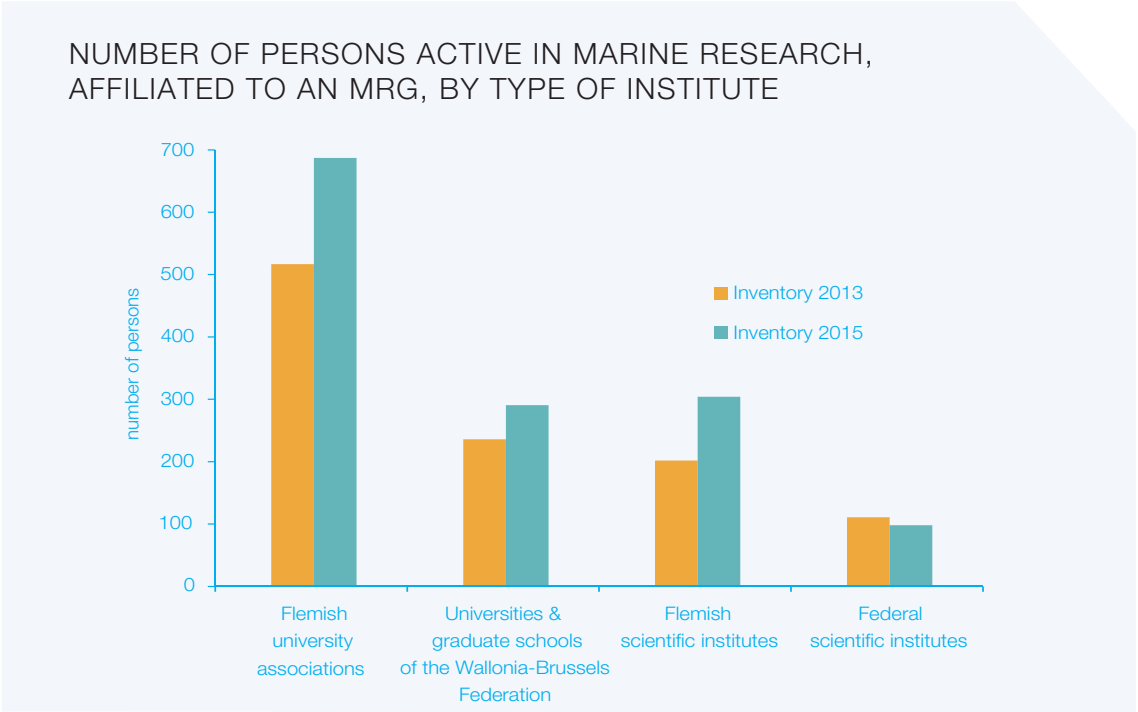

Figure 8. Number of persons active in marine research, affiliated to MRGs (2014-2015), by type of institute (Source: VLIZ survey 2014-2015).

of women active in research in higher education and the public sector in Belgium amounted to 44.6% (figures 2011[2], source: R&D statistics *Commissie Federale Samenwerking, Overleggroep CFS/STAT*). The male/female division within the Flemish universities reveals that in 2014, 60% of the assistants and 47% of the doctoral assistants were female (*Debackere & Veugelers 2015*).

The median of the number of employees active in marine research per research group (marine researchers and specialised personnel) amounts to 9 persons per MRG. Only 7 MRGs have more than 30 'marine' staff members. This mainly concerns the scientific institutes. More detailed figures about the MRGs are available in *VLIZ (2014)* (updated annually).

Marine research capacity by research domain and discipline

The bulk of the marine research at the MRGs is carried out within the research domain of natural sciences: 65 research groups out of the 99 inventoried MRGs (with 1,021 marine staff members; survey 2014-2015) focus completely or partially on biological, chemical or earth sciences. The research domains can be further divided into several research disciplines (figure 9), in which the share of biological sciences (41 MRGs, 624 marine staff members) and earth sciences (25 MRGs, 455 marine staff members) stands out. In addition, research is carried out in no less than 16 other research disciplines ranging from fisheries and aquaculture sciences (6 MRGs), civil engineering (10 MRGs), history and archaeology (5 MRGs), economics and business (4 MRGs) to law and legal studies (3 MRGs). Note that one MRG can be allocated to several disciplines.

SCIENTIFIC OUTPUT

The scientific output of MRGs is diverse and includes peer-reviewed publications, books, (project) reports, proceedings, scientific advices, theses, multimedia, etc. In the figures below, only the output that can be collected in an exhaustive way is taken into account: peer-reviewed and VABB publications. In **Chapter 2 'Use of the Sea'**,

[2] Since 2012, technicians and other personnel constitute one category in the national R&D statistics. The more recent figures (after 2011) are therefore no longer comparable.

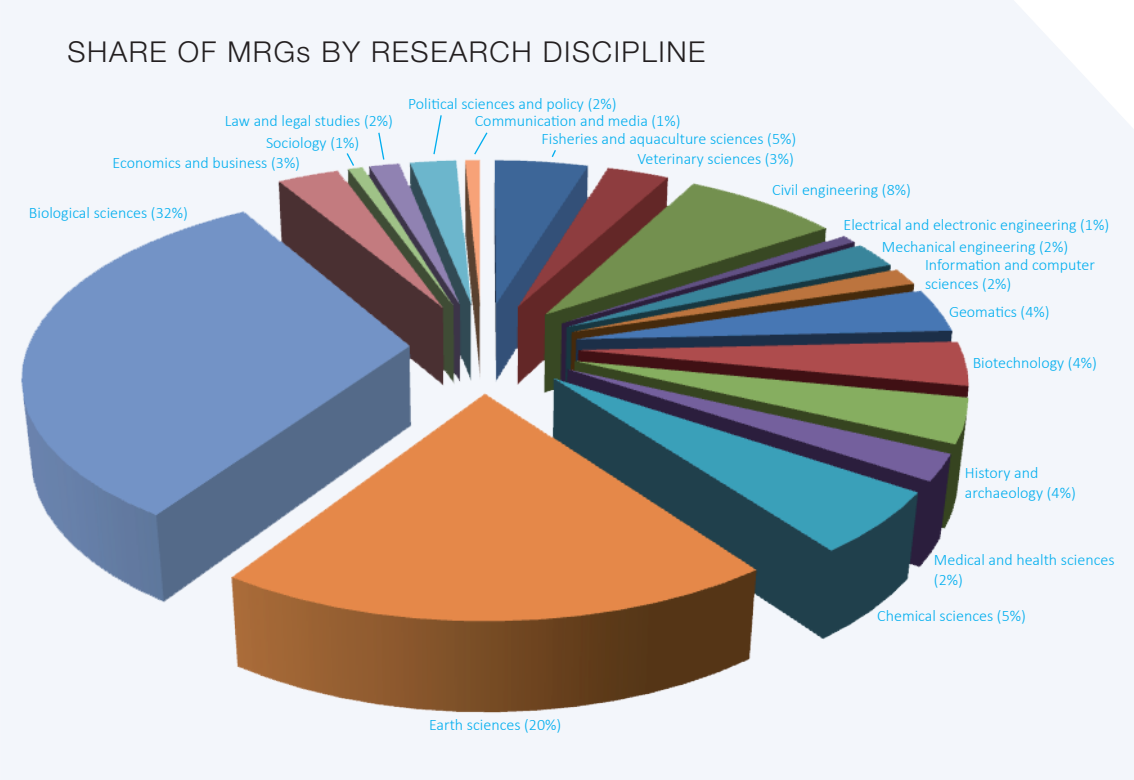

Figure 9. Share of MRGs by research discipline (2015). Note: MRGs can be allocated to several research domains and disciplines.

other types of publications are disclosed, linked with the respective themes. Hence, it is not the intention to express a value judgement about the different types of publications in this context. In the future the aim is to expand the inventory of scientific output towards other types of publications as well as to research domains that are less focused on publishing in peer-reviewed journals.

Number of marine peer-reviewed publications

Between 2008 and 2013, the Belgian MRGs published on average 432 marine peer-reviewed publications every year, with an increase of 382 publications in 2008 to 486 in 2013 (figure 10). In line with the research capacity (see above), the majority of the marine peer-reviewed publications is published at the universities (*VLIZ 2014*). In this regard, it is important to bear in mind that the scientific institutes mainly concentrate on various types of policy-supporting or policy-preparing knowledge outputs, such as advices, project reports, monitoring or evaluations of policy objectives. Hence, these institutes are less focused on publishing their research in peer-reviewed articles.

In the seven years between 2008 and 2014[3], a total of 1,698 unique authors were active (an average of 571 unique authors per year). These persons are affiliated with an MRG and act as (co-)authors of a marine peer-reviewed or VABB publication. In line with the increase in personnel of the MRGs, a gradual growth of the number of authors can be noticed during recent years. The majority of these authors were affiliated to Flemish university associations (56%) and an even larger part was working in the research domain of natural sciences (65%).

Between 2008 and 2014, the MRGs published in 721 different peer-reviewed journals with 77 publications in the most frequently used journal. Especially remarkable is the rapid increase of the share of Open Access journals from 6.2% in 2008 to 20.5% in 2014[3].

The largest share of marine peer-reviewed publications (including peer-reviewed VABB publications) is published by MRGs in the research domain of natural sciences (87%) and the domain of engineering and technology (24%) (2008-

[3] The numbers of 2014 are incomplete at present.

2014). This is in accordance with the research capacity (MRGs and staff members), but is also the result of the nature of the surveyed database (Web of Science, see **Methodology**) and the culture within the research field of natural sciences to publish in peer-reviewed journals.

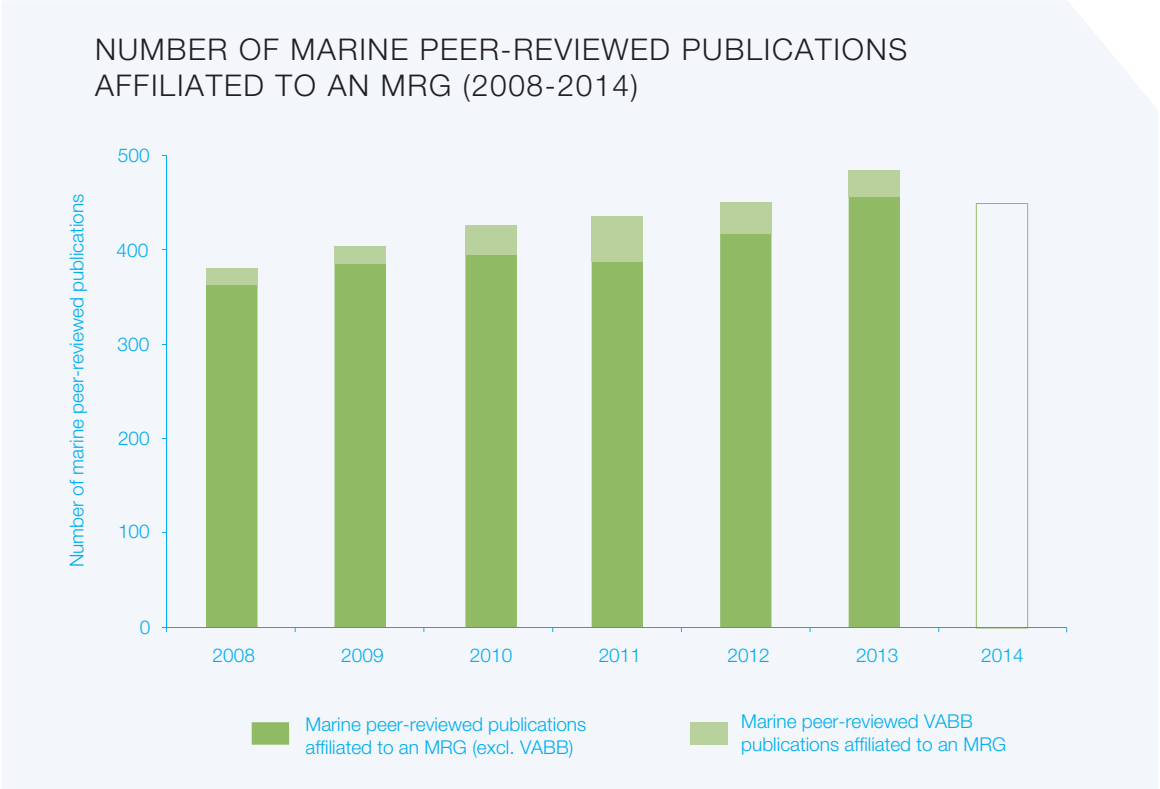

Figure 10. Number of marine peer-reviewed publications affiliated to an MRG. Note: the numbers of 2014 have a lower degree of completeness. In order to conduct a trend analysis, it is necessary to take into account a period of more than 5-10 years. It is therefore preferable to determine an average for this survey.

Relative citation indicators, peer-reviewed publications

Although relative citation indicators are no direct measure for the quality of the conducted research, they enable to benchmark according to an internationally accepted standard method. In cooperation with *ECOOM*[4], relative citation indicators were calculated for a list of 2,071 marine peer-reviewed publications affiliated to the MRGs (2008-2013). A time frame of three years was used for these citations. This means the year of publication and the two following years. For publications included in the database in 2012 and 2013, the time frame for citations was therefore not complete.

An important parameter in this context is the Relative Citation Rate (RCR), which is defined as the ratio of the Mean Observed Citation Rate (MOCR) and the Mean Expected Citation Rate (MECR) (table 5). An RCR value of more than 1 therefore means that the set of publications is cited more than can be expected based on the journals in which they have been published. For the publication list of the MRGs, the RCR is 1.16. The Normalised Mean Citation Rate (NMCR) of the publications of the MRGs also scores above the globale average with a value of 1.34. This relative indicator is defined in the same way as the RCR, but the actual impact of the citation is implicitly compared with the expectations, based on the subdomains in which these publications have appeared. These relative citation indicators show that the publications of the MRGs rate above the global average with regard to citations (figure 11 and table 5).

[4] The analysis of the relative citation inidactors was performed in collaboration with ECOOM (Bart Thijs, Wolfgang Glänzel & Koenraad Debackere, KULeuven). Analysis based on UT-codes in Web of Science.

Table 5. The relative citation indicators of the marine peer-reviewed publications of the MRGs.

RELATIVE CITATION INDICATORS	
MOCR (Mean Observed Citation Rate) = 4.27	The average number of citations per publication, calculated as the ratio of the number of observed citations in a three year time frame and the number of publications.
MECR (Mean Expected Citation Rate) = 3.69	The average number of expected citations per publication, calculated as the ratio of the number of expected citations and the number of publications.
RCR (Relative Citation Rate) = 1.16	The ratio of the MOCR and the MECR. An RCR value of more than 1 means that the set of publications is cited more than can be expected based on the journals in which they have been published. An RCR value of 1 means that the observed value corresponds exactly with the global average.
NMCR (Normalised Mean Citation Rate) = 1.34	This relative indicator is defined in the same way as the RCR, but the actual impact of the citation is implicitly compared with the expectations, based on the subdomains in which these publications have appeared.
NMCR/RCR = 1.16	This indicator reveals to what extent the citation impact of the journals, in which the publications appeared, is in accordance with the field standard. An indicator value of less/more than 1 therefore means that the set of publications on average appeared in journals with a lower/higher impact than can be expected based on the fields to which the publication belongs.

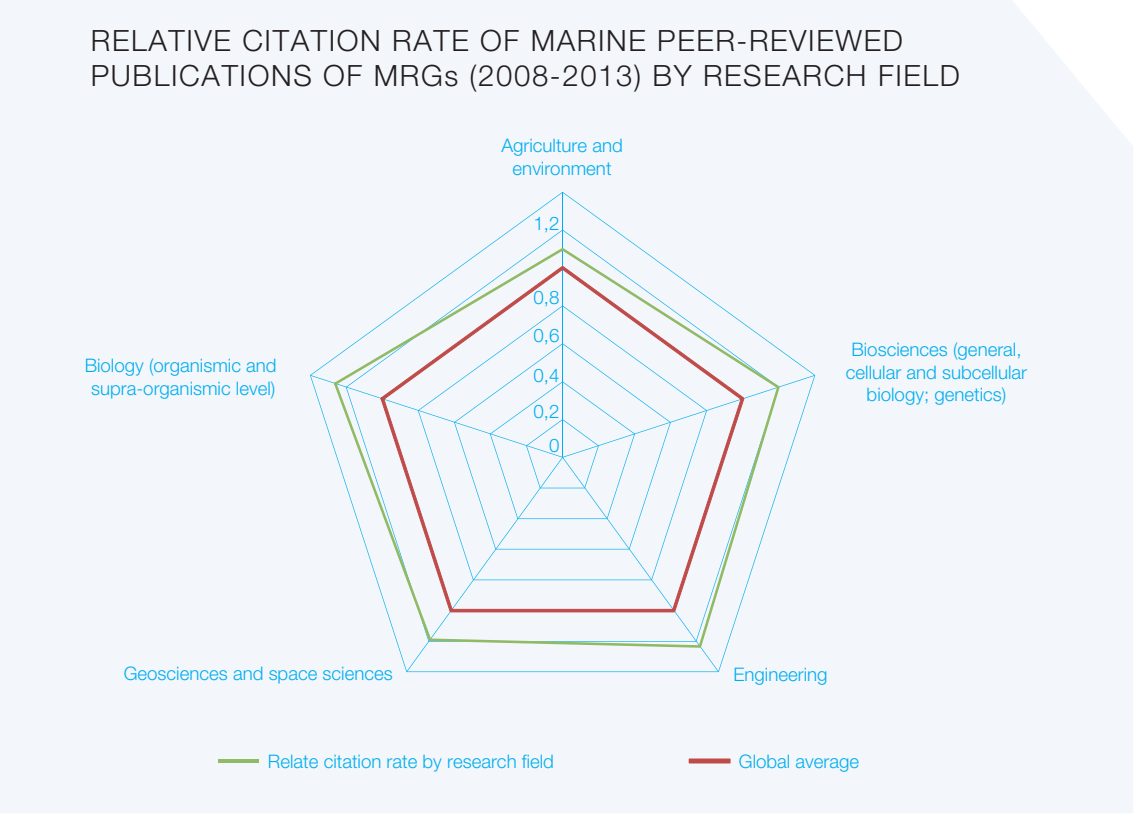

Figure 11. The Relative Citation Rate (RCR) according to the research domain to which the marine publications of the MRGs belong in Web of Science. Only domains containing more than 100 publications for the concerned period (2008-2013) have been included in the analysis.

Geographical study areas of the marine research, based on the peer-reviewed publications

A detailed analysis of the study area of the publications (2008-2010-2012-2013) reveals the international character of the research performed by the MRGs. The percentage of publications (in which study areas are included) that can be considered part of the international research amounts to 74.8% (figure 12). The remaining 25.2% can be considered as regional research and includes the Belgian part of the North Sea, the Belgian coastal zone (beach, dunes and coastal polders), the Scheldt Estuary and the Southern Bight of the North Sea. 6.5% of the publications specifically

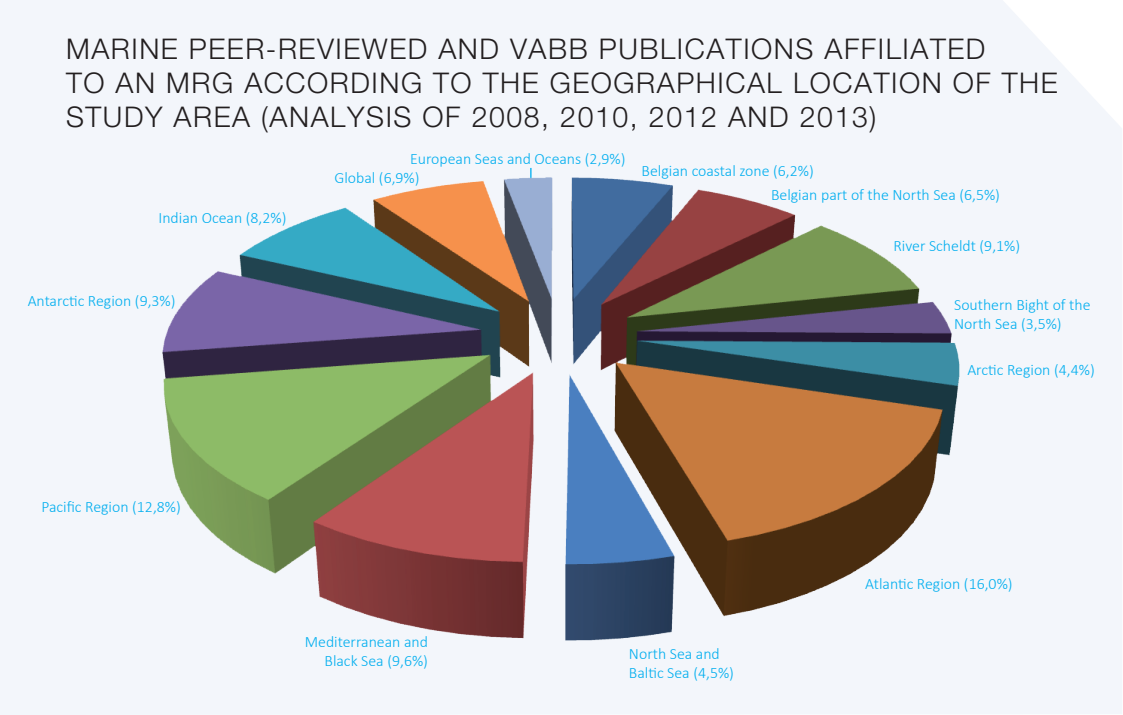

Figure 12. Marine peer-reviewed and VABB publications affiliated to an MRG, according to the geographical of the study area, analysis based on the years 2008, 2010, 2012 and 2013. A publication is always assigned to one geographical area, unless multiple areas are explicitly mentioned.

focus on research in the BNS. In this context, it is important to bear in mind that part of the scientific knowledge about the BNS is published in types of publication that are not part of this analysis, or are not publicly available. The relative importance of the various geographical study areas remains relatively stable throughout the analysed period. For a certain part of the publications (39.3%), it was not possible or not relevant to indicate a geographical study area.

Collaboration between MRGs, according to peer-reviewed publications

Between 2008 and 2014, on average 30% of the peer-reviewed and VABB publications resulted from a collaboration between at least two MRGs. Although the cooperation for these joint publications mainly occurred between MRGs within the research domain of natural sciences (25.0%), 9.3% and 3.3% of the co-publications were also the result of collaborations between natural sciences and, respectively, the domain of engineering and technology and the domain of agricultural and veterinary sciences. The aforementioned figures are, to a large extent, a consequence of the research capacity in the different types of institutes and research domains (for detailed figures, see *VLIZ 2014*).

The collaborations mainly occurred between MRGs affiliated with universities, both within the language regions (Flanders: 12.2%, Wallonia-Brussels Federation: 6,4%) and across the language border (5.0%) (2008-2014). Additionally, a significant number of publications resulted from the cooperation of MRGs at Flemish universities with federal (6.0%) and Flemish scientific institutes (5.1%).

These figures only reflect the collaboration concerning marine research with regard to the peer-reviewed and VABB publications. In addition, there is also a range of partnerships in projects, education, monitoring, etc. which do not necessarily result in joint peer-reviewed publications.

International collaboration, according to peer-reviewed publications

With regard to international cooperation, 73.1% of the examined publications from 2013 resulted from the collaboration with at least one foreign author (originating from 70 different countries). This means that the MRGs score higher than the average Belgian and Flemish percentage regarding international peer-reviewed co-publications, which amounted

to 66.2% and 64.9% respectively in 2013 (*Debackere & Veugelers 2015*)[5]. The Belgian MRGs mainly collaborated with the neighbouring countries: France, the Netherlands, the UK and Germany. The USA is an important partner as well with regard to joint publications (see further, figure 23). The Belgian MRGs act as first author in on average 50.2% of the international co-publications[6].

Use of research vessels, according to peer-reviewed publications

For at least 21.5% of the marine peer-reviewed and VABB publications of the MRGs in 2013, a research vessel was used for sampling or data collection (34.7% in 2010). In 33% of these publications, the research vessel was specifically mentioned by name. It concerns a total of 31 different research vessels, originating from 14 different countries, with the RV Belgica, RV Polarstern, RV Zeeleeuw and RV Pelagia as the most frequently mentioned vessels. These publications constitute the sea-going research of the MRGs. The other publications mainly concern coastal and estuarine research, modelling studies, experimental research in laboratories, social and economic studies, historical research, etc. An unknown share of the aforementioned publications, however, indirectly relies on sea-going research (e.g. for the validation of models or experiments).

2.4 Funding of marine research

In addition to the regular operational funds, MRGs at university associations and scientific institutes have several instruments at their disposal for the funding of marine research. Depending on the type of research and the research objectives, different funding sources are available on both a Flemish, federal and European level (*Pirlet et al 2015a*, Guide to funding instruments). Unlike most of its neighbouring countries, Belgium does not dispose of programmatic funding or a dedicated budget line for marine research. Hence, no figures exist concerning the (evolution of) funding of this type of research. However, with the exception of some initiatives like the Ocean of Tomorrow-call in FP7, other funding instruments also lack earmarked marine budgets. Therefore, the sources and databases for project funding can not be directly surveyed with regard to the budget for marine research. The selection of projects with MRGs as project partners makes it possible to systematically map the funding of marine research in MRGs, comparable to the inventory of the research capacity, infrastructure and output.

The inventory of the funding is based on the individual project participations and project resources, for the different funding instruments that were surveyed (FWO, IWT, VLIR-UOS, BELSPO, FP7, Horizon 2020 and EFRD). However, the inventory does not provide an exhaustive representation of the available budgets for marine research in Flanders and Belgium, as not all instruments were screened and some limitations are in place for a number of the surveyed funding instruments.

This inventory focusses on research projects and resources with the following characteristics:

- Funding based on competitive resources and specific/special grants;
- Used for marine research;
- Granted to MRGs in Flanders and Belgium;
- Granted in the period 2008-2014, according to the year of allocation;
- Funding instrument focused on R&D, on a Flemish, federal and European level.

A definition and breakdown of the types of research are presented in *Soete (2012)* and *VRWI advice 114 (2007)*. The methodology for the survey of the funding channels, the detailed figures, the preconditions and the limitations which are taken into account, are available in a detailed report (*VLIZ 2015*).

FUNDING OF MARINE RESEARCH - FLANDERS

The inventory reveals that the Flemish MRGs received an average annual subsidy of 10.7 million euros between 2008 and 2014, from competitive resources financed by the Flemish government (FWO, IWT and VLIR-UOS). On top of that, an annual subsidy of on average 2.6 million euros is granted for the support and coordination of the marine research (research vessel RV Simon Stevin, VLIZ, science communication). In order to finance its international engagements concerning marine research and data management, the Flemish government provides an additional 1.8 million euros per year (IODE Project Office IOC-UNESCO, EMODnet Project Office, JPI Oceans, Flanders-UNESCO

[5] By way of comparison: the average share of international co-publications in 2000 amounted to 48.8% for Flanders and 50.3% for Belgium.
[6] Average for the years 2008-2010-2012-2013: counted as the percentage of publications with at least one foreign author; each country is only counted once per publication.

Science Trust Fund (FUST)). Since 2013, the Hercules Foundation contributes another 2 million euros per year for the *ESFRI* research infrastructures which are relevant for the marine research community (*ICOS*, *LifeWatch*, *EMBRC*). Hence, the targeted Flemish public funding resources for marine research amount to 17.1 million euros per year.

In addition, the MRGs have access to important public resources for the direct funding of research organised in academic institutes (Special Research Fund (BOF), Industrial Research Fund (IOF), etc.). The annual operational and investment funds of the Flemish scientific institutes and strategic research centres (SOC), account for a part of the budget which is dedicated for personnel and resources for marine research and monitoring. Budgets for (policy related) research and monitoring are provided by the policy domains of Science, Technology and Innovation (EWI), Environment, Nature and Energy (LNE), Mobility and Public Works (MOW), Foreign Affairs (IA), Agriculture and Fisheries (LV), etc. Additional public resources are provided for valorisation-oriented research (e.g. IOF, *TETRA-funds* for technological research at graduate schools (IWT), etc.). Information on these last resources is fragmented and/or not publicly available and is therefore not quantified in this inventory.

As a partner of VLIZ, the Province of West Flanders provides a fixed annual subsidy of 0.15 million euros to support marine research.

Research Foundation Flanders (FWO)

The Research Foundation Flanders (*FWO*) finances fundamental scientific research at universities through PhD fellowships, post-PhD research, temporary and fixed fellows, grants to scientists for research projects, participations in congresses and symposia, as well as to knowledge exchange networks and excellence programmes (such as the Methusalem and Odysseus programmes).

Marine FWO projects

Between 2008 and 2014, a total of 82 marine projects with promotors affiliated to MRGs were funded by FWO. The total budget of these marine projects amounted to 17.3 million euros (2008-2014), with an annual average of 2.5

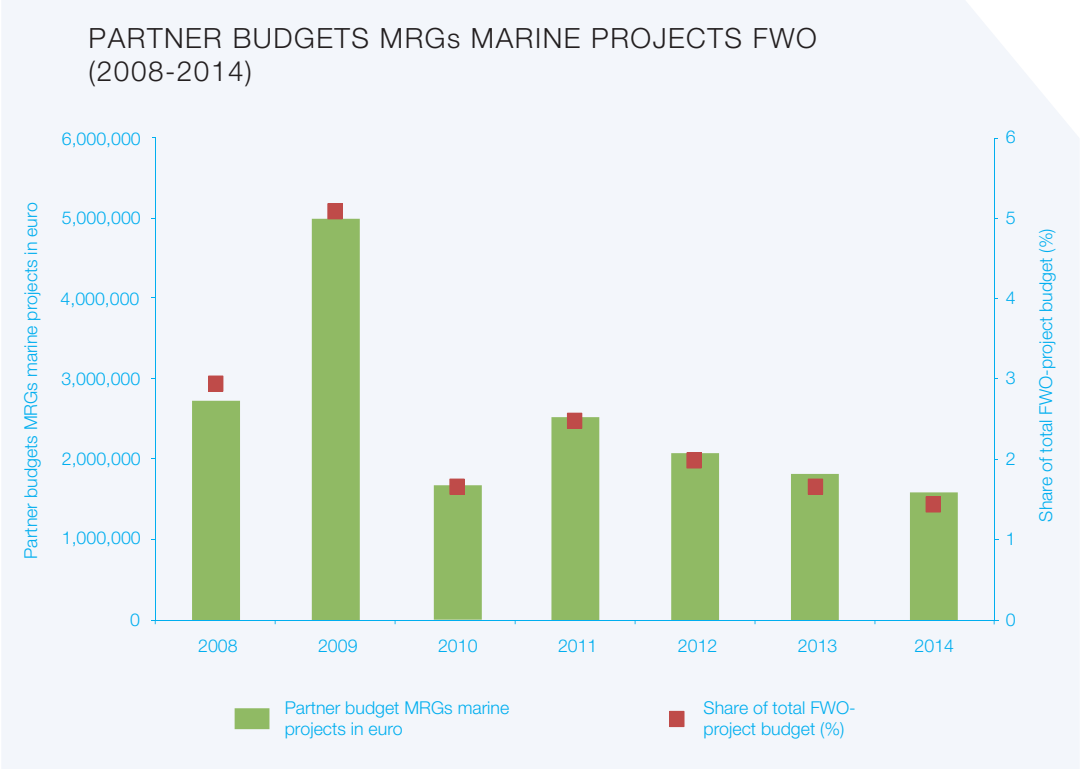

Figure 13. Marine FWO projects: partner budgets of MRGs (euros) and share (%) of the total budget for FWO projects, according to the year of allocation (Source: FWO and FWO expenditure analysis 2005-2014, processed by VLIZ).

million euros (figure 13). This 'marine share' corresponds to an average of 2.4% of the total budget for FWO projects between 2008 and 2014 (according to the year of allocation). In 2009, a significantly higher budget was granted to marine research projects compared to the rest of the analysed period. This variation can be explained by the limited number of marine projects. Hence, in order to perform a trend analysis, the collection of data over a longer period of time is necessary.

Marine FWO fellows

Between 2008 and 2014, a total of 124 marine fellows affiliated to MRGs were funded by FWO. The total budget for the funding of these marine fellows amounted to 18.2 million euros (2008-2014), with an annual average of 2.6 million euros (figure 14). This 'marine share' corresponds to an average of 1.1% of the total budget for FWO fellows between 2008 and 2014 (according to the year of allocation). In 2009 and 2013, this share was slightly higher compared to the average of the examined period.

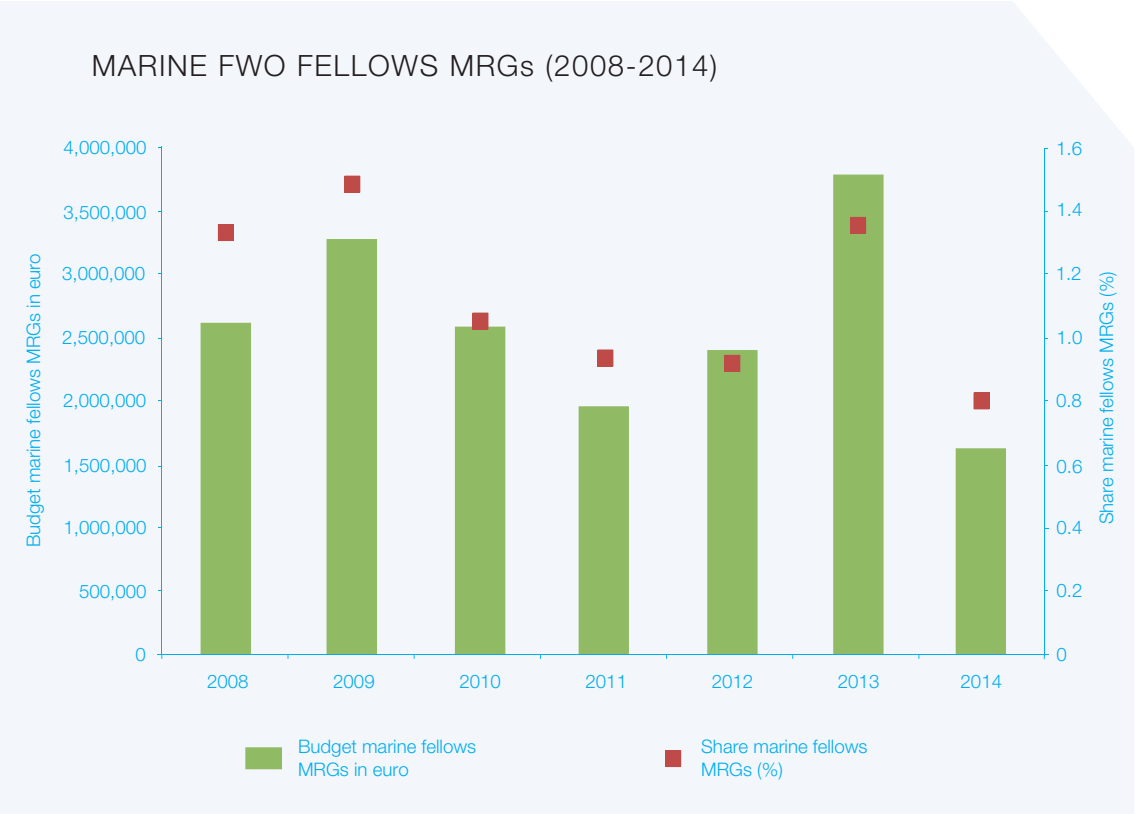

Figure 14. Marine FWO fellows affiliated to MRGs: subsidies for MRGs (euros) and share (%) of unique fellows (2008-2014), according to the year of allocation (Source: FWO and FWO expenditure analysis 2005-2014, processed by VLIZ). Note: the share (%) of the budget for marine fellows concerns an indirect estimate based on the number of fellows and an average subsidy per fellow.

Agency for Innovation by Science and Technology (IWT)

IWT focuses on specialised scholarships and on projects.

Marine IWT projects

Between 2008 and 2014, IWT financed a total of 51 marine projects (total budget of 27.9 million euros). In 23 of these marine projects an MRG was involved, representing a total budget of 24.3 million euros. The IWT budget granted to these marine projects with MRG involvement corresponds to an annual average of 3.5 million euros and an average

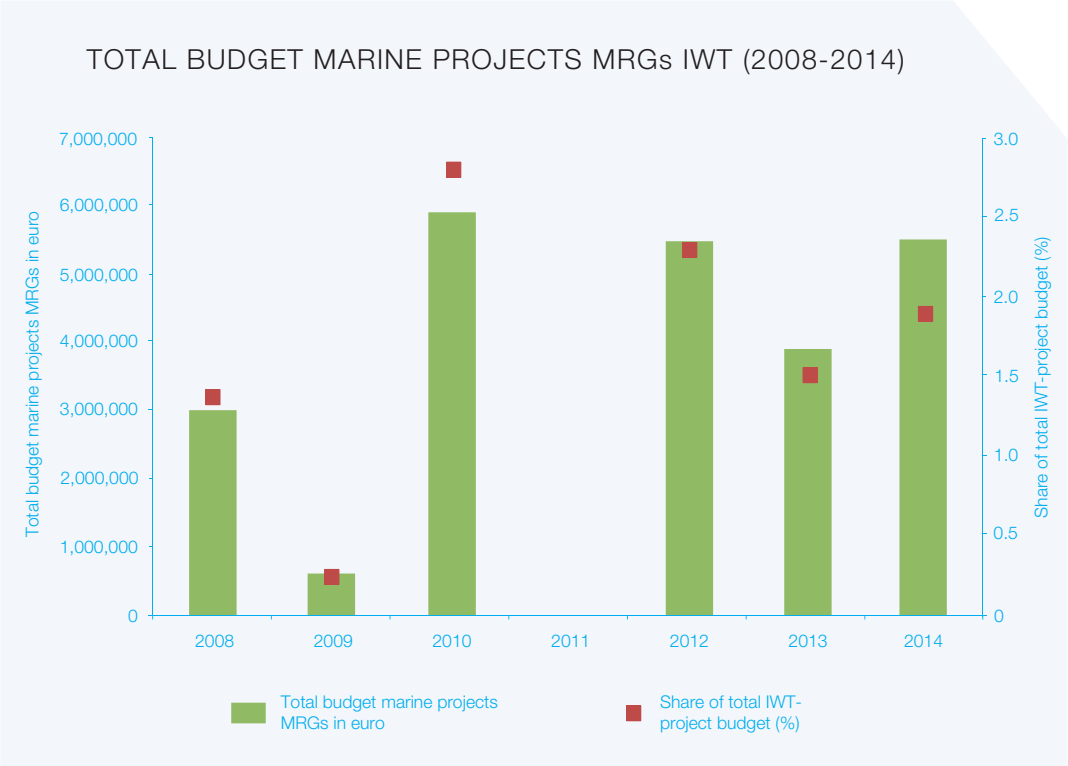

Figure 15. Total budget (euros) of marine IWT projects with MRG participation (2008-2014) and share (%) of the total IWT budget (projects), according to the year of allocation (Source: IWT, processed by VLIZ). Note: Unlike other funding channels, which were analysed on the level of individual partner budgets, the budgets for IWT projects refer to the total project budgets, which results in an overestimation of the subsidies for the MRGs.

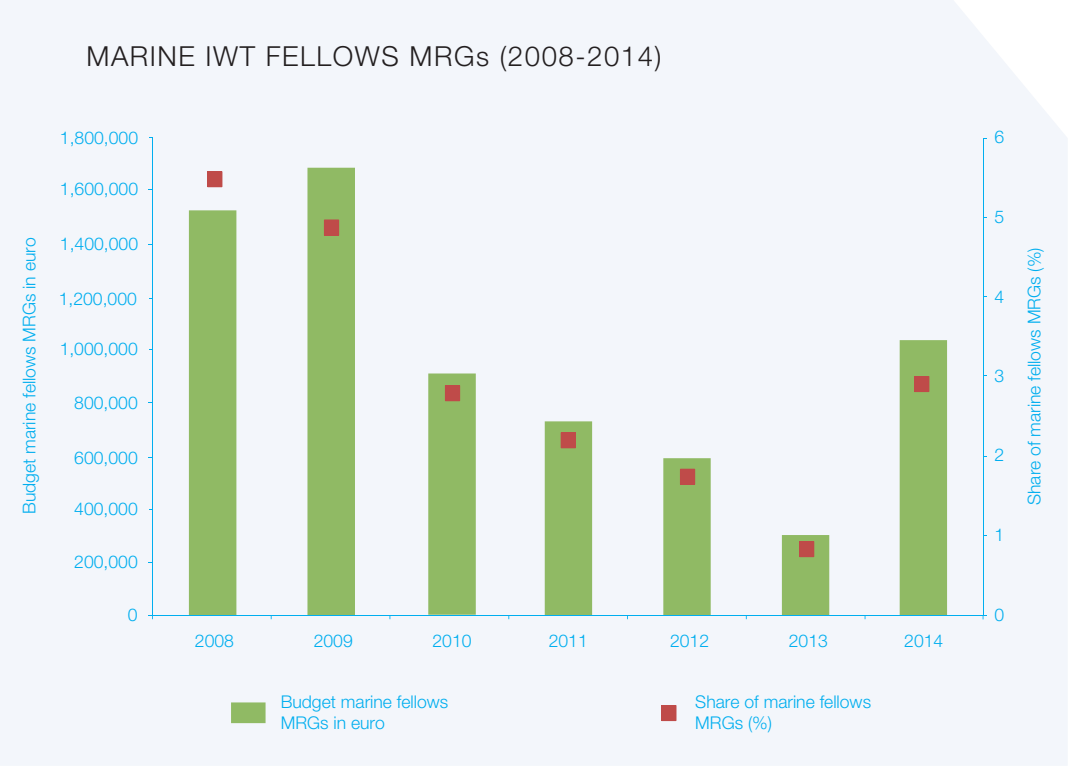

Figure 16. Marine IWT fellows MRGs: budget (euros) and share (%) of 'marine' fellows (2008-2014), according to the year of allocation (Source: IWT, processed by VLIZ).

percentage of 1.7% of the total IWT budget for projects (2008-2014) (figure 15). It is however important to point out that this analysis is based on the total project budgets and consequently results in an overestimation of the subsidies for the MRGs.

IWT fellows

With regard to the IWT fellows, a total of 46 grants were allocated between 2008 and 2014 to marine fellows which are affiliated to an MRG. These fellows represent a total budget of 6.8 million euros (2008-2014) and an annual average of 1.0 million euros. The number of granted marine fellows decreased from 11 in 2008 (1.5 million euros) to 2 (0.3 million euros) in 2013. This decrease is also observed in the share of the marine fellows of MRGs in the total IWT budget for fellows: from 5.4% in 2008 to 0.8% in 2013 (figure 16). The recent increase in 2014 brings the average percentage of marine fellows between 2008 and 2014 to 2.9%.

Flemish Interuniversity Council (VLIR)

The VLIR secretariat for university development cooperation (*VLIR-UOS*) finances projects to strengthen the higher education in the South and the internationalisation of higher education in Flanders. Between 2008 and 2014, a total of 54 marine projects with promotors affiliated to MRGs were funded by VLIR-UOS. The largest number of partnerships were established in Kenya, Tanzania and Vietnam. The total budget of these marine projects amounted to 7.9 million euros (2008-2014) with an annual average of 1.1 million euros (figure 17). This 'marine share' corresponds to an average of 3.3% of the total budget of VLIR-UOS between 2008 and 2014. It is however important to point out that this analysis is based on the total project budgets and consequently results in an overestimation of the subsidies for the MRGs.

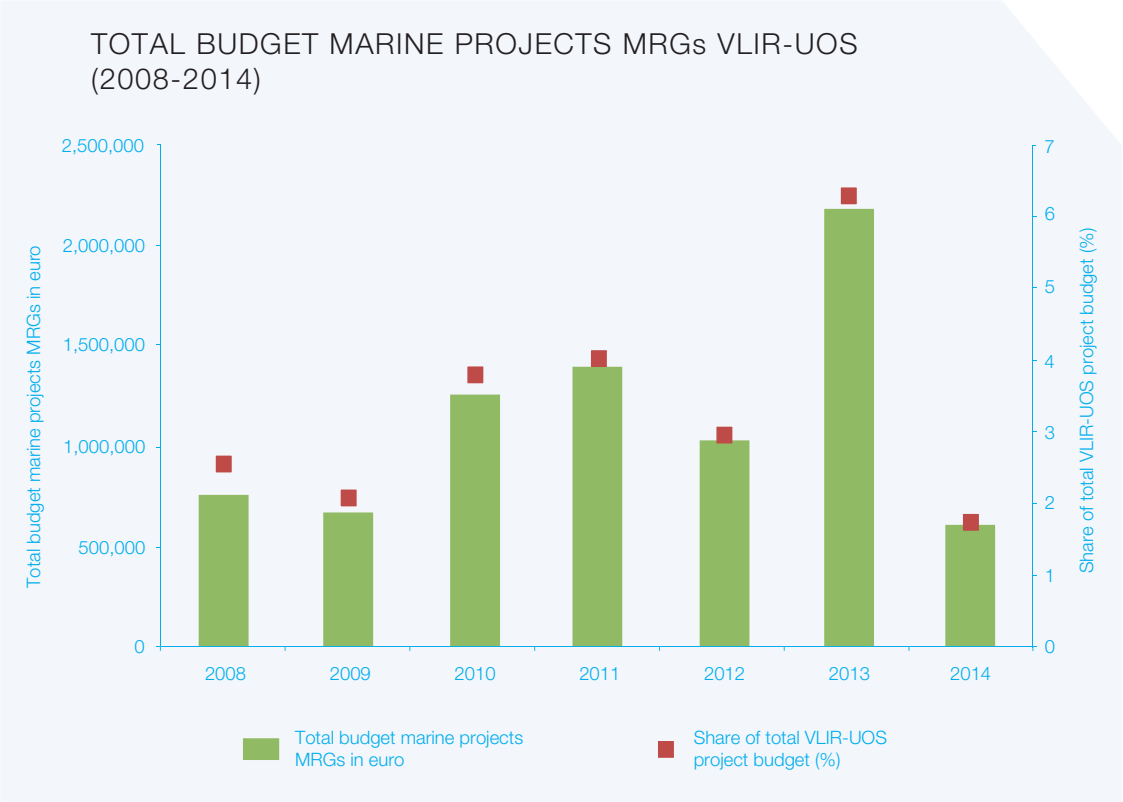

Figure 17. Marine VLIR-UOS projects with an MRG-participation: total budget (euros) and share (%) of the total VLIR-UOS budget (2008-2014), according to the year of allocation (Source: VLIR-UOS, processed by VLIZ). Note: Unlike other funding channels, which were analysed on the level of individual partner budgets, the budgets for VLIR-UOS projects refer to the total project budgets, which results in an overestimation of the subsidies for the MRGs.

Special Research Fund (BOF)

BOF is an important funding channel for stimulating academic research in Flanders. The BOF resources include calls for fellows, grants, scholarships and initiatives such as Methusalem, which are attributed according to the regulations stipulated by the EWI department (Flemish government). The allocation of BOF resources is based on scholarly results and the academic publication output. Aiming at a qualitative policy, part of the BOF resources have been attributed based on the publication and citation output (with a weighing factor of up to 35%) from 2003 onwards. At present, there are no official figures about the specific funding of marine research with BOF resources. A rough estimate of the total BOF resources awarded to MRGs amounts to 3 million euros per year. This estimation is based on the figures which were made available for a limited number of promotors associated with MRGs. These figures were extrapolated to the total number of staff members of the MRGs associated with Flemish universities.

Hercules Foundation

The *Hercules Foundation* is a funding channel of the Flemish government for investments in medium-scale and large-scale research infrastructure for both fundamental and strategic research. An online *inventory* is available for all funded projects since the beginning of the programme (2007). Since 2013, the Hercules Foundation annually provides 2 million euros for ESFRI research infrastructures (*ICOS*, *LifeWatch* and *EMBRC*).

FUNDING OF MARINE RESEARCH - FEDERAL

The PPS Belgian Science Policy (*BELSPO*) provides the operational and investment resources of the federal scientific institutes such as the Royal Belgian Institute of Natural Sciences (*RBINS*) and the Royal Museum for Central Africa (*RMCA*). Additionally, BELSPO manages competitive resources to support the marine research of the MRGs which amount to an annual average of 3 million euros (Belgian Research Action through Interdisciplinary Networks (*BRAIN-be*), Interuniversity Attraction Poles (*IUAP*)). Furthermore, BELSPO attributes 2.5 million euros a year for the operational costs of the RV Belgica and 0.1 million euros a year for *JPI Oceans*. The federal government also provides additional resources for research and monitoring in the Belgian part of the North Sea through the federal public services. The Marine Environment department (DMM) of the FPS Public Health, Safety of the Food Chain and Environment finances specific assignments and public tenders for marine research amounting to an annual average of 0.1 million (Source: DMM, processed by VLIZ 2015). Other public services are also relevant for marine research themes, such as FPS Economy, SMEs, Self-employed and Energy, FPS Mobility and Transport, FPS Finance, FPS Interior, Ministry of Defence and the Federal Police.

Between 2008 and 2014, BELSPO funded 38 marine projects with promotors affiliated to MRGs. The total marine project budgets (including BRAIN-be) amounted to 14.5 million euros, or an annual average of 2 million (figure 18). Since the start of BRAIN-be in 2012, the programme funded a total of 14 marine projects equalling a total budget of about 10 million euros. MRGs participated in 11 of the 14 projects for a total budget of 7,697,900 euros. The proportion of marine projects with MRG participation represents 14% of the total BRAIN-be budget (figure 18).

In addition, BRAIN-be finances the participation of RBINS in the JPI Oceans pilot action on deep-sea mining (0.3 million euros).

IUAP (Phase VI and VII) funded 2 marine projects between 2008 and 2014, both with participation of an MRG, with a total budget of 3 million euros (annual average of 0.4 million euros). The share of marine projects with MRG participation within IAP amounts to 1.6%. The current ‘marine’ IUAP project (Phase VII) focuses on ecotoxicological research for aquaculture applications. During Phase VI, research was conducted on the modelling of natural and anthropogenic processes on the hydrodynamics of the Scheldt Estuary and the interactions with the North Sea.

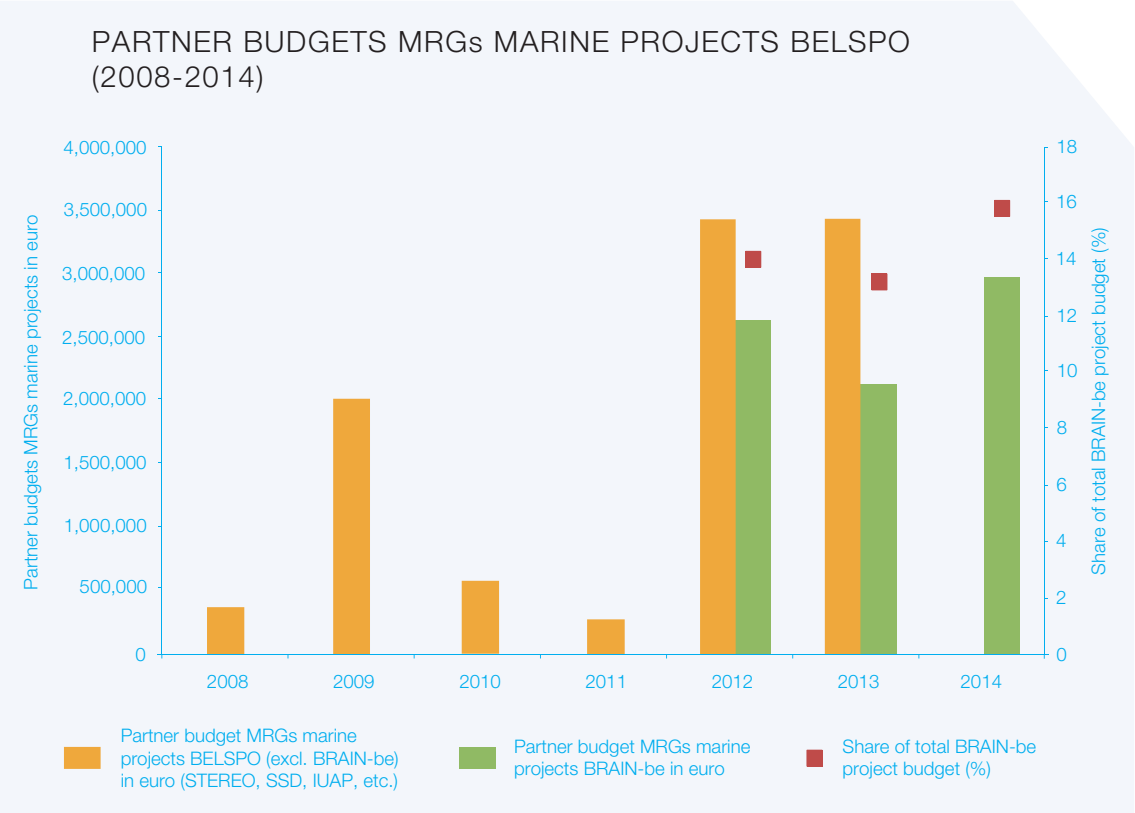

Figure 18: Marine BELSPO projects with participation of MRGs between 2008-2014: BRAIN-be (2012-2014) and other (STEREO, SSD, etc.), according to the year of allocation. For BRAIN-be, both the MRG partner budgets (euros) and the share (%) of the total BRAIN-be budget are mentioned (2012-2014) (Source: BELSPO, processed by VLIZ).

BELGIAN MARINE RESEARCH IN A EUROPEAN CONTEXT

The Belgian MRGs acquire on average about 4.7 million euros per year from European competitive funds, such as FP7, H2020 and ERDF. Additionally, MRGs also pursue several funding channels for marine research or the support of expert networks (EUROCORES, ESA, COST, European Fisheries Fund (EFF), tenders in the framework of the integrated maritime policy (IMP-grants), etc.).

From FP5 to Ocean of Tomorrow (FP7)

Europe is an important player in the steering of the marine research agenda. Despite the fact that marine research in Flanders and Belgium is mainly funded on a national level by fixed and competitive resources, an increasing share of the resources originates from international and European funding mechanisms.

In the period prior to the seventh Framework Programme (FP7), about 130 European marine projects, in which at least one Belgian knowledge institute participated, were financed by programmes such as FP6, COST, EUREKA, EUROCORES, INTERREG III, etc. (Source: EurOcean 2012). During FP6, investments in marine research amounted to 600 million euros (DG R&I 2012[7]). One of the priorities in FP6 was the transnational cooperation in project consortia. Belgian knowledge institutes (not only MRGs) participated in 101 FP6 projects, of which the Belgian partners coordinated 21 projects, corresponding with a total project budget of 32.19 million euros (Source: detailed analyses by EurOcean 2012). This is a significant increase compared to the period prior to FP6, during which Belgian institutes participated in only 31 marine research and innovation projects, mainly funded by MAST III and strategic programmes of the Directorate-General Environment (*DG ENV*). By way of comparison: during FP6, the UK had the

[7] No detailed analyses are available for other EU programmes regarding the investments in marine research during this period.

highest participation rate with 282 marine projects, while France managed the highest FP6 budgets (166.29 million euros) (EurOcean 2012). Belgium participated in 3 of the largest EU FP6 projects in the field of marine research[8].

During FP7 (2007-2013), Belgian partners (including companies and international partners with headquarters in Belgium) participated in 178 marine projects corresponding with a total partner budget of 38 million euros. MRGs participated in 71 unique projects (91 participations) with a total partner budget of 22.1 million euros or an annual average of 3.2 million euros between 2008 and 2014 (figure 19). The involved MRGs were mainly affiliated with Flemish universities (57 projects; total partner budget of 14.1 million euros). The annual variability (figure 19) is mainly caused by the timing and the type of the calls for project proposals.

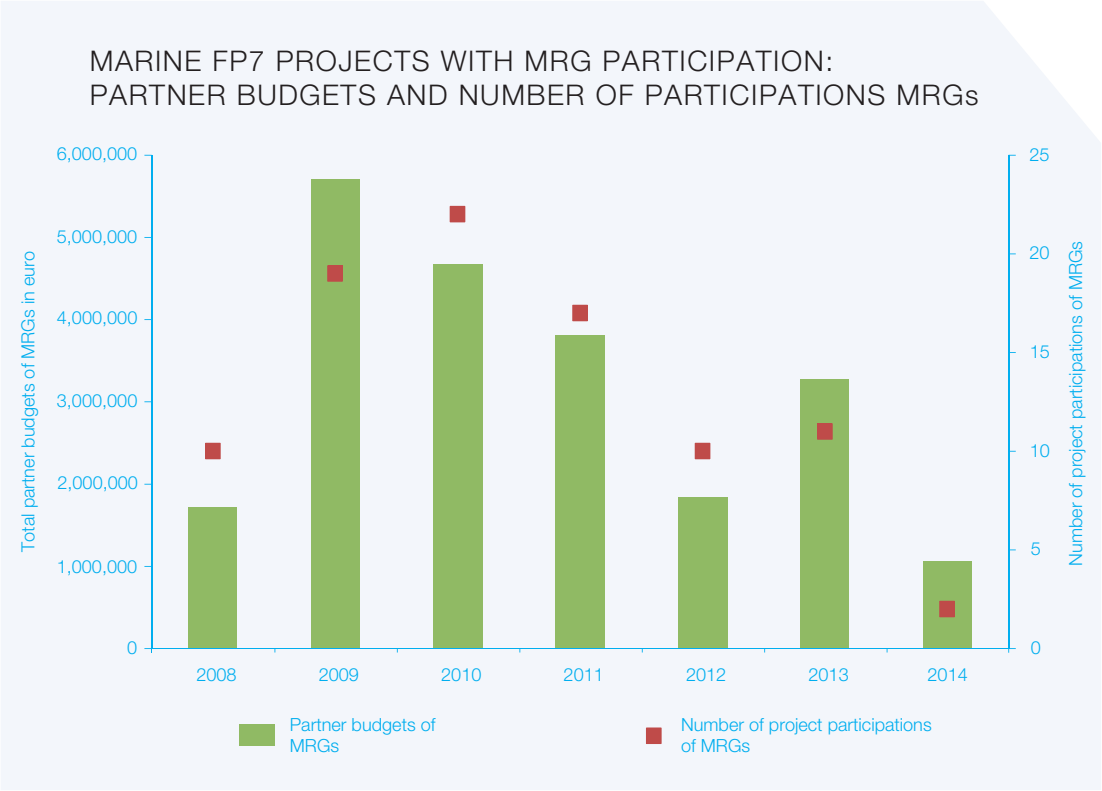

Figure 19. Marine FP7 projects with MRG participation: partner budgets (euros) and number of participations (2008-2014), according to the year of allocation (Source: EWI 2015, processed by VLIZ).

Multidisciplinary research in Ocean of Tomorrow

Marine research was funded in various kinds of thematic programmes and priorities within FP7. An important initiative for marine research within FP7, was the interdisciplinary call for marine research in Ocean of Tomorrow (FP7-OCEAN). With Ocean of Tomorrow, the EC aimed for a multidisciplinary approach and collaboration between scientific disciplines and economic sectors in order to provide innovative solutions for important marine challenges. An important aspect in this regard was the possibility for companies (including SMEs) to participate. Ocean of Tomorrow included 31 projects for a total EU contribution of 195.6 million euros (2010-2013). Belgian partners participated in 16 projects equalling a total project budget of 127.5 million euros.

Ocean of Tomorrow was an important opportunity for the internationalisation of marine research of the Belgian MRGs: in no less than 10 of the 31 Ocean of Tomorrow projects an MRG was involved (total project budget of 70.3 million euros) which corresponds with a total partner budget of 3 million euros (see table 6 for an overview of the research that was conducted within these 10 projects).

[8] DAMOCLES (16 million euros, participation of the International Polar Foundation – IPF) for the development of models and observation capacities for long-term studies in the Arctic environment; ENSEMBLES (15 million euros, participation of the Université Catholique Louvain – UCL) regarding the forecast of climatic changes and the associated effects; HERMES (15 million euros, participation of Ghent University – UGent) focusing on deep-sea ecosystems in European seas.

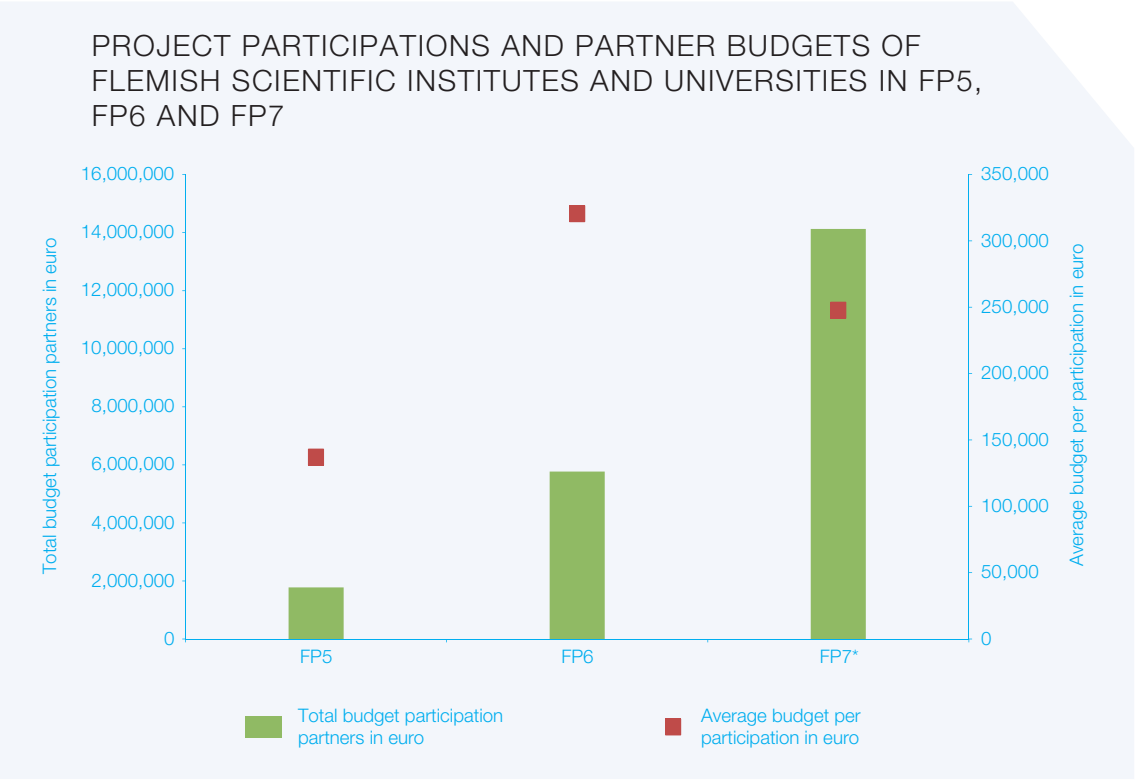

Figure 20. Marine research FP5-FP7: project participations and partner budgets of Flemish scientific institutes and universities. Note: The figures of FP7 refer to the participation of Flemish MRGs according to the definition of the inventory. The figures of FP5 and FP6 refer to the participation of Flemish universities and scientific institutes, since no definition for MRGs is available during this period.

The participation rate of Flemish marine knowledge institutes in FPs shows a continuous increase, both in the number of project participations (13 in FP5 up to 57 in FP7) and the partner budgets (1.7 up to 14.1 million euros). The average partner budgets for each project decreased in FP7 in comparison to FP6 (figure 20).

Horizon 2020

7 marine projects with MRG participation were identified within *Horizon 2020* (MyOcean, C-Cascades, EU-PolarNet, SeaChange, COLUMBUS, ALFF, SubCULTron), corresponding with a total partner budget of 1.8 million euros (6 unique MRGs and 8 participations). Horizon 2020 is still in its initial phase and the current analysis focused on the period January 2014 until April 2015. Therefore, a relative comparison of the marine projects and their respective budgets is not deemed useful at the moment.

European Fund for Regional Development (EFRD)

Additional to the above-mentioned funding instruments, research is also financed through the European Fund for Regional Development (*EFRD*). EFRD is a structural fund aiming at the realisation of the European 2020 Strategy which focuses on sustainable economic development and employment. Enterprise Flanders (*AO*) manages the Flemish EFRD programme and is responsible for the coordination and follow up of the 4 cross-border, 2 transnational and 3 interregional programmes in which Flanders participates. Over the period 2008-2014, a total of 15 marine projects, with a promotor affiliated to an MRG, were financed by INTERREG-ERFD. Those 15 marine projects correspond with 17 project participations of MRGs (10 unique MRGs) equalling a total budget (sum of individual partner budgets) of 3.9 million euros (annual average of 0.5 million euros).

Table 6. Overview of the 10 Ocean of Tomorrow projects with MRG participation.

PROJECT	KNOWLEDGE OUTPUT	PARTNER BUDGET MRGs
ECO2	• CO_2 sub-seabed storage to implement EC directive on the geological storage of CO_2 (2009) • Multidisciplinary research on the impact of sub-seabed CO_2 storage on marine ecosystems	200,000 euro
MERMAID	• Concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy extraction, aquaculture and platform related transport • Guidelines to assist offshore industries in plan, establish and operate their business in the most optimal way possible • Case studies in 4 EU regional seas	220,078 euro
PERSEUS	• An effective and innovative research governance framework, to turn back the tide on marine life degradation in the southern European seas • Merge natural and socio-economic sciences to predict the long-term effects of pressures on marine ecosystems	170,000 euro
AquaTrace	• Sustainable aquaculture through improved competitiveness and environmentally-friendly production • Collective effort of research institutions and aquaculture industry across EU • Development of sustainable EU aquaculture and achievement of the 'Good Environmental Status' (GES) in the MSFD	407,516 euro
MICRO B3	• Novel bioinformatics tools to enhance EU optimal use of big data to develop marine ecosystems' biology and biotechnology • Long-lasting interoperable structures and resources for data mining: from sampling to storage, analysis and downstream use of environmental and bioinformatics • Increased understanding of marine microbial ecosystems	279,253 euro
BENTHIS	• Mitigation of adverse effects of bottom-trawl fisheries • Innovations for a 'green fishing technology' • Multidisciplinary research on the impact of sub-seabed CO_2 storage on marine ecosystems • Fishing/seabed habitat risk assessment method applied in regional seas	210,389 euro
CleanSea	• Protocols and tools for marine litter research • Innovation and business opportunities for industry and SMEs • Leadership in marine litter monitoring and remediation	159,782 euro
ECsafeSEAFOOD	• New detection tools for safe and high quality seafood • Monitoring of non-regulated chemical contaminants, risk assessment, toxicity, links between contaminants in the environment and that in seafood, effect of climate changes • Societal impacts in the sustainability of the sea food sector	561,614 euro
KILL-SPILL	• Economically and environmentally viable biotechnological solutions and tools for oil spill remediation and clean-up market • Biosensors to monitor hydrocarbon degradation, novel environmentally friendly dispersants and adsorbents, combined microbial and additives formulations, multifunctional bioremediation agents and tools for sediments decontamination	644,343 euro
BYEFOULING	• Full production line for high volume production of low toxic and environmentally friendly antifouling coatings for mobile and stationary maritime applications • Procedures, guidelines and fabrication tools for short time to market for new coating concepts • New antifouling coatings with enhanced performance	351,900 euro

European Cooperation in Science and Technology (COST)

COST supports the coordination of pan-European research networks (COST actions). The research itself is funded through other (national or regional) channels (FWO for Flanders). In the period 1971-2013, 26 marine COST actions with a Belgian partnership were financed. 13 actions were situated in the period 2008-2014, including at least 16 individual project participations of MRGs. Because of its particular structure, COST funding can not be analysed in a similar way as other projects. Therefore, the identification of individual partner budgets is not possible.

Information about the earlier FPs and the current Horizon 2020 is available through the Community Research and Development Information Service (*CORDIS website*). An overview of the European funding instruments, including the programmes of the Directorate-Generals of the European Commission, is available in the Guide to funding instruments (*Pirlet et al. 2015a*).

2.5 Challenges and opportunities for marine research in Flanders and Belgium

The policy with regard to economic development and innovation in Flanders is centered around its greatest asset: science and technology-based knowledge (*Muyters 2014*, *Coalition Agreement of the Flemish Government 2014-2019*, *Muyters 2015*). Science and innovation are key to the necessary transformation of the industrial fabric. This policy also emphasises the role of scientific research and scientific institutions in order to address the current and future societal challenges (*VRWI-Memorandum 2014-2019*). Given the societal importance and economic potential of the seas and oceans, there is a significant role for marine research in answering these needs and challenges. The marine science community in Flanders and Belgium has responded by jointly subscribing the common European vision, as well as by means of the Ostend Declaration (*McDonough & Calewaert 2010*), Navigating the Future IV (*European Marine Board 2013*) and the Rome Declaration (*European Marine Board 2014*). These vision documents emphasise an ecosystem approach as a basic requirement for a sustainable maritime economy and highlight the role of marine research and innovation in achieving European leadership in this field.

The characteristics and strengths of the marine research in Flanders and Belgium (*VLIZ 2014*) were screened by an expert panel of marine scientists (April 2015) in the context of the current societal challenges and with a view on the opportunities ahead. The panel was composed of 40 directors of Belgian MRGs and representatives from the Flemish and federal science administration. Below, some of the topics which were adressed by this panel have been laid out for further discussion:

MARINE RESEARCH: DIVERSITY AND QUALITY ARE KEY

The MRGs in Flanders and Belgium have a leading position in the EU and globally. Unlike many of the neighbouring countries, Belgium does not have a fully dedicated national marine research institute or a marine research programme to coordinate the existing capacity and expertise[9]. In terms of research capacity (personnel), the marine research landscape in Flanders and Belgium is comparable to that of the larger marine institutes in neighbouring countries (*Herman et al. 2013*). Also in terms of scientific output, measured as the annual number of marine peer-reviewed publications (figure 21), the joint scientific output of MRGs in Flanders and Belgium is comparable to that of the larger foreign marine research institutes[10].

The Relative Citation Frequency (RCR) of the marine peer-reviewed publications demonstrates that MRGs in Flanders and Belgium perform above the global standard. This also applies to the citation indicators for each of the individual disciplines (figure 11, see **Inventory of marine research**) (ECOOM). Despite the limited size of the research community and with the wide range of expertise that is covered, the Belgian marine research community has gained a reputation at the EU and global level as a result of the high quality of published research.

The high impact of the publications of Belgian marine researchers is also confirmed by international studies (Council of Canadian Academies 2013)[11].

[9] Since 1976, RBINS has a unit, the Operational Directorate of Natural Environment (OD Nature) which combines both the research in the BNS, science-policy support, and monitoring tasks. Since October 1999, the Flanders Marine Institute (VLIZ) provides a coordination and information platform for marine scientific research.
[10] Note: the specific tasks and mandates of research institutes (advice, monitoring and evaluation of policy objectives, teaching assignments) determine the extent to which researchers can be dedicated to effective research assignments.
[11] Ocean Science in Canada: meeting the challenge, seizing the opportunity. 2013. Council of Canadian Academics. Based on Scopus database analysis for 2003-2011.

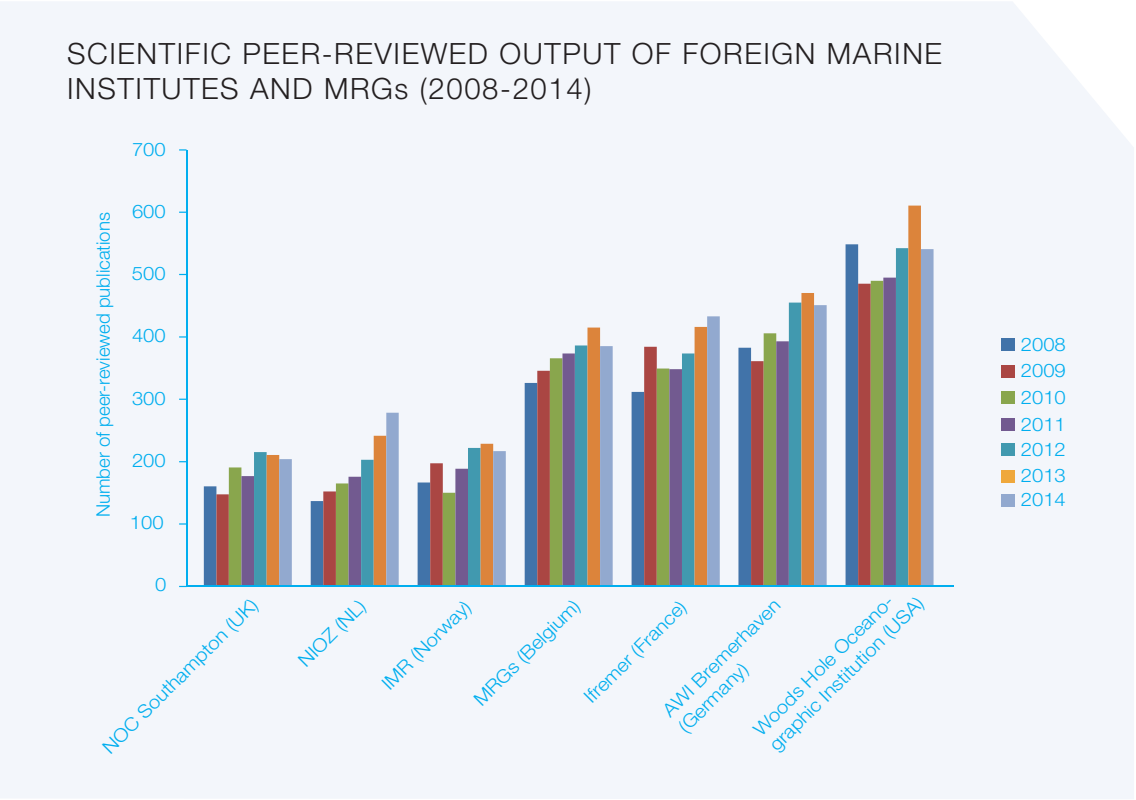

Figure 21: Scientific output of foreign marine research institutes and a comparison with the scientific output of the MRGs in Flanders and Belgium: number of marine peer-reviewed publications 2008-2014. This comparison is based on a query via the 'affiliation search' module in the Scopus literature database. The inventory of the marine peer-reviewed publications of the MRGs for 2014 has a lower degree of completeness. For a trend analysis, measurements over a longer period are necessary.

The Open Access movement makes rapid progress in marine research as well: the share of publications in Open Access journals increased from 6.2% in 2008 to 20.5% in 2014 (see **Inventory of marine research**). This open access culture has measurable effects on the integration and availability of scientific output and thus stimulates creation of new knowledge (*EC MEMO/11/891*, *Muyters 2014*).

Research capacity and expertise in a variety of research disciplines

Despite its limited coastline, the marine science community in Flanders and Belgium consists of aproximately 1,400 marine scientists and specialised staff (see **Inventory of marine research**, *VLIZ 2014*). This expertise is fragmented over 99 MRGs associated with Flemish, French and federal research institutions (see **Inventory of marine research**). Although the emphasis of the marine research is on the biological and earth sciences, the research is conducted in a wide range of disciplines. This diversity in expertise is a strong asset when tackling complex issues (impact of climate change, food security, biodiversity conservation, etc.) where multi- and interdisciplinary research is a necessity. The MRGs have an established expertise, particularly in the areas that were put forward in the Communication on a European Strategy for Marine and Maritime Research (COM (2008) 534), and in the agenda for innovation in the Blue Economy as the challenges for future research (COM (2014) 254, *European Marine Board 2013*).

The inventory of marine research reflects the dynamic character of the organisation of marine research, which is necessary to quickly respond to emerging topics both in fundamental and applied research. The expertise of the MRGs is in line with the major challenges for current and future research in the fields of: fisheries and innovative aquaculture systems, engineering and coastal protection, climate, marine biotechnology, offshore engineering and materials, maritime law, offshore renewable energy technologies, maritime transport, public health in relation to seas and oceans, and sustainable extraction of raw materials from the deep sea (see Brochure marine research in Belgium, *Mees et al. 2015*). This knowledge is valued in international partnerships with both industry and research, as well as in collaborations between research institutes.

Fundamental and applied research as a knowledge base

The leading position of the marine research in Flanders and Belgium is the result of efforts over the past years. In order to sustain this position, it is necessary to continue to invest in this knowledge base[12]. In the current dynamic setting of the marine research landscape, the access to a stable and dedicated research budget is a key issue for marine researchers. The latter is a prerequisite to be able to move from existing research towards new and innovative applications. Fundamental research establishes the necessary knowledge to understand and evaluate marine ecosystems and processes. Furthermore, this kind of research has the potential to lead to new applications, and innovation opportunities in the context of the Blue Economy in the medium or long term. The development of fundamental knowledge on marine ecosystems and their functioning is considered the basis for a sustainable use of oceans and seas. Therefore, balanced budgets should be made available to support both applied and fundamental research.

A continuous need for a coordination platform in a fragmented and complex landscape

The marine research expertise is dispersed in Flemish, French and federal research institutes (see **Inventory of marine research**). Although indicators of the degree of inter- and multidisciplinary research are currently lacking, an analysis of the publications and projects suggests that long term multidisciplinary cooperation takes place between the MRGs from Flemish and French-speaking universities, as well as with research institutes across Belgium. The multidisciplinary approach to research is needed to address the major societal challenges with regard to the seas and oceans.

Since 1999, VLIZ acts as a coordination and information platform for marine research in Flanders. The institute facilitates cooperation and networking by improving access to scientific data and information for researchers, administration and policy-makers, and through the transfer of marine knowledge to certain user groups. Furthermore, VLIZ maps the expertise of MRGs in Flanders and Belgium and supports networking both in international and national initiatives.

Programmatic research as a lever for international and multidisciplinary collaboration

The inventory of marine research funding (see **Inventory of marine research**) suggests a reduction or at least a stagnation in financial resources for marine research. In terms of EU research funding, there is a tendency towards supporting fewer, yet larger projects or consortia (in number of partners and budget) (figure 19). In the past, core funding for marine research was secured at the national level through the multi-annual research programme 'Project Sea' (1970) and the subsequent phases of the North Sea research programme (BELSPO, see **Inventory of marine research**). Project Sea also marked the start of multidisciplinary and collaborative marine research in Belgium. Such a programmatic approach may stimulate the research with regard to the grand challenges and acts as a lever to strengthen the participation of the MRGs in the international and European consortia that address these research challenges (*VRWI 2010*). The analysis of marine research output suggests that investments in marine research infrastructure (research vessels, collections, etc.) and the utilisation thereof are an important factor for international cooperation in marine research. The current restructuring of the Flemish administrations for science and innovation (FWO, IWT, the Hercules Foundation, AO) provides new opportunities for the further development of a coordinated marine research programme. In this regard, a more active cooperation between research partners and the private sector is crucial.

Careers for (young) marine researchers

Thanks to the efforts of the Flemish government (through IWT and FWO) and fiscal measures (Maribel Plan, Pegasus, etc.), an increase is observed in the overall number of PhD students (pre- and postdoctoral) in Flanders since 2000 (*Debackere & Veugelers 2015*). However, this increase in government spending is currently not reflected in the number of PhD students on marine research topics (see FWO and IWT fellows, **Funding of marine research**). This is

[12] Following the Barcelona objective, the Pact 2020 reflects the long-term vision of the Flemish government to spend 3% of its GDRP to R&D activities, by 2020. Flanders scores above the EU 28 average with 2.54 % (ECOOM, 2015) but is below the level of the leading countries (*VRWI Memorandum 2014 to 2019*). Based on a ratio of 1/3 public and 2/3 private funding, the goal of achieving the 1% level for public R&D investments will be reached when a growth path is used with an annual increase of 150 million euro on average from 2015 till 2020 (*VRWI Memorandum 2014 to 2019*, *Speurgids Ondernemen & Innoveren*, *EWI 2015*).

of particular importance as early stages of new research themes (emerging topics) are usually studied by PhD fellows at the universities and scientific institutes.

Continued efforts are needed to provide early career scientists with sufficient prospects of a career after completion of a (post-) doctoral mandate, in which they can further develop and apply their expertise. Besides an academic career, an improved flow of marine researchers and highly skilled personnel to the non-academic world allows to optimise the valorisation of marine expertise in innovation and business applications. Tax policies (e.g. tax exemptions for R&D activities to hire expertise at the level of master and bachelor degrees, tax deductions for the training of highly-qualified personnel, etc.) are proposed by the industry and SMEs to boost this process (VOKA 2015)[13].

VALORISATION OF MARINE RESEARCH IN THE KNOWLEDGE SOCIETY

Integrated research and science-based policy

An estimated 25 to 30% of the marine research in Belgium focuses on the Flemish coast, the Scheldt Estuary, the BNS and the southern North Sea[14]. These regional studies can rely on well-developed research infrastructures (research vessels, a marine station, a network of buoys and measuring systems, mathematical models, etc.). The BNS is one of the best studied marine areas in the world featuring a high data density, data quality and long term data series in a geographically limited marine area. Hence, the BNS and adjacent areas provide an interesting case study and testing area for the development of new research hypotheses and continued multidisciplinary research that can be relevant for other marine regions. This is particularly true for research conducted in the context of large-scale interventions (e.g. energy infrastructures, coastal protection, seabed exploitation) and in applying the ecosystem approach in the BNS. Moreover, historical data and timeseries are often crucial in underpinning marine policy and (policy) scenarios.

The analysis of the publications of the MRGs suggests that research in the BNS is primarily linked to policy issues such as the implementation of the MSFD and Natura 2000 at sea. Certain calls for projects in the federal research programme BRAIN-be have an explicit link with policy issues attended by federal administrations. The competent authorities and advisory bodies are supported by different 'science-policy' structures which inform the policy and accelerate the transfer of marine research outcomes to science-based policy decisions.

Clusters for innovation in the Blue Economy

The industry and the research institutes are facing the challenge to jointly develop the necessary technological and scientific knowledge to foster innovation in the blue economy. Targeted cooperation between science and industry for a blue economy in Flanders is not new on the agenda: Flanders Maritime Cluster (*FMC*) has supported this mission since 2010. FMC encourages companies to cooperate in the development, demonstration and marketing of innovative solutions in the context of the Blue Economy and sustainable coastal and ocean management. In addition to networking and promotion of skills and competences, pilot projects are being implemented to stimulate the valorisation of knowledge and cross-sectoral innovation. Furthermore, the *Flemish Aquaculture Platform*, the *Flemish Algae Platform*, the *Flemish Marine Biotechnology Platform*, the *Blue Energy Cluster* (Factories for the Future), *OWI-Lab*, the Flemish Industrial Biotech Cluster (*CINBIOS*) and the Flanders Innovation Hub for Sustainable Chemistry (*FISCH*) have taken up this role for specific sectors of the Blue Economy in Flanders.

In parallel with the restructuring of the agencies that support the technology and innovation landscape in Flanders, it is crucial for an efficient Blue Economy (COM (2012) 494) and Blue Innovation (COM (2014) 254) to support the development of marine clusters of SMEs, larger companies and research institutes. Through these marine clusters, partners can initiate joint projects and add international leverage to their expertise. An initial analysis of project-based collaborations[15] shows that initiatives were launched between science and industry around some of the growth sectors of the Blue Economy. The largest share of public funding in these innovative projects focus on blue energy (28% of the total analysed budget), aquaculture (23%), marine biotechnology (13%), sensors and monitoring techniques (9%) and offshore engineering and materials (9%) (figure 22).

[13] *Project lead Plants and Lead Companies*, VOKA.
[14] Analysis based on peer-reviewed and VABB publications of the MRG 2008-2014 (see also **Inventory of marine research**).
[15] Analysis of the available funding resources, based on the screening of MRGs in the project databases of FP7, ERDF, BELSPO, IWT and FWO between 2008 and 2014, total analysed budget 43 million euros.

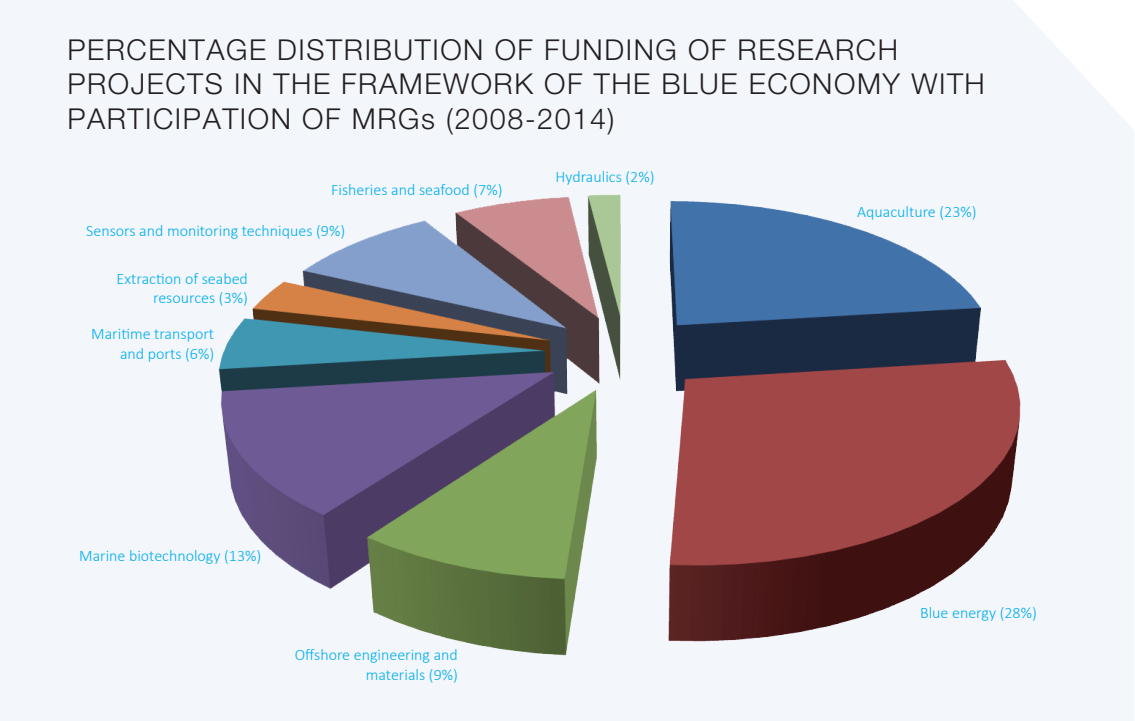

Figure 22. Distribution of the funding of research projects with participations of MRGs* (2008-2014), according to the sector of the Blue Economy. N = 124 projects (Source: IWT, FWO, BELSPO, ERDF and FP7 project databases). * For IWT, FWO and BELSPO the total project budget is considered. FP7 and ERDF projects only take the project budget for Belgian partner(s) into account.

In cooperation with the maritime industry, a coordinated approach is developend for education and training opportunities of qualified staff (e.g. Technical University Alliance for economic transformation in West Flanders (*TUA West*), *Greenbridge*, European Marine Biological Resources Centre (*EMBRC*)).

GLOBAL CHALLENGES: POSITIONING OF BELGIAN MARINE RESEARCH IN THE INTERNATIONAL RESEARCH COMMUNITY

Internationalisation

A significant share of the research of the MRGs in Flanders and Belgium is conducted in the framework of international networks and cooperation with foreign experts. This is evident from the cooperation in European projects (see **Inventory of marine research**) and the analysis of the authors of scientific publications of the MRGs. This analysis shows that in 68% of the publications in the period 2008-2014, at least one foreign (co)author was involved (international co-publications). The international (co)authors come from 83 different countries (figure 23). The MRGs also score above the world average with regard to the citation of their work. Hence, the increased international cooperation in marine research can be directly linked to the enhanced citation rates. Indeed, it is generally known that international co-publications receive on average more citations than publications without participation of foreign (co)authors (*Debackere & Veugelers 2013*). An analysis of the geographical focus of the publications confirms the international scope of the Belgian marine research community: 75% of the analysed publications refers to study areas with an international perspective (Europe and worldwide).

Besides the strength of international cooperation, the long-term scope of marine research and the high data density in the BNS offer unique opportunities to test new research hypotheses. The knowledge and expertise available for the BNS are therefore often exported as a case-study and highly valued in international project consortia. Examples include marine spatial planning and the development of offshore technologies, among others, for the blue energy sector.

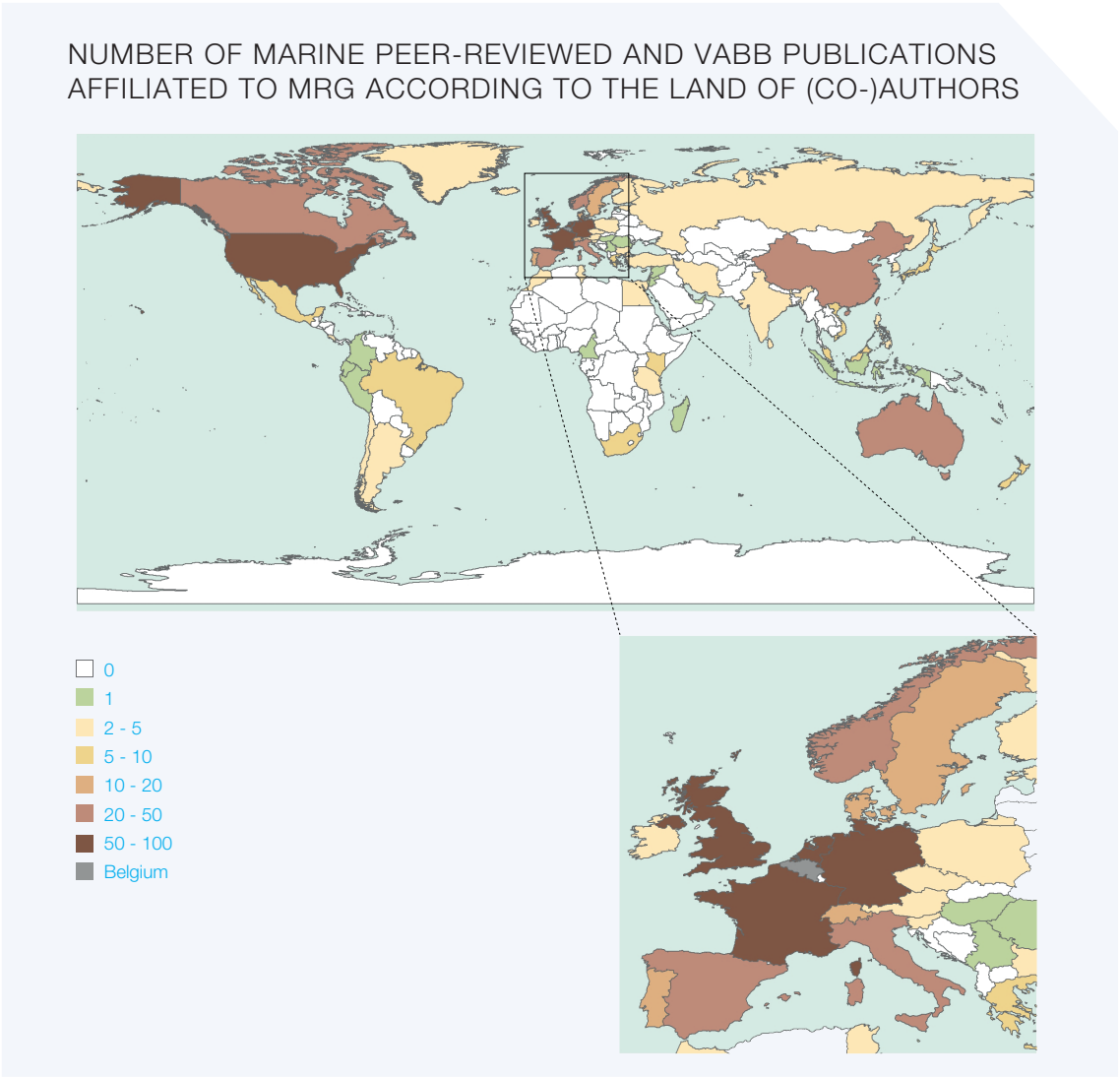

Figure 23. Geographical visualisation of international cooperation, based on the international co-publications of MRGs between 2008 and 2014 (number of marine peer-reviewed and VABB publications of the MRGs by country of affiliation of (co)authors) (see Inventory of marine research).

Research infrastructure is a leverage for (international) cooperation

The research infrastructures in Flanders and Belgium (*Pirlet et al. 2015b*) provide an important leverage for co-operation: in addition to serving the needs of regional and national research, research infrastructure is also deployed in the framework of international cooperation. This is particularly the case for research vessels. The scientific publications of the MRGs in 2013 refer to cooperation with at least 31 different research vessels from 14 different countries. The analysis of the research output highlights the importance of permanent access to these infrastructures and networks to maintain the current international leading position of Belgian marine research. This is particularly the case for seagoing research. In this regard, the access to two complementary research vessels is a key issue for the marine research community in Flanders and Belgium. Also, the first steps are being taken to implement a joint offshore testing- and research infrastructure for marine research institutes and industry (*POM West-Vlaanderen 2015*). Along with the further development of the facilities at the Marine Station Ostend (*MSO*, VLIZ), continued efforts aim for an increased access to collections and specimens (EMBRC), data and information, and research instruments.

Science sharing as a modality in development cooperation

One of the important issues in the context of globalisation is the openness in addressing the major global problems (*Dierick et al. 2005*), in particular for those issues that are high on the agenda of developing countries. Belgium and Flanders have gained relevant experience in marine science sharing in the context of development cooperation (e.g. *VLIR-UOS*, see above). In the marine context, the alignment of research agendas is one of the aspects of science sharing. Flanders plays a leading role in the marine science collaboration with Kenya (*KMFRI*), in particular in the deployment of the RV Mtafiti (former RV Zeeleeuw) in the Indian Ocean which is the least studied oceanic region worldwide. Flanders also supports global marine and coastal-related programmes through the Flanders-UNESCO Science Trust Funds.

Outcome

Despite the 'decentralisation' of marine research in Flanders and Belgium, it has achieved a leading position both at a regional and international level. Capacities are in place to perform multidisciplinary marine research in a broad range of research areas. A sense of collectivity is needed in this international and European context to develop a coherent vision for research topics, technological requirements and infrastructure needs. Structural support for partnerships - including sience-industry - is one of the pillars of our knowledge society and is key in addressing the grand challenges for the current and future marine research.

Flanders as an international partner in marine research

In the policy note (*Beleidsnota (2014-2019)*) of the Flemish minister competent for science, technology and innovation, Philippe Muyters, the priorities for the R&D policy are aligned with the grand challenges at an international and European level. The current coalition agreement of the Flemish government (*Flemish Government 2014*) reconfirms its commitment to the objective of the *Pact 2020*: 'By 2020 Flanders aims to be among the top five European regions with an employment rate of 76% and a budget of 3% of its GDP for research and development'.

In a small region like Flanders, upscaling is a prerequisite to ensure a competitive position in the long term. Cornerstones in this policy are: excellence in scientific research and education and a strong collaboration between science, industry and government for the valorisation of knowledge and innovative applications for the global market. Infrastructures that support research and technology developments are an important pillar in this regard.

The *Hercules Foundation* is the funding instrument of the Flemish government for investments in large- and medium-scale infrastructures for fundamental and strategic research in all scientific disciplines. The European Strategy Forum on Research Infrastructures (*ESFRI*) identifies the needs of the EU member states for pan-European research infrastructures and acts as a consultation platform between member states to achieve these infrastructures. Flanders is participating in five projects within the ESFRI framework (via the Hercules Foundation), three of which have a relevance for marine research: the Integrated Carbon Observation System (*ICOS*), the e-Science European Infrastructure for Biodiversity and Ecosystem Research (*LifeWatch*) and the European Marine Biological Resource Centre (*EMBRC*). EMBRC is a distributed European research infrastructure that integrated the expertise and resources that are present in leading marine biology research centres and stations in Europe. Flanders is also represented in networks and organisations that aim for an optimal use of large-scale infrastructures on a European level, e.g. the European Research Vessel Operators (*ERVO*). Furthermore, Flanders plays an active role in global networks that focus on information management and the standardisation and integration of marine data (e.g. *Aphia*, *WoRMS*, *OBIS*, *EMODnet*, *IODE*, etc.).

In October 1999, Flanders Marine Institute (*VLIZ*) was established which acts as a coordination and information platform for marine research in Flanders. VLIZ is located on the Innovocean site in Ostend. This site has gained an important international reputation due the presence of renowned international partners:

Since 2005, the Flemish government provides structural support for the the UNESCO/IOC Project Office (*IODE Project Office*) through the provision of office space, local staff and operational funding (0.54 million euros). The Flanders-UNESCO Science Trust Funds (FUST) contributes an additional 1.53 million euros per year via UNESCO. Approximately 60% of this budget is dedicated to the support of marine and coastal-related programmes and projects. With this support, Flanders contributes to the international coordination efforts in the fields of oceanography and capacity building, and stimulates the promotion of the sustainable development of coastal areas worldwide.

In 2012, the European Commissioner for Maritime Affairs and Fisheries decided to accept the offer of the Flemish government to host the central secretariat of the European Marine Observation and Data Network (*EMODnet*) on the InnovOcean site in Ostend (a annual subsidy of 180,000 euros). EMODnet is the central pillar of the European initiative Marine Knowledge 2020 (COM (2010) 461).

The European Marine Board (*EMB*) was founded in 1995 to enhance the coordination between European marine research organisations - both the research and research-funding bodies - and to develop a strategy for marine sciences in Europe. Since 2006, the secretariat of this European forum for marine sciences is hosted at the InnovOcean site. VLIZ is the representative of FWO in the EMB (since 2014 as chairman of the Board).

Flanders and Belgium have actively supported the development of *JPI Oceans* since its early stages. In addition, the Flemish government contributes to JPI Oceans (a subsidy of 200,000 euros per year) and by seconding VLIZ staff to the JPI Oceans secretariat since 2011. In 2012, the Coordination and Support Action (CSA) Oceans (FP7) started, with eleven partners from nine different countries joining forces towards the operationalisation of JPI Oceans.

These concerted efforts bring marine research in Flanders closer to the relevant actors in a European and global context. They stimulate participation in international networks and aim for a more integrated and multidisciplinary approach in marine research.

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ETC.			
Abbreviations	Title	Year of conclusion	Year of entering into force
UNCLOS	United Nations Convention on the Law of the Sea	1982	1994
Bonn Agreement	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	1983	1989
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR Convention	The Convention for the Protection of the marine Environment of the North-East Atlantic	1992	1998
HELCOM	The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area	1992	
Bucharest Convention	The Bucharest Convention on the Protection of the Black Sea against Pollution	1992	
Barcelona Convention	The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean	1995	

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations	Title	Year	Number
Directives			
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
Marine Strategy Framework Directive	Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Birds Directive	Directive 2009/147/EC on the conservation of wild birds	2009	147
	Directive 2014/89/EU establishing a framework for maritime spatial planning	2014	89
Regulations			
	Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006 Text with EEA	2013	1290
Common Fisheries Policy	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
Other			
Integrated Maritime Policy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union	2007	575

EUROPEAN LEGISLATION (continuation)			
Abbreviations	Title	Year	Number
	Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - 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 to the Council the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain	2009	538
Marine Knowledge 2020	Communication from the Commission: Marine Knowledge 2020 marine data and observation for smart and sustainable growth	2010	461
	Communication from the Commission: Blue Growth opportunities for marine and maritime sustainable growth	2012	494
Limassol Declaration	Declaration of the European Ministers responsible for the Integrated Maritime Policy and the European Commission, on a Marine and Maritime Agenda for growth and jobs	2012	
	Communication from the Commission: Action Plan for a Maritime Strategy in the Atlantic area Delivering smart, sustainable and inclusive growth	2013	279
	Communication from the Commission: Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth	2014	254

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Royal decrees		
KB van 22 augustus 2006	Koninklijk besluit tot wijziging van het KB/WIB 92 op het stuk van de aangifte in de bedrijfsvoorheffing	2006-08-22/34
Decrees		
Decreet van 30 april 2009	Decreet betreffende de organisatie en financiering van het wetenschaps- en innovatiebeleid	2009-04-30/A0


MSC

Chapter 2

Use of the sea

1

Nature and environment

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Citation:

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With an average 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)). 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 3,454 km² in the Southern Bight of the North Sea (*Belpaeme et al. 2011*). More geographical information about the BNS can be found on *www.kustatlas.be* and *http://odnature.naturalsciences.be/marine-atlas/*. The current text elaborates on the aspects which are characteristic for the BNS and its adjacent coastal area.

1.1 Characteristics of the marine and coastal environment

1.1.1 Sea

BATHYMETRY AND SUBSTRATE

The BNS is a shallow part of the North Sea with a seabed that gradually deepens in a north-west direction up to a depth of 40 to 45 m (see figure 1). The relief of the seabed is characterised by the presence of a complex system of gullies and sandbanks up to 30 m high relative to these gullies, 15 to 25 km long and 3 to 6 km wide. The orientation of the banks varies from parallel to the coast to a southwest-northeast orientation further offshore (*Mathys 2009*, *Mathys 2010*). The substrate of the seabed mainly consists of non-consolidated Quaternary sediments with a thickness that varies between a few meters in the gullies to 50 meters around the sandbanks. Underneath these Quaternary sediments, there is a layer of Tertiary clay which is locally exposed in the gullies (*Lanckeus et al. 2001* (*BUDGET project BELSPO*), *Le Bot et al. 2003* (BELSPO), *Mathys 2009*, *Mathys 2010*, *TILES* (*TILES project BELSPO*)). In general, the grain size of the sediment on the seabed increases from silty sediment near the coast over fine to coarse sandy sediment in deeper water (*Verfaillie et al. 2006*, *Van Lancker et al. 2007* (*MAREBASSE project BELSPO*)).

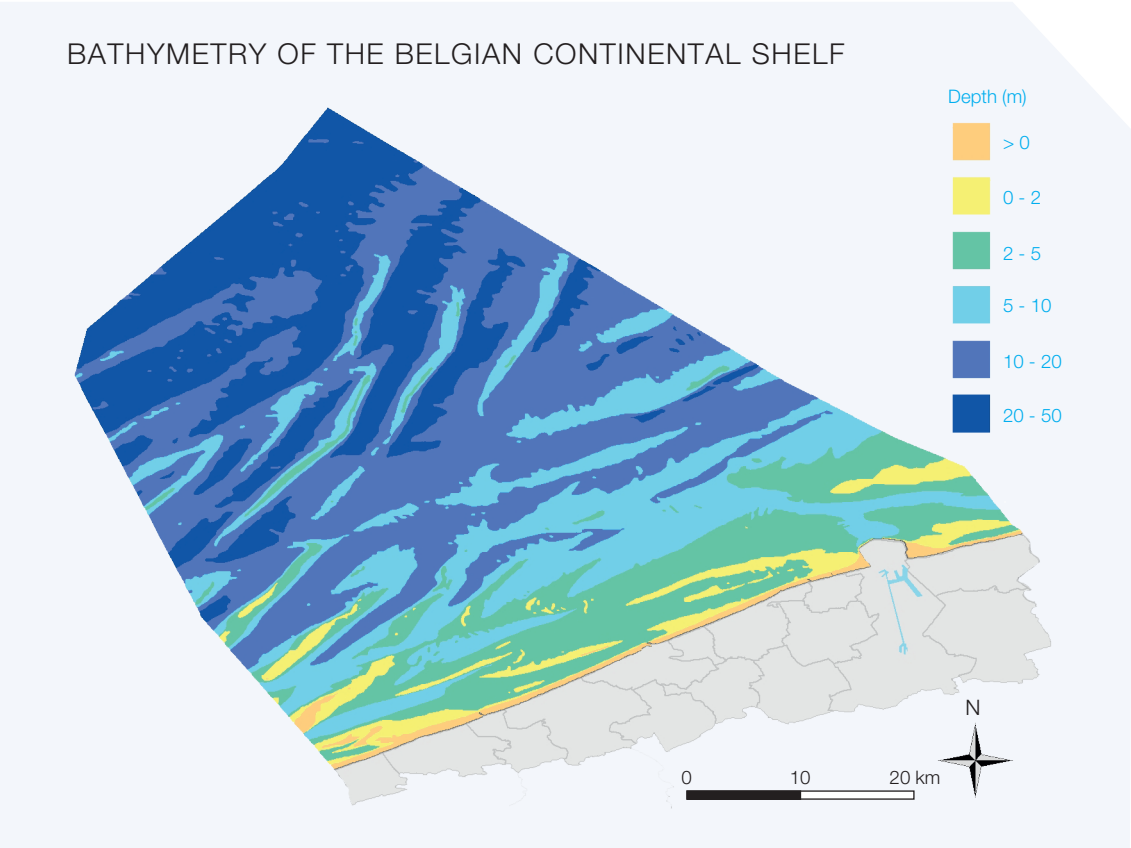

Figure 1. The bathymetry of the Belgian continental shelf (Source: agency for Maritime and Coastal Services).

HYDRODYNAMICS AND SEDIMENT TRANSPORT

The currents in the BNS are dominated by semi-diurnal tides. The tidal amplitude varies between 3 m during neap tide and more than 4.5 m during spring tide, with the tidal range decreasing towards the northeast. The tidal currents can reach up to 1.2 m/s and are an important means of sediment transport, although tides caused by wind may also play an important role (*Fettweis & Van den Eynde 2003*, *De Moor 2006*, *Van Lancker et al. 2012* (*QUEST4D project BELSPO*), *Baeye 2012*). Along the Belgian coast, a high concentration of suspended sediment occurs resulting in turbidity maximums (*Fettweis & Van den Eynde 2003*, *Fettweis et al. 2007* (*MOCHA project BELSPO*), *Baeye 2012*).

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*. Operational models of these hydro-meteorological data are available on the *website of the Operational Directorate Natural Environment (RBINS)*.

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 rivers Scheldt, Rhine, Seine and Meuse which reduce the salinity of the Atlantic water (salinity 35) entering via the Channel (*Lacroix et al. 2004*). The carbon chemistry of the seawater undergoes a seasonal variation and affects the acidity of the water with a pH that fluctuates between 7.95 and 8.25 (*Gypens et al. 2011*) (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 OSPAR, the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (see **Policy instruments**). The impact of climate change on the seawater characteristics in the BNS is discussed in *Van den Eynde et al. (2011)*, (*CLIMAR project BELSPO*) (see also theme **Safety against flooding**).

A LARGE DIVERSITY OF BENTHIC LIFE

The sandbanks in the BNS are characterised by a very rich benthic life (benthos) that plays an important role in the marine food web. The benthic organisms have been intensively studied since 1970 (e.g. *Cattrijsse & 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*, *TROPHOS project* (*TROPHOS project BELSPO*), *WESTBANKS project* (*WESTBANKS project BELSPO*)). The benthos constitutes an important food source for fish, shrimps and crabs, and is actively involved in the decomposition and transport of organic material. The marine food web largely depends on suspended food particles. Once these particles reach the seabed, they are processed by benthos (by the microbial community as well as by other small organisms (bivalves, polychaete worms, crustaceans, nematodes, etc.)) (e.g. *Braeckman et al. 2010*, *Braeckman 2011*). A complete overview of the species present in the BNS is available in the Belgian Register of Marine Species (*BeRMS*, *Vandepitte et al. 2010*).

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 larvae of fish and shrimps (see *inter alia* *Mees 1994*, *Dewicke 2002*, *Beyst 2001*, *Fockedey 2005*). Large numbers of starfish, brittle stars, crabs, lobsters, demersal fish and squids can be observed on the seabed which constitute together with less common species, the epibenthos (e.g. *Hostens 2003*, *Calewaert et al. 2005*). Most species can be found between the sand grains, up to an average depth of 10 cm below the seabed. These are mainly bivalves, polychaete worms, small crustaceans (macrobenthos, *Degraer et al. 2006*), nematodes and copepods (meiobenthos[1]). The occurrence of these benthic organisms is not uniform and is related to the physical characteristics of the seabed. Up to 81 species of macrobenthos have been counted in sediment samples (surface of 0.1 m^2), with a total of 150,000 organisms per square meter, in the 'richer' areas of the Western Coastal Banks, the Flemish Banks and the Zeeland Banks. Each species prefers a certain type of sediment which is in turn determined by the current pattern. The seabed of the BNS is characterised by (1) soft substrates (ranging from silt to fine or coarse sand) interspersed with (2) geogenic reefs (reefs whose topographical expression is the result of geological features such as the gravel beds of the Hinderbanken sandbanks) with a typical fauna that lives on top of the gravel beds (so-called epifauna with e.g. sponges, oysters, bryozoans, sea anemones) (*Houziaux et al. 2008*) and by (3)

[1] Organisms who live on or in the seabed and measure between 1 and 0.063 mm.

biogenic reefs (e.g. shaped by *Lanice conchilega*) (*Rabaut et al. 2009*). In the soft mobile substrates of the subtidal sandbanks, four general types of macrobenthic communities are to be found: the *Macoma balthica* community, the *Abra alba* (– *Mysella bidentata*) community, the *Nephtys cirrosa* community and the *Ophelia borealis* (– *Glycera lapidum*) community. These communities are characterised by a specific species composition, diversity and density, and occur in a specific and well-defined environment (*Degraer et al. 2003*, *Van Hoey et al. 2004*).

Recently, the increase in artificial hard substrates (e.g. offshore wind turbines) has created new possibilities for benthic organisms. The effects of hard substrates on the fauna as well as the impact on the surrounding soft substrates are monitored in detail (e.g. *Degraer et al. 2013*, *Baeye & Fettweis 2015*).

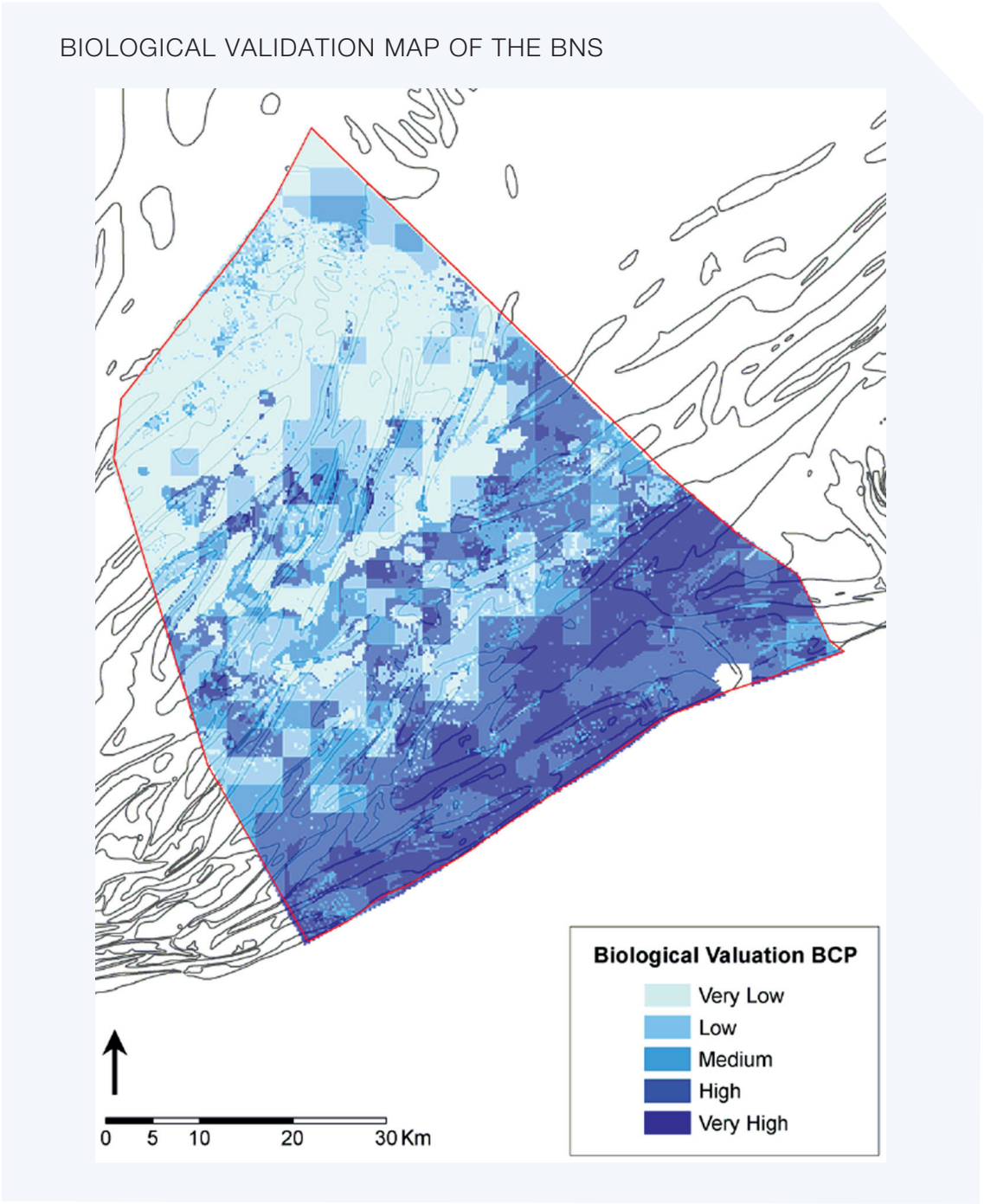

Figure 2. The biological validation map of the BNS, which combines the validation maps of the seabirds, macrobenthos, epibenthos and demersal fish (*Derous et al. 2007*, *BWzee project*, *BELSPO*).

THE PELAGIC ECOSYSTEM

The pelagic ecosystem constitutes the largest habitat in the world. Unlike the benthic ecosystem, the pelagic ecosystem has been investigated or monitored very little in Belgian waters. The zooplankton[2] community of the BNS mainly has a coastal nature but is occasionally influenced by species from the inflow of Atlantic water (*Van Ginderdeuren 2013*). The crustaceans or more specifically the calanoid copepods (holoplankton[3], 66%), dominate the zooplankton with species such as *Temora longicornis*, *Acartia clausi, Paracalanus parvus, Centropages typicus* and *Centropages hamatus* (*Van Ginderdeuren et al. 2012a*). Also, meroplanktonic[4] 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, consisting of 46 holo-, 50 mero- and 41 tychoplanktonic[5] species (*Van Ginderdeuren et al. 2014a*). May and June are the months with the highest mean densities, followed by a smaller autumn peak in September. Zooplankton densities vary between 150 and 15,000 ind.m^{-3} and are highest a few kilometers off the coast, in the transition zone from coastal to offshore waters. Other elements of the ecosystem (demersal fish, epibenthos, macrobenthos) also exhibit high densities and a high diversity in the zone a few kilometers off the coast (*Van Hoey et al. 2004*, *De Backer et al. 2010*). Phytoplankton is the most important food source for zooplankton and modifications in the dynamics of this phytoplankton may strongly influence the zooplankton. Hence, it is important to monitor the problems related to the annual seasonal changes in the phytoplankton composition (e.g. *Phaeocystis* blooms) caused by eutrophication (see also theme **Agriculture**).

Since 2012, special attention has been paid to jellyfish, especially because of the presence of the non-indigenous species *Mnemiopsis leidyi* that has populated the entire Belgian coastal zone since 2007 (*Van Ginderdeuren et al. 2012b*). Similar to zooplankton s.s., the diversity of gelatinous zooplankton is rather high (33 taxa), with hydromedusa as the most diverse and abundant group (*Vansteenbrugge et al. 2015a*). The highest densities of jellyfish are observed during summer and autumn. At present, the occurrence of *Mnemiopsis leidyi* seems limited to the nearshore zone, including ports and Western Scheldt Estuary (*Vansteenbrugge et al. 2015b*).

Zooplankton is used as a major food source by several organisms, including most of the fish species. Furthermore, pelagic fish constitute an important food source for higher trophic levels like seabirds, commercial fish species and marine mammals. However, research on pelagic fish in the BNS is limited. *Van Ginderdeuren et al. (2014b)* revealed that herring and sprat are common in the BNS. It mainly concerns immature individuals (0-, 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 mackerel is present in the offshore pelagic fish community (*Van Ginderdeuren et al. 2012a*).

Zooplankton is generally considered as one of the better bio-indicators to demonstrate alterations in the environment. New developments (a zooplankton biodiversity index for the southern part of the North Sea), sampling technology (*Zooscan*, plankton video recorder) and intensive monitoring efforts are of great importance to monitor the marine environment, *inter alia* in the context of the Marine Strategy Framework Directive (MSFD) (*Van Ginderdeuren 2013*). For the research on pelagic fish (but also on plankton) the use of sonar devices (e.g. fish finder) is indispensable.

THE IMPORTANCE OF THE BELGIAN PART OF THE NORTH SEA FOR BIRDS AND MARINE MAMMALS

The BNS is an important wintering and foraging area for seabirds (*Seys 2001*, *Stienen & 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* frequently reside here. Furthermore, important numbers of the red-throated loon *Gavia stellata* and the common scoter *Melanitta nigra* are often observed in the BNS and have both been included in appendix 1 of the Birds Directive (see **Policy instruments**).

The beaches, groins and piers along the coast constitute resting places for internationally significant numbers of the European herring gull *Larus argentatus* and the ruddy turnstone *Arenaria interpres* (*Adriaens & Ameeuw 2008*). In spring and summer, the coastal zone is an important foraging area for terns that mainly breed in the harbour of

[2] Generic term for floating or drifting heterotrophic organisms in water.
[3] Organisms that are planktonic during their entire life.
[4] Organisms that are planktonic in a certain stage of their life.
[5] Organisms that end up in the plankton due to a disturbance of their benthic habitat.

Zeebrugge. Three tern species regularly exceed the 1%-limit, namely: the Sandwich tern *Sterna sandvicensis*, the common tern *Sterna hirundo* and the little tern *Sternula albifrons* (*Degraer et al. 2010*).

Finally, the BNS functions as an important migration corridor which is used by more than a million seabirds. During the migration period, internationally significant numbers (> 1%) of the lesser black-backed gull *Larus fuscus*, the little gull *Hydrocoloeus minutus*, the Sandwich tern and the common tern are often found (*Stienen et al. 2007*).

The Belgian marine waters are important for two types of marine mammals that are discussed in appendix 2 of the Habitats Directive (see **Policy instruments**), namely the harbour porpoise *Phocoena phocoena* and the harbour seal *Phoca vitulina* (*Degraer et al. 2010*). 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*).

1.1.2 Beach

Beaches are relatively narrow, elongated strips that follow the boundary between land and sea, part of which is alternately situated above and below the water due to changes in the water level. The beaches along the Belgian coast are generally characterised by a microrelief: low, elongated sand ridges separated by shallow trench-shaped depressions (*zwinnen*), as well as other smaller features such as *wallen* and *hoornen*. Waves and currents shape all sorts of ripple marks on the beach. The sand along the Belgian coast is characterised by medium to fine quartz sand with a lot of debris from shells. 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 beach is given in *De Moor (2006)*.

The beach is a unique habitat where large numbers of organisms are present. In *Speybroeck et al. (2005)* and *Speybroeck et al. (2008)*, an overview is given of the principal habitats, species and their interactions. Near the land wash, on the dry beach and in the embryonic dunes, vascular plants can be found that are generally short living and dispersed by the sea (the most common species are: European sea rocket *Cakile maritima*, prickly glasswort *Salsola kali* subsp. *kali*, and sea sandwort *Honckenya peploides*). These zones are also the habitat for several terrestrial arthropods (the most common species: the sand hopper *Talitrus saltator* and true flies *Diptera*). Microphytobenthos[6], especially diatoms, constitutes an important primary producer at the Belgian coast. The meio-[7] and macrobenthos on the beach include specific communities such as the *Scolelepis squamata–Eurydice pulchra* community. The geomorphology of beaches, including their grain size and slope, determines to a significant extent the distribution of the (marine) benthic life on beaches. Beaches with gentle slopes and fine grains are generally richer than steep-slope beaches with coarse sand particles (*Degraer et al. 2003*, *Vanden Eede et al. 2014a*). This beach fauna is an important food source for higher trophic levels of the marine environment, such as young fish (e.g. plaice *Pleuronectes platessa*) and brown shrimps *Crangon crangon*. Birds only breed in the quiet beach reserves of Heist and Lombardsijde (e.g. the little tern *Sternula albifrons*, the common ringed plover *Charadrius hiaticula* and the Kentish plover *Charadrius alexandrinus*). However, the beaches remain an important resting and foraging area for e.g. the sanderling (*Calidris alba*).

On the basis of the available biological information about macro-, epi- and hyperbenthos and birds, biological validation maps have been created in *Vanden Eede et al. (2014b)* for a number of beaches along the Belgian coast.

1.1.3 Dunes – Sand dynamics, water, biota

The dune area of the Belgian coast covers an area of approximately 75 km². Pedologically, 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 in general they are 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 then (*De Ceunynck 1992*, *De Clercq & De Moor 1996 – Ecosysteemvisie Vlaamse Kust - Geomorfologie*). At this moment, most of the coastal dynamics are limited to the dunes bordering the beach. 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*). Quantitatively, however, the ecological diversity is mainly determined by the soil moisture, which is in turn

[6] Microscopic small plants that live on and in the uppermost centimeters of the soil.
[7] Organisms that live on or in the soil and have a size between 1 and 0.063 mm.

determined by the dune relief in combination with the hydrology. The complex of soil and vegetation developments and numerous biotic interactions lead to a further differentiation of ecotypes (*Rappé 1996 – Ecosysteemvisie Vlaamse Kust - Biologie*, *Provoost et al. 2004*). In terms of the European Habitats Directive (see **Policy instruments**), it is possible to distinguish 14 more or less natural coastal ecotypes (*Decleer 2007*) (see also *https://www.natura2000.vlaanderen.be/gebied/duingebieden* for more information). Six of these ecotypes are intertidal, the others belong to the dunes:

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

In general, half of the species 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 boundary between land and sea, the typical microclimate, the wet-dry gradient and calcareous and decalcified environments. In the dunes, the typical coastal species can almost all be found in the embryonic shifting dunes, the white dunes and the grey dunes (*Provoost & Bonte 2004*). In the context of the European Habitat and Birds Directive (see **Policy instruments**) the following species deserve special attention (see also *https://www.natura2000.vlaanderen.be/gebied/duingebieden*):

- 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* and brown long-eared bat *Plecotus auritus*, Brandt's 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 & Velter 2004 in *Provoost & Bonte 2004*);
- Birds in appendix I: black-crowned night heron *Nycticorax nycticorax*, little egret *Egretta garzetta*, European honey buzzard *Pernis apivorus*, pied avocet *Recurvirostra avosetta*, Kentish plover *Charadrius alexandrinus*, common tern *Sterna hirundo*, little tern *Sternula albifrons*, European nightjar *Caprimulgus europaeus*, middle spotted woodpecker *Dendrocopos medius*, woodlark *Lullula arborea* and bluethroat *Luscinia svecica*;
- Amphibians: northern crested newt *Triturus cristatus* (appendix II) and natterjack toad *Epidalea calamita* (appendix IV);
- 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 shifting dynamics of dunes have largely stopped, and thicket and forest development have greatly altered the vegetation structure. Over the past decades, several invasive non-indigenous plant species have proliferated as well, causing a potential threat to indigenous fauna and flora (*Provoost et al. 2004*).

1.1.4 Estuaries, mudflats and marshes

Along the Belgian coast mudflats and salt marshes occur in three areas: the Estuary of the Yser, the Bay of Heist and Zwin. Only in the Estuary of the Yser, truly estuarine nature is present. The bibliography of these areas can be searched thematically in the *catalogue* of the VLIZ-library.

Zwin used to belong to an estuary reaching Bruges (see *inter alia* *Claeys 1981*, *Termote 2012*). Nowadays, Zwin is a cross-border nature reserve (Belgium-the Netherlands) consisting of an interrupted dune belt with mudflats and salt marshes behind it. The North Sea can enter the area through a gully, creating a system of creeks. The protection of the types of habitats and species occurring in Zwin, by means of the European Habitats Directive is discussed in *Bot (2007a)*. The intertidal area serves as an important place to rest, feed, moult, breed and migrate for several birds, including different species which are protected by the European Birds Directive (see *Bot 2007b*). Due to the siltation of Zwin, measures have been taken in the context of the Development Sketch 2010 for the Scheldt Estuary

(*Ontwikkelingsschets 2010 Schelde-estuarium*) (see theme **Scheldt Estuary**) to restore the mudflats and salt marshes and expand the nature reserve (*Verhaegen et al. 2010*).

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 Estuary of the Yser (*Hoffman 2006*). As a result of a nature restoration project, the natural transitions of the different components of the coastal ecosystem (including mudflats and salt marshes) have been restored (*Hoffman et al. 2006*). The protection of nature in the Estuary of the Yser by the European Birds and Habitats Directive is elaborated 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*).

1.1.5 Polders and polder complex

'The polders' is the name of a former marine intertidal area that was reclaimed during the Middle Ages. It is a flat, rural zone characterised by a flat and low-lying landscape with inversion relief, caused by the consolidation of clay layers and the subsidence of peat (*Provoost & Hoffman 1996*, *Baeteman 2007*). It is also the name of the habitats directive area in the coastal zone (ministerial decree of 24 May 2002) which overlaps with the birds directive area 'poldercomplex' (ministerial decree of 17 July 2000) (see **Policy instruments**) (More information about the Polders in the context of Natura 2000 can be found on *https://www.natura2000.vlaanderen.be/gebied/polders*).

These special protection areas have been designated for 6 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 the northern crested newt *Triturus cristatus*. For this last species, only few recent observations in the polders are known.

The birds directive area 'poldercomplex' 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*, tundra swan *Cygnus bewickii*, whooper swan *Cygnus cygnus*, 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*, European golden plover *Pluvialis apricaria*, wood sandpiper *Tringa glareola* and common kingfisher *Alcedo atthis* (*Courtens & Kuijken 2004*). The poldercomplex 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 (*Wetlands International 2006 – Waterbird Population Estimates*).

The polders are also characterised by the presence of valuable historically permanent grasslands (*historisch permanente graslanden*). Their location was mapped by *De Saeger et al. (2013)*.

1.2 Ecosystem goods and services

The Millennium Ecosystem Assessment (*MEA 2005*) describes ecosystem services as the benefits humans obtain from the ecosystem. They can be divided into goods, regulatory services, cultural services and supporting 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 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 US$ 24 trillion. The demarcation of marine protected areas in 20 to 30% of all seas would create 1 million jobs worldwide (*Balmford et al. 2004*). This equals an estimated yield of 294 billion euros (compared to a cost of up to 15 billion euros in protection measures) (*Seys 2006*, *Slabbinck et al. 2008*).

The *BEES project* aims to map the ecosystem services in Belgium. *Jacobs et al. (2010)* published the first inventory of the ecosystem services (and potential ecosystem profits) of 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 available on the *LNE website* and in *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 or other evaluations of (infrastructure) projects with an impact on nature (more information: *Liekens et al. 2013*).

Only a few studies on the topic of ecosystem goods and services which specifically address the BNS are currently available. However, in the new ecosystem vision for the coast (in progress) the ecosystem services will be tackled as well. A preliminary overview of the types of goods and services delivered by marine biodiversity can be found in *Beaumont et al. 2007*. In addition, the *socio-economic analysis of the users of the BNS (2012)* has been elaborated in the framework of the Marine Strategy Framework Directive (MSFD).

1.3 Impact on the marine and coastal environment

The marine and coastal environment, described above, is a region where various human activities take place that each have a specific impact on the environment. In a number of reports, an overview of the activities and the associated impact is provided: *Maes et al. (2004)* (*MARE-DASM project BELSPO*), *Maes et al. (2005)* (*GAUFRE-BELSPO*), *Goffin et al. (2007)*, *André et al. (2010)*, *Initiële beoordeling van de staat van het mariene milieu (Belgische Staat 2012a)*, but also *OSPAR QSR (2010)* and *State of Europe's Seas (2015)* on a larger geographical scale. Besides these integrated reports, numerous studies exist on the (specific) 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 Compendium for Coast and Sea is given, in which information sources on a specific impact can be found. This table does not provide an exhaustive overview of the impacts on the marine and coastal environment but serves as a readers' guide.

Table 1. Overview of which type of impact is discussed in the theme texts 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 pipelines)
Impact on the pelagic ecosystem (eutrophication, pollution, etc.)	Energy (incl. cables and pipelines); 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 pipelines)
Impact on seabirds and marine mammals	Energy (incl. cables and pipelines); Maritime transport, shipping and ports; Fisheries; Aquaculture; Military use
Impact on the seabed / habitats	Sand and gravel extraction; Dredging and dumping; Energy (incl. cables and pipelines); Military use; Safety against flooding; Fisheries; Aquaculture; Agriculture
Impact on hydrographical characteristics	Energy (incl. cables and pipelines); Maritime transport, shipping and ports; Military use; Safety against flooding; Aquaculture; Dredging and dumping; Sand and gravel extraction
Impact on spatial use (incl. Impact on nature area)	Social and economic environment; Tourism and recreation; Energy (incl. cables and pipelines); Fisheries; Aquaculture; Agriculture; Safety against flooding; Sand and gravel extraction; Maritime transport, shipping and ports
Impact on beaches and dunes	Tourism and recreation; Safety against flooding
Impact on groundwater	Tourism and recreation; Agriculture; Safety against flooding

1.4 Protection of the marine environment

1.4.1 Policy context: administrations and organisations

The environmental policy concerning the coast and sea is directed by several international, European and regional organisations. The International Maritime Organization (*IMO*) of the United Nations (*UN*) is a specialised agency responsible for the safety and security of shipping and the prevention of marine pollution caused by ships. 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 the European level, the Directorate-General for the Environment (*DG Environment*) 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 EC is competent for two policy domains: the Common Fisheries Policy (*CFP*) (see theme **Fisheries**) and the Integrated Maritime Policy (*IMP*). The IMP intends to provide an integrated answer to the current challenges of the European Seas: marine pollution, environmental protection, coastal development, job creation, etc. 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 countries from Western Europe (including Belgium) collaborate to protect the marine environment of the Northeast Atlantic Ocean.

In Belgium, the *Marine Environment department* of the FPS Public Health, Safety of the Food Chain and Environment is competent for the environmental policy of the BNS. The department also presides the advisory commission for marine spatial planning (royal decree 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 (*MUMM*) of the Royal Institute of Natural Sciences (*RBINS*). 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 *policy statement (2014)* of the state secretary which is *inter alia* competent for the North Sea stipulates the current North Sea policy.

All aspects of the environmental policy with regard to the coast (landward of the baseline) are an exclusive competence of Flanders (*Policy note environment 2014-2019*). The Environment, Nature and Energy department (*LNE*) plays a coordinating role in the Flemish environmental administration. The department is responsible for the preparation, steering and monitoring of the execution and evaluation of the Flemish environmental policy. The LNE 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. Important players within the LNE department are the Agency for Nature and Forest (*ANB*), the Research Institute for Nature and Forest (*INBO*), the Flemish Agency for Energy (*VEA*), the Public Waste Agency of Flanders (*OVAM*), the Flemish Environment Agency (*VMM*), the Flemish Land Agency (*VLM*) and the Flemish Regulator of the Electricity and Gas market (*VREG*) (*website LNE*).

The *Province of West Flanders* acts as an intermediary between the regions and municipalities, and has competences with regard to the *environment* as it is responsible for the coordination of an integrated water policy, the management of the provincial domains and green axes, 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 amongst the citizens and other target groups (*website LNE*).

1.4.2 Policy instruments

The intense activities in the sea and 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. 2014*). These mostly sectoral legislations and regulations are discussed in the theme texts of the relevant user functions in the sections ‘Policy context’ and ‘Sustainable use’. Hence, important policy instruments such as the MARPOL Convention will not be treated here, but in the theme about **Maritime transport, shipping and ports**. A selection of the most relevant policy instruments related to nature and environment for the BNS and the coastal zone is given below.

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 specifically addresses the protection and preservation of the marine environment.

RAMSAR CONVENTION

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

OSPAR CONVENTION

The *OSPAR Convention* constitutes an overarching legal framework for the protection of the marine environment of the Northeast Atlantic Ocean. 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*) and the protection and preservation of the ecosystems and biological diversity are part of the OSPAR Convention (*Goffin et al. 2007*).

MARINE STRATEGY FRAMEWORK DIRECTIVE

The European Marine Strategy Framework Directive (MSFD) (directive 2008/56/EC) is the environmental pillar of the Integrated Maritime Policy (IMP) (COM (2007) 575) of the European Union (EU). The MSFD intends to achieve the Good Environmental Status (GES) of the European marine waters by 2020 as well as the protection of the resources on which economic and social activities depend. The GES is described in article 9 of this directive based on 11 descriptors (see table 2). The member states need to define indicators and associated target values for each of these descriptors (*DG Leefmilieu 2012*). The EU supports the member states by developing methodologies for these indicators and by giving scientific advice for every descriptor (see table 2). Based on these scientific advices, a decision (2010/477/EU) has been published which further elaborates on the criteria and methodological standards for the implementation of the MSFD and the determination of the GES of the marine waters.

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

DESCRIPTORS MSFD		
1	Biological diversity	*Cochrane et al. (2010)*
2	Non-indigenous species	*Olenin et al. (2010)*
3	Commercially exploited fish and shellfish	*Piet et al. (2010)*
4	Food webs	*Rogers et al. (2010)*
5	Eutrophication	*Ferreira et al. (2010)*
6	Seafloor integrity	*Rice et al. (2010)*
7	Hydrographical features	
8	Contaminants and pollution effects	*Law et al. (2010)*
9	Contaminants in fish and other seafood	*Swartenbroux et al. (2010)*
10	Marine litter	*Galgani et al. (2010)*
11	Underwater noise and other forms of energy	*Tasker et al. (2010)*

In the context of the implementation of the MSFD in the BNS (royal decree of 23 June 2010 - marine strategy), Belgium drafted an initial assessment of the state of the marine waters (*initiële beoordeling van de staat van het mariene milieu (Belgische Staat 2012a)*, including a socio-economic analysis of the users of the BNS (*socio-economische analyse van de gebruikers van het BNZ (Belgische Staat 2012b)*). Furthermore, a report with the description of the GES and the environmental targets for the BNS was published (*Omschrijving van de Goede Milieutoestand & vaststelling van Milieudoelen (Belgische Staat 2012c)*). Based on this document, *MUMM* has developed a monitoring programme (*monitoringsprogramma (2014)*) in order to monitor the evolution and condition of the environment. Subsequently, the Marine Environment department coordinates the development of a programme of measures. Every six years (2018, 2024, etc.), a revision should be conducted based on the results of the monitoring programme and the programme of measures (*DG Leefmilieu 2012*).

WATER FRAMEWORK DIRECTIVE

The European Water Framework Directive (WFD) (directive 2000/60/EC) stipulates that all European 'natural' surface waters should achieve a good ecological (GES) and good chemical status (GCS) by 2015. For 'heavily modified' or 'artificial' water bodies[8], the ecological targets are adapted and 'good ecological potential' (GEP) is used. The deadline (2015) to achieve these objectives can be extended (under certain conditions) up to a maximum of two adjustments of the river basin management plan (2021/2027). With regard to the GES, the WFD applies to 1 nautical mile seaward from the low tide mark and up to 12 nautical miles seaward from the low tide mark for the GCS (*Coördinatiecommissie Integraal Waterbeleid 2010* (river basin management plan 2016-2021, in preparation), *FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu 2009*).

To achieve the objectives of the WFD, the member states need to develop river basin management plans every six years. The first plans were drafted in 2009. The next version of the management plans is due by the end of 2015 (more information: *tijdsschema en werkschema tweede generatie stroomgebiedbeheerplannen 2012* and *website Coördinatiecommissie Integraal Waterbeleid*). All surface waters of the coastal zone belong to the international River Basin District of the Scheldt: in accordance with the competences of the Flemish and federal government, the river basin management plans are divided into a river basin management plan for the Scheldt (*Coördinatiecommissie Integraal Waterbeleid 2010*) (river basin management plan 2016-2021, in preparation) and a river basin management plan for the Belgian coastal waters (*FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu 2009*). Coordination between the competent authorities of the river basin district (the Netherlands, France, the three regions and the federal government of Belgium) takes place in the International Scheldt Commission (*ISC*) and at the Belgian level in the Coordination Committee for International Environmental Policy (*CCIEP*).

The WFD is supplemented by directive 2006/118/EC (on the protection of groundwater against pollution and deterioration) and directive 2008/105/EC (on environmental quality standards in the field of water policy). Furthermore, the WFD is closely related to a number of directives which are discussed in more detail in other theme texts of the Compendium for Coast and Sea. It *inter alia* concerns the Urban Waste Water Directive (91/271/EC), Nitrates Directive (91/676/EC) (theme **Agriculture**), Bathing Water Directive (2006/7/EC) (theme **Tourism and recreation**) and the Floods Directive (theme **Safety against flooding**).

The WFD has been implemented by the royal decree of 23 June 2010 with regard to the federal legislation and by the decree of 18 July 2003 for the Flemish legislation.

HABITATS DIRECTIVE

The European Habitats Directive (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 (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*.

The aim is to achieve a favourable conservation status for the habitats listed in annex I and for the species in annex II and IV of this directive. The conservation status is determined by means of scientifically underpinned conservation objectives (see also *Bot 2007* and *T'Jollyn et al. 2009*).

[8] 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.

According to the Habitats Directive (art. 17), the member states are obligated 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. The conservation objectives of the marine natura 2000 areas have not yet been determined (*DG Leefmilieu 2010*, *Raeymaekers 2011*). A proposal for the objectives for the protected species and habitats of the BNS has been elaborated by *Degraer et al. (2010)*. 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.

BIRDS DIRECTIVE

The European Birds Directive (directive 2009/1147/EC) aims at the protection of all wild bird species. Special protection measures have been taken for the habitats of the bird species from annex I and all species that occur in certain areas in internationally significant numbers as breeding, migratory or winter birds. Each member state needs to designate special protection areas (bird directive areas) that are part of the European Ecological *Natura 2000 Network*. According to the Birds Directive (art. 12), the member states are obligated to report every six years about the conservation status of the species and the results of the policy pursued to the EC. The most recent reporting in the framework of the Birds Directive covers the period 2007-2012 (see *Anselin et al. 2013*). An official report directed towards Europe about the status of these bird species compared to the conservation objectives has not yet been published. In *Paelinckx et al. (2009)* and *Degraer et al. (2010)*, the 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 described in support of the determination of the conservation objectives.

The implementation of the Habitats and Birds Directives in the federal legislation has been provided by several decrees of the law of 20 January 1999: e.g. the royal decree of 21 December 2001, the royal decree of 14 October 2005, the royal decree of 5 March 2006 and the royal decree of 20 March 2014. The decision of the Flemish government on 23 March 2014 led to a definitive designation of the special protection areas on the landward side of the coast (*Achterhaven Zeebrugge-Heist*, *Duingebieden* and *Polders*) and the related conservation objectives (see *www.natura2000.vlaanderen.be*).

MARINE ENVIRONMENT AND MARINE SPATIAL PLANNING LAW

The law on the marine environment and marine spatial planning (law of 20 January 1999) intends to maintain the nature, the biodiversity and the integral character of the marine environment by means of protective measures (*inter alia* the demarcation of marine protected areas) and by means of measures to repair environmental damage. In addition to the prohibition of some activities, this law has introduced objective liability in case of damage and environmental disturbance (*Goffin et al. 2007*). Furthermore, the law stipulates which activities are subject to a permit or authorisation by the competent minister and associated environmental impact assessment. Since 20 July 2012, this law also regulates the organisation and procedure with regard to marine spatial planning.

DECREE OF THE DUNES - FLEMISH ECOLOGICAL NETWORK - SPATIAL IMPLEMENTATION PLANS

Besides the aforementioned Ramsar Convention and the Habitats and Birds Directives, other policy instruments for the protection of nature areas in the coastal zone are of importance. At the Flemish level, the decree of 21 October 1997 on nature preservation 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 decree of the dunes (Chapter 9 of the law of 12 July 1973), additional areas have been protected, either as ‘protected dune area’ or as ‘agricultural area important for the dune area’ (*Provoost 1999*).

The Flemish Ecological Network (*FEN*) comprises current valuable nature in Flanders, supplemented with areas with a high nature potential or nature corridor. In these areas, nature is additionally protected, and users and owners receive extra instruments and opportunities to help build a natural- and human-friendly environment. For the FEN-areas, nature policy plans (*natuurinrichtingplannen* (*NRP*)) have been elaborated in which measures suited to the area have been agreed upon, in addition to general protection regulations (e.g. *NRP Duinen van de Middenkust tussen Oostende en Blankenberge 2007*).

Finally, space for nature development is provided by spatial planning through the demarcation of the natural structure in the spatial structural plans (*Ruimtelijk Structuurplan Vlaanderen*, *Provinciaal Ruimtelijk Structuurplan West-Vlaanderen*), subsequently implemented as spatial implementation plans (formerly: regional spatial plans).

1.4.3 Protected areas

Belgium has several statutes for the protection of nature areas in the coastal and marine zone: Wetlands or Ramsar areas, natura 2000 areas, Flemish and recognised nature reserves, forest reserves, areas of the Decree of the Dunes, protected landscapes and the Flemish Ecological Network (FEN) (see **Policy instruments**). The working areas of 2 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 (see table 3 and figure 3).

Table 3. An overview of the protected areas, their surface, status and associated legislation (Source: *DG Leefmilieu 2010*).

PROTECTED AREAS IN THE BNS			
Protected area	Surface	Status	Legislation
Special protection area SBZ-1 (Birds Directive)	110.01 km²	• Policy plan available (*Beleidsplan*) • Conservation objectives to be determined (scientific advice: *Degraer et al. 2010*) • Management plan to be determined	royal decree of 14 October 2005 – *speciale beschermingszones en speciale zones voor natuurbehoud*
Special protection area SBZ-2 (Birds Directive)	144.80 km²	• Policy plan available (*Beleidsplan*) • Conservation objectives to be determined (scientific advice: *Degraer et al. 2010*) • Management plan to be determined	
Special protection area SBZ-3 (Birds Directive)	57.71 km²	• Policy plan available (*Beleidsplan*) • Conservation objectives to be determined (scientific advice: *Degraer et al. 2010*) • Management plan to be determined	
Special protection area H2 *Vlakte van de Raan* (Habitats Directive)	19.17 km²	• Designation as habitats directive area annulled in 2008	royal decree of 14 October 2005 – *speciale beschermingszones en speciale zones voor natuurbehoud* royal decree of 16 October 2012
Special protection area 'Flemish Banks' (Habitats Directive)	1,099.939 km²	• Expansion of the area 'Trapegeer-Stroombank' • Study of demarcation of the area: *Degraer et al. (2009)* • Conservation objectives to be determined (scientific advice: *Degraer et al. 2010*) • Management plan to be determined	
Marine reserve (Bay of Heist)	6.76 km²	• Policy plan available (*Beleidsplan*)	royal decree of 5 March 2006
Ramsar site Western Coastal Banks	19 km² (*list Ramsar areas*)		

The *Marine Environment department* of the FPS Public Health, Safety of the Food Chain and Environment is currently working on a new royal decree on the procedures with regard to the designation and management of natura 2000 areas in the BNS. Within this royal decree, the following matters will be addressed: the designation of an area, the conservation objectives, conservation measures and management plans, the execution of an appropriate assessment and the monitoring.

The impact of activities on the protected marine areas will still be subject to an appropriate assessment and activities will only be allowed when there is no risk of negative consequences for the area. Activities that may have negative effects could be permitted when there is a compelling motive of great public interest, but only when there are no alternatives available.

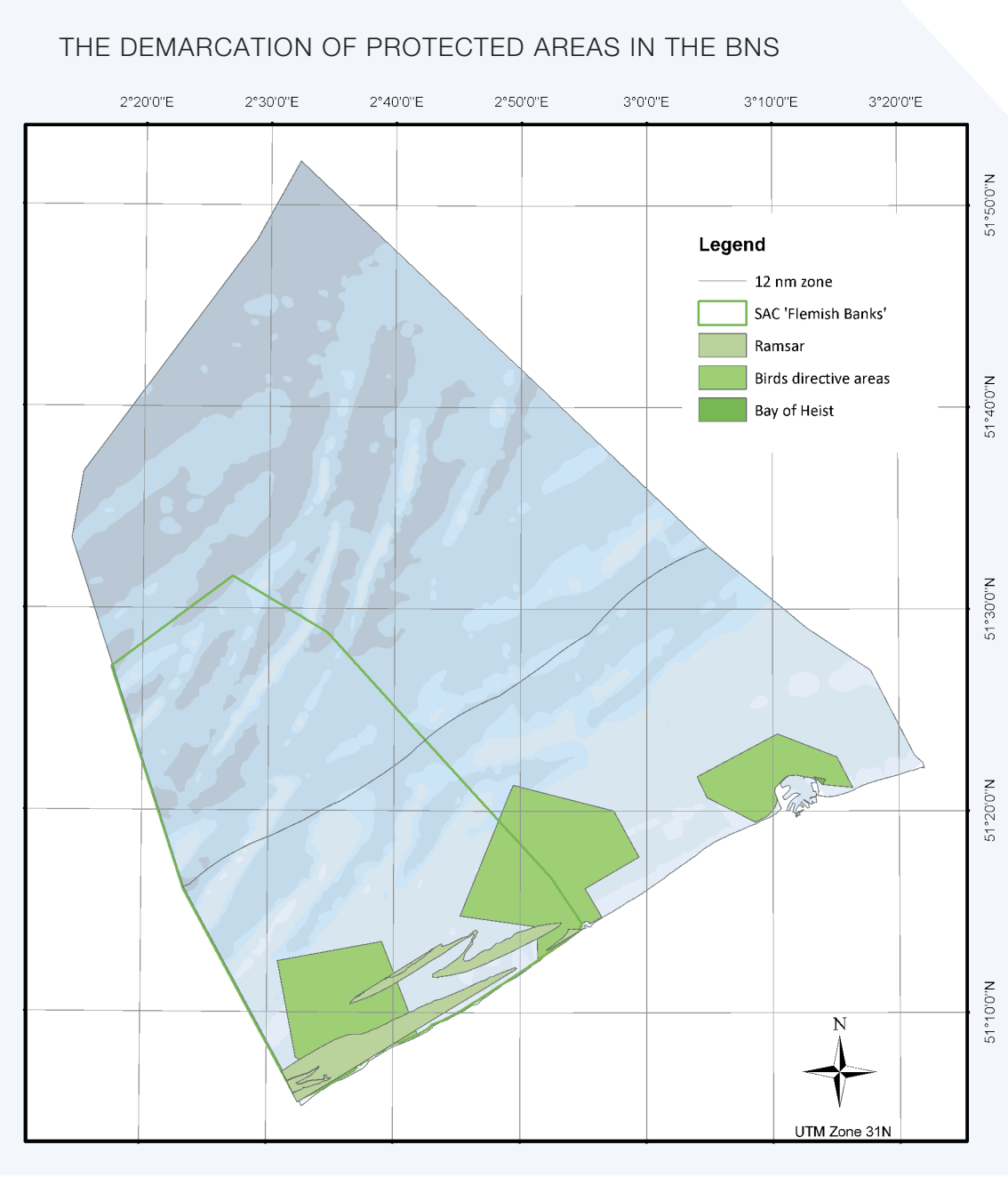

Figure 3. A map of the protected areas in the BNS (Source: IRSNB, marineatlas.be, based on the royal decree of 20 March 2014).

The marine spatial plan (MSP) (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*, *http://odnature.naturalsciences.be/marine-atlas/data*) does not add any additional protected areas. The marine spatial plan aims to streamline the activities in the existing areas with the protection of the environment.

Hence, a number of subareas have been delineated within the special protection area of the Flemish Banks. In these subareas, there are certain restrictions with regard to bottom-disturbing activities such as trawl fisheries (*Pecceu et al. 2014*) and sand and gravel extraction. In addition, the marine spatial plan also discusses opportunities for the multiple use of space with a view to nature protection or development (more information: *actieplan Zeehond*).

Approximately 22% of the surface of the coastal communities has been assigned with some kind of protection with regard to nature conservation. This share is higher compared to the hinterland (± 16%) and Flanders (± 14%) (*Maelfait et al. 2012*). The maps and surface of the natura 2000 areas in the coastal zone can be consulted on *www.natura2000.vlaanderen.be*.

The remaining ecologically valuable dune areas with a total surface of approximately 2,830 ha are almost entirely protected (figures 4 and 5). 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 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 law of 12 July 1973) (*Dumortier et al. 2003*).

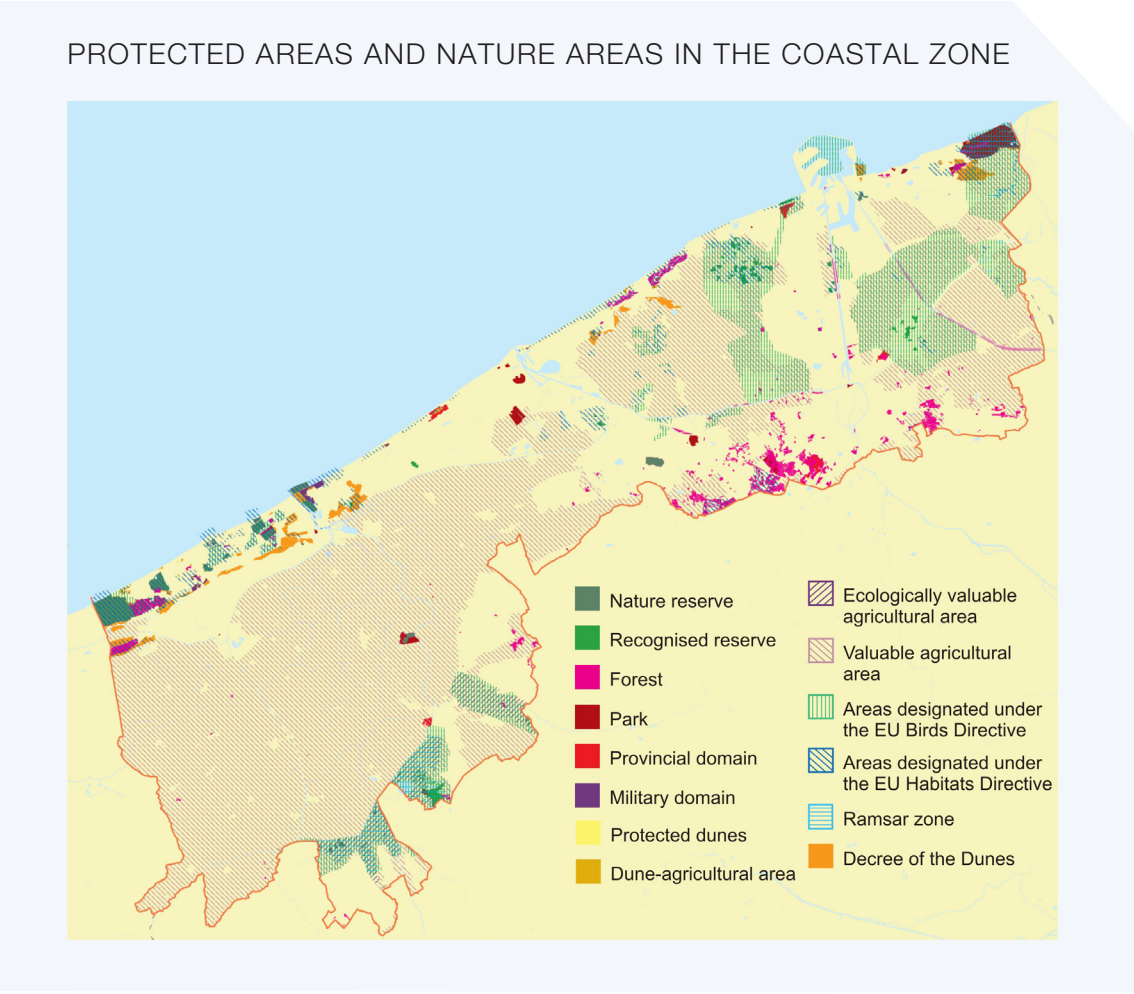

Figure 4. Protected areas and nature areas in the coastal zone (Source: *Coastal Atlas*).

These statutes only provide spatial protection, but do not guarantee that the present nature values are preserved. This requires active nature management (*Maelfait et al. 2012*). The decree of 21 October 1997 is a suitable legal framework that addresses the designation of nature reserves and the drafting of management plans.

According to *De Saeger et al. 2013* there are approximately 12,000 acres of historic permanent grasslands in the coastal polders. The decree of 21 October 1997 stipulates a prohibition or authorisation with regard to alterations of the vegetation and specific physical properties of these grasslands. In 2015, the Flemish government decided to protect 8,000 acres of grasslands. A part will be protected by means of nature legislation, whereas another part will be covered by the European agricultural policy.

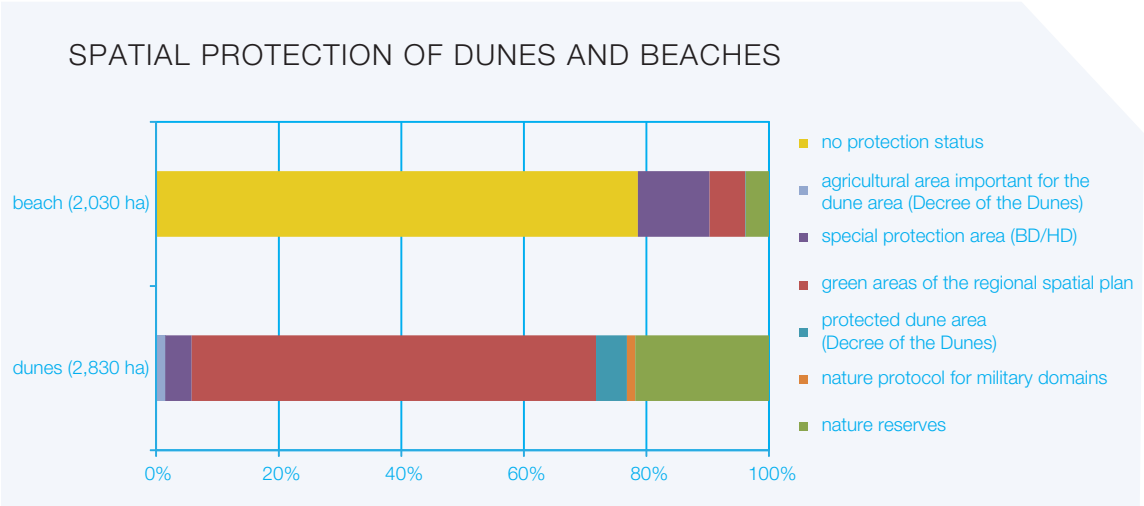

Figure 5. Spatial protection of the ecologically valuable dune ecotypes and beaches according to the different statutes for nature preservation (*Dumortier et al. 2003*).

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
Ramsar Convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat	1971	1975
MARPOL Convention	International convention for the prevention of pollution from ships, as modified by the Protocol of 1978	1973	1978
UNCLOS	United Nations convention on the law of the sea	1982	1997
OSPAR Convention	Convention for the protection of the Marine Environment of the North-East Atlantic	1992	1998

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
	Council Directive concerning urban waste-water treatment	1991	271
Nitrates Directive	Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources	1991	676
Habitats Directive	Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive establishing a framework for Community action in the field of water policy	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	2006	118
Floods Directive	Directive on the assessment and management of flood risks	2007	60
Marine Strategy Framework Directive	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
	Directive on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council	2008	105
Birds Directive	Directive on the conservation of wild birds	2009	147
Other (Decisions, Communications, White Papers, etc.)			
Integrated Maritime Policy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union	2007	575
	Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters	2010	477

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databanken*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 12 juli 1973	Wet op het natuurbehoud: Vlaamse Gewest	1973-07-12/35
Wet van 20 januari 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
Royal decrees		
KB van 21 december 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
KB van 14 oktober 2005 – speciale beschermingszones en speciale zones voor natuurbehoud	Koninklijk besluit tot instelling van speciale beschermingszones en speciale zones voor natuurbehoud in de zeegebieden onder de rechtsbevoegdheid van België	2005-10-14/35
KB van 14 oktober 2005 – gebruikers-overeenkomsten en beleidsplannen	Koninklijk besluit betreffende de voorwaarden, sluiting, uitvoering en beëindiging van gebruikersovereenkomsten en het opstellen van beleidsplannen voor de beschermde mariene gebieden in de zeegebieden onder de rechtsbevoegdheid van België.	2005-10-14/36
KB van 5 maart 2006	Koninklijk besluit tot instelling van een gericht marien reservaat in de zeegebieden onder de rechtsbevoegdheid van België en tot wijziging van het koninklijk besluit van 14 oktober 2005 tot instelling van speciale beschermingszones en speciale zones voor natuurbehoud in de zeegebieden onder de rechtsbevoegdheid van België	2006-03-05/48
KB van 23 juni 2010 – oppervlaktewa-tertoestand	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
KB van 23 juni 2010 – mariene strategie	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 16 oktober 2012	Koninklijk besluit van 16 oktober 2012 tot wijziging van het koninklijk besluit van 14 oktober 2005 tot instelling van speciale beschermingszones en speciale zones voor natuurbehoud in de zeegebieden onder de rechtsbevoegdheid van België.	2012-10-16/05
KB van 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
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Decrees		
Decreet van 14 juli 1993	Decreet houdende maatregelen tot bescherming van kustduinen	1993-07-14/31
Decreet van 21 oktober 1997	Decreet betreffende het natuurbehoud en het natuurlijk milieu	1997-10-21/40
Decreet van 18 juli 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Other		
Besluit van de Vlaamse regering van 17 juli 2000	Besluit van de Vlaamse regering tot wijziging van het besluit van de Vlaamse regering van 17 oktober 1988 tot aanwijzing van speciale beschermingszones in de zin van artikel 4 van de richtlijn 79/409/EEG van de Raad van de Europese Gemeenschappen van 2 april 1979 inzake het behoud van de vogelstand betreffende de speciale beschermingszone «3.2. Poldercomplex»	2000-07-17/70
Besluit van de Vlaamse regering van 24 mei 2002	Besluit van de Vlaamse regering tot vaststelling van de gebieden die in uitvoering van artikel 4, lid 1, van Richtlijn 92/43/EEG van de Raad van de Europese Gemeenschappen van 21 mei 1992 inzake de instandhouding van de natuurlijke habitats en de wilde flora en fauna aan de Europese Commissie zijn voorgesteld als speciale beschermingszones	2002-05-24/44

2

Maritime transport, shipping and ports

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Neyts, D., Maes, F., Merckx, J.P., Pirlet, H., 2015. Maritime transport, shipping and ports. In: Pirlet, H., Verleye, T., Lescrauwaet, A.K., Mees, J. (Eds.), Compendium for Coast and Sea 2015: An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Ostend, Belgium, p. 75-96.

Currently, more than 90% of the globally traded goods are transported by sea. In 2013, 9.5 billion tons of goods were transported by seagoing ships. By the end of 2014, the world merchant fleet consisted of 87,726 ships, equalling a total of 1,091.59 million GT. In 2014, the merchant fleet of the EU consisted of 13,603 ships, 203 of which were Belgian (*UNCTAD - Review of Maritime Transport*, see also *list Belgian seaships*).

The Belgian sea ports are situated at some of the busiest trade routes worldwide (over 150,000 ship movements a year, *Goffin et al. 2007*, *Vermeersch & Desnouck 2009*), in the so-called Le Havre-Hamburg range (with Antwerp, Ghent, Zeebrugge, Rotterdam, Amsterdam, Bremen, Hamburg, Dunkirk and Le Havre as the main sea ports). Ostend has also been taken into account in the figures of the Flemish sea ports. The total traffic in the Le Havre-Hamburg range in 2014 was 1,131 million tons, with the Flemish ports accounting for a market share of 23.8% (*Merckx & Neyts 2015*).

Maritime transport and shipping in the Belgian part of the North Sea (BNS) will be discussed in detail below. With regard to the ports, only sea ports (with the main purpose of handling sea-going 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*).

2.1 Policy context

On an international level, shipping and maritime transport are covered by several international treaties and resolutions of the International Maritime Organization (*www.imo.org*, *Brochure IMO 2013*). 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 the constitution of the sea, discussing the general rights and obligations of nations (flag states, coastal states, port states). Furthermore, the IMO is responsible for a significant amount of other conventions about, *inter alia*, safety at sea, traffic regulations and pollution prevention (see *list at IMO website*). Some of these conventions are discussed further in the section **Sustainable use** and in *Verleye et al. (2015)*.

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). Furthermore, the European Maritime Safety Agency (*EMSA*) is relevant 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 on the *website of the Flemish Port Commission (VHC)* and in the publication *Merckx et al. (2012)*. Several of the policy instruments are also further elaborated in *Verleye et al. (2015)*.

In Belgium, maritime transport is a federal matter, covered by the *FPS Mobility, Directorate-General (DG) Maritime Transport* (*Policy statement Mobility 2014*, *Policy statement Social fraud, Privacy and North Sea 2014*, other federal actors are listed in table 1). The DG Maritime Transport ensures that ships sailing under a Belgian flag or ships entering Belgian ports comply with the international maritime regulations 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 Maritime Transport represents Belgium within the IMO. The regulations with regard to navigation which ships have to follow, 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)*.

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 law of 2 March 1999 that constitutes the basis for the current port policy (see also the website of *VHC*). Moreover, a *Long term vision for the Flemish port policy* was developed between 2002 and 2005.

The coordination and the consultation between federal, Flemish as well as regional authorities (table 1) and the Province of West Flanders (cooperation agreement of 8 July 2005) is carried out by the *Coast Guard*. The organisational structure of the Coast Guard consists of a policy-making body, a consultation body and a secretariat. The policy-

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

FLEMISH PARTNERS OF THE COAST GUARD	FEDERAL PARTNERS OF THE COAST GUARD
Fleet	*FPS Interior* (Civil protection, Crisis Centre, Maritime and River Police)
Ports and Water Policy division	*FPS Foreign Affairs*
International Environmental Policy division	*FPS Economy, S.M.E.s, Self-Employed and Energy*
Maritime Access division	*FPS Finances* (*Belgian Customs*)
Shipping Assistance division	*FPS Mobility and Transport* (*DG Maritime Transport*)
Coastal division	*FPS Health, Food Chain Safety and Environment* (*Marine Environment department*)
Pilotage	*Ministry of Defence*
Sea Fisheries service	*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*))

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).

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 (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 and the border control 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 Flemish government of 26 October 2007 and the royal decree of 6 February 2009.

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

- The Flemish Port Commission (*VHC*) – advice and information on socio-economic aspects of port projects as well as advice on port projects of over 10 million euros which have requested subsidies;
- *Milieu- en Natuurraad van Vlaanderen* (*Minaraad*) – advice on environmental aspects of port projects of over 10 million euros which have requested subsidies;
- The initiative *Flanders Port Area* aims to promote the cooperation between the four Flemish sea ports. Within this context, the Flemish ports of Antwerp, Ghent, Ostend and Zeebrugge and the Flemish Port Associations have concluded a cooperation agreement. Based on 30 points of action, this agreement intends to strengthen the competitiveness of the Flemish ports on an international scale.

An overview of the legislation concerning shipping and ports is also available in the coastal codex, 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)*.

2.2 Spatial use

In the Marine Spatial Plan (MSP, royal decree of 20 March 2014, see also *Van de Velde et al. 2014*), the most important shipping routes necessary 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. Other activities are allowed, as long as shipping is not threatened. For a number of these routes, a routeing system (*ship's routeing, IMO*) has been adopted within the International Maritime Organisation (*IMO*):

- Traffic separation scheme Noordhinder South;
- Precautionary area (where ships have to navigate carefully) Noordhinder Junction;

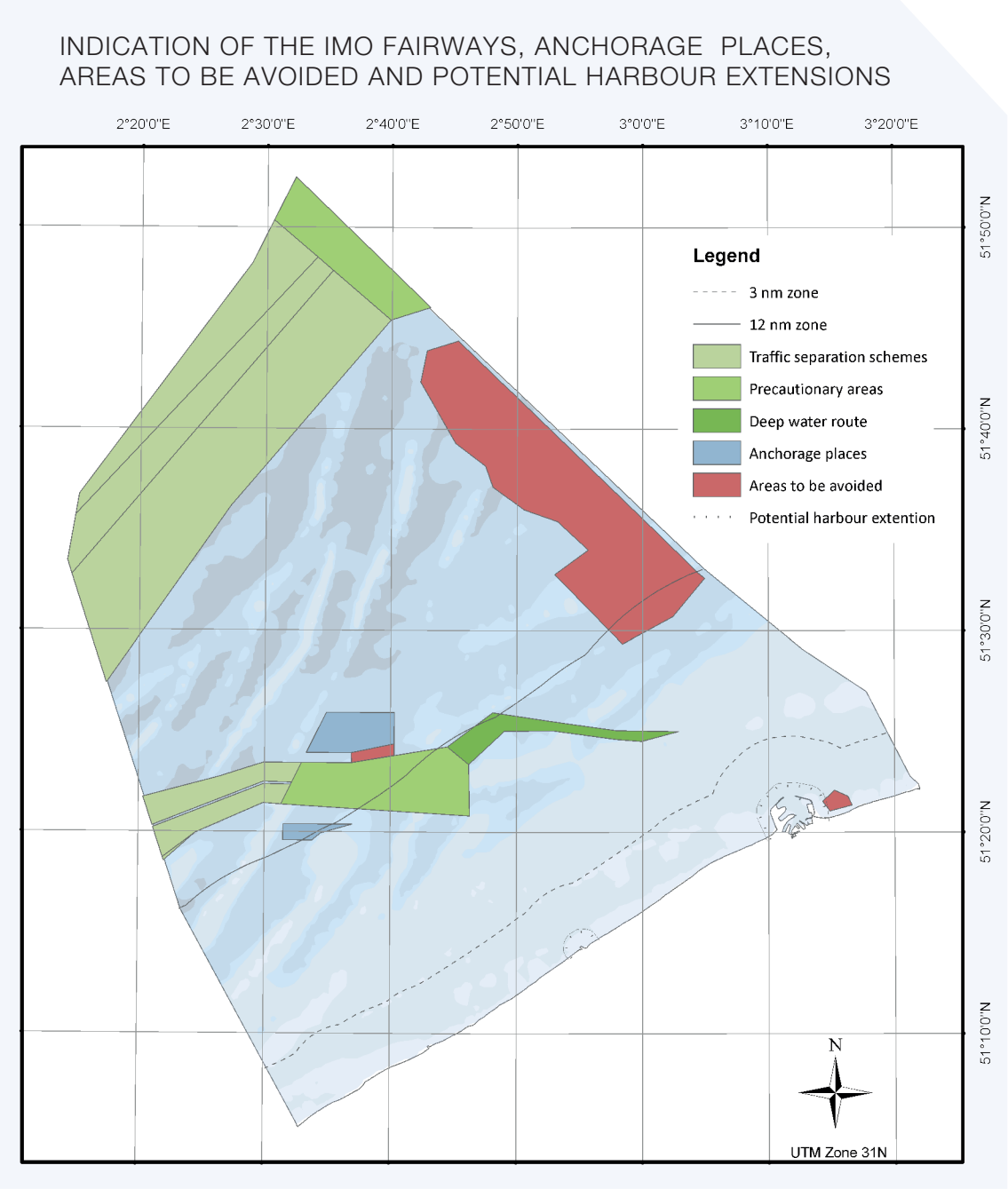

Figure 1. Indication of the IMO fairways, anchorage places, areas to be avoided and potential harbour extensions (Source: RBINS/IRSNB, *marineatlas.be*, based on RD of 20 March 2014).

- Traffic separation scheme Westhinder;
- Precautionary area Westhinder;
- Area to avoid Westhinder;
- Deepwater route (specifically for ships with a limited manoeuvrability due to their draught) for approaching the Western Scheldt.

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 are also pilotage routes

where a maritime pilot will board the ship to advise the captain on the navigation. Most of the merchant ships are subject to compulsory pilotage.

- Precautionary area around the zone reserved for the construction and exploitation of installations for the production of electricity from water, currents or winds (with a safety zone of 500 m). There is also a safety zone around every fixed construction within the concession zone (royal decree of 11 April 2011, see also theme **Energy (including cables and pipelines)**);
- Traffic route Westpit, along the south side of the zone reserved for wind turbines in an east-west direction;
- Traffic route of the precautionary area Westhinder via Scheur and Zand to the port of Zeebrugge;
- Traffic route of the precautionary area Westhinder via Scheur and Zand to the Scheldt Estuary;
- Traffic route between Ostend and Zeebrugge, south of Wenduine Bank;
- Traffic route Ostend-Dover, north of Stroom Bank and Nieuwpoort Bank, south of Oostende Bank, Middelkerke Bank and Kwinte Bank, between Binnen Ratel and Buiten Ratel;
- Traffic route of Scheur to the port of Ostend, west of Wenduine Bank;
- Traffic route to the port of Nieuwpoort across Westdiep;
- Traffic route of Westpit, west of the zone reserved for wind turbines, towards the precautionary area Noordhinder Junction;
- Traffic route of Goote Bank, over Westhinder Bank, east of Fairy Bank, joining the International Maritime Organisation traffic separation scheme Noordhinder Zuid;
- Traffic route of Goote Bank over Oosthinder Bank, south of Noordhinder Bank, joining the International Maritime Organisation traffic separation scheme Noordhinder Zuid;
- Traffic route from the buoy Noordoost Akkaert and in western direction between Goote Bank and Akkaert Bank, along the north side of the deepwater route, to the precautionary area Wandelaar.

In the MSP, the anchorage zones of Oostdyck and Westhinder are demarcated and space is provided for the construction of a mooring platform on the location of a high voltage station, on the condition that it will not disturb the primary function.

Information concerning shipping in the BNS is communicated via the Notices to Mariners (*BaZ*, general provisions: *BaZ 2015 nr. 1*).

2.2.1 Port zones

According to the spatial structure plan Flanders (*RSV*), the Port Decree and the coalition agreements, every Flemish sea port should have a strategic plan (including a strategic environmental assessment (SEA) (see also **Impact**) and spatial safety reports (RVR)) in which it is investigated how the economic interests can be aligned with other societal interests when the port area is developed further. This plan is the basis of the demarcation of 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 spatial policy plan: *Beleidsplan Ruimte*.

When the port development causes a loss of natural sites, this will be compensated by creating new nature 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 (see theme **Scheldt Estuary**).

The demarcation of the different port zones has been stipulated in the royal decree of 2 February 1993 and in the decision of the Flemish government 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 (royal decree 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. An expansion of the mole of Zeebrugge has also been included in the *Masterplan Vlaamse Baaien (2014)* which provides a vision of coastal development on the long term (2100, see also theme **Safety against flooding**). In this masterplan, the accessibility of the ports is discussed as well. In this context, the development of an island belt, east of Zeebrugge, is identified as a potential solution with regard to the accessibility of the Scheldt ports.

Table 2. Overview of the Flemish sea ports and their total surface and water surface (*Merckx & Neyts 2015*).

PORTS	TOTAL SURFACE	WATER SURFACE
Port of Ostend	658 ha	199 ha
Port of Ghent	4,648 ha	623 ha
Port of Zeebrugge	2,857 ha	1,000 ha
Port of Antwerp	13,057 ha	1,992 ha

2.3 Societal interest

2.3.1 Employment

The total employment in the Belgian ports (= the Flemish sea ports of Antwerp, Zeebrugge, Ghent and Ostend, and the ports of Liège and Brussels) amounted to 259,168 full-time equivalents (FTEs) in 2013 (figure 2). This figure can be divided into 116,724 direct FTEs and 142,444 indirect FTEs. The Flemish sea ports account for 88.8% of this employment, with Antwerp accounting for more than half (52.7%), followed by Ghent (23.4%), Zeebrugge (8.3%) and Ostend (4.4%). This difference in employment is partly related to the type of industry and shipment of goods in the different ports (see below). In 2013, the total employment in the ports equalled 6.5% of the Belgian employment. Until 2008, there was a slow increase in the number of FTEs in the Belgian ports, followed by a decrease from 2009, as a result of the global economic crisis (*Van Nieuwenhove 2015*).

The Economic importance of the Belgian ports in 2013 (*Van Nieuwenhove 2015*) also presents a social balance of the employment in the ports (composition of the staff, education, rotation of the staff, working time, type of contract, wage costs, promotion measures and training). The workforce in the ports in 2013 largely consisted of males (84%). Blue-collar workers constitute the majority of the port staff, with 52% in 2013, followed by white-collar workers (44%) and other staff (4%).

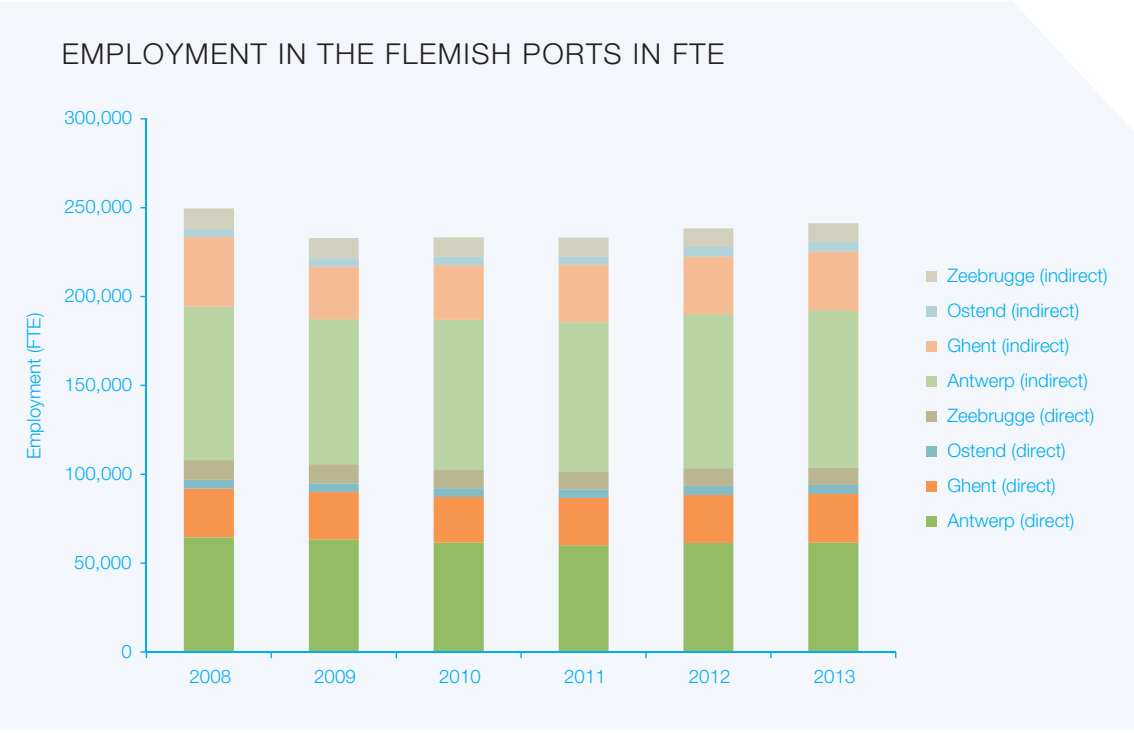

Figure 2. Employment in the Flemish ports in FTE (Source: *Van Nieuwenhove 2015*).

2.3.2 Added value

The total added value of the Belgian ports equalled 30,408.5 million euros in 2013. A distinction can be made between the direct (16,446.3 million euros) and indirect added value (13,962.2 million euros) (figure 3). Between 2008 and 2013, the total added value of the ports decreased by 0.2%. The Flemish sea ports accounted for 89.7% of the direct added value in 2013, with Antwerp accounting for more than half of the direct added value (59.9%), followed by Ghent (20.8%), Zeebrugge (6.0%) and Ostend (3.0%) (*Van Nieuwenhove 2015*).

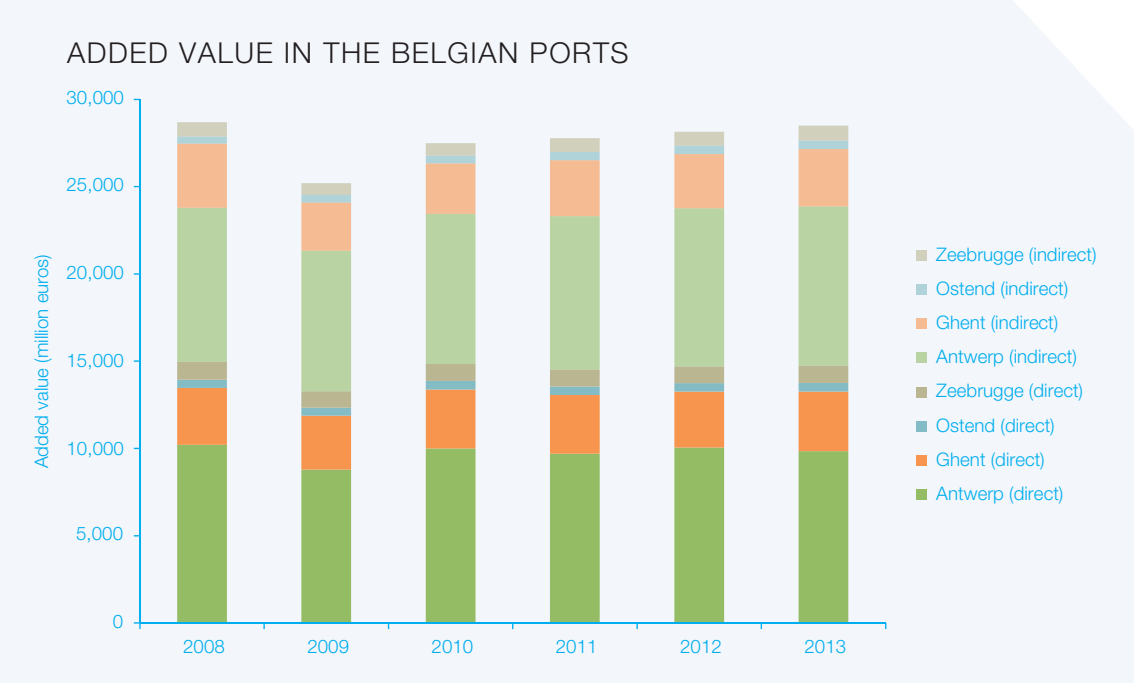

Figure 3. Added value in the Belgian ports (Source: *Van Nieuwenhove 2015*).

2.3.3 Shipment of goods

After a decrease in 2009 due to the worldwide economic crisis, cargo traffic in the Flemish ports increased to more than 265 million tons in 2011. In 2014, the traffic amounted to 268.880 million tons (figure 4). In terms of shipment of goods, Antwerp remains by far the most important port with 199.012 million tons in 2014. Cargo traffic in Zeebrugge, Ostend and Ghent amounted to 42.548, 1.431 and 25.889 million tons respectively. In 2014, cargo traffic in the Flemish ports accounted for 23.8% of the total amount in the Le Havre-Hamburg range (*Merckx & Neyts 2015*).

In 2014, the port of Antwerp was the leader in the handling of containers (108.317 million tons) (more information on intermodal container traffic: *Notteboom 2006*, *Merckx & Neyts 2009*), liquid cargo (62.834 million tons) and break bulk cargo (9.885 million tons). Zeebrugge is the most important port with regard to roll-on/roll-off traffic with 13.043 million tons and Ghent with regard to dry bulk (16.740 million tons) (*Merckx & Neyts 2015*, more information on car traffic: *Notteboom 2010*).

2.3.4 Passenger traffic

In 2014, a total of 822,173 passengers embarked or disembarked in the Flemish ports (figure 5). Zeebrugge accounted for the majority of this figure with 806,265 passengers, followed by Ostend (11,690 passengers), Antwerp (3,204 passengers) and Ghent (1,014 passengers). Since the 1980s, passenger traffic in the Flemish ports has decreased substantially as more than 5 million passengers embarked or disembarked in 1980 (*Merckx & Neyts 2015*). This decline can be attributed to the opening of the Channel Tunnel, the cessation of the *Regie voor Maritiem Transport* (RMT) ferry service and the cancellation of certain ferry lines (*Notteboom 2004*).

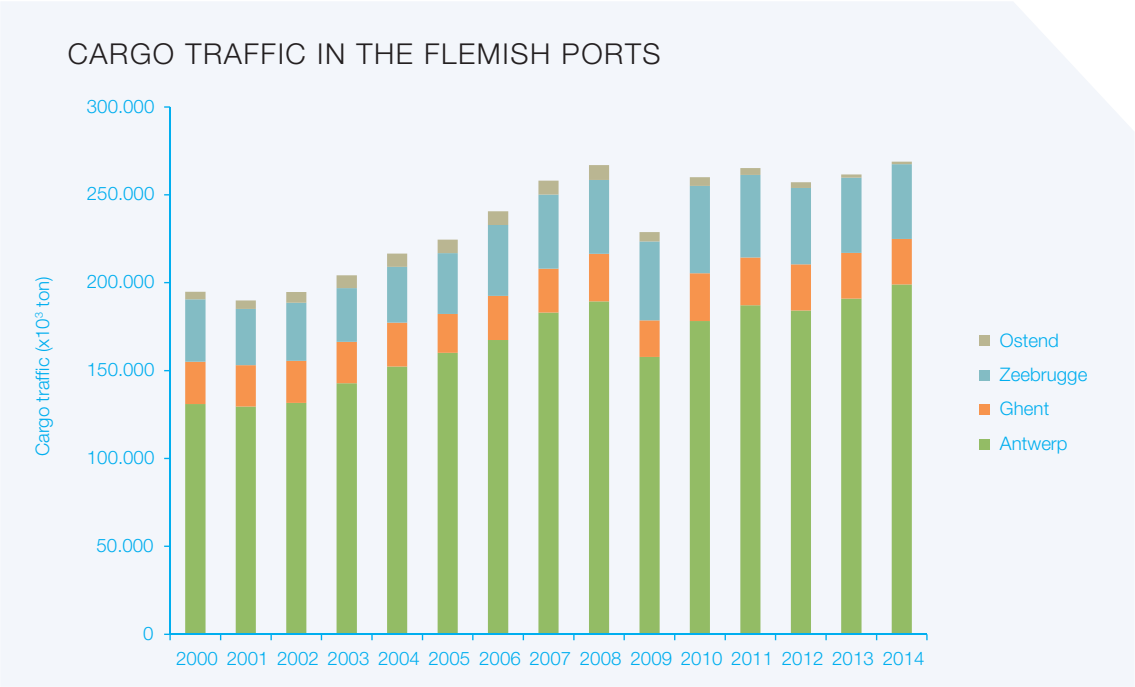

Figure 4. Cargo traffic in the Flemish ports (Source: *Merckx & Neyts 2015*).

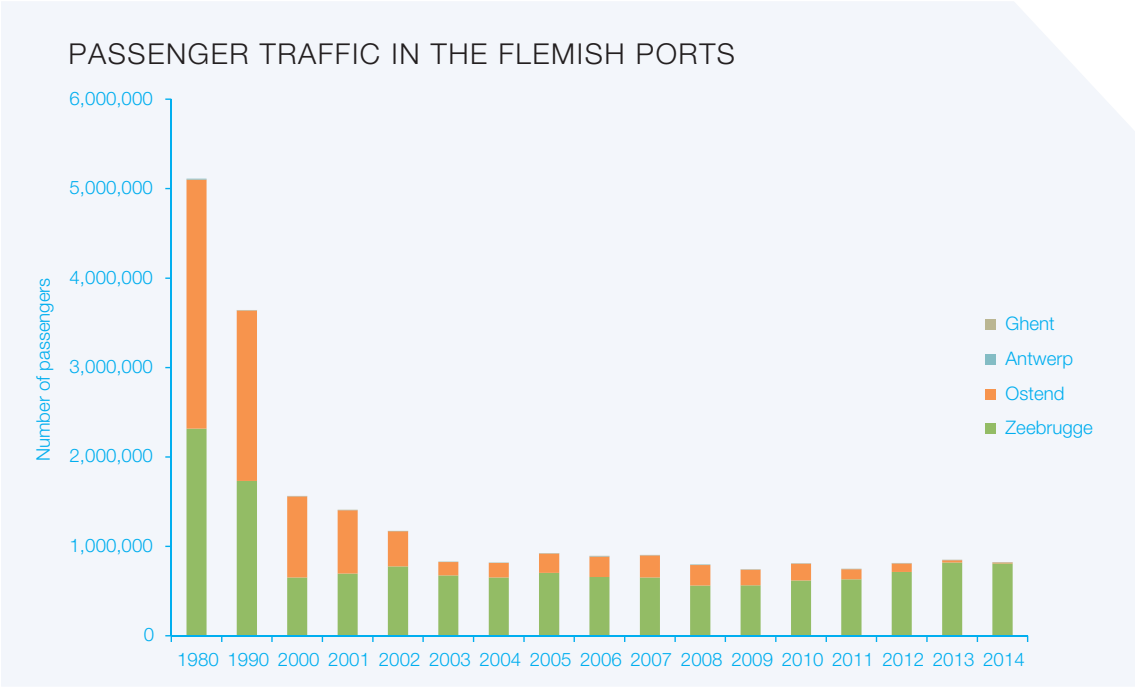

Figure 5. Passenger traffic in the Flemish ports (Source: *Merckx & Neyts 2015*).

2.3.5 Investments

In 2013, direct investments in the Belgian ports equalled 3,305.7 million euros, a decrease of 3.3% in comparison to 2012 (figure 6). In total, 3,027.2 million euros were invested in the Flemish sea ports. The majority of these investments were destined for the port of Antwerp (2,314.3 million euros), followed by Ghent (424.7 million euros),

Zeebrugge (212.3 million euros) and Ostend (75.9 million euros). Moreover, 202.4 million euros were invested in maritime companies outside the Belgian port areas (*Van Nieuwenhove 2015*). Public expenditures in the Flemish ports in 2014 equalled 453.63 million euros, 349.68 million euros (77.1%) of which were allocated to maritime access (figure 7). Besides maritime access, 61.57 million euros were spent on the port of Antwerp, 5.91 million euros on Ghent, 20.42 million euros on Zeebrugge and 16.05 million euros on Ostend (*Merckx & Neyts 2015*).

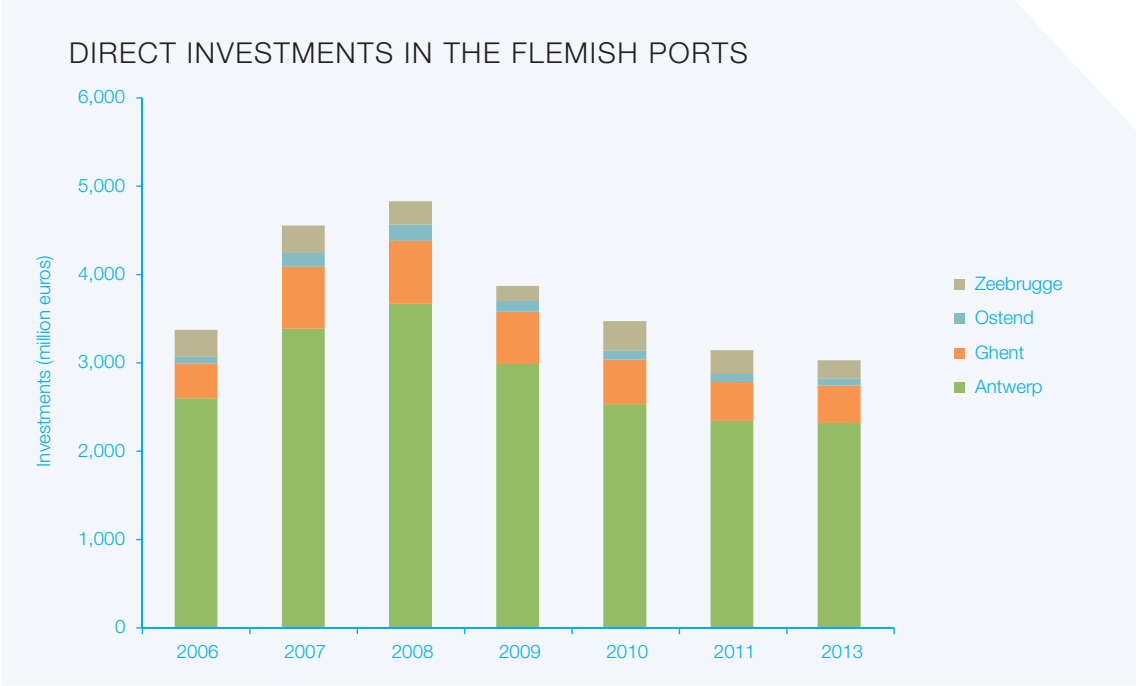

Figure 6. Direct investments in the Flemish ports (Source: *Van Nieuwenhove 2015*).

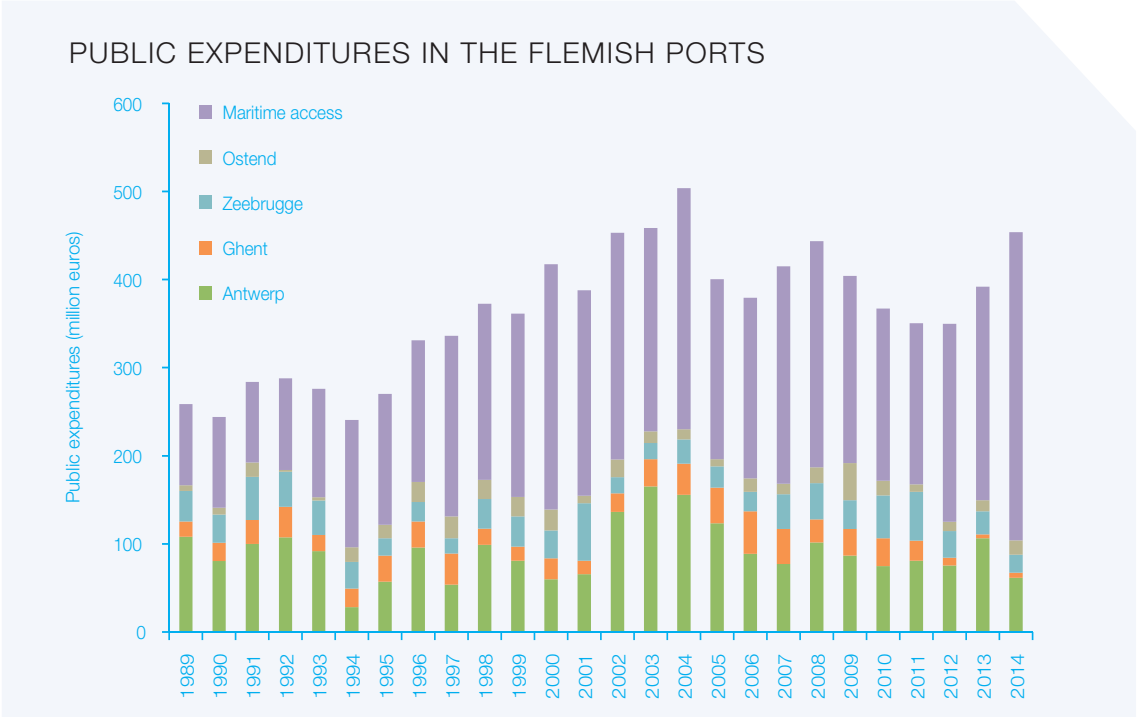

Figure 7. Public expenditures in the Flemish ports (Source: *Merckx & Neyts 2015*).

2.4 Impact

Shipping traffic has a number of effects on the marine environment. Table 3 gives an overview of the different types of impact and the relevant literature.

Table 3. Overview of the effects of shipping on the environment.

IMPACT	LITERATURE
Oil pollution and pollution by other pollutants and toxic materials due to accidental, operational or illegal discharge	*Schallier 2001*, *Seys & Kerckhof 2003*, *Maes et al. 2004* (*MARE-DASM project BELSPO*), *Seys 2004*, *Schrijvers & Maes 2005* (*GAUFRE project BELSPO*), *Le Roy et al. 2006* (*RAMA project BELSPO*), *Lescrauwaet et al. 2006*, *Volckaert et al. 2006* (*MIMAC project BELSPO*) , *Goffin et al. 2007*, *OSPAR QSR 2010*, *André et al. 2010*, *Dittman et al. 2012*, *Lagring et al. 2012*, *Maebe et al. 2012*, *Van Roy et al. 2013*, *Dulière et al. 2013* (*OSERIT project BELSPO*)
Air pollution caused by particles in the emissions of marine engines (NO_x, SO_x, CO_2, etc.)	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *Schrijvers & 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*)
Waste dumping	*Schallier 2001*, *Lescrauwaet et al. 2006*, *Goffin et al. 2007*, *Claessens et al. 2010*, *OSPAR QSR 2010*, *André et al. 2010*, *Van Franeker et al. 2011*, *Claessens et al. 2013* (*AS-MADE project BELSPO*), *Van Cauwenberghe et al. 2013*, *State of Europe's Seas 2015*, *Devriese et al. 2015*, *Van Cauwenberghe et al. 2015*
Leaching of polluting anti-fouling substances (e.g. tributyltin (TBT))	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *Schrijvers & Maes 2005* (*GAUFRE project BELSPO*), *Goffin et al. 2007*, *OSPAR QSR 2010*, *Claessens et al. 2010*
Introduction of non-indigenous species due to their attachment to the keel or the discharge of ballast water	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *Schrijvers & 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*
Pollution and physical impact due to the loss of ships or cargo	*Schallier 2001*, *Seys & Kerckhof 2003*, *Le Roy et al. 2006* (*RAMA project BELSPO*), *Goffin et al. 2007*, *De Baere et al. 2010*, *OSPAR QSR 2010*
Other physical impact such as noise and collisions with marine mammals	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *OSPAR QSR 2010*, *André et al. 2010*, *compilation national reports ASCOBANS*
Impact on other users (safety, spatial impact, etc.)	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *Schrijvers & Maes 2005* (*GAUFRE project BELSPO*), *Le Roy et al. 2006* (*RAMA project BELSPO*), *Volckaert et al. 2006* (*MIMAC project BELSPO*), *State of Europe's Seas 2015*

Moreover, the installation and operation of the ports also have certain effects on the environment. These effects are *inter alia* indicated in the environmental impact assessments (EIAs) and strategic environment assessments (SEAs) of the strategic plans of the ports (see table 4, non-exhaustive list, see also *dossierdatabank, departement LNE*).

2.5 Sustainable use

2.5.1 Sustainable development of EU maritime transport

On a European level, a White Paper Roadmap to a Single European Transport Area (COM (2011) 144) was drafted in 2011 with 40 concrete initiatives to achieve a resource-efficient and competitive European traffic system. Specifically for maritime transport, the strategic objectives and recommendations for the EU maritime traffic policy until 2018 have already been elaborated in COM (2009) 8. In table 5, a selection of important initiatives and concepts within this European maritime transport policy are discussed. More information about the European policy instruments/ regulations is available on the *website of the Flemish Port Commission (VHC)* and in the publication *Merckx et al. (2012)*.

Table 4. An overview of the documents concerning the SEAs and EIAs of the Flemish sea ports.

PORT	EIAs
Ostend	• *Plan MER strategisch plan haven Oostende (kennisgevingsnota) 2004* • *Richtlijnen milieueffectrapportage Strategisch plan haven Oostende* • *Goedkeuring milieueffectrapport Strategisch plan haven Oostende* • *Plan MER kustverdediging en maritieme toegankelijkheid Oostende 2007*
Antwerp	• *Richtlijnen milieueffectrapportage Strategisch plan haven van Antwerpen* • *Kennisgeving plan MER Strategisch plan haven van Antwerpen 2006* • *Plan MER strategisch plan haven van Antwerpen (niet-technische samenvatting) 2008* • *Goedkeuring MER Strategisch plan haven van Antwerpen 2009* • *Kennisgeving Verruiming vaargeul Beneden-Zeeschelde en Westerschelde 2006* • *Tussenstijds strategisch plan haven van Antwerpen 2006*
Zeebrugge	• *Plan MER strategisch plan haven van Zeebrugge 2004* • *Kennisgeving project MER van het strategisch haveninfrastructuurproject (SHIP) in de westelijke achterhaven van Zeebrugge 2011* • *Richtlijn milieueffectrapportage van het strategisch haveninfrastructuurproject (SHIP) in de westelijke achterhaven van Zeebrugge 2011*
Ghent	• *Nota-plan MER strategisch plan haven van Gent* • *Gewestelijk ruimtelijk uitvoeringsplan 'Afbakening Zeehavengebied Gent - Fase 2*

Table 5. A number of important initiatives and concepts within the European maritime transport policy.

INITIATIVE/CONCEPT	EXPLANATION	SOURCE
Trans-European Transport Network (*TEN-T*)	A European network of transport infrastructure of roads, railways, air and water. The Connecting Europe Facility (*CEF*) funds TEN-T projects to eliminate bottlenecks in this network.	Regulation 1315/2013
Motorways of the Sea	The Motorways of the Sea concept aims at introducing new intermodal maritime-based logistics chains in Europe, which should bring about a structural change in our transport organisation within the next years.	SEC (2007) 1367
Short Sea Shipping (*SSS*)	SSS comprises transport of goods and/or passengers on water using short sea lanes. SSS is the most important mode of transport in the concept of the Motorways of the Sea. On a Flemish level, the government started a *Promotion Centre on Shortsea Shipping* in 1998. This neutral advisory body has gathered *statistics* on SSS since 1999 for the 4 Flemish ports.	COM (2004) 453
European maritime transport space without barriers	Proposal for a maritime transport space without barriers to decrease and harmonise the administrative procedures for SSS.	COM (2009) 10
Blue Belt initiative	The further development of a European maritime transport space without barriers to a blue belt in which maritime transport can operate freely (reduction of the administrative burden for maritime transport to a level that is comparable to that of other modes of transport).	COM (2012) 573

2.5.2 Measures with regard to safety at sea: construction, equipment and crew of sea-going ships

A lot of legislation exists concerning safety at sea, the prevention of ship disasters and the protection of human life at sea. In table 6, the most relevant international conventions are presented. These conventions are further elaborated in *Verleye et al. (2015)*.

The DG Maritime Transport (FPS Mobility and Transport) ensures that all ships navigating under the Belgian flag comply with the international maritime regulations concerning shipping safety as well as the protection of the marine environment (*inter alia* by means of the ship inspection regulation – royal decree of 20 July 1973 and often revised). The Belgian Port State Control (FPS Mobility and Transport) inspects ships under foreign flag that call at Belgian ports to investigate whether they meet all international regulations accepted by the IMO and the International Labour Organisation (ILO). When ships do not meet these standards, departure can be refused or special conditions can be

Table 6. Most relevant international conventions concerning safety at sea.

CONVENTION	EXPLANATION
SOLAS Convention (International Convention for the Safety of Life at Sea)	The SOLAS Convention is considered as the most important international convention concerning safety on merchant ships. The principal aim is to specify minimum standards for the construction, equipment and operation of ships to guarantee the safety of human life at sea.
COLREG (The International Regulations for Preventing Collisions at Sea, *IMO*)	This convention provides regulations to determine safe speed limits, to reduce the risk of collisions and to provide guidance to ships which operate in, or in proximity of, traffic separation schemes.
SAR Convention (International Convention on Maritime Search and Rescue, *IMO*)	The international convention on search and rescue (SAR) at sea aims at developing an international SAR-plan to ensure that rescue-operations are conducted by a SAR-organisation in every sea. Currently, more emphasis is put on the regional approach and the coordination between SAR operations at sea and in the air.
STCW Convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, *IMO*)	The STCW Convention is an international convention that stipulates the minimum requirements that have to be met by seafarers with regard to training, diplomacy and watchkeeping. The convention also aims to promote the safety of human life and goods as well as the protection of the marine environment. With directive 94/58/EC on the minimum level of training of seafarers, the EU has also drafted rules concerning the minimum level of training of seafarers on EU ships, and on ships calling at EU ports.

imposed (e.g. reparations in the nearest shipyard when the damage cannot be fixed in a Belgian port and the repairs are necessary to guarantee the safety of the ship and its crew) (for the 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) guarantees safe and smooth shipping on the access routes from and to the Belgian ports by providing Vessel Traffic Services (VTS).

2.5.3 Preventing and combating pollution from shipping

There is a wide range of regulations to prevent and combat the pollution of the marine environment due to shipping. The UN Convention on the Law of the Sea (*UNCLOS*, 1982) provides a general international legal framework which *inter alia* addresses pollution of the sea (part XII). In case of accidental or operational pollution of the marine environment, the *MARPOL Convention (1973/1978)* is the most important international treaty. In addition, there are some other important conventions from the *IMO* (table 7, more information about this regulation is provided in *Verleye et al. 2015*).

Other relevant international conventions and agreements not drafted within the IMO are the *Bonn Agreement* and the OSPAR Convention:

- The *Bonn Agreement* regulates the collaboration between the coastal states of the North Sea with regard to the detection, reporting and combating of pollution in the North Sea caused by oil and other pollutants from ships and offshore installations. Since 1991, air surveillance on the BNS has been organised in the context of this agreement to detect illegal discharges by ships and to provide evidence for potential prosecution. The observation programme is executed by MUMM (Operational Directorate Natural Environment, RBINS) in cooperation with the Ministry of Defense (*website MUMM*). The annual results of the air surveillance are reported in *Van Roy et al. (2013)* (see also *website MUMM*). Since the beginning of the air surveillance, a decreasing trend has been observed in the number of discharges and the estimated oil volume (figure 7). Hence, the measures taken in the framework of European directive 2000/59/EU concerning the port reception facilities and the MARPOL Convention, as well as the increased surveillance have a positive effect (*Goffin et al. 2007*, *André et al. 2010*, *Lagring et al. 2012*, *Maebe et al. 2012*). In recent years, an increase in operational discharges of hazardous substances other than oil has been observed (*Van Roy et al. 2013* and *website MUMM*). Within the Coast Guard, action is taken by developing more detailed monitoring procedures in the framework of MARPOL;
- In the context of the OSPAR Convention, certain biological indicators have been set, e.g. the degree of oil contamination in guillemots is considered a proxy for oil pollution in the marine environment. This indicator is a so-called EcoQO or Ecological Quality Objective. The Research Institute for Nature and Forest (INBO) annually reports the degree of oil contamination of the birds washed ashore on the Belgian beaches (*Verstraete et al.*

2007, *2008*, *2009*, *Stienen & Van de Walle 2010*, *Stienen et al. 2014*). The statistics can also be consulted on the following *website about beached birds*. Furthermore, operational discharge practices are managed in the framework of OSPAR by a North Sea Network of Prosecutors and Investigators (NSN).

Table 7. IMO conventions on pollution from shipping.

INTERNATIONAL IMO REGULATION		
Convention	**Explanation**	**Ratification by Belgium**
MARPOL Convention (MARPOL 73/78) (International Convention for the Prevention of Pollution from Ships, IMO)	This convention aims to prevent pollution of the marine environment by ships from operational or accidental causes.	x
OPRC Convention (*IMO*)	International convention on oil pollution preparedness, response and co-operation	-
OPRC-HNS protocol (*IMO*)	Protocol on preparedness, response and co-operation to pollution incidents by hazardous and noxious substances, 2000	-
HNS Convention (*IMO*)	The international convention on liability and compensation for damage in connection with the carriage of hazardous and noxious substances by sea	-
CLC Convention (*IMO*)	International convention on civil liability for oil pollution damage	x
FUND Convention (*IMO*)	International fund for compensation for oil pollution damage	x
Bunker Oil Convention (*IMO*)	International convention on civil liability for bunker oil pollution damage	x
LLMC Convention (*IMO*)	International convention on limitation of liability for maritime claims	x
Nairobi International Convention on the Removal of Wrecks (*IMO*)	Nairobi international convention on the removal of wrecks	-

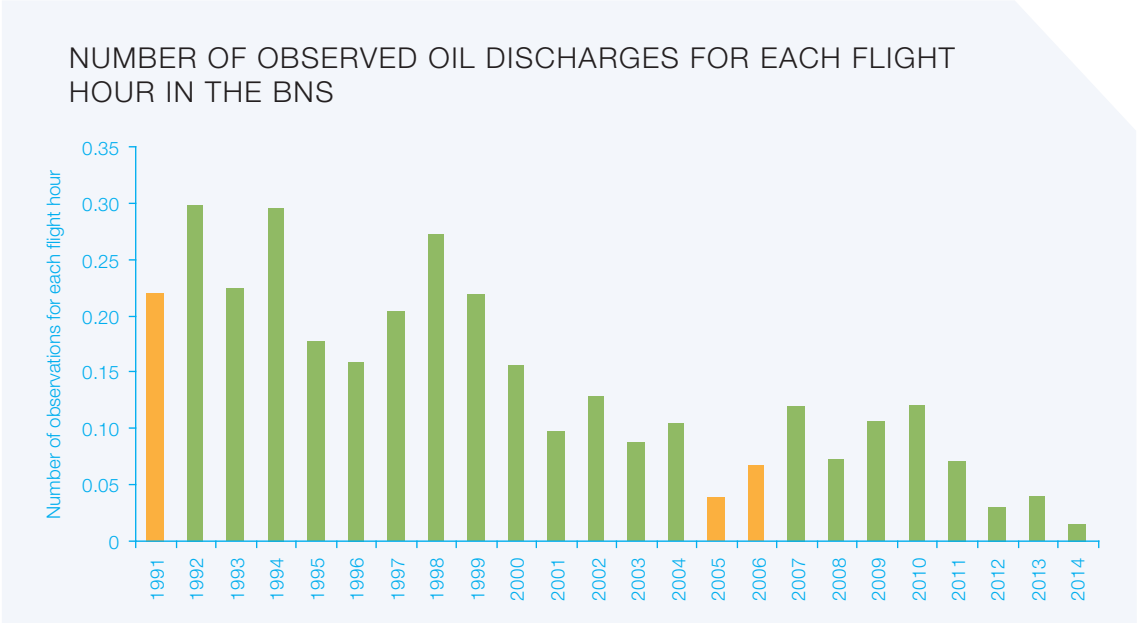

Figure 8. Number of observed oil discharges for each flight hour of the observation programme in the BNS (1991, 2005 en 2006 were transitional years, indicated in orange) (RBINS, Operational Directorate Natural Environment).

At a European level, a lot of measures have been taken in the context of the so-called Erika legislative packages (table 8). In addition, concentrations of polluting substances have been included in the Marine Strategy Framework Directive (MSFD) (2008/56/EC), as one of the descriptors for the environmental status, and pollution by ships has been identified as a pressure (more information: *Law et al. 2010*).

On the Belgian level, the law of 6 April 1995 constitutes the legislative framework for the implementation of the MARPOL Convention. In case of severe pollution, the intervention will be executed according to the new ANIP North Sea which has been operational since 2015 and replaces the MD of 19 April 2005. Since the shipping disaster with the oil tanker Erika (1999), the Belgian government has a more elaborate set of instruments at its disposal to combat oil pollution (*website FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu*). Furthermore, an intervention plan was drafted in 2005 for the shelter and care of birds affected by oil pollution at sea (*Interventieplan Vogels, 2007*). A new instrument in the fight against oil pollution is the advanced 3D-model OSERIT (Oil Spill Evaluation Response

Table 8. Selection of European measures adopted in the framework of the Erika initiatives.

ERIKA LEGISLATIVE PACKAGE	SELECTION OF MEASURES	EXPLANATION
After the shipping disaster with the oil tanker Erika in 1999, a series of measures, known as Erika I (COM (2000) 142), II (COM (2000) 802) and III (COM (2005) 585) have been issued by Europe in order to enhance the maritime safety.	Monitoring Directive (2002/59/EC)	Directive establishing a community vessel traffic monitoring and information system to increase safety and efficiency of sea traffic in Europe.
	Directive 2009/15/EC	Common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations.
	Directive on Port State Control (2009/16/EC)	This directive aims to reform the control mechanisms in ports to efficiently ascertain if ships meet the regulations concerning safety at sea, maritime security, protection of the marine environment as well as living and working conditions.
	Directive 2009/17/EC	Establishing a community vessel traffic monitoring and information system.
	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 for maritime claims.
	Directive 2009/21/EC	Compliance with flag state requirements.
	Directive 2010/65/EU	The aim of this directive is the simplification and harmonisation of the reporting formalities for ships arriving in and/or departing from ports of the member states by means of the introduction of an electronic transfer of data (at the latest by 1 June 2015).
	Regulation on the design requirements for double-hull oil tankers	As a consequence of the accident with the oil tanker Prestige off the Spanish coast in November 2002, the EU has accelerated the phasing-out of single-hull tankers according to regulation 417/2002/EC by means of regulation 1726/2003/EC and 530/2012/EC. The IMO has adopted this accelerated phase-out and followed the EU example. According to regulation 1726/2003/EC, single-hull oil tankers sailing under the flag of a member state and other oil tankers may not enter the ports or offshore terminals under the jurisdiction of a member state after 2010.
	Regulation establishing a European Maritime Safety Agency (*EMSA*) (1406/2002/EC)	This agency wants to decrease the risk of maritime accidents, pollution by ships and the loss of human life at sea. EMSA manages initiatives such as *SafeSeaNet* (a central European information platform for the exchange of maritime data between the competent authorities) and *CleanSeaNet* (satellite service to detect oil pollution from ships).
	Regulation 391/2009/EC	Common rules and standards for ship inspection and survey organisations
	Regulation 392/2009/EC	The liability of carriers of passengers by sea in the event of accidents

Integrated Tool, developed by MUMM (Operational Directorate Natural Environment, RBINS)). The model can simulate the impact of oil pollution (including the water column) and identify the polluter by means of backtracking (*Dulière et al. 2013*, *OSERIT project BELSPO*).

2.5.4 Measures against the disposal of waste from ships

The *MARPOL Convention (1973/1978)* regulates which waste can be discharged into the marine environment by ships (see also above). In this regard, a remarkable increase of Annex V violations (waste from ships) has been observed during recent years (*Van Roy et al. 2013* and *website MUMM*). The problem of ship-generated waste is also addressed by directive 2000/59/EC concerning the port reception facilities for ship-generated waste and cargo residues. This directive intends to oblige ships to return their waste to the ports in a sustainable way. In the MSFD (2008/56/EC), the presence of marine litter has been included as one of the descriptors for the marine environmental status and has been identified as a physical pressure on the environment. The criteria and methodological standards concerning the determination of the Good Environmental Status (GES) with regard to marine litter have been elaborated in *Galgani et al. (2010)*.

In Flanders, the policy with respect to the management of ship-generated waste in ports is stipulated in the decree of 23 December 2011 and VLAREMA (decision of the Flemish government of 17 February 2012) (article 5.2.10 marine shipping and article 5.2.11 inland shipping). The waste management of ships in the Flemish ports between 2004 and 2006 is also discussed in *Goffin et al. (2007)*. An exhaustive study of the waste streams in the ports has been conducted in the context of the ECOWARE project (*Maes & Buyse 2000*). The waste streams of fishing boats have been discussed in *Maes & Douvere (2004)* and *Belpaeme (2006)*. In the Fishing for Litter project, fishermen have been reimbursed for collecting marine-sourced litter (*Bonne & Tavernier 2007*). Furthermore, there is a new European project called *Waste Free Oceans*, in which the industry pays fishermen for removing litter (*Vanagt et al. 2012*).

2.5.5 Measures against air pollution from shipping

The air pollution generated by sea-going ships is regulated in Annex VI of the *MARPOL Convention (1973/1978)*. This annex was amended in 2008 reducing the sulphur content of fuel to a maximum of 3.5% (0.5% after 1 January 2020) and 1% (0.1% after 1 January 2015) in certain areas (Emission Control Areas, ECAs). The convention also prohibits the emission of substances damaging the ozone layer such as CFCs, and imposes emission limits for nitrogen. Furthermore, the amendment of Annex VI in 2012 introduced a new Chapter 4 concerning a better energy efficiency technology (EEDI) for newly built ships and an efficient management plan with regard to energy for all ships over 400 BT.

The EU has also issued a series of measures in order to combat air pollution generated by ships: directive 1999/32/EC (sulphur content of liquid fuels), modified by directive 2005/33/EC (sulphur content of shipping fuels) and directive 2012/33/EU. These directives ensure that similar conditions as those stipulated in Annex VI of MARPOL 73/78 will be applied in the EU (see above). In addition, a maximum sulphur content of 0.1% for gasoline fuels has been introduced for the auxiliary engines of sea-going ships in the European ports.

On a national level, the measures against air pollution from shipping are discussed in the royal decree of 27 April 2007 (implementation of the MARPOL Convention and the EU directives on the Belgian level). Since January 2015, employees of *DG Maritime Transport* have carried out inspections aboard ships in ports in the framework of MARPOL Annex VI (including fuel sampling and analyses).

On a Flemish level, the government decided on 23 April 2014 to introduce an Integrated Approach to Nitrogen Depositions (*PAS*). The PAS programme addresses the problem of nitrogen depositions in the special protection areas of the Habitats Directive (directive 92/43/EC) by means of measures targeting the source as well as the effects of the emission.

Other important measures with respect to the reduction of air pollution from shipping are the conversion of ships to Liquefied Natural Gas (LNG) as an alternative fuel and the improved availability of cold ironing (see *Margarino 2014*). The use of LNG causes a negligible emission of sulphur and particulates. The NO_x and carbon emissions of this fuel are 85 to 90% and 15 to 20% lower, respectively. In all Flemish sea ports, preparations are in progress to enable LNG supply. On the other hand, cold ironing facilities ensure that ships at the quayside do not have to use their generators

or engines while in port. In several Flemish ports and at quays of the inland shipping network, cold ironing facilities will be installed for boating, inland shipping and sea shipping. Moreover, it is possible to submit a request to the Public Waste Agency of Flanders (*OVAM*) for a reduced contribution for ships which use environmentally friendly fuel in the context of the European directive 2000/59/EU.

2.5.6 Measures against the introduction of non-indigenous species

In order to combat the introduction of non-indigenous species by means of the ballast tanks of ships, the *Ballast Water Convention* (IMO, 2004) obliges ships to draft a 'Ballast Water and Sediment Management Plan' and to keep a 'Ballast Water Record Book', reporting all ballast operations. In addition, the management of ballast water must take place according to standard procedures (see *website IMO*) and systems recognised by IMO should be used for the treatment of ballast water. Until the ratification of this convention, OSPAR advises to adopt certain measures concerning the ballast water of ships on a voluntary basis (*OSPAR general guidance 2010*). Prior to the IMO Ballast Water Convention, the IMO resolution from 1997 (*A.868(20)*) provided guidelines for the control and treatment of ballast water in order to reduce the transfer of harmful aquatic organisms and pathogens.

The International Council for the Exploration of the Sea (*ICES*) has established two working groups in order to investigate biological invasions and non-indigenous 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 the European level, regulation 1143/2014 prevents and manages the (intentional and unintentional) introduction and distribution of invasive alien species. This regulation applies to terrestrial species, freshwater species as well as marine organisms. The introduction of non-indigenous species has been included in the MSFD (2008/56/EC) as a biological disturbance. It has also been introduced as a descriptor for a Good Environmental Status (GES). The criteria and methodological standards for the determination of the GES concerning non-indigenous species have been elaborated in *Olenin et al. (2010)*.

In Belgium, the intentional as well as the accidental introduction of non-indigenous species (through ballast water) is prohibited by the law of 20 January 1999, and the subsequent implementation by means of the royal decree of 21 December 2001. In the context of the *Belgian Forum on Invasive Species*, a protocol has been elaborated (invasive species environmental impact assessment (ISEIA), *Branquart 2009*) in order to evaluate the impact of non-indigenous organisms on the environment as well as the potential distribution and colonisation. The non-indigenous species in the BNS are reported to the ICES working group (*WGITMO*) by MUMM. An overview of the alien species in the BNS is given by *Kerckhof et al. (2007)* and the *list* of the *VLIZ alien species consortium* (more information: *Vandepitte et al. 2012*).

Projects such as *RINSE*, *MEMO* and *SEFINS* address the problem of invasive non-native species in the Southern Bight of the North Sea and its estuaries by conducting scientific research, developing tools, exchanging best practices, etc.

2.5.7 Measures against harmful anti-fouling substances

On 5 October 2001 (London), *IMO* adopted the *International Convention on the Control of Harmful Anti-fouling Systems on Ships* which entered into force on 17 September 2008. This convention prohibits the use of harmful substances in anti-fouling paint for ships (e.g. tributyltin compounds (TBT)) and resulted from the IMO resolution (A.895(21)) (*Goffin et al. 2007*). Organic tin compounds have been included in the *OSPAR list of chemicals for priority action 2011* (more information: *OSPAR background document on organic tin compounds 2011*).

At the European level, the use of organic tin compounds in anti-fouling substances of ships is prohibited by directive 2002/62/EC, which was preceded by directives 89/677/EC and 99/51/EC. In regulation 782/2003 the measures of the IMO convention have been implemented in the European legislation. In the Water Framework Directive (2000/60/EC) organic tin compounds have been included in the list of priority substances and certain other pollutants.

In Belgium, the IMO Convention on the Control of Harmful Anti-fouling Systems on Ships has been implemented by the law of 16 January 2009 and the decree of 9 May 2008.

2.5.8 Measures against underwater noise from shipping

On the international level, recommendations have been formulated in the context of the Marine Environment Protection Committee (*MEPC*) of the IMO by means of resolutions which limit the effects of underwater noise on cetaceans (*Guidelines MEPC 2014*). In the context of *ASCOBANS*, measures against the impact of underwater noise from shipping on small cetaceans are discussed (*resolution ASCOBANS 2003*, *resolution ASCOBANS 2006*).

On the European level, the problem of underwater noise has been included in the MSFD (2008/56/EC) where underwater noise and other forms of energy have been identified as a descriptor for a GES (*Tasker et al. 2010*) (see also **Energy (incl. cables and pipelines)**).

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ETC.			
Abbreviations	Title	Year of conclusion	Year of entering into force
CLL Convention	International Convention on Load Lines	1966	
CLC Convention	International Convention on Civil Liability for Oil Pollution Damage	(1969) - 1992	(1975) - 1996
FUND Convention	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	1992 – (2003)	1996
COLREG	Convention on the International Regulations for Preventing Collisions at Sea	1972	1977
MARPOL Convention	International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978 relating thereto	1973	1978
SOLAS Convention	International Convention for the Safety of Life at Sea	1974	1980
LLMC Convention	Convention on Limitation of Liability for Maritime Claims	1976	1986
STCW Convention	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers	1978	1984 (major revisions in 1995 and 2010)
SAR Convention	International Convention on Maritime Search and Rescue	1979	1985
UNCLOS	United Nations Convention on the Law of the Sea	1982	1994
Paris MoU	Paris Memorandum of Understanding on Port State Control	1982	
Bonn Agreement	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	1983	1989
HNS Convention	The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea	1984	
OPRC Convention	International Convention on Oil Pollution Preparedness, Response and Co-operation	1990	1995
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR Convention	The Convention for the Protection of the marine Environment of the North-East Atlantic	1992	1998
OPRC-HNS protocol	Protocol concerning the preparation on, the battle against and the collaboration with the cases of pollution of damaging and hazardous substances	2000	2007
	International Convention on the Control of Harmful Anti-fouling Systems on Ships	2001	2008
Bunker Oil Convention	International Convention on Civil Liability for Bunker Oil Pollution Damage	2001	2008
Ballast Water Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments	2004	
	Nairobi International Convention on the Removal of Wrecks	2007	

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations	Title	Year	Number
Directives			
	Council Directive of 21 December 1989 amending for the eighth time Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations	1989	677
Habitats Directive	Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
	Council Directive of 22 November 1994 on the minimum level of training of seafarers	1994	58
	Directive relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC	1999	32
	Commmission Directive 1999/51/EC of 26 May 1999 adapting to technical progress for the fifth time Annex I to Council Directive 76/769/EEC on the approximations of the laws, regulations, and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (tin, PCP and cadmium)	1999	51
	Directive port reception facilities for ship-generated waste and cargo residues	2000	59
Water Framework Directive (WFD)	Directive establishing a framework for community action in the field of water policy	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 adapting to technical progress for the ninth time Annex I to Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (organostannic compounds)	2002	62
	Directive amending Directive 1999/32/EC as regards the sulphur content of marine fuels	2005	33
Marine Strategy Framework Directive (MSFD)	Directive establishing a framework for community action in the field of marine environmental policy	2008	56
	Directive on common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations	2009	15
PSC Directive	Directive on port State Control	2009	16
	Directive establishing a Community vessel traffic monitoring and information system	2009	17
	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 shipowners 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	2010	65

EUROPEAN LEGISLATION (continuation)			
Abbreviations	Title	Year	Number
	Richtlijn tot wijziging van Richtlijn 1999/32/EG van de Raad wat het zwavelgehalte van scheepsbrandstoffen betreft	2012	33
Regulations			
	Regulation on the accelerated phasing-in of double hull or equivalent design requirements for single hull oil tankers and repealing Council Regulation (EC) No 2978/94	2002	417
	Regulation establishing a European Maritime Safety Agency	2002	1406
	Regulation on the prohibition of organotin compounds on ships	2003	782
	Regulation amending Regulation (EC) No 417/2002 on the accelerated phasing-in of double-hull or equivalent design requirements for single-hull oil tankers	2003	1726
	Regulation on common rules and standards for ship inspection and survey organisations	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
	Verordening (EU) betreffende richtsnoeren van de Unie voor de ontwikkeling van het trans-Europees vervoersnetwerk en tot intrekking van Besluit nr. 661/2010/EU	2013	1315
	Verordening (EU) betreffende de preventie en beheersing van de introductie en verspreiding van invasieve uitheemse soorten	2014	1143
Other			
Erika I	Communication from the Commission to the European Parliament and the Council on the safety of the seaborne oil trade	2000	142
Erika II	Communication from the Commission to the European Parliament and the Council on a second set of community measures on maritime safety following the sinking of the oil tanker Erika	2000	802
	Communication from the Commission on Short Sea Shipping	2004	453
Erika III	Communication from the Commission: Third package of legislative measures on maritime safety in the European Union	2005	585
	Communication from the Commission: Keep Europe moving - Sustainable mobility for our continent Mid-term review of the European Commission's 2001 Transport White Paper	2006	314
	Commission staff working document (SEC): Report on the Motorways of the Sea State of play and consultation	2007	1367
	Communication from the Commission: towards an EU strategy on invasive species	2008	789
	Communication from the Commission: Strategic goals and recommendations for the EU's maritime transport policy until 2018	2009	8
	Communication from the Commission: Communication and action plan with a view to establishing a European maritime transport space without barriers	2009	10
	White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system	2011	144
	Communication from the Commission: Single Market Act II Together for new growth	2012	573

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Wet van 20 januari 1999	Wet ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Wet van 6 april 1995	Wet betreffende de voorkoming van de verontreiniging van de zee door schepen	1995-04-06/94
Wet van 16 februari 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
Royal decrees		
KB van 20 juli 1973	Koninklijk besluit houdende zeevaartinspectiereglement	1973-07-20/30
KB van 2 februari 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
KB van 21 december 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
KB van 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
KB van 6 februari 2009	Koninklijk besluit tot oprichting en organisatie van het maritiem informatiekruispunt	2009-02-06/39
KB van 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
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Decrees		
Havendecreet (2 maart 1999)	Decreet houdende het beleid en het beheer van de zeehavens	1999-03-02/37
Decreet van 16 juni 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
Decreet van 9 mei 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
Materialendecreet (23 december 2011)	Decreet betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen	2011-12-23/33
Ministerial decrees		
MB van 19 april 2005	Ministerieel besluit tot vaststelling van het « Rampenplan Noordzee »	2005-04-19/40
Other		
Besluit van de Vlaamse regering van 13 juli 2001	Besluit van de Vlaamse regering houdende de aanduiding van de voorlopige begrenzing van de havengebieden	2001-07-13/93
Besluit van de Vlaamse regering van 26 oktober 2007	Besluit van de Vlaamse Regering betreffende het Maritiem Reddings- en Coördinatiecentrum	2007-10-26/30
Besluit van de Vlaamse regering van 26 oktober 2007	Besluit van de Vlaamse Regering betreffende de begeleiding van de scheepvaart	2007-10-26/31

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
Besluit van de Vlaamse regering van 17 februari 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
Samenwerkingakkoord van 8 juli 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

3 Dredging and dumping

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Citation:

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Dredging comprises all activities necessary to extract sand, silt and other layers from the bottom of waterbodies, but also in the context of land reclamation and nature development. This theme text will provide more information about the dredging and dumping of sediment for the purpose of maintaining and deepening the maritime access channels. The focus is on dredging and dumping activities in the Belgian part of the North Sea (BNS). The specific situation of these activities in the Scheldt Estuary is discussed in the theme text about the **Scheldt estuary**.

Over 99% of the sediments dumped at sea result from dredging in ports and fairways. Between 1990 and 2007, the total amount of materials dumped at sea in the OSPAR region (North-East Atlantic Ocean and North Sea) varied between 80 and 130 million tons (dry weight). About 90% of all dredged sediments are dredged and dumped in the southern part of the North Sea. This is largely due to the maintenance of the fairways to big ports such as Hull, Zeebrugge, Rotterdam, Bremen, Emden, Hamburg, Esbjerg, etc. In 2007, Germany and France dumped the largest amount of sediments in the OSPAR region, with *10^3 tons and 24.402*10^3 tons (dry weight) (each year) respectively (*OSPAR QSR 2010*). In Belgium, 11.845*10^3 tons (dry weight) were dumped in 2013 (*Lauwaert et al. 2014*). The evolution of the amount of sediment dumped in the BNS has been recorded since 1991 by the Management Unit of the North Sea Mathematical Models (MUMM) (RBINS) (*table dredged material*, figure 1). In the future, the amount of dredged and dumped sediments will probably increase due to the growing vessel size and the probable associated widening and deepening of fairways (*OSPAR QSR 2010*). The most commonly used techniques for dredging and dumping and the nature of the dredged sediments in the BNS are described in more detail in the section about the **Impact**.

3.1 Policy context

The maintenance and deepening of the maritime access channels to ports and the maintenance of the depth in the ports falls under the Flemish Region. The department of Mobility and Public Works (MOW), *Maritime Access Division*, is responsible for the fairways and for ports 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 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 concluded on 12 June 1990 between the Flemish Region and the federal State. This agreement was modified by the cooperation agreement of 6 September 2000.

The procedure for obtaining a permit to dump dredged materials at sea has been stipulated by the royal decree 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*).

3.2 Spatial use

In the Marine Spatial Plan (MSP, royal decree of 20 March 2014, also see *Van de Velde et al. 2014*), 5 sites for sediment dumping have been demarcated: *Bruggen en Wegen*, Zeebrugge Oost, Ostend, Nieuwpoort, S1 and S2 (see figure 2) (*Lauwaert et al. 2014*). In the MSP, an area west of the port of Zeebrugge is reserved as an alternative dumping site to reduce the reflux of dredged sediments.

In 2013, a dumping experiment commissioned by the Marine Access division was conducted to investigate the alternative dumping site west of Zeebrugge. The results of this experiment will be made available in 2015. In *Van Hoey et al. (2014a)*, the impact of a potential new dumping site on shrimp fishing in the region west of Zeebrugge has been investigated.

3.3 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 ships, it is necessary to regularly maintain the channels to the ports, as well as to deepen and widen these fairways. Each year, the Flemish government invests about 200 million euros to safeguard the accessibility of the ports (including the Scheldt Estuary, see figure 3, *Merckx & Neyts 2014*). The accessibility of

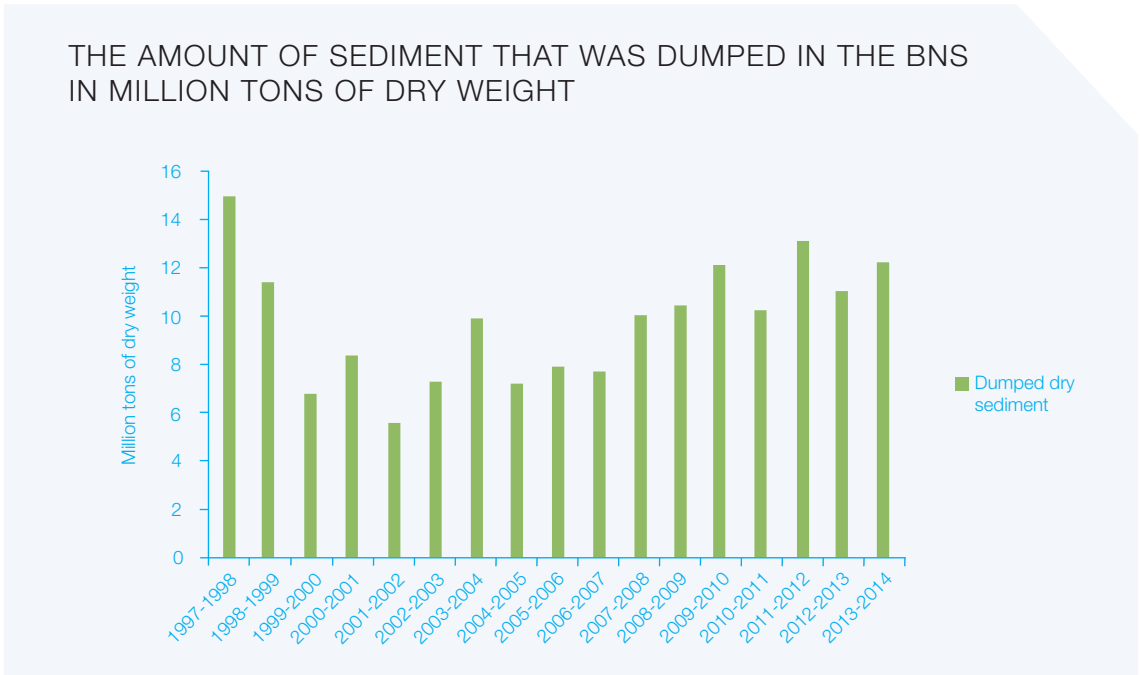

Figure 1. The amount of sediment that was dumped in the Belgian part of the North Sea, in tons of dry weight (Source: MUMM - RBINS).

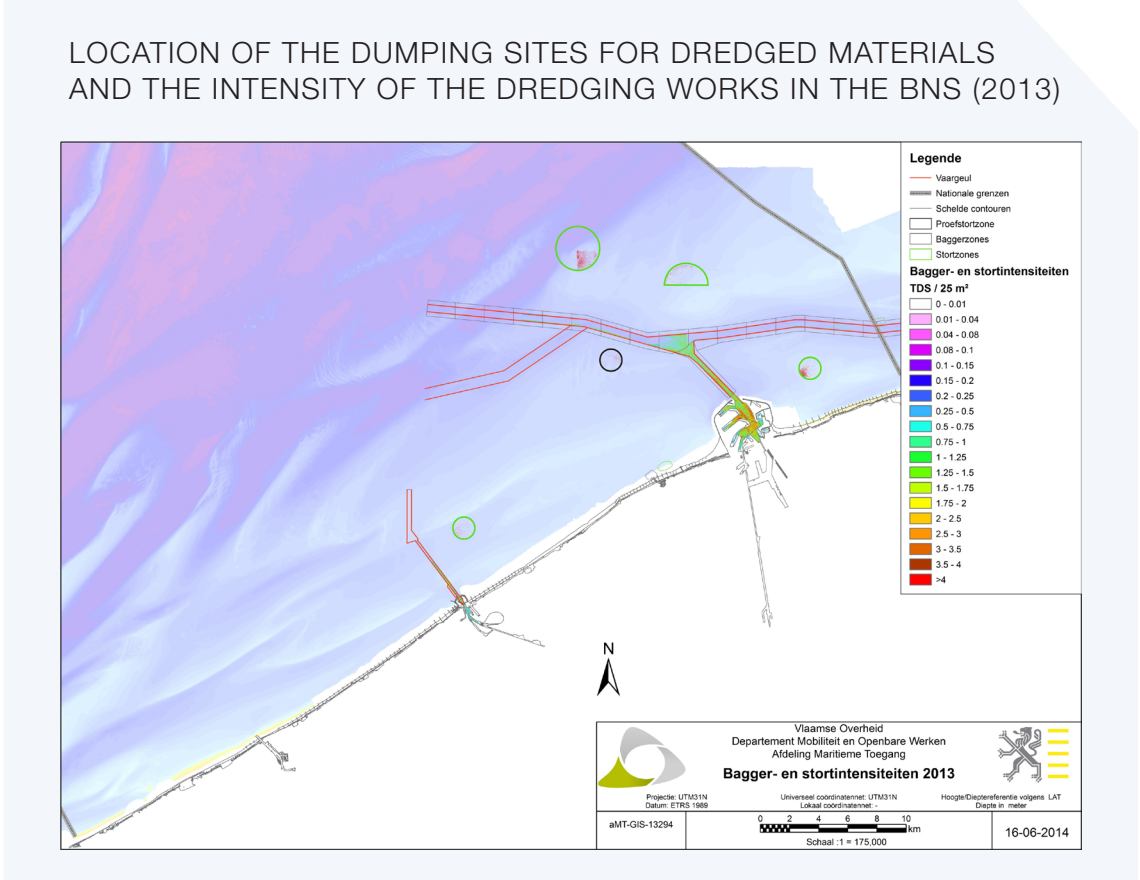

Figure 2. The location of the dumping sites for dredged sediments and the intensity of dredging in the BNS in 2013 (Source: Maritime Access division).

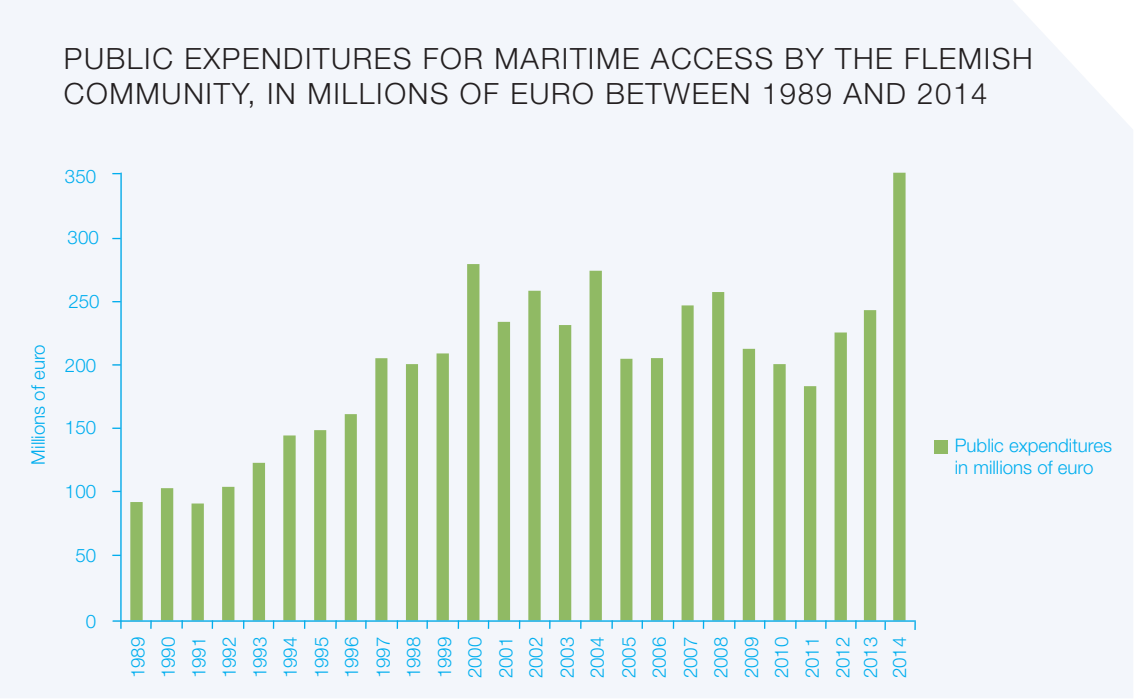

Figure 3. The government spending on maritime access by the Flemish Community in millions of euro between 1989 and 2014 (in 2014 rates) (Source: *Merckx & Neyts 2015*, after: Flemish Community, department MOW, Maritime Access division).

the Flemish ports of Ostend, Zeebrugge, Ghent and Antwerp is guaranteed by the *Martime Access division* of the MOW department. The tasks of this department include maintenance dredging works, wreck salvage, deepening of the channels and sludge processing (also see decision of the Flemish Government of 13 July 2001). The ministerial decrees of 28 December 2011 granted 4 permits for the dumping of 26.450 million tons of dry weight at 4 dumping sites in the BNS to the Maritime Access division from 1 January 2012 until 31 of December 2013. In addition, the agency for Maritime and Coastal Services was granted 4 permits for the dumping of a total of 1,970,000 tons of dry weight during this period (also see ministerial decree of 15 September 2012). Both permit holders together dumped 10,349,961 and 11,845,573 tons of dry weight in 2012 and 2013 respectively. The above-mentioned permits regarding the amount of dredged materials the Maritime Access division and the Coastal division are allowed to dump, (ministerial decrees of 28 December 2011 and the ministerial decree of 15 September 2012) have been prolonged until 31 December 2016 by the ministerial decree of 19 December 2013.

Belgium and the Netherlands together have access to the largest and most modern dredging fleet in the world. The feasibility study (*haalbaarheidsstudie, 2010*) of the non-profit organization Flanders Marine (the current Flanders Marine Cluster) indicates that in 2008, 2.9% of the total direct employment in the marine/maritime sector in the Flemish Region was situated in the dredging sector.

3.4 Impact

The most common type of dredging ship which is used for the maintenance of fairways is the trailing suction hopper dredger. This ship is equipped with big suction pipes and a large dredge head that functions as an enormous hoover, sucking the sediment out of the channels. In this process, the sediment is removed until the minimum guaranteed nautical depth is achieved, including a small margin to anticipate sudden sedimentation. The sediment ends up in the hopper of the ship and can be dumped at the licensed dumping sites by opening the doors or slides. In certain cases the sediment can be taken ashore. Besides the trailing suction hopper dredger, the cutter suction dredger is also commonly used for deepening work. This is a stationary or autonomous vehicle that removes material from the seabed by using a rotating cutting head.

The nature of the dredged sediment varies according to the location along the coast. The dumping site in Nieuwpoort is characterized 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%). The dredged materials are checked for heavy metals, PCBs and pesticides. Between 2009 and 2010, the lead and PCB levels were exceeded at a few sites (*Van Hoey et al. 2012*).

The dredging and dumping activities have a physical, chemical and biological impact on the marine environment (*Lauwaert et al. 2014* and table 1). The impact of dredging and dumping activities on other users is discussed in *Verfaillie et al. 2005* (*GAUFRE project BELSPO*) and *Van Hoey et al. (2014a)*.

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

ENVIRONMENTAL IMPACT	LITERATURE
Physico-chemical impact: changes in seabed morphology and composition (grain size) and sedimentological effects (sediment plumes, turbidity, release of contaminants, etc.)	*Lauwaert et al. 2002*, *Fettweis et al. 2003 (MOMO)*, *Fettweis et al. 2004a (MOMO)*, *Fettweis et al. 2004b (MOMO)*, *Lauwaert et al. 2004*, *Fettweis et al. 2005a (MOMO)*, *Fettweis et al. 2005b (MOMO)*, *Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *Fettweis et al. 2006a (MOMO)*, *Fettweis et al. 2006b (MOMO)*, *Lauwaert et al. 2006*, *Fettweis et al. 2007a (MOMO)*, *Fettweis et al. 2007b* (*MOCHA project BELSPO*), *Goffin et al. 2007*, *Du Four & Van Lancker 2008*, *Fettweis et al. 2008a (MOMO)*, *Fettweis et al. 2008b (MOMO)*, *Lauwaert et al. 2008*, *Fettweis et al. 2009a (MOMO)*, *Fettweis et al. 2009b (MOMO)*, *Fettweis et al. 2009c (MOMO)*, *Lauwaert et al. 2009*, *Van Hoey et al. 2009*, *Fettweis et al. 2010 (MOMO)*, *André et al. 2010*, *Fettweis et al. 2011a (MOMO)*, *Fettweis et al. 2011b (MOMO)*, *Fettweis et al. 2011c*, *Lauwaert et al. 2011*, *Fettweis et al. 2012 (MOMO)*, *Fettweis et al. 2013a (MOMO)*, *Fettweis et al. 2013b (MOMO)*, *Fettweis et al. 2014a (MOMO)*, *Fettweis et al. 2014b (MOMO)*, *Lauwaert et al. 2014*, *Vanhellemont & Ruddick 2015*, *Fettweis et al. 2015 (MOMO)*
Biological impact: effects on fauna and flora (disruption of benthos, influence of released contaminants, etc.)	*Seys 2002*, *Lauwaert et al. 2002*, *Lauwaert et al. 2004*, *Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *Lauwaert et al. 2006*, *Lauwaert et al. 2008*, *Lauwaert et al. 2009*, *Van Hoey et al. 2009*, *André et al. 2010*, *Lauwaert et al. 2011*, *Van Hoey et al. 2012*, *De Witte et al. 2013a*, *De Witte et al. 2013b*, *Lauwaert et al. 2014*

3.5 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 northeastern part of the Atlantic Ocean (including the North Sea). OSPAR has also issued guidelines for the sustainable use of dredged materials (*OSPAR Guidelines for the management of Dredged Material 2009*).

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 important pollutants. In the MSFD, some of the descriptors for a good environmental status (GES) of the marine environment are relevant for dredging and dumping: seafloor integrity (more information: *Rice et al. 2010*), underwater noise and other forms of energy (more information: *Tasker et al. 2010*), concentrations of contaminants (more information: *Law et al. 2010*) and the permanent alteration of the hydrographical conditions. In the Marine Strategy Framework Directive (MSFD), changes in siltation due to dredging and dumping activities are incorporated in the list of pressures and impacts. The implementation of the MSFD in Belgian legislation is provided by the royal decree of 23 June 2010 (see theme **Nature and environment**). 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, given the obligation of an assessment before the execution of a project. *Van Hoey et al. (2014b)* elaborates on the Benthic Ecosystem Quality Index (BEQI) in the framework of the WFD, MSFD and Habitats Directive 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. The royal decree of 12 March 2000 stipulates that a synthesis report must be presented to the competent minister every five years. In this report, 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*). Moreover, the dredged material that is dumped needs to meet certain sediment quality criteria (*website MUMM*, *Goffin et al. 2007*, *OSPAR national action levels for dredged material 2008*). If the limits of three criteria are exceeded, the dredged material cannot be dumped in the sea. If the result of the analysis is situated between the target and the limit value, further analysis is required. About every 10 years, a large-scale monitoring programme is established to determine the sediment quality of dredging areas (*website MUMM*).

In the context of the permits, the license holder is subject to a monitoring and scientific programme. In the MOMO-programme, MUMM is responsible for the monitoring and modelling of cohesive sediment transport and the evaluation of the effects of dredging and dumping on the marine ecosystem (see *inter alia* *Fettweis et al. 2015 (MOMO)*). The Institute for Agricultural and Fisheries Research (*ILVO*) investigates the biological and chemical aspects and works on the optimization of the monitoring programme.

Currently, there is a movement 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 feeding methods 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

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
London Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	1972	1975
London Protocol	Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	1996	2006
OSPAR Convention	Convention for the protection of the Marine Environment of the North-East Atlantic	1992	1998

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

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

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 20 januari 1999	Wet ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Royal Decrees		
KB van 12 maart 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
KB van 23 juni 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 18 oktober 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
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
Ministerial Decrees		
MB van 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	
MB van 28 december 2011	Machtiging voor het storten van baggerspecie bij ministeriële besluiten van 28 december 2011	
MB van 19 december 2013	Machtiging voor het storten van baggerspecie Verlenging Bij ministerieel besluit van 19 december 2013	
Other		
Besluit van de Vlaamse Regering van 13 juli 2001	Besluit van de Vlaamse Regering betreffende de aanduiding van de maritieme toegangswegen en de bestanddelen van de haveninfrastructuur	2001-07-13/90
Samenwerkingsakkoord van 12 juni 1990	Samenwerkingsakkoord tussen de Belgische Staat en het Vlaamse Gewest ter vrijwaring van de Noordzee van nadelige milieu-effecten ingevolge bagger-specielossingen in de wateren die vallen onder de toepassing van de Conventie van Oslo	1990-06-12/38
Samenwerkingsakkoord van 6 september 2000	Samenwerkingsakkoord tot wijziging van het Samenwerkingsakkoord van 12 juni 1990 tussen de Belgische Staat en het Vlaamse Gewest ter vrijwaring van de Noordzee van nadelige milieu-effecten ingevolge bagger-specielossingen in de wateren die vallen onder de toepassing van de Conventie van Oslo.	2000-09-06/31

4

Sand and gravel extraction

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Up to 100 million m³ of marine sediments are extracted annually in the OSPAR Region (Northeast Atlantic Ocean and North Sea). These are mainly sand and gravel 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 (23.2 million m³ in 2013), the United Kingdom (16.0 million m³ in 2013), France (12.5 million m³ in 2013) and Denmark (7.7 million m³ in 2013) (*Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (ICES, WGEXT) 2014*). 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 1.5 and 3 million m³ and amounted to more than 5.5 million m³ in 2014 (Source: FPS Economy, Continental Shelf service). Due to the low quantities in extraction areas, gravel is not extracted (*Brochure Continental Shelf service 2014*).

4.1 Policy context

The sand and gravel extraction in the BNS is a federal competence that belongs to the FPS Economy, SMEs, Self-employed and Energy and is regulated by the law of 13 June 1969 (*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 (royal decree of 12 August 2000).

4.2 Spatial use

The various zones for sand and gravel extraction are legally demarcated in the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*). In order to monitor the impact on the environment, a reference zone where extraction is prohibited, has been delineated. This area is located on the Thornton Bank (see zone THBREF in figure 1).

The geographical demarcation and accessibility of the zones for the exploitation and exploration of mineral and other non-living resources in the territorial sea and on the continental shelf have been registered in the royal decree of 1 September 2004 (table 1 and figure 1, recently changed by the royal decree of 19 April 2014) (see also *Reglementering Zand- en Grindwinning in het BNZ 2014*). Prior to this demarcation, a study about the possible concession zones for sand extraction was conducted (*Schotte 1999*). In total, three control zones[1] 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. 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.

Table 1. An overview of the different control zones for sand extraction in the Belgian part of the North Sea (BNS) with their location and accessibility.

CONTROL ZONE	SECTOR	LOCATION	ACCESSIBILITY
1	A	Thornton Bank	Open, except for the area THBREF
2	KB	Kwinte Bank	Open, except for KBMA and KBMB
	BR	Buiten Ratel	Open, except for BRMC
	OD	Oostdyck	Open
3	A	Sierra Ventana	Open
	B	Sierra Ventana	Closed as long as the sector is used as a dumping site for dredged material
4	A	Noordhinder	Open
	B	Oosthinder	Open
	C	Oosthinder	Open
	D	Westhinder	Open

[1] A control zone is a legally defined area where sand extraction is allowed (see demarcation in the marine spatial plan – royal decree of 20 March 2014).

THE DEMARCATION OF THE CONTROL ZONES FOR SAND EXTRACTION ON THE BCS

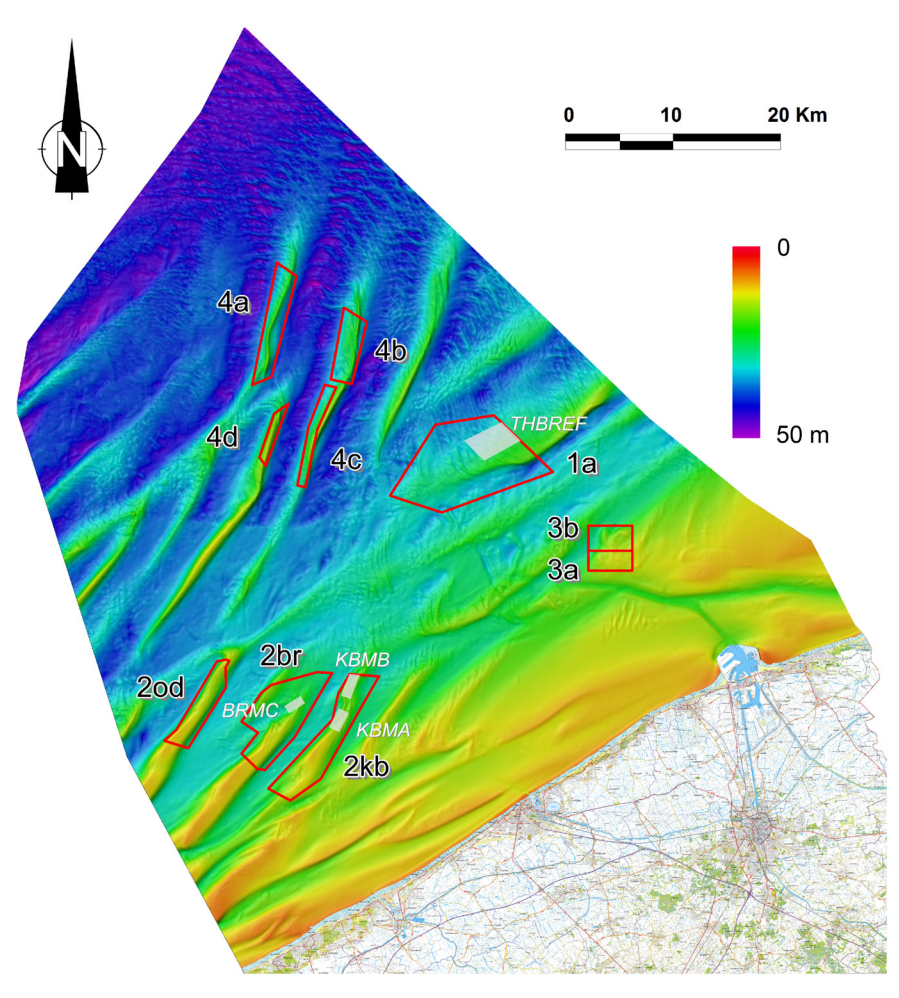


Figure 1. The demarcation of the control zones for sand extraction in the BNS (Source: website FPS Economy).

The offshore extraction of sand and gravel requires a concession permit (see 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 royal decree of 1 September 2004 concerning the granting procedure. Furthermore, the royal decree of 1 September 2004 about the environmental impact assessment (EIA) defines that an environmental impact report has to be submitted to the Management Unit of the North Sea Mathematical Models (*MUMM*) (RBINS) (*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*). The EIA by MUMM (*milieueffectenbeoordeling Pichot 2006*) is subsequently transferred to the minister/state secretary 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*) (see table 2).

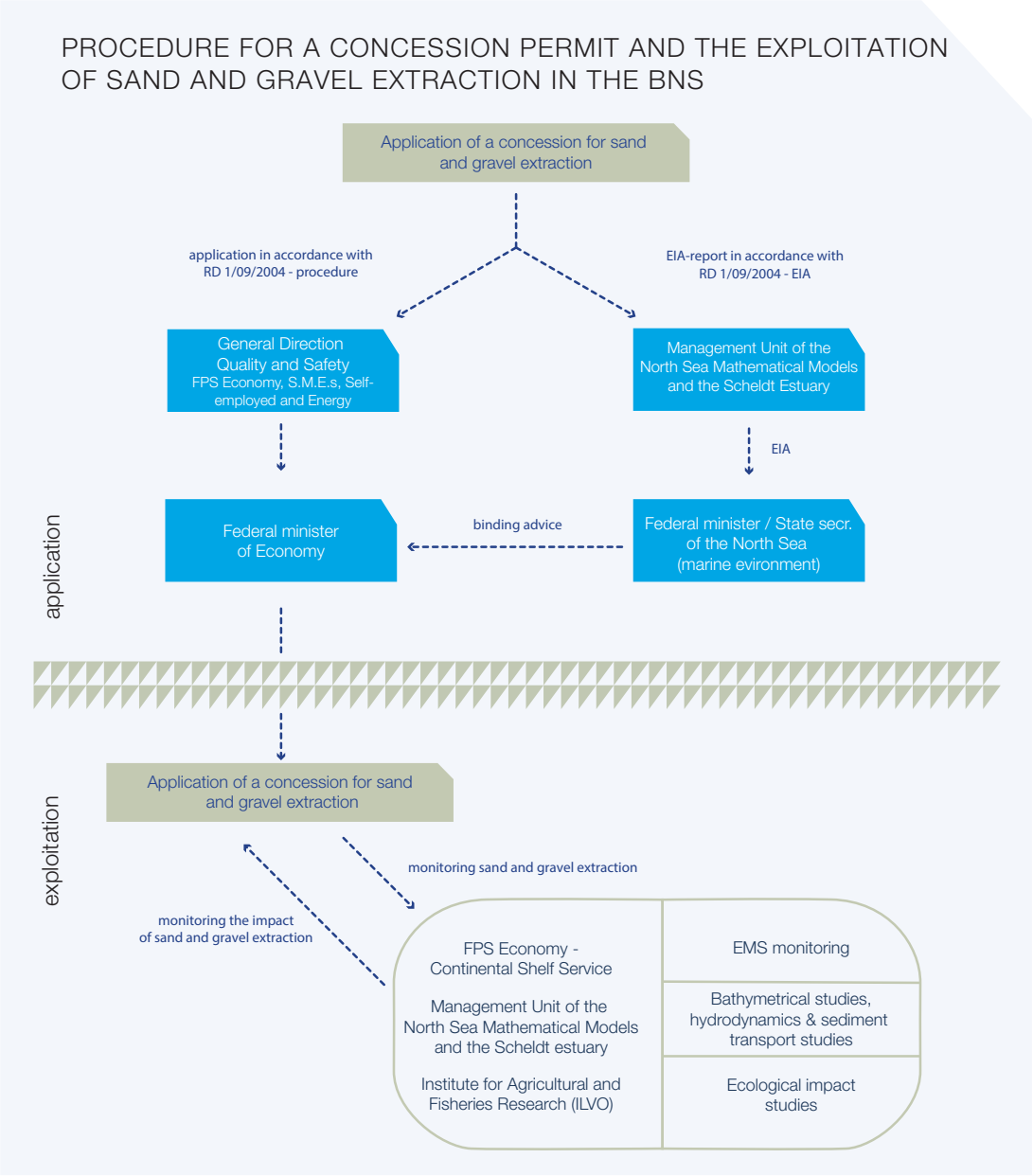


Figure 2. Flowchart of the procedure for a concession permit and the exploitation of sand and gravel extraction in the BNS (law of 13 June 1969 and associated implementation decisions).

4.3 Societal interest

The extraction of sand and gravel in the BNS has strongly increased over the past few years (see figure 3). In 1976, a sediment volume of 29,000 m³ was extracted; this volume amounted to 5.82 million m³ in 2014. A volume of approximately 4 million m³ was reached in 1997 due to the construction of submarine pipelines (Interconnector and Norfra) (*Goffin et al. 2007*, *André et al. 2010*, see also theme **Energy (incl. cables and pipelines)**). Between 2003 and 2010, more than 75% of the sediment was extracted in zone 2 with a gradual shift from sectors 2KB to 2BR. Furthermore, a significant volume of sand was exploited in zone 1 on the Thornton Bank (*Degrendele et al. 2014*). Currently, a maximum of 15 million m³ of sediment can be extracted in the control zones over a period of 5 years (this number does not take into account exceptional projects such as coastal protection). The extracted sediment is mainly landed in Flanders, although some sediment is also landed in ports in France and the Netherlands (up to 16% in 2007) (*De Smet et al. 2009*).

Table 2. An overview of the concessionaires for sand extraction in the BNS with the maximum extraction volume for 2015 (Source: FPS Economy, Continental Shelf service).

CONCESSIONAIRE	MAXIMUM EXTRACTION VOLUME FOR 2015
Betoncentrale Van den Braembussche NV	100,000 m³
Charles Kesteleyn NV	100,000 m³
Dranaco NV	100,000 m³
CEI - De Meyer NV (will merge into Van Oord Belgium NV)	140,000 m³
Satic NV	150,000 m³
De Hoop Bouwgrondstoffen BV c.o. Satic NV	150,000 m³
TV Zeezand Exploitatie NV	175,000 m³
Alzagri NV	200,000 m³
Flemish government – Maritime Access division	350,000 m³
Belmagri NV	500,000 m³
DC Industrial NV	500,000 m³
Nieuwpoortse Handelsmaatschappij NV	550,000 m³
DEME Building Materials NV	600,000 m³
CBR Cementbedrijven NV (division Sagrex)	600,000 m³
Flemish government – Coastal division	1,750,000 m³ and 2,000,000 m³ (Masterplan Coastal Safety)

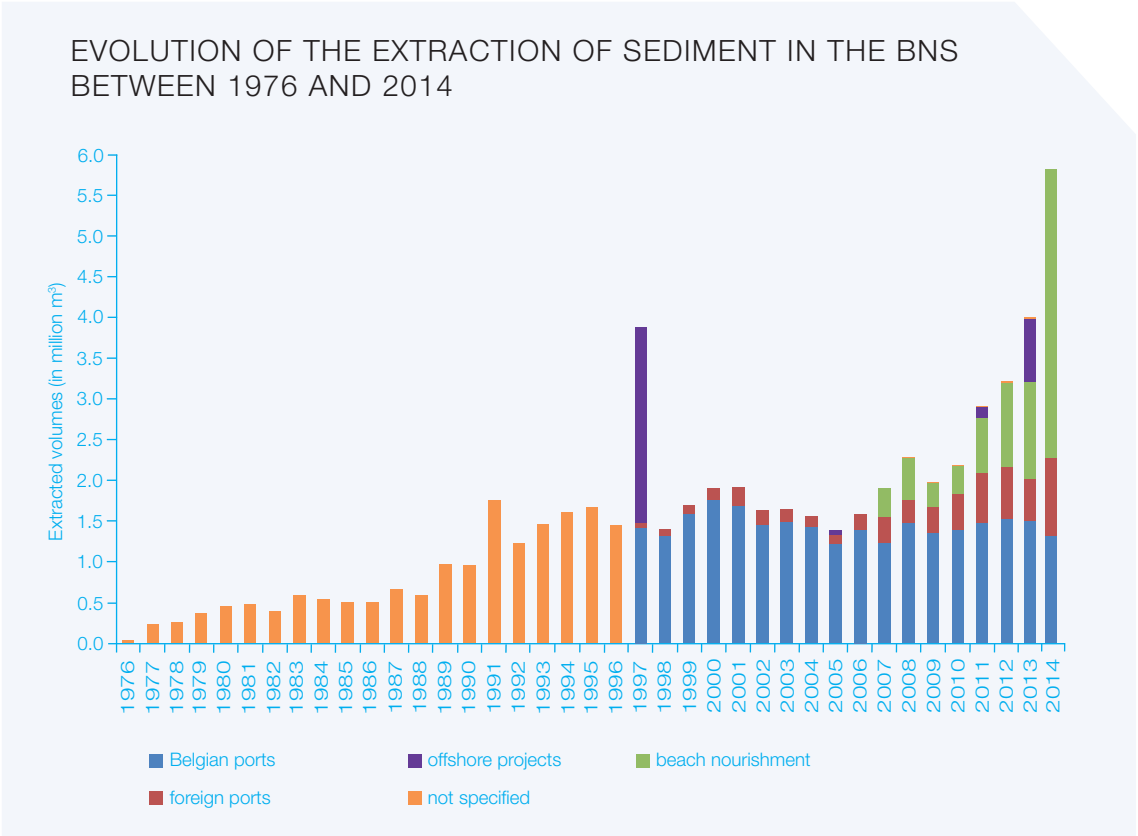


Figure 3. The evolution of the extraction of marine sand in the BNS between 1976 and 2014. Comment: Construction of submarine pipelines in 1991 and 1997 (Source: FPS Economy, Continental Shelf service).

The sediments from the BNS constitute an important source of construction materials. The application of the sediment mainly depends on the quality and the grain size. Sand is mostly used in the concrete industry (sand with a grain size of > 500 µm and with a certain distribution and consistency of the grain), but it can also be used as filling material or as raw material for asphalt production (*Van De Kerckhove 2011*, *Brochure Continental Shelf service 2014*). In recent years, the extracted sediments have also been used for coastal protection (beach nourishments) (*Van Quickelborne 2014*) and other maritime works such as the construction of offshore wind farms (*Vanden Eede et al. 2014*).

Recently, new concession zones have been defined in the Hinder Banks region. These zones should provide 35 million m³ of sediment over the next 10 years in the context of the Masterplan Coastal Safety and the OW plan (plan for the coastal safety and the maritime accessibility of Ostend) in Ostend (*MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ, 2010*, *Mathys et al. 2011*, *Rumes et al. 2011*). Sand which is used for beach nourishments usually has a grain size of 250-350 µm (D50) and ± 200 µm (D50) for foreshore replenishments (see theme **Safety against flooding**).

No recent data is available about the economic value of the sand extraction sector in the BNS. In a study by Zeegra vzw concerning the economic importance of sand extraction in the BNS (*het economisch belang van de sector van zandwinning op zee in België (2004)*), an estimation was made of the employment (295 persons), turnover (264,931,000 euro, based on 19 out of 22 companies that were active in the BNS) and gross value added (31,245,000 euro) in 2002. The feasibility study (*haalbaarheidsstudie, 2010*) of npo Flanders Marine (the current *Flanders Maritime Cluster*) gives a rough estimate of the employment in the sector of the extraction of natural resources compared to the total marine/ maritime sector in 2008.

4.4 Impact

The most commonly used vessel for sand extraction is the trailing suction hopper dredger, which makes channels of 1-3 m wide and 0.2-0.5 m deep in the seabed (*Degrendele et al. 2010*, *Newell & Woodcock 2013*). The royal decree 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 3 and 4).

Table 3. An overview of the effects of sand extraction on the environment.

ENVIRONMENTAL IMPACT	LITERATURE
Seabed and water (changes in the bathymetry, sedimentology, sediment plumes, turbidity, hydrodynamic regime, etc.)	*Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *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 & 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 & Baeye 2015*
Fauna, flora and biodiversity	*Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *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 & Mathys 2011*, *De Backer et al. 2014a*, *De Backer et al. 2014b*, *De Backer & Hostens 2014*, *Van Lancker et al. 2014a*, *Van Lancker et al. 2014b*, *Van Lancker et al. 2015*
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 & Mathys 2011*
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 & Mathys 2011*

Table 4. An overview of the effects of sand extraction on the other users.

IMPACT ON USERS	LITERATURE
Risks 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 & Mathys 2011*
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 & Mathys 2011*, *Van Haelst & Pieters 2014*
Interaction with other human activities (incl. coastal protection)	*Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *Verwaest & 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 & Mathys 2011*, *Vandenborre 2014*
Cumulative effects (e.g. in combination with activities in the offshore wind farms)	*MER voor de extractie van mariene aggregaten in de exploratiezone van het BNZ, 2010*, *De Sutter & Mathys 2011*, *Van Lancker et al. 2015*

4.5 Sustainable use

Within the OSPAR Region, all countries that extract sand and gravel on a large scale have 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 *Report of the Working Group on the effects of extraction of marine sediments on the marine ecosystem (ICES, WGEXT) 2003*). These also discuss nature conservation and spatial conflicts between 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*. Belgium is represented in this working group by *MUMM* (RBINS) and the Institute for Agricultural and Fisheries Research (*ILVO*).

At the European level, the impact on the marine environment caused by the extraction of sediments is also included in the Marine Strategy Framework Directive (2008/56/EC) (MSFD, see also royal decree of 23 June 2010) (*Degraer & Vanden Berghe 2014*). In the MSFD, several descriptors for a good environmental status (GES) are identified, some of which are relevant for the extraction of marine sediments: seafloor integrity (more information: *Rice et al. 2010*), underwater noise and other forms of energy (more information: *Tasker et al. 2010*) and the permanent alteration of the hydrographical conditions. Furthermore, the descriptors biodiversity (more information: *Cochrane et al. 2010*) and marine food chain (*Rogers et al. 2010*) are (indirectly) affected by the extraction of sediments. The selective extraction due to exploration and exploitation of living and non-living resources on the seabed and subsoil is listed among the pressures and impacts. The European Habitats Directive (92/43/EEC) (see also royal decree 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*) against pressures such as sediment extraction. 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 been incorporated into the monitoring programme (Flemish government) related to the sand extraction (*Van Lancker et al. 2014a*, *Van Lancker et al. 2014b*, *Van Lancker et al. 2015*). In the marine spatial plan (royal decree 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, and in the habititats directive area Flemish Banks the extraction activities have been limited (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 (*Brochure Continental Shelf service 2014*, *Reglementering Zand- en Grindwinning in het BNZ 2014*, *Degrendele et al. 2014*, *Van Lancker et al. 2014*, *De Backer et al. 2014*). Each concessionaire needs to pay a fee in proportion to the extracted volume. This fee is used to fund the ongoing research on the impact of exploitation and exploration

activities on the marine environment and the seabed (*Degrendele 2008*, *Brochure Continental Shelf service 2014*, *Reglementering Zand- en Grindwinning in het BNZ 2014*). Every three years, the monitoring results are presented at a conference organized by the Continental Shelf service (e.g. *De Mol & Vandenreyken 2014*).

The extraction activities are controlled by means of the registers of the dredgers on the one hand and by means of the '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. 2014*). This system was introduced in 1996, modernized in 2014 and is managed by MUMM, as commissioned by the Continental Shelf service (*Degrendele 2008*, *Degrendele et al. 2014*). Furthermore, the physical impact of extraction on the seabed is monitored by the Continental Shelf service and MUMM. The sediment volumes in the control zone are followed up by means of the research vessel Belgica. 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 (*De Mol et al. 2014*). 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*). The biological environment research group of 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 & Hostens 2014*). In exploitation zone 4 (demarcated in 2010) an elaborate 'baseline' study has been executed to estimate the impact of the current extraction activities (*Mathys et al. 2011*, *Van Lancker et al. 2014a*).

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), QUEST4D (*Van Lancker et al. 2009*, *QUEST4D project BELSPO*) and *TILES* (*TILES project BELSPO*) (*Van Lancker et al. 2014b*) contribute to a better understanding of the impact and a sustainable management of the sand and gravel extraction. In the *TILES* project a harmonized geological basic knowledge is developed which supports natural resource management in the Belgian and Dutch part of the North Sea in the long term. The basis of this project is constituted by 3D geological models that map the quality and quantity of the exploitable geological layers. By linking this to numeric impact models, threshold values are defined with regard to sustainable exploitation. The generated knowledge and information will be made available in a multi-criteria decision support system.

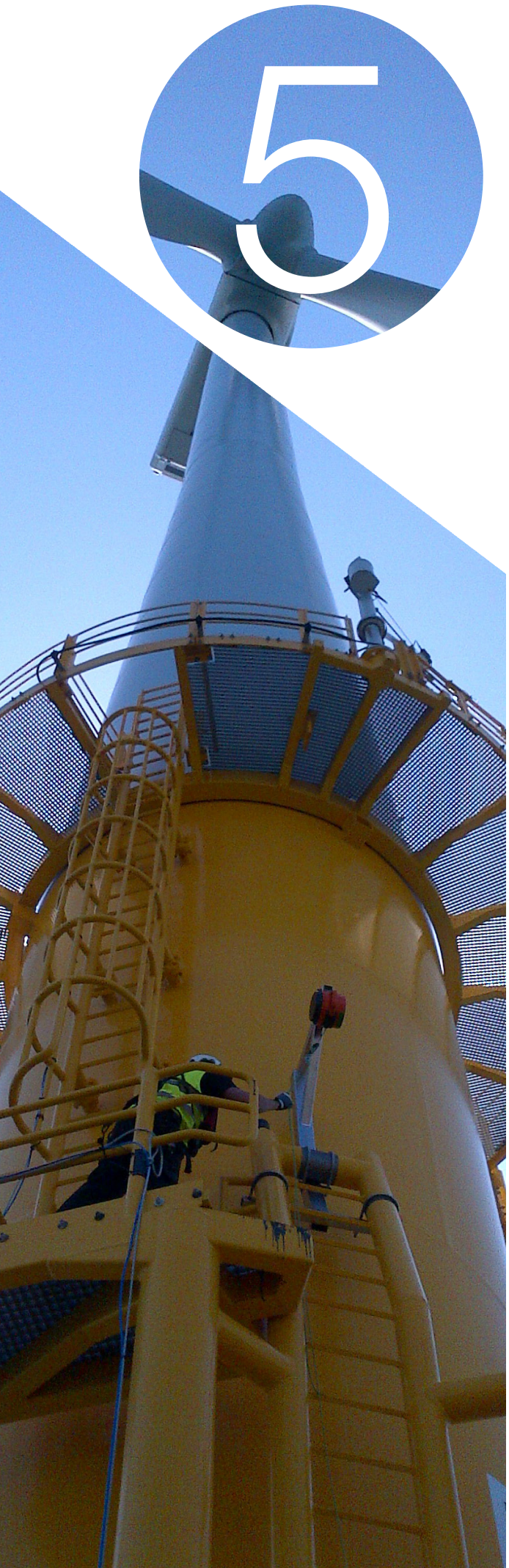
Legislation reference list

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
EIA Directive	Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment	1985	337
Habitats Directive	Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Marine Strategy Framework Directive	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 13 juni 1969	Wet inzake de exploratie en exploitatie van niet-levende rijkdommen van de territoriale zee en het continentaal plat	1969-06-13/30
Royal Decrees		
KB van 12 augustus 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
KB van 1 september 2004 – toekenningsprocedure	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
KB van 1 september 2004 – milieueffectenbeoordeling	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
KB van 14 oktober 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
KB van 23 juni 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
KB van 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



5 Energy (including cables and pipelines)

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Citation:

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5.1 Offshore wind energy

Europe is the world leader in the offshore wind energy sector. In 2014, 2,488 turbines were installed and connected to the power grid in the European seas, with a total installed capacity of 8,045.3 MW. These wind turbines are distributed over 74 wind farms in 11 different countries (*The European offshore wind industry, EWEA 2015*). The UK, Germany and Denmark are currently the main actors in Europe regarding offshore wind energy. In Belgium, three wind farms (C-Power, Belwind and Northwind) were operational at the end of April 2014 totalling 182 wind turbines and a total installed capacity of 712 MW, which ranks us fourth in Europe (*The European offshore wind industry, EWEA 2015*). In 2015, part of the Belwind concession zone was transferred to *Nobelwind*.

In the following years, five additional offshore wind farms are scheduled to be constructed: Seastar, Mermaid, Northwester 2, Norther and Rentel. When all of these projects will be realised (prognosis: 2020), their total capacity will be around 2,200 MW with a production of 8 TWh each year. This corresponds to 10% of the total Belgian electricity consumption (*Vande Velde 2014*).

5.1.1 Policy context

At the European level, the policy with regard to energy is developed by the *Directorate-General for Energy*. An important aspect of this policy is the strategy regarding sustainable energy (including offshore wind turbines). A crucial instrument in this context is directive 2009/28/EC concerning the promotion of the use of energy from renewable sources. This directive stipulates that Belgium should incorporate 13% of renewable energy into its final energy consumption by 2020[1]. Furthermore, the directive also determines that each member state needs to elaborate a national action plan on how to reach the renewable energy goals (*nationaal actieplan België hernieuwbare energie 2010*).

Besides, the Directorate-General for Maritime Affairs and Fisheries (*DG MARE*) has developed the so-called Blue Economy 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) 08).

The policy concerning renewable energy is a regional competence (*Vlaamse beleidsnota energie 2014-2019*). However, as the Belgian North Sea (BNS) is a federal competence, the policy with regard to offshore wind energy is developed on the federal level by the minister responsible for energy and the minister (or state secretary) responsible for the North Sea (*FPS Economy, S.M.E.s, Self-Employed and Energy*, more information about the division of competences: *het nationaal actieplan hernieuwbare energie 2010*).

The websites of the Commission for the Regulation of Electricity and Gas (*CREG*) and the *FPS Economy* provide an overview of European and national legislation on the electricity market.

5.1.2 Spatial use

Prior to the installation of the wind farms, a study was conducted with regard to the seabed, wind supply and grid capacity in the available areas for an optimal development of the offshore wind energy (*Le Bot et al. 2004*, *project BELSPO*). This kind of survey is *inter alia* important for the selection of the foundation type of the turbines (*Van de Walle 2011*). In addition, the spatial needs of other users of the sea need to be considered as well (see section on **Impact**).

The spatial demarcation of the zones selected for the installation of the wind farms in the BNS is tackled in figure 1 and table 1 and 2.

In order to actually realise an offshore wind farm, a project must have multiple permits. Currently the following federal permits are required:

- A ministerial decision for the granting of a concession zone by the minister responsible for Economy;
- A ministerial decision for the granting of a permit for the construction of the wind farm, the cables and the

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

operation by the minister (or state secretary) responsible for the North Sea. This decision is based on an Environmental Impact Assessment (EIA) and an advice from MUMM (RBINS);
- (A ministerial decision for the granting of a permit for the installation of offshore cables by the minister responsible for Economy (see also **Pipelines and cables**)).

PROCEDURE WITH REGARD TO CONCESSION ZONES

Each project should also pass the procedure for the designation of a concession zone for the proposed project area (figure 2). This procedure and the conditions for the granting of a concession have been stipulated in the royal decree of 20 December 2000. As a result of a modification by the royal decree of 28 September 2008, applications for a concession zone for the construction and operation of offshore installations in the BNS have to be directed to and are handled by the delegate of the Minister, who subsequently advises the Minister responsible for Energy (see also the ministerial decree of 16 March 2009).

Table 1. History of the spatial demarcation of the concession 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 the North Sea and Energy were given the task to demarcate areas for offshore energy farms
RD of 17 May 2004	Demarcation of an area for offshore wind farms of 260 km²
Cabinet of 3 December 2010	Ministers responsible for the North Sea and Energy were given the task to adjust the northwestern 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 the zone of the RD of 17 May 2004 with the subsequent adjustments by the RD of 3 February 2011, was included (see also *Van de Velde et al. 2014*)

Table 2. An overview of the location and use of space of the various concession zones for offshore wind farms in the BNS (*Brochure FPS Economy*, website *MUMM*, see also EIAs of the different wind farms in the section Impact).

PROJECT NAME	LOCATION	TOTAL AREA (excl. safety zone)	WATER DEPTH	DISTANCE TO THE COAST
Mermaid	Northwest of the Bligh Bank	16.7 km²	24.5 - 39.5 m	50 km
Northwester 2	Northwest of the Bligh Bank	11.7 km² (potential expansion in EIA to 15.2 km²)	24.2 - 39.9 m	46 km
Belwind / Nobelwind	Bligh Bank	35.6 km²	15 - 37 m	46 - 52 km
Seastar	In between the Lodewijk Bank and the Bligh Bank	18.4 km²	22 - 38 m	38 km
Northwind (formerly Eldepasco)	Lodewijk Bank	9.0 km²	16 - 29 m	37 km
Rentel	Southwest Schaar	18.4 - 27.3 km²	22 - 38 m	31 km
C-Power	Thornton Bank	13.7 - 18.1 km²	12 - 27.5 m	30 km
Norther / North Sea Power	South of the Thornton Bank	28.2 km²	14 - 30 m	21 km
Total area reserved for wind farms (incl. safety zones)		238.0 km²		

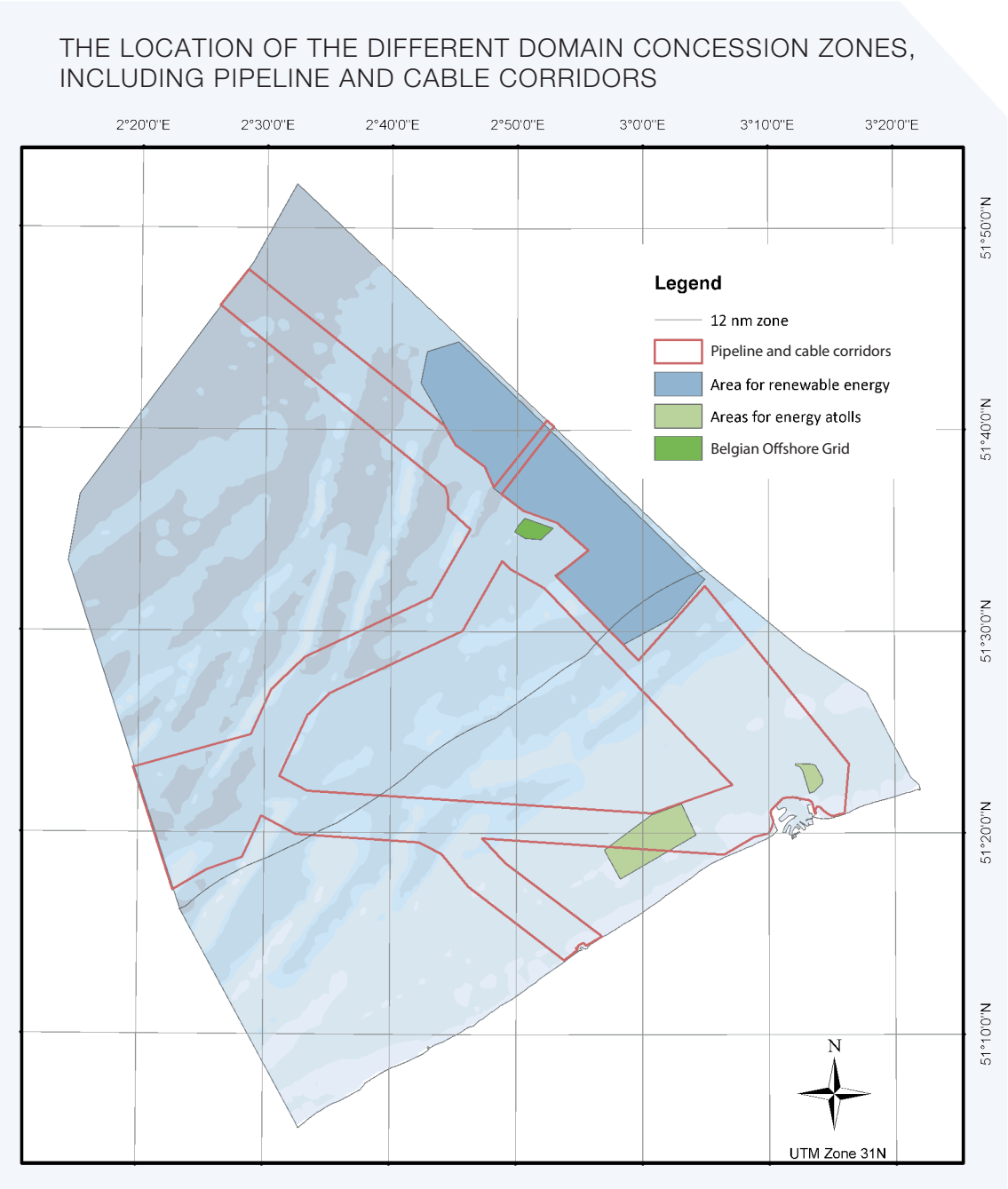

Figure 1. The location of the concession zones for wind farms and energy atolls, the Belgian Offshore Grid and the pipeline and cable corridors in the BNS (Source: KBIN/IRSNB, *marineatlas.be*, based on RD of 20 March 2014).

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 royal decree of 7 September 2003 (procedure for the licensing and authorisation of certain activities in the BNS) and the royal decree of 9 September 2003 (rules of the environmental impact assessment). The environmental impact assessment (EIA) is performed by the Management Unit of the North Sea Mathematical Models (MUMM, RBINS) which subsequently advises the competent minister (or state secretary) (*website MUMM*).

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. Moreover, a notification of this authorisation should be made in accordance with the applicable law. If any of the additional required permits or final permissions are refused, the concession zone expires on the date of notification of this refusal. In Belgium, 8 concession zones have already been granted to different project developers (table 2).

In Belgium, a ban on regular shipping (not wind farm related) has been established in the zone of the offshore wind turbines as well as in areas reserved for installations for hydro-electric energy storage (so-called energy atolls) and offshore substations of the network operator (royal decree of 11 April 2012). From the operational phase onwards, a safety zone of five hundred meters (measured from the outer boundary) is established around artificial islands, installations or infrastructure for the generation of energy from water, currents and winds (e.g. offshore wind farms) (decree of 11 April 2012).

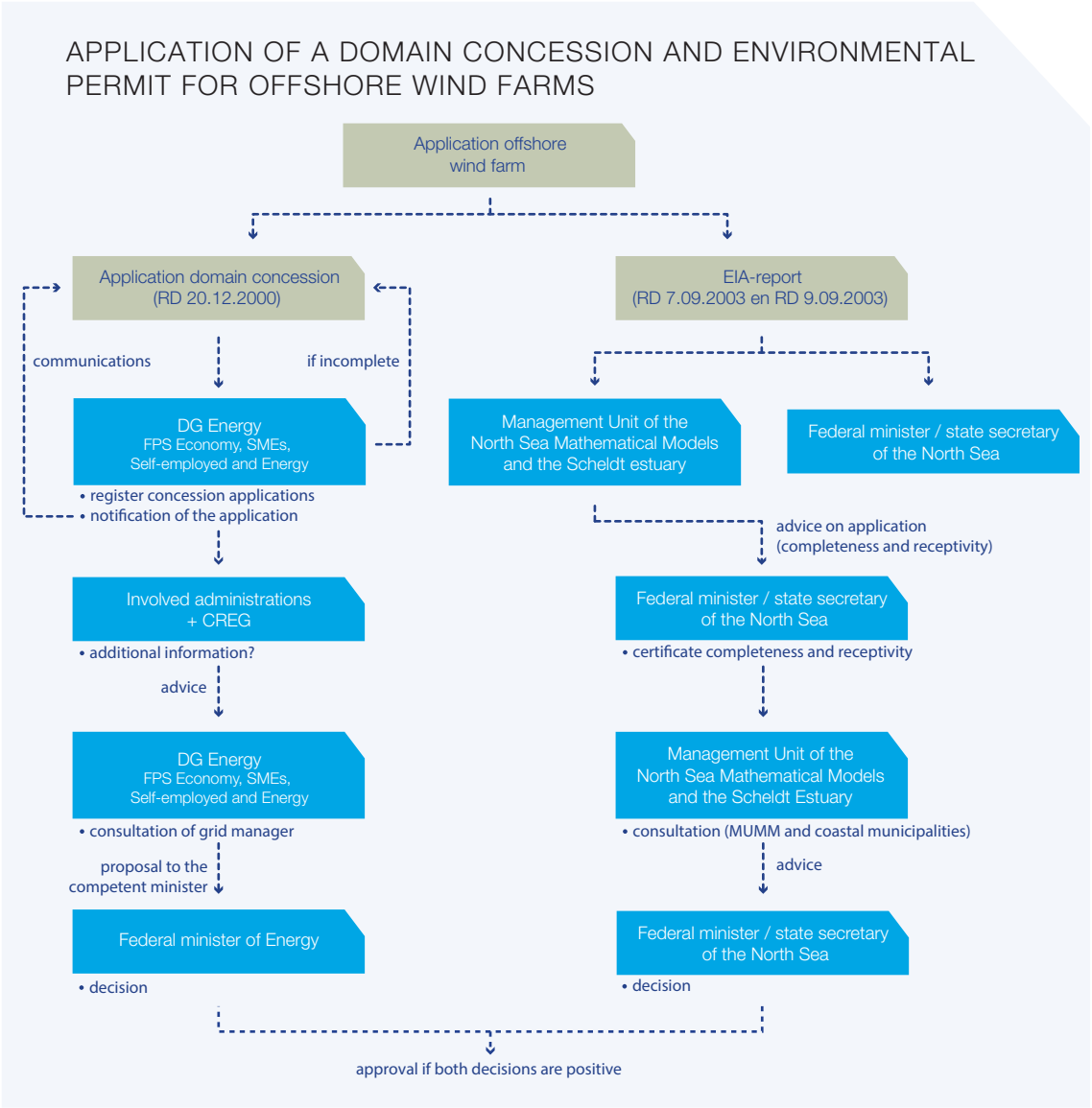

Figure 2. Flowchart for the application of a concession zone and environmental permit for offshore wind farms (RD of 20 December 2000, RD of 9 September 2003).

5.1.3 Societal interest

THE ENERGY PRODUCTION OF OFFSHORE WIND FARMS

Based on the European member states' national action plans for renewable energy, 494.6 TWh of electricity will be produced by wind energy by 2020, of which 133.3 TWh will be generated offshore. It is possible that by 2030 more capacity will be present offshore than on land. In total, 4% and 14% of the demand for energy in the EU could be covered by offshore wind energy by 2020 and 2030 respectively (COM (2012) 494, see also *study energy potential EEA*).

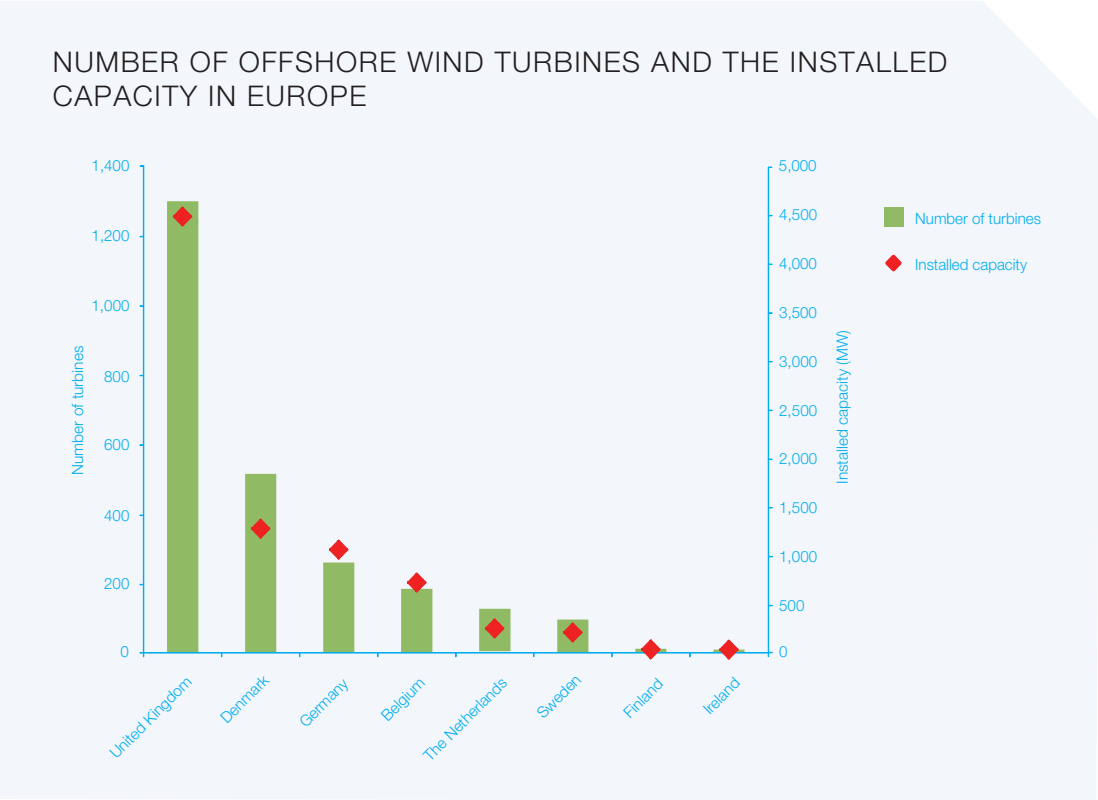

Figure 3. The number of offshore wind turbines and the installed capacity in Europe in 2014 (*The European offshore wind industry, EWEA 2015*).

The total capacity that could potentially be installed in the BNS was first assessed in 2009 by *Mathys et al. (2009)* (*OPTIEP-BCP project BELSPO*). The total capacity of all projects that were granted a concession zone by 2014 amounts to around 2.2 GW, but this figure may vary depending on the configuration of the farms (table 3, *Brochure FPS Economy*). In 2014 two wind farms were completely operational and one was partially operational, totalling an installed capacity of 712.2 MW (*The European offshore wind industry, EWEA 2015*) (figure 3). The annual production of wind farms that are currently operational is given 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).

In Belgium around 5,000 jobs were created during the construction of the first three wind farms. The construction of an average offshore wind farm (300 MW) generates approximately 1,400 direct jobs during its development and construction phase and an equal amount of indirect jobs. The exploitation phase creates on average 100 new jobs for every wind farm. Hence, the realisation of the 8 planned farms could lead to around 20,000 temporary workplaces (expressed in man year) and 800 new, permanent jobs during exploitation (minimum of 20 years) (*Vande Velde 2014*).

Table 3. An overview of the status, the number of turbines and the total capacity of the wind farms in the BNS (website *MUMM*, see also EIAs of the various wind farms in the section Impact).

PROJECT NAME	STATUS	NUMBER OF TURBINES	TOTAL CAPACITY	ANNUAL PRODUCTION
C-Power	Operational since 2009, completely operational since 2013	54	325 MW	1,050 GWh/year (electricity for 300,000 households)
Northwind (formerly Eldepasco)	Completely operational since 2014	72	216 MW	875 GWh/year (electricity for 250,000 households)
Belwind / Nobelwind	Phase 1: operational since December 2010 Phase 2: construction planned for 2016 (Nobelwind)	111	336 MW	550 GWh/year (electricity for 160.000 households)
Rentel	Concession and environmental permit granted Construction planned for 2017	47 - 78	289 - 468 MW	
Norther / North Sea Power	Concession and environmental permit granted Construction planned for 2017	47 - 100	258 - 470 MW	(electricity 300.000 households)
Seastar	Concession and environmental permit granted Construction planned for 2018	41	246 MW	
Northwester 2	Concession granted	22 - 32	217 - 227 MW	
Mermaid	Concession granted Environmental permit (end of February 2015)	27 - 41	232 - 266 MW / 20 - 61 MW (capacity of pilot project wave power convertors)	900 – 1.200 GWh/ year

The construction of offshore wind turbines also increases employment in the port of Ostend, which focuses on services with regard to offshore energy. 180 new, mainly specialised workplaces were created by 2014 (*Gerard 2014*). It should be mentioned that economic activities related to the offshore wind farms are also being undertaken in the port of Zeebrugge. However, no statistics are available for this port.

5.1.4 Impact

The installation of wind farms in the BNS has a number of effects on the ecosystem and on the users of the sea (table 4 and 5). The impacts on the marine environment that should be addressed in the environmental impact assessment (EIA) have been stipulated in the royal decree of 9 September 2003 on EIA. The EIAs and related documents are available on the website of *MUMM* (table 4). In addition, numerous scientific studies have been conducted in order to elucidate the impact of wind turbines on the marine environment (table 5).

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

WIND FARM	ENVIRONMENTAL IMPACT REPORTS, EIAs AND ADDITIONAL DOCUMENTS
C-Power	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010*, *MEB C-Power 2004*, *MEB C-Power wijziging 2006*
Northwind (formerly Eldepasco)	*MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008*, *Di Marcantonio et al. 2009 – MEB Eldepasco*
Belwind / Nobelwind	*MER Offshore Windpark Bligh Bank. Belwind NV 2007*, *Di Marcantonio et al. 2007 – MEB Belwind*
Rentel	*Milieueffectenrapport windpark Rentel 2012*, *Rumes et al. 2012 – MEB Rentel*
Norther / North Sea Power	*MER Norther-project* and *wijzigingsMER*, *Rumes et al. 2011 – MEB Norther*
Seastar	*MER - windpark Seastar 2013*, *Rumes et al. 2013 – MEB Seastar*
Northwester 2	*MER Mermaid en Northwester 2*, *Rumes et al. 2015 – MEB Mermaid*
Mermaid	*MER Mermaid en Northwester 2*, *Rumes et al. 2015 – MEB Mermaid*

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

IMPACT ON THE ENVIRONMENT/USERS	LITERATURE
Effects on the hydrodynamic regime	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Van den Eynde et al. 2010*, *Verhaeghe et al. 2011*, *Van den Eynde et al. 2013*, *Vanhellemont & Ruddick 2014*, *Baeye & Fettweis 2015*
Effects on the sediment transport and geomorphology	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Van den Eynde et al. 2010*, *Verhaeghe et al. 2011*, *Van den Eynde et al. 2013*, *Vanhellemont & Ruddick 2014*
Underwater noise	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Norro et al. 2010*, *Norro et al. 2011*, *Verhaeghe et al. 2011*, *Haelters et al. 2012*, *Norro et al. 2012*, *Norro et al. 2013*, *Haelters et al. 2013a*, *Debusschere et al. 2014*
Effects on the fish and benthos (introduction of hard substrate, habitat loss, disturbance, etc.)	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Kerckhof et al. 2010*, *Reubens et al. 2010*, *Coates & Vincx 2010*, *Derweduwen et al. 2010*, *Reubens et al. 2011a*, *Kerckhof et al. 2011*, *Reubens et al. 2011b*, *Vandendriessche et al. 2011*, *Coates et al. 2011*, *Van Hoey et al. 2011*, *Verhaeghe et al. 2011*, *Kerckhof et al. 2012*, *Coates et al. 2012*, *Vandendriessche et al. 2012*, *Derweduwen et al. 2012*, *Coates et al. 2013a*, *Coates et al. 2013b*, *Vandendriessche et al. 2013a*, *Vandendriessche et al. 2013b*, *Reubens et al. 2013*, *Reubens 2013*, *Coates 2014*, *De Mesel et al. 2013*, *Rumes et al. 2013*, *De Mesel et al. 2015*
Effects on seabirds	*Stienen et al. 2002a*, *Stienen et al. 2002b*, *De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Everaert & Stienen 2007*, *Stienen et al. 2007*, *Vanermen et al. 2009*, *Brabant & 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*
Effects on marine mammals	*Stienen et al. 2002a*, *De Wachter & 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*
Impact on the water and air quality	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Verhaeghe et al. 2011*
Impact on the seascape	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Vanhulle et al. 2010*, *Houthaeve & Vanhulle 2010*, *Di Marcantonio et al. 2013*
Maritime safety	*De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *van Iperen & van der Tak (2009)*, *Verhaeghe et al. 2011* (see also **Maritime transport, shipping and ports**)
Spatial impact (e.g. conflicts with other users)	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Vandendriessche et al. 2011*, *Vandendriessche et al. 2013*

5.1.5 Sustainable use

MEASURES CONCERNING THE IMPACT ON THE MARINE ENVIRONMENT

On an international level, OSPAR has published a guide (*OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development 2008*) in which the impact of wind turbines on the marine environment is discussed. Within the context of the *ASCOBANS Agreement* (on the conservation of small cetaceans), the impact of wind turbines on marine mammals has been evaluated (*Evans 2008*). In 2009, a *resolution* was issued against the negative effects on marine mammals of underwater noise during the construction of offshore energy installations.

At the European level, the Marine Strategy Framework Directive (2008/56/EC) (MSFD) provides a framework to reduce or avoid the impact of offshore wind farms on the environment. In this context, underwater noise and other forms of energy are identified as one of the descriptors for a Good Environmental Status (GES) (*Tasker et al. 2010*). Other descriptors of the MSFD which are relevant for the installation and operation of offshore wind turbines are the integrity of the seabed (*Rice et al. 2010*), non-indigenous species (*Olenin et al. 2010*) and the permanent alteration of hydrographic conditions.

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 coordinated by MUMM and has a twofold objective:

- To adjust, reduce or even stop the activities if extreme damage to the marine environment occurs;
- To gain insight into the impact of offshore wind turbines on the environment to support the policy, management and design of future wind turbines.

The monitoring programme examines the physical, biological and socio-economic aspects of the marine environment (*Degraer & Brabant 2009*, *Degraer et al. 2010*, *Degraer et al. 2011*, *Degraer et al. 2012*, *Degraer et al. 2013*) compared to a reference condition (e.g. *De Maersschalck et al. 2006*, *Henriet et al. 2006*, *Van den Eynde 2005*).

Within the framework of the *action plan Zeehond (2012)*, the offshore wind turbines are used as a laboratory for testing the effects of artificial reefs and artificial resting places in order to increase the biodiversity and productivity. In the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*) the multiple use of space in wind farms is encouraged with opportunities for aquaculture, nature development, wave and tidal energy production, etc.

THE DEVELOPMENT OF OFFSHORE WIND ENERGY - CHALLENGES AND MEASURES

At the European level, a number of measures have been taken to stimulate the development of offshore wind energy. For example:

- The Strategic Energy Technology Plan (SET-plan, COM (2007) 723) – A strategic plan to accelerate the development of cost-efficient technologies with low carbon emissions.
- COM (2008) 768 on offshore wind energy – Action needed to deliver on the energy policy objectives for 2020 and beyond.
- In the context of the Integrated Maritime Policy (IMP, COM (2007) 575) a long-term strategy has been developed for sustainable growth in marine and maritime sectors (Blue Growth, COM (2012) 494). For the blue energy sector (e.g. offshore wind energy), measures have been drafted to maximise the potential of ocean energy in European seas and oceans by 2020 and beyond in COM (2014) 8.

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 the projects in the context of *Oceans of Tomorrow (2014)*.

The Belgian federal government has decided on a series of measures to stimulate the renewable energy production 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 that transmission system operator ELIA has to finance one third of the cost of the submarine cable, up to a maximum amount of 25 million euros per project (see also **Pipelines and cables**).

- The royal decree of 16 July 2002 develops a system for granting certificates which guarantee the origin of the produced energy as well as 'Green Current Certificates' (GCC) for electricity produced from water, currents or wind in the BNS. The Commission for the Regulation of Electricity and Gas (*CREG*) grants GCCs to energy producers that hold a concession zone and a certificate with a guarantee of the origin. Minimum prices have been established for the resale of certificates received for green energy production. For energy generated by offshore wind turbines, the network operator is obliged to purchase the GCCs at a minimum price of 107 euro/MWh for the production from the first 216 MW of the installed capacity and 90 euros/MWh from the installed capacity above the first 216 MW. This purchase obligation must constitute a part of the contract between the concessionaire and the network operator and should be approved by *CREG*.

The development of wind energy in the BNS has been limited by the challenges related to the connection to the electricity grid for several years. Both on land and offshore, there is a need for grid reinforcement (*Soens 2005*, *Mathys et al. 2009* (*OPTIEP-BCP project BELSPO*)). Within the Stevin project, network operator ELIA is working on an additional high-voltage power line connecting Zomergem and Zeebrugge (completion expected by 2017-2018), which should reinforce the 380 kV power grid (*Tant 2014*, *website ELIA*).

To date, offshore wind farms in the BNS have been individually connected to the electricity grid on land. However, a more coordinated system for connecting offshore energy to the mainland is being investigated, given the technological, economic and ecological advantages. An offshore meshed grid (Belgian Offshore Grid) has been suggested, in which wind farms are connected to high-voltage substations which are in turn connected to the onshore grid (*visie Elia offshore grid 2012*, *MER - Belgian Offshore Grid 2013*, *Aanvraagdossier Belgian Offshore Grid 2013*). The practical implementation of this Belgian Offshore Grid is currently elaborated in a Master Plan Offshore Cables (*Masterplan Zeekabels*) in cooperation with the involved wind farms and other involved stakeholders. The further development of this master plan also depends on the aforementioned Stevin project.

In the future, the construction of a meshed offshore power grid could be connected to an international DC platform. These connections enable the transport of larger capacities across greater distances. Neighbouring countries are currently also working on the expansion of grids in their part of the North Sea. This vision is in accordance with the energy policy of the European Commission and the *North Sea Countries' Offshore Grid Initiatief* in which 10 North Sea countries have signed a memorandum of understanding to develop an offshore network in the North Sea. This network will ensure the future supply of electricity and will provide the necessary onshore connections (*Brochure FPS Economy*, *Offshore Electricity Grid Infrastructure in Europe 2011*). Progress reports of this initiative can be found on *http://www.benelux.int/NSCOGI/*.

The development of the offshore wind farms is also supported by initiatives such as 'Factories of the Future' (*Fabrieken voor de Toekomst*) in which a Blue Energy Cluster was established by the West Flanders Development Agency (*POM West-Vlaanderen*). This cluster consists of the relevant players from government, industry as well as from the scientific field (*Dangreau 2014*). In the roadmap of the Blue Energy Cluster (*Vanden Berghe 2014*), a vision (2025) and gap analysis for this sector have been elaborated. Another initiative which supports the innovation with regard to the offshore wind farms concerns Offshore Wind Infrastructure Application Lab (*OWI-Lab*) which aims to increase the reliability and efficiency of offshore wind farms by investing in testing and monitoring equipment. Furthermore, a number of platforms and clusters which represent the blue energy and related sectors are active: e.g. *Flanders Maritime Cluster*, *Belgian Offshore Cluster* and *Belgian Offshore Platform*.

5.2 Natural gas installations in Zeebrugge

In Belgium, more than 17 billion m³ of natural gas is consumed each year and about 95 billion m³ of natural gas is reserved in the long term for border-to-border transport. This includes Dutch and Norwegian gas for France and Spain, British gas for continental Europe, Russian gas for the UK, 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 which is needed to supply the European Union (*België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010*). Currently, plans exist to expand the capacity in Zeebrugge using a fifth storage tank of 180,000 m³ LNG (Liquefied Natural Gas) (*Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*).

5.2.1 Policy context

The European policy on energy has been developed by the *Directorate-General for Energy*. An enumeration of the (European) legislations relevant to natural gas is given on the websites of *CREG* and *FPS Economy*.

The federal government (*FPS Economy, S.M.E.s, Self-employed and Energy*) is responsible for the large infrastructures for energy storage, transportation and production, and defines the policy with regard to the rate for the managers (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 concerning rates and the more technical aspects of network access (code of conduct) (for more information: *website Fluxys*, *website CREG*, *website FPS Economy*). Furthermore, there is a federal regulator: the Commission for the Regulation of Electricity and Gas (*CREG*). Flanders is competent for the public distribution of gas, which is managed by the so-called *intercommunales*, as well as for the rational use of energy (special law on institutional reform) (law of 8 August 1980) (more information: *website FPS Economy*).

5.2.2 Spatial use

The LNG terminal is located in the eastern part of the port of Zeebrugge. The peninsula on which the LNG terminal is located covers an area of approximately 32 ha (source: *niet-technische samenvatting MER LNG-terminal Zeebrugge*). At present, there are plans for an expansion with a new 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*). In the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*), space is provided for the expansion of the port of Zeebrugge which also hosts, in addition to the LNG terminal, the terminals of the Zeepipe and Interconnector gas pipelines (see theme **Pipelines and cables**).

5.2.3 Societal interest

Zeebrugge is a cornerstone in the supply chain of natural gas to Northwest Europe with the LNG terminal and the terminals of the Zeepipe and Interconnector gas pipelines (see theme **Pipelines and cables**). Furthermore, the Zeebrugge Hub is one of the leading short-term markets in Europe (*België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010*, *Brouwers et al. 2011*). In 2010, a total of 62 billion m³ of gas was traded in the Zeebrugge Hub (*Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011*).

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*). At present, there are plans for an additional storage tank of 180,000 m³ of LNG (*Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*). Fluxys has opted for a model of cooperation for the development of an LNG terminal in Dunkirk and participates for 25% in this project. A pipeline connection between the two terminals is being prepared through a new interconnection point in Alveringem and Maldegem.

5.2.4 Impact & sustainable use

The construction of natural gas installations in Zeebrugge implies a certain impact, both on the environment and on other users. These effects are discussed in the corresponding environmental impact assessments (EIAs, see *MER-databank Vlaamse Overheid*, *Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*).

In these EIAs, a number of measures have already been proposed to mitigate or avoid the environmental impact of the LNG terminal (see *MER-databank Vlaamse Overheid*, *Niet-technische samenvatting MER uitbreiding Fluxys LNG, Zeebrugge*).

There are a number of advantages with regard to natural gas as an energy source in comparison to fossil fuels (*website Fluxys*). The use of LNG as fuel for ships is being promoted, since it emits less harmful substances than diesel or heavy fuel oil (*Margarino 2014*, see theme **Maritime transport, shipping and ports**).

5.3 Pipelines and cables

In the OSPAR area, the 1,300 oil and gas platforms are connected with a pipeline network of more than 50,000 km (*OSPAR QSR 2010*). In the Belgian part of the North Sea (BNS), there are 3 gas pipelines with a total length of 163 km (*Verfaillie et al. 2005*, *GAUFRE project BELSPO*):

- The Zeepipe pipeline connects the Distrigaz terminal in the port of Zeebrugge to a pipeline on the Norwegian shelf and has a total length of 814 km;
- The Interconnector pipeline has a length of 215 km and is located between Zeebrugge and Bacton (south coast, UK);
- The Norfra pipeline (now also called Franpipe) is a 840 km long pipeline between the Norwegian shelf and the port of Dunkirk which partially crosses the BNS (*Maes et al. 2000*).

In addition, the North Sea and the North Atlantic Ocean are intersected by telecommunication and power cables. Telecommunication cables are mainly situated in the southern part of the North Sea, in the Celtic Seas and in the trans-Atlantic corridor. Power cables can be found in the North Sea and Celtic Seas (*OSPAR QSR 2010*). On the Belgian Continental Shelf (BCS), there are 27 telecommunication cables, 16 of which are in use, with a total length of 914 km (*Verfaillie et al. 2005*, *GAUFRE project BELSPO*). In the future, the share of power cables will increase due to the installation of offshore wind turbines (see **Offshore wind energy**). In early 2013, four cable licenses had already been delivered (2 C-Power cables, 2 Belwind cables, 1 Northwind cable and 2 Norther cables) of which three cables are in use (2 for C-Power, 1 for Belwind and 1 shared by Belwind and Northwind). The idea of a meshed electricity network (Belgian Offshore Grid) is elaborated in the Master Plan Offshore Cables (*Masterplan Zeekabels*) which coordinates the onshore connection of the wind farms that still need to be built. Finally, a submarine power cable will be realised between Belgium and the UK in the framework of the *NEMO project* (*Milieueffectenrapport - NEMO LINK 2012*, *Brochure NEMO-STEVIN 2013*).

5.3.1 Policy context

The procedure for the installation of power cables in the BNS has been stipulated in the royal decree of 12 March 2002 (see also ministerial decree of 8 May 2008) (figure 4). The applications are sent to the minister of Energy or his delegate. The documents for the application are 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 EIA is performed by the Management Unit of the North Sea Mathematical Models (MUMM).

The procedure for the construction of pipelines is determined by the law of 12 April 1965 on the transport of gas and other gaseous products by pipelines. This law has been supplemented by various royal decrees.

The agreement between Norway and Belgium with regard to the Norfra pipeline has been formalised in the law of 13 May 2003 and in the law of 19 September 1991 concerning the Zeepipe pipeline. The agreement related to the transport of gas in the Interconnector pipeline between Britain, Northern Ireland and Belgium has been formalised in the law of 26 June 2000. For an overview of the legislation with regard to the pipelines in the BNS, see *coastal codex, theme cables and pipelines*.

5.3.2 Spatial use

In the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*) a corridor has been demarcated in which cables and pipelines should be bundled as much as possible. Activities which interfere with the installation or exploitation of these cables and pipelines are prohibited in this zone. The spatial use in the proximity of power cables in the BNS is discussed in the royal decree of 13 March 2002 (table 6).

The connection points at the coast for power cables from offshore wind farms are located in Ostend (Slijkens) and Zeebrugge (Belwind and Northwind). For the remaining wind farms, the onshore connection is coordinated by the Master Plan Offshore Cables (*Masterplan Zeekabels*) which elaborates the practical implementation of the Belgian Offshore Grid. This master plan largely depends on the reinforcement of the power grid in the coastal area in the context of the Stevin project which plans a high-voltage connection between Zomergem and Zeebrugge (*Tant 2014*, *website ELIA*).

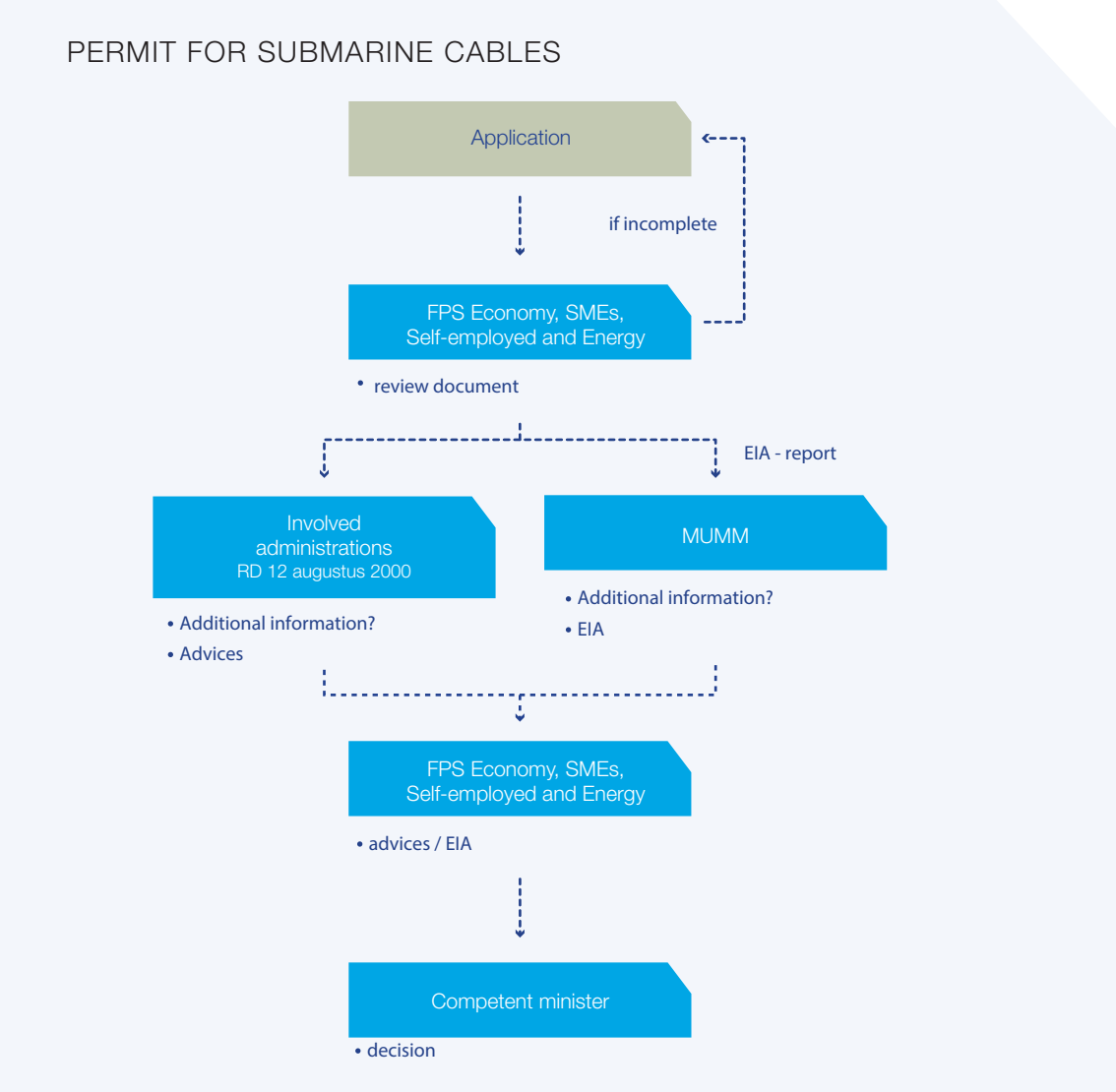

Figure 4. Flowchart of the permit for submarine cables (royal decree of 12 March 2002).

Table 6. An overview of the use of space in the BNS in the proximity of power cables (royal decree of 12 March 2002).

SPATIAL USE IN THE PROXIMITY OF POWER CABLES (RD of 12 March 2002)	
Protected area (250 m on either side)	**Reserved area (50 m on either side)**
Anchoring prohibited	No installation, no cable or pipeline construction
No activities that put the cable at risk (except the installation of a cable under certain conditions)	
Exception:	Exception:
Interventions by the owner in the framework of production	Unipolar cables on the same safety switch, arrival of cables from and departure of cables to a wind turbine in parallel with others, point of arrival from and departure to an infrastructure with one or more cables, convergence point of several cables that are part of the same mechanism to return to the mainland, repaired cables

5.3.3 Societal interest

Due to the increasing importance of offshore wind turbines (see also **Offshore wind energy – Societal interest**), there is a growing demand for submarine power cables for the transport of energy to the mainland. In addition, submarine cables are also important for transnational energy and communication networks (OSPAR QSR 2010).

The transport of gaseous products to our country takes place by means of submarine pipelines:

- The Zeepipe pipeline is managed by Statoil and transports approximately 13 billion m³ of gas per year with a daily capacity of 41 million m³;
- The Norfra pipeline has been operational since 1998 and transports 40 million m³ of gas per day between Dunkirk and the Norwegian shelf. The pipeline has a capacity of 15 billion m³ per year;
- The Interconnector pipeline has been operational since October 1998 between the south coast of England and Zeebrugge. This pipeline is bidirectional and can thus be used for the import / export of gas from / to England. In winter, there is import from England with a capacity of 8.5 billion m³ per year and in summer there is export to England with a capacity of 20 billion m³ per year.
  (*Verfaillie et al. 2005* (*GAUFRE project BELSPO*), *Brouwers et al. 2011*)

5.3.4 Impact

The construction and operation of pipelines and cables have a (local) impact on the marine environment. This impact is usually included in the environmental impact assessment (EIA) of the offshore wind farm concerned (see **Offshore wind energy - Impact**). A number of studies and environmental impact assessments which specifically focus on the effects of cables on the environment are included in table 7.

Table 7. An overview of the effects of the construction and operation of cables and pipelines on the (marine) environment.

IMPACT	LITERATURE
Toxic pollution due to the pipeline's zinc coating	*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*
Sediment disturbance during the 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*
Effect on the 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*
Electromagnetic field around the 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*
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*
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*

5.3.5 Sustainable Use

MEASURES CONCERNING THE IMPACT ON THE MARINE ENVIRONMENT

At present, there are no common programmes or measures to address the impact of pipelines and cables on the marine environment on an international level (*OSPAR QSR 2010*). At the European level, 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 (*Tasker et al. 2010*), the integrity of the seafloor (*Rice et al. 2010*) and non-indigenous species (*Olenin et al. 2010*).

At the Belgian level, the effects of power cables on the marine environment are briefly addressed in the monitoring programme for offshore wind farms (*Degraer & Brabant 2009*, *Degraer et al. 2010*, *Degraer et al. 2011*, *Degraer et al. 2012*, *Degraer et al. 2013*) and in the EIAs of the offshore wind farms (*website MUMM*).

MASTER PLAN OFFSHORE CABLES

To date, offshore wind farms in the BNS have been individually connected to the main land grid. However, a more coordinated system for connecting offshore energy to the main land is being investigated, given the technological, economic and ecological advantages. An offshore meshed grid (Belgian Offshore Grid) has been suggested, in which wind farms are connected to high-voltage substations which in turn connect to the onshore grid (*visie Elia offshore grid 2012*, *MER - Belgian Offshore Grid 2013*, *Aanvraagdossier Belgian Offshore Grid 2013*). The practical implementation of the Belgian Offshore Grid is currently elaborated in a Master Plan Offshore Cables (*Masterplan Zeekabels*) in cooperation with the involved wind farms and other involved stakeholders. The further development of this master plan also depends on the Stevin project which deals with the reinforcement of the onshore electricity grid (*Tant 2014*, *website ELIA*).

THE NEMO LINK PROJECT

The *Nemo Link project* is a two-way submarine high-voltage cable between Zeebrugge and Richborough (United Kingdom) of approximately 1,000 MW DC (*Milieueffectenrapport - NEMO LINK 2012*, *Brochure NEMO-STEVIN 2013*). This project should accommodate a better connection between the electricity provider and users in the UK and the European mainland. Economic studies have shown the usefulness of such a connection and the project has been selected by the European Commission as a 'project of common interest' in the framework of the Trans-European Energy Infrastructure (TEN-E, Regulation 347/2013). The application has been completed and the construction should take place in 2017/2018. For the grid connection on the Belgian side, the available capacity created by the Stevin project between Zeebrugge and Zomergem would be partly used (*Brochure NEMO-STEVIN 2013*, *Tant 2014*, *website ELIA*).

NORTH SEA OFFSHORE GRID

On a higher geographical level, energy providers of the countries surrounding the North Sea are considering an Offshore North Sea Grid. This grid interconnects the various clusters of wind farms in the North Sea (and other offshore renewable energy sources) and should ensure that the necessary onshore connections are in place in the future (*Mathys et al. 2009* (*OPTIEP-BCP project BELSPO*), *Offshore Electricity Grid Infrastructure in Europe 2011*, *Brochure FPS Economy*). An overview of the policy framework as well as the technical and economic aspects of this initiative is given in the publication *Offshore Electricity Grid Infrastructure in Europe (2011)*. European plans to develop an offshore network are addressed in the blueprint for an integrated European energy network (COM (2010) 677).

5.4 Tidal and wave energy

In the Blue Growth Strategy of the European Commission (COM (2012) 494, *website DG MARE*), blue energy is considered to be one of the most important fields. With the exception of offshore wind energy, technologies for offshore renewable energy (such as tidal and wave energy production) are still in an early stage of development. This is also apparent from the member states' plans to install only a modest capacity of 2 to 4 GW by 2020. In order to realise the potential of the ocean's energy (tidal energy, wave energy and energy extraction from temperature and salinity gradients), measures have been taken by the Commission (COM (2014) 08). Indeed, the potential of wave energy is impressive. According to *Cruz et al. (2008)* and *Brouwers et al. (2011)*, the total available wave power of all coastlines in the world is comparable to the current global electricity consumption.

At present, a lot of research is being conducted to further develop technologies with regard to ocean energy (see for example *website DG Research and Innovation*, *Ocean Energy Era-Net* and the European projects in the context of the *Ocean of Tomorrow Calls 2014*). In table 8, publications and research projects about the development of ocean energy in the BNS are listed.

Table 8. An overview of the research on wave and tidal energy extraction in 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*
	Potential (wave climate in the 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*
	Development of a prototype	*FlanSea-project* (*beschrijving project*, *Van In 2014*), *Laminaria*
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 in the BNS)	*Mathys et al. 2009* (*OPTIEP-BCP-project BELSPO*), *Mathys et al. 2012* (*BOREAS-project BELSPO*)

In order to further stimulate tidal and wave energy in Flanders, an action plan called *Gen4Wave* has been elaborated by partners from the academic world, the industry and the government. In this plan, a coast and ocean basin will be constructed to test scale models. Additionally, the West Flanders Development Agency (*POM West-Vlaanderen*) has established a Blue Energy Cluster in the framework of the so-called 'Factories of the Future' (*Fabrieken voor de Toekomst*), which *inter alia* focusses on the development of wave and tidal energy (*Dangreau 2014*, *Vanden Berghe 2014*). This development is also stimulated by certain ports such as the port of Ostend (see *BEPPO-project*).

In the area of the BNS reserved for the offshore wind farms, the construction and exploitation of installations for tidal and wave energy production is allowed as well (RD of 20 March 2014 and RD of 20 December 2000, amended by RD of 3 February 2011). A pilot project with wave converters is planned in the Mermaid concession zone (*Aanvraag Mermaid 2014*). The EIA of this concession zone discusses the potential impact of these convertors on the environment (*Rumes et al. 2015 – MEB Mermaid*, *Rumes et al. 2015*).

5.5 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 buffer this variability, hydro-electrical energy storage in a so-called energy atoll in the BNS is considered (*studie van het Milieu Innovatieplatform van de Vlaamse overheid (MIP, 2013)*, *Van de Walle 2013*). In the coalition agreement of the federal government (*regeerakkoord van de federale regering 2014*) energy storage is deemed one of the important challenges for the following years. Offshore energy storage by means of an energy atoll is discussed in a policy statement of the state secretary for the North Sea (*Beleidsverklaring van de staatssecretaris voor de Noordzee (2014)*). The energy atolls have also been incorporated into the Master Plan 'Flemish Bays' (*Masterplan Vlaamse Baaien (2014)*) in which a long-term (2100) (see also theme **Safety against floods**) vision on the development of the coast is elaborated.

In the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*) two zones are demarcated for energy storage in an energy atoll: off the coast of Wenduine and near the port of Zeebrugge. This last one should be adjusted to the current port activities and future port expansion. The marine spatial plan also stipulates that an energy atoll can only be realised when active environmental management measures are in place. The conditions and the procedure for acquiring a concession zone for such an energy atoll have been defined in the royal decree of 8 May 2014 which implements the law of 29 April 1999 (see figure 5). Prior to this royal decree, the Commission on the

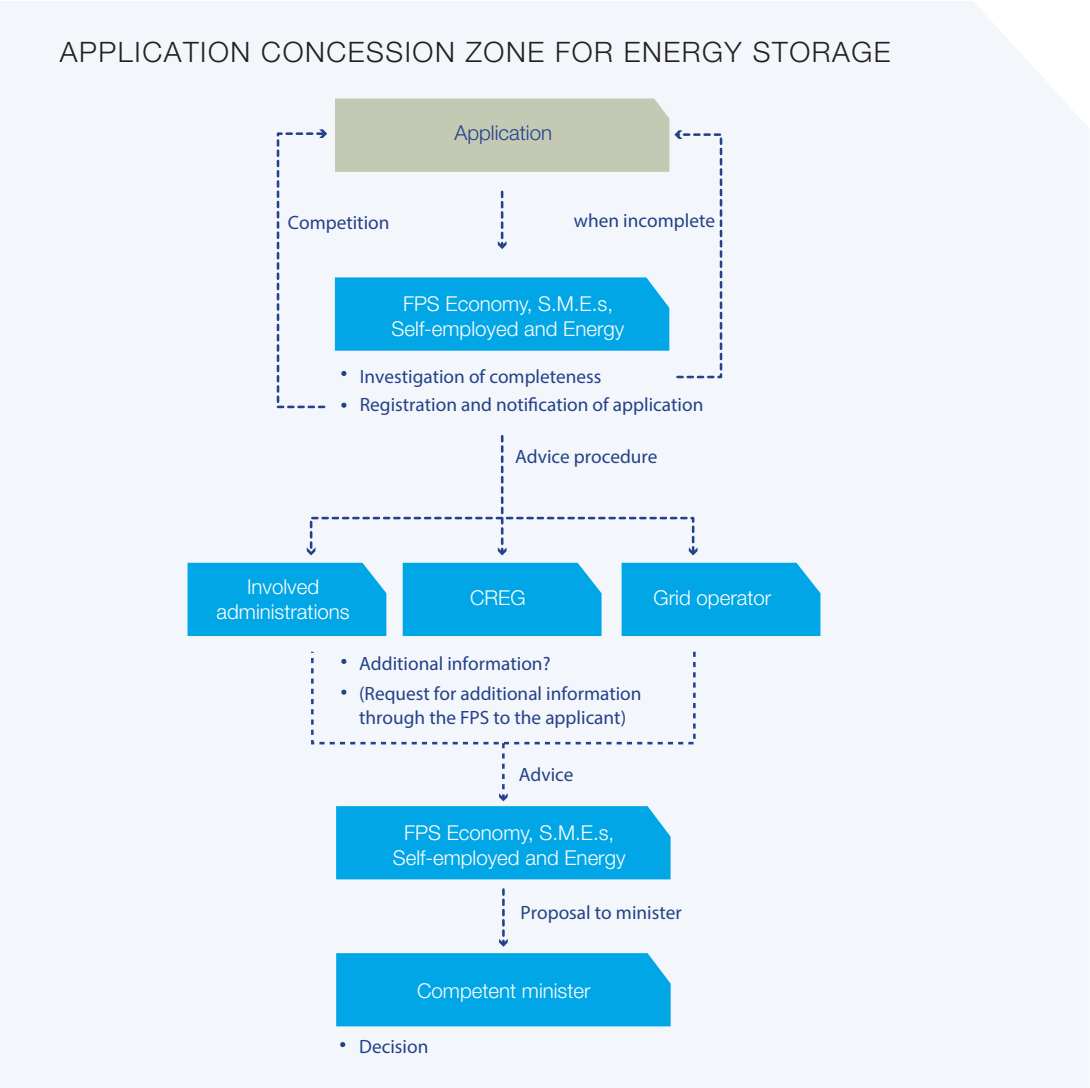

Figure 5. Flowchart for the application of a concession zone for energy storage (RD of 8 May 2014).

Regulation of Electricity and Gas (*CREG*) *advised* that it is pertinent to reserve a zone for energy storage. Furthermore, the construction of an energy atoll needs to comply with the conditions of the environmental permit procedure in accordance with the law on the protection of the marine environment (law of 20 January 1999), the royal decree of 7 September 2003 (procedure for permits and authorisation of certain activities in the BNS) and the royal decree of 9 September 2003 (regulation regarding environmental impact assessment).

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 consisted of a basic scenario with an installed capacity of 550 MW and an available energy content of 2 GWh (source: FPS Economy). However, the application was refused by the state secretary for the North Sea in September 2015.

In *Zimmerman et al. (2013)* the effects on currents, coastal morphology and coastal safety have been investigated. In the study *studie van het Milieu Innovatieplatform van de Vlaamse overheid (MIP, 2013)*, the ecological, legal and economic aspects of an energy atoll are discussed on 4 different locations. For each of these locations a SWOT analysis has been elaborated.

5.6 Renewable energy in the coastal zone

The coastal zone has a number of natural features that make it an interesting region for some forms of renewable energy production. A study about the average wind speeds in Flanders (*Windplan voor Vlaanderen*) has concluded that the coast has a significantly higher wind range (see also *Dehenauw 2002*). In our wind climate, a production factor of ± 11% is present in the inland areas, whereas this factor increases to ± 23% near the coast and to ± 34% at sea (*Brouwers et al. 2011*). Furthermore, measurements have revealed that the duration of sunshine in the coastal zone is on average 1,700 hours per year compared to 1,550 hours in Uccle (inland). The biggest differences occur during summer when the coast receives a surplus of up to 20 hours of sunshine per month (*Dehenauw 2002*). Also, in the Belgian *climate atlas* of the Royal Meteorological Institute of Belgium (RMI), parameters such as *sunshine duration* and *insolation* clearly reveal increased values for the coastal zone. Hence, the coastal zone has an increased potential for solar energy. Of course, other forms of renewable energy production are also present in the coastal zone (e.g. biomass, biogas, etc.). However, as the coast does not constitute a specific environment for these forms of renewable energy, they will not be further discussed here.

At the European level, the policy with regard to energy is developed by the *Directorate General for Energy*. A crucial instrument in this context is directive 2009/28/EC concerning the promotion of the use of energy from renewable sources. This directive stipulates that Belgium should incorporate 13% of renewable energy into its final energy consumption by 2020[2]. Furthermore, the directive also determines that each member state needs to elaborate a national action plan on how to reach the renewable energy goals (*nationaal actieplan België hernieuwbare energie 2010*).

Unlike nearshore energy production, renewable energy on land is a regional competence, which is mostly regulated by the Energy Decree of 8 May 2009 (*Environment, Nature and Energy Department*, *Vlaamse beleidsnota energie 2014-2019*). The Flemish Energy Agency (VEA) implements this policy (*website VEA*). A comprehensive overview of the laws and regulations on renewable energy can be found on the *website of VEA*.

On 1 September 2014, a total of 12,609 installations with a total installed capacity of 223.6 MW that qualify for Green Current Certificates (GCCs) were present in the coastal zone (10 coastal municipalities + 9 hinterland municipalities). The vast majority of the installed capacity is located in Bruges and Ostend (*Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

More specifically, 17 wind turbines (with a total installed capacity of 54.8 MW) were present in the coastal zone in September 2014: in Zeebrugge (on the breakwater of the port), Bruges, Gistel, Diksmuide and Middelkerke. These turbines account for 11.3% of the total capacity of Flemish wind turbines (*Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

Regarding photovoltaic panels, 12,221 installations <= 10 kW were present in the coastal area, totalling an installed capacity of 55.2 MW (1 September 2014). Furthermore, 356 installations > 10 kW with a total installed capacity of 56.2 MW were present (*Vlaamse Regulator van de Elektriciteits- en Gasmarkt, VREG*).

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

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ETC.			
Abbreviation	Title	Year of conclusion	Year of entering into force
ASCOBANS	Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations	Title	Year	Number
Directives			
Marine Strategy Framework Directive (MSFD)	Directive establishing a framework for community action in the field of marine environmental policy	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
Regulations			
	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
Other			
	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	08

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 12 april 1965	Wet betreffende het vervoer van gasachtige producten en andere door middel van leidingen	1965-04-12/30
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Wet van 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	1999-01-20/33
Wet van 20 januari 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België	
Wet van 29 april 1999	Wet betreffende de organisatie van de elektriciteitsmarkt, inzonderheid op artikel 6	1999-04-29/42
Wet van 26 juni 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
Wet van 13 mei 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
Royal decrees		
KB van 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
KB van 12 maart 2002	Koninklijk besluit 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	2002-03-12/37
KB van 16 juli 2002	Koninklijk besluit betreffende de instelling van mechanismen voor de bevordering van elektriciteit opgewekt uit hernieuwbare energiebronnen	2002-07-16/39
KB van 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
KB van 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
KB van 17 mei 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

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
Royal decrees		
KB van 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
KB van 3 februari 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
KB van 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
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
KB van 8 mei 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
Ministerial decrees		
MB van 8 mei 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	
MB van 16 maart 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	
Decrees		
Decreet van 8 mei 2009	Decreet houdende algemene bepalingen betreffende het energiebeleid (het energiedecreet)	2009-05-08/27

6

Fisheries

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In 2013, the worldwide production of fisheries products amounted to 191 million tons. Wild catches accounted for 49% (93.8 million tons) of the total production, of which 82.1 million tons were sea fish (*FAO Fisheries and Aquaculture Information and Statistics Service 2015*). The fleet of the European Union is responsible for 5% of the global fish catches. Half of the European catches have been caught by Denmark, the United Kingdom, France and Spain. The Belgian fisheries sector is rather small in the European context. In 2013, Belgian catches accounted for 0.2% of the European total (*FAO Fisheries and Aquaculture Information and Statistics Service 2015*). In 2014, the Belgian fishing fleet accounted for 0.1% of the European fleet with a tonnage and engine capacity of 0.9 and 0.7% of the European total, respectively (*Facts and figures on the Common Fisheries Policy, 2014*).

6.1 Policy context

The European fisheries efforts are mainly regulated by the Common Fisheries Policy (CFP) (regulation (EU) No. 1380/2013) proposed by the Directorate-General for Maritime Affairs and Fisheries (*DG MARE*) of the European Commission (EC) (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 in the *World Summit on Sustainable Development in Johannesburg (2002)* (see **Sustainable use**). 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 (ACs) (see *Council Decision 2004/585/EC*), as well as from a number of national and international organisations and instances such as the Scientific, Technical and Economic Committee for Fisheries (STEFC) of the EC and the International Council for the Exploration of the Sea (ICES) (*Adriansens 2009*, *handleiding voor het GVB, 2009*). The European fisheries management relies on scientific data, collected by the member states based on the regulation (EC) No. 199/2008 and regulation (EC) No. 665/2008 which are currently being reformed by the EC (see **Sustainable Use**).

The regional Flemish government has the exclusive authority with regard to sea fisheries (decree of 28 June 2013) with the exception of the crew and examination conditions for which the federal government is still the competent authority. 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 *Visserijbeleid en Kwaliteit Dier* 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. This concerns the implementation of the European (European Maritime and Fisheries Fund, EMFF) and Flemish (*Financieringsinstrument voor de Vlaamse Visserij- en aquacultuursector*, FIVA) policy for investments and actions in support of fisheries. The Belgian operational programme (EMFF) 2014-2020 (see **Sustainable use – Sustainable fisheries**) creates a framework and a manual for the funds of the EMFF. The implementation of the policy also implies the control of fishing activities and the reporting of the data in *annual* reports. The *Sea Fisheries service* is part of the latter division and guarantees the coordination, implementation and enforcement of the fisheries policy.

The policy is also supported by the Institute for Agricultural and Fisheries Research (*ILVO*). The Strategic Advisory Council for Agriculture and Fisheries (*SALV*) advises the Flemish government and the Flemish parliament concerning the policies and the development regulations on the economic, ecological, social and societal aspects of the (agriculture and) fisheries policy. This advice is prepared by the Technical Commission Fisheries of the SALV. *Milieu- en Natuurraad van Vlaanderen* (*Minaraad*) provides 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 Foundation for Sustainable Fishery Development (SDVO) aims to represent the interests of the Belgian sea fisheries cluster and to support them in all domains that contribute to a sustainable fisheries sector. The Redercentrale as well as SDVO are represented in the ACs that are relevant for Belgian fisheries. The Flanders' Agricultural Marketing Board (*VLAM*) coordinates the promotion campaigns of home-produced fish (e.g. fish of the year, seasonal fish). The Belgian fisheries policy is discussed in more detail in *Vanderperren & Polet (2009)* (CLIMAR project *phase 1* and *phase 2* BELSPO), the Belgian operational programme (EMFF) 2014-2020 and *VIRA 2014*. An extensive overview of the legislation concerning fisheries is given in the *coastal codex, theme fisheries*.

The regulation for recreational fisheries is listed on the following website of the *Agriculture and Fisheries department*. An extensive overview of the legislation for recreational fishermen using boats is elaborated within the LIVIS project and is discussed in *Verleye et al. (2015a)*.

6.2 Spatial use

The CFP is valid in the Belgian fisheries zone (law of 10 October 1978), the borders of which correspond to the exclusive economic zone (EEZ, law of 22 April 1999). In this zone, the performance of fisheries activities is subject to Belgian jurisdiction (although fisheries is a Flemish competence, see above). However, the rights of foreign vessels in the context of the CFP and the relevant international regulations are taken into account (*Maes et al. 2004* (*MARE-DASM project BELSPO*)). Hence, the Belgian fisheries zone gives unlimited access to all EU member states, except for Spain, Portugal and Finland, which may only catch unrestricted fish species and species without quota (*Douvere & Maes 2005*, *GAUFRE project BELSPO*).

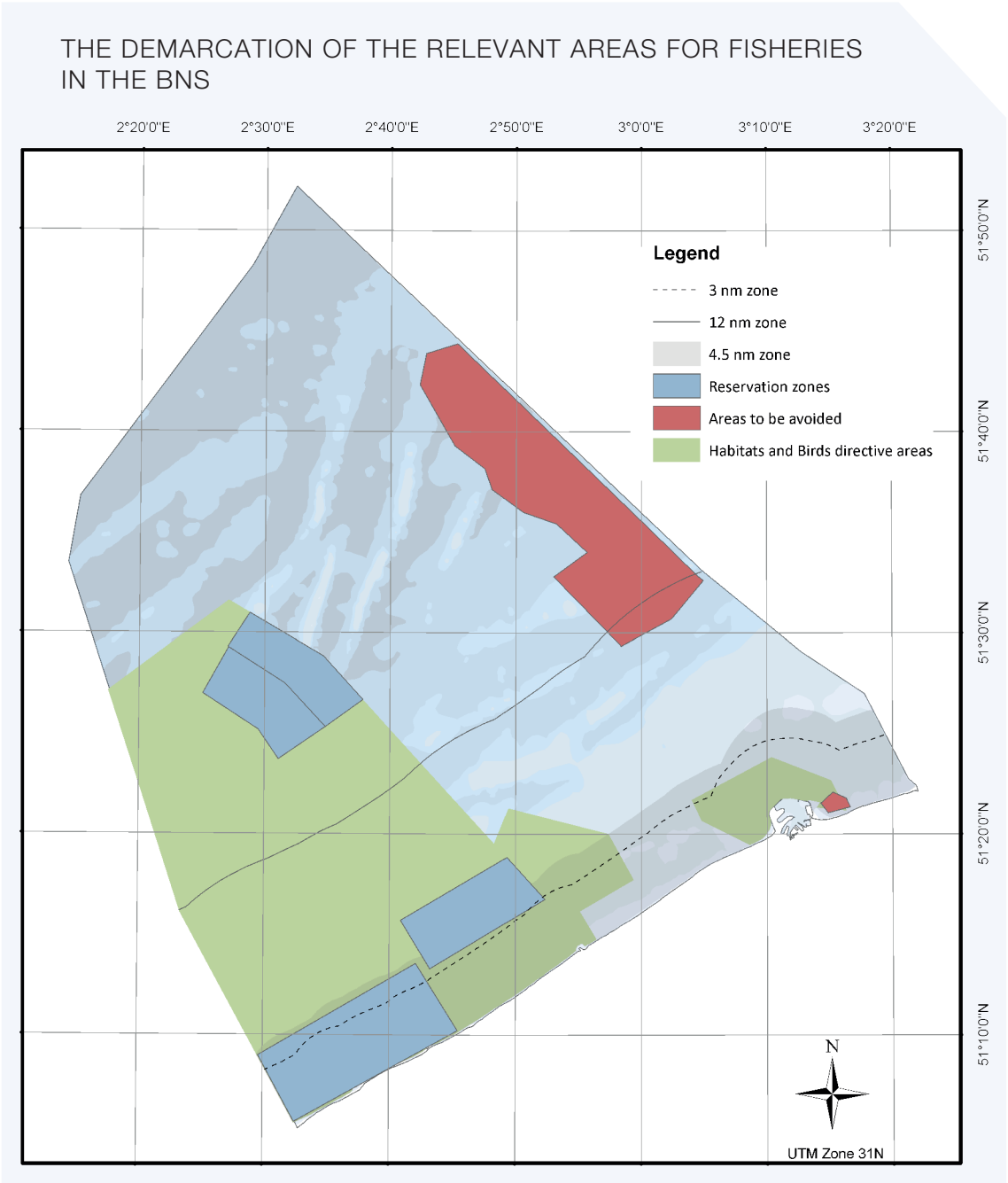

Figure 1. The demarcation of the relevant areas for fisheries in the BNS (Source: RBINS/IRSNB, *marineatlas.be* (based on RD of 20 March 2014)).

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, while in the 0-3 nm zone, only ships of <70 GT registered in the Coastal Fleet Segment are allowed to fish (see also **Societal interest – Belgian fishing fleet**). An extension of this zone towards 4.5 nm is included in the RD of 20 March 2014 on marine spatial planning, but has not yet been approved on a European level. In the territorial waters, fisheries are exclusively reserved for Belgian fishermen, although French and Dutch fishermen are allowed as well under certain conditions as a result of multilateral conventions (*Douvere & Maes 2005*, *GAUFRE project BELSPO*) and the European legislation:

- The treaty regarding the reform of the treaty establishing the Benelux Economic Union of 3 February 1958 (2008) attributes unlimited rights to Dutch fishermen for fishing in the Belgian territorial waters;
- 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;
- Regulation (EU) No. 1380/2013 also includes the access to Belgian coastal waters and gives the Netherlands unrestricted access to the Belgian 3-12 nm zone and the French herring fisheries to the entire territorial sea (0-12 nm).

Fishing is forbidden at the Paardenmarkt site, a munitions dump site (*Maes et al. 2000*) (see also theme **Military use**). Furthermore, the royal decree of 11 April 2012 prohibits shipping (and therefore also fisheries) in a safety zone of 500 m around wind farms (see also theme **Energy (incl. cables and pipelines)**). The compatibility of offshore wind farms and passive fisheries and mariculture has been investigated in the context of the MARIPAS project (*Verhaeghe et al. 2011*) and in the *Aquavalue project* (see also theme **Aquaculture**).

In the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*), measures have been established in 4 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**). These reservation areas have to be approved by Europe. Recreational fisheries are allowed in the entire protected area as long as the activities have no impact on the seabed (with some exceptions for the recreational shrimp fisheries).

A detailed overview of the fisheries activities of the Belgian, Dutch and British vessels in the BNS, i.e. the geographical distribution of the fleet (VMS-data) and information about the target species over the past three years (log data) is given in *Pecceu et al. (2014)*. The results of the analyses of fisheries intensity and the landings of target species 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 10% (past 5 years, unpublished data from ILVO) of the total landings originate from this area. By contrast, the Belgian coastal fishing vessels as well as the Dutch beam trawlers and pulse trawlers are quite active in the BNS.

Belgian fishermen are also active outside the BNS in the Southern and Central North Sea as well as in the western waters. 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 2014*). Furthermore, Belgian fishermen have access to limited quota in Norwegian waters and in a few ICES-areas. A detailed list of these areas is given in *VIRA (2014)*.

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).

6.3 Social interest

6.3.1 Employment

Employment in the fisheries sector has declined due to the crisis that has affected the fisheries sector (see **Sustainable use**). In 2013, the fisheries sector in Belgium consisted of 541 accredited sea fishermen. In addition, approximately 2,057 people worked in the fish-processing and marketing industry (assimilation and conservation companies (904), wholesale business (593) and retail (560)) (*VIRA 2014*). One of the most important challenges within the sector is to promote the attractiveness of the sector and to find well trained young adults, as also mentioned in *SALV-advies over de beleidsnota Landbouw en Visserij 2014-2019, deel visserij*. Efforts are made to improve the inflow of young persons 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 2015: decision of the Flemish government of 3 July 2015). The

number of young ship crew members decreased in the period between 1980 and 2014 from 222 to 66, despite the increases in the maximum age in 1988 and 2001.

6.3.2 Belgian fishing fleet

Based on the decision of the Flemish government of 16 December 2005, the fishing fleet is divided into 3 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 and a tonnage of maximum 70 GT, which take part in sea trips of maximum 48 hours with the start and end situated in a Belgian port. Joining the coastal fleet segment occurs on a voluntary basis.

In 2014, the Belgian sea fishing fleet consisted of 79 ships with a total engine power of 46,289 kW and a gross tonnage of 14,556 GT (*Tessens & Velghe, 2015*). The reported total engine power does not correspond to the reported engine power in the *Officiële lijst van de Belgische vissersvaartuigen (2014)* 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, does not reveal a comparable decrease (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*).

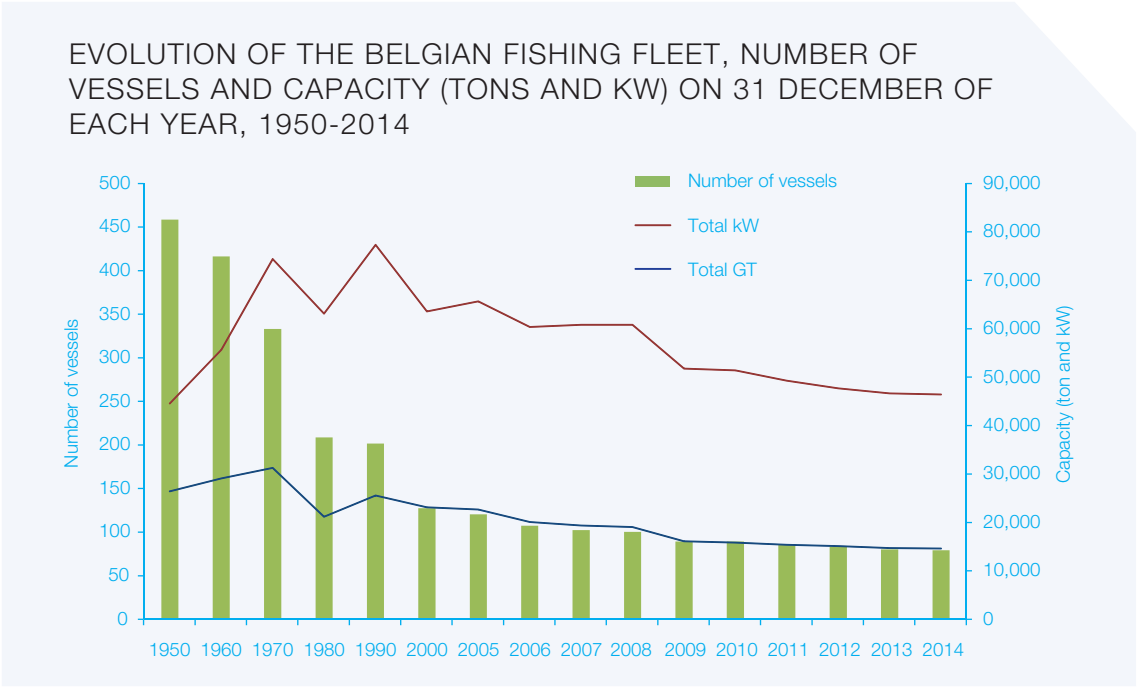

Figure 2. Evolution of the Belgian fishing fleet, number of vessels and capacity (tons and kW) on 31 December of each year, 1950-2014 (*Visserijrapport (VIRA) 2014*).

Another important challenge with regard to the development of the sector is the rejuvenation of the Belgian fishing fleet. The average age of the hull has increased to 25 years, with 52 ships older than 20 years (*VIRA 2014*). The age of the engines averages around 11 years since a number of vessels have used more efficient engines after the fuel crisis in 2008. However, there is an increasing demand for replacing the old vessels with new ships, but the CFP does not support the construction of new vessels (*VIRA 2014*). Other figures regarding the different fleet segments can be found in *Tessens & Velghe (2015)* (see **Societal interest - Landings and value**). In *VIRA (2014)* the profitability, labour costs, fuel costs, etc. of the fishing fleet are discussed as well.

6.3.3 Landings and value

The landings of the Belgian sea fisheries 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 (figure 3). Landings peaked after the Second World War, when more than 70,000 tons of fish were landed in the Belgian ports each year. The supply subsequently decreased gradually until 2009 (19,175 ton), followed by an increase up to 24,273 tons in 2014 (*Tessens & Velghe 2015*). The long-lasting decrease of the landings until 2009 can be largely explained by a change in the species composition of the catch (*VIRA 2014*), but the fuel crisis, declining fish stocks, the declining fishing fleet, limiting quota and the fishing effort limits also contributed to lower landings (see **Sustainable use**). In 2014, 19,623 tons were landed in Belgian ports and 4,651 tons in foreign ports. The port of Zeebrugge covered 65.3% of the landings in Belgian ports, Ostend 33.8% and Nieuwpoort 0.9%. Plaice, sole and cod were the most important species in 2014 in terms of landing volume (*Tessens & Velghe 2015*).

The value of landings or turnover is the yield 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 euros (indexed value with respect to the reference year 2007) to peaks of approximately 130 million euros 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 euros in 2009, followed by an increase to 81.267 million euros in 2014. Sole remains the most important fish species for Belgian fisheries with 44% of the value of landings in 2014 (*Tessens & Velghe 2015*). 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.

6.3.4 Trade and consumption of fish products

In Belgium there are three active fish auctions: Zeebrugge, Ostend and Nieuwpoort. Zeebrugge and Ostend together constitute the *Vlaamse Visveiling* 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 euros per kilo in 2006. In 2014, the average price for fish in Belgian ports amounted 3.50 euros per kilo (*Tessens & Velghe 2015*).

Figures from the GfK Panel Services Benelux for VLAM reveal that in 2013, Belgians bought on average 9.4 kilos of fish, molluscs and crustaceans per capita, for a total amount of 104.5 euros. The degree of self-sufficiency for fish, molluscs and crustaceans in Belgium and Luxemburg from fisheries and aquaculture amounted to 14.6% in 2008 (Source: VLAM). In 2013, the value of imported fish products amounted to 1.64 billion euros with the Netherlands as the main provider. The export value totaled 835 million euros (97.7% within the EU) with France and the Netherlands as the most important outlets (*VIRA 2014*).

6.3.5 Fisheries communities

The social dimension of the fisheries sector (training, employment, wellbeing, safety, etc.) is discussed in detail in *VIRA (2014)*. The impact of the CFP on the social and economic aspects of fisheries 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 (*Assessment of the status, development and diversification of fisheries-dependent communities. Oostende Case Study Report 2010*). The *GiFS project* investigated the socio-economic and cultural importance of inshore fisheries for coastal communities. Within the institute for Agricultural and Fisheries Research (*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, acknowledgement 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. 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)*.

6.4 Impact

Fisheries 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. 2015*). This will cause changes in the natural stability after fishing. Furthermore, other factors such as the use of fossil fuels and waste production influence the environment (*VIRA 2014*). An overview of the impact of fishing activities is given in *Polet & Depestele (2010)* and *Strategische Milieubeoordeling van het Nationaal Operationeel Programma voor de Belgische visserijsector, 2014 - 2020*. The latter Strategic Environmental Assessment (SEA) is required by the royal decree of 18 May 2008. In the following, a few of the effects will be further elaborated.

6.4.1 Overfishing and illegal, unreported and unregulated fisheries

A structural lack of stability between the capture capacity of a (mostly international) fishing fleet and the biological potential of the exploited fish stocks, will lead to overfishing of these fish stocks. Especially when overfishing causes a reduced reproduction capacity, this will often result in the collapse of the concerned fish stocks. Furthermore, fisheries may cause irreversible changes in the structures of populations and the food web (*Pauly et al. 1998*, *Polet et al. 2008*, *OSPAR QSR 2010*). Quota overviews and additional quota measures are published on the *website* of the Sea Fisheries service. Belgian quota overruns are rather exceptional. In 2014 however, the EC imposed a quota reduction in Belgium for some stocks of haddock, herring, plaice and stingray (*overview*) because the quota of the mentioned fish species had been exceeded in 2013 in the respective areas. The legal basis for these reductions is provided by *regulation (EC) No. 1224/2009*.

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*). An estimation of the unreported catch and bycatch of the Belgian 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. The biomass levels have to be high enough and the fishing mortality has to be low enough to ensure a permanent maximum sustainable yield (*VIRA 2012*). In *Moreau & Volckaert (2012)* and in the context of *VIRA (2014)*, seven North Sea fish stocks were tested against the MSY reference framework. In 2013, four of these fish stocks were catalogued as biologically healthy: herring, haddock, plaice and mackerel. In the same year, the biomass of saithe was too low. The biomass of sole reached sufficiently high values, but its fishing mortality remained above the sustainable limit. The cod stock is evolving in a favourable direction, but still has negative values on both criteria (*ICES advices*).

6.4.2 Impact of fishing gear

The impact of fisheries on the ecosystem and the biological communities strongly depends on the fishing gear and the time and place of fishing, although some other factors such as mesh width and the expertise of the fishermen will also play an important role. In 2012, the European project *BENTHIS* was initiated to study in detail the impact of fisheries on benthic ecosystems, including one case study in the North Sea. Improved scientific insights based on high-resolution fisheries distribution data tend to nuance the effect of seabed disturbances on the associated mortality of benthic organisms (*Teal et al. 2014*, Eigaard et al. submitted). In table 1, an overview of the impact of the most abundant types of fishing gear in the Belgian fisheries is given. Note that otter trawling has increased in the past few years. However, limited research on the impact of this technique has been conducted. Some alternative fisheries technics are discussed in *Polet & 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 (targeting fish and/or shrimp)	Seabed disturbance and associated effect on benthos and habitat	*Lindeboom & De Groot 1998 (Impact II)*, *Operationeel Programma in uitvoering van het Nationaal Strategisch Plan voor de Belgische visserijsector 2007-2013*, *Houziaux et al. 2008* (*Project BELSPO*), *Polet et al. 2008*, *Rabaut et al. 2008*, *Depestele et al. 2008*, *Polet et al. 2010*, *Polet & 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 et al. 2015*
	Bycatch and discards	*Operationeel Programma in uitvoering van het Nationaal Strategisch Plan voor de Belgische visserijsector 2007-2013*, *Polet et al. 2008*, *Depestele et al. 2008*, *Vandendriessche et al. 2008*, *Polet et al. 2010*, *Polet & Depestele 2010*, *Depestele et al. 2011*, *Depestele et al. 2012* (*WAKO-II project BELSPO*), *Verschueren et al. 2012*, *Depestele et al. 2014*, *Depestele 2015*
	Shifts in the feeding behaviour of seabirds caused by discards	*Depestele et al. 2012* (*WAKO-II project BELSPO*), *Sotillo et al. 2012*, *Sotillo et al. 2014*, *Depestele et al. 2014*, *Depestele 2015*
	Use of fuels and resources	*Depestele et al. 2007*, *Operationeel Programma in uitvoering van het Nationaal Strategisch Plan voor de Belgische visserijsector 2007-2013*, *Polet et al. 2008*, *Polet et al. 2010*, *Polet & Van Peteghem 2010*, *Polet & Depestele 2010*
Entangling nets (a type of gill net)	Bycatch of seabirds and marine mammals	*Haelters & Kerckhof 2004*, *Depestele et al. 2006*, *Depestele et al. 2008*, *Haelters & 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*)

6.4.3 Impact on other users

The spatial impact of fishing activities on other users of the sea is discussed in *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 (royal decree of 20 march 2014, see also *Van de Velde et al. 2014*).

6.4.4 Recreational fisheries

In the BNS, recreational fisheries mainly consist of beach angling or angling on piers or beach heads, beach fisheries with passive nets, sea angling on boats and shrimp fisheries with small trawls. With the exception of passive fisheries using fixed nets, sport fisheries do not need a license in the Belgian waters. As a consequence, little is known about

the extent of this kind of fisheries (*Goffin et al. 2007*). In 2015, the Flemish government has decided to prohibit the use of entangling and gill nets by recreational fishermen in the intertidal zone in order to protect marine mammals (decision of the Flemish government of 13 March 2015). The royal decree of 21 December 2001 already forbade the use of entangling and gill nets below the low water line.

Sportvisserij Vlaanderen vzw represents approximately 2,000 recreational fishermen. The size of the recreational fishing fleet, as well as a first insight into the fishing effort and fishing locations is given by *Verleye et al. (2015a)* (LIVIS, *GIFS*). The LIVIS project also tries to create a framework in Belgium to stimulate the transition to a smaller fisheries segment that has yet to be established. A first estimation of the recreational catches of cod is given in *ILVO (2007)*, a broader survey of the recreational fisheries was carried out by Van Den Steen (2010). The socio-economic interest and a rough estimation of the catches are also discussed in *Persoon (2015).* In *Lescrauwaet et al. (2013)* an estimation of the extent of recreational fisheries between 1929 and 2010 is given.

In Oostduinkerke, 12 horseback shrimp fishermen (licensed as Unesco heritage) and 3 *kruwer* associations (manual shrimp fisheries in the intertidal zone with a small dredge) are also active. In the first place, they can be considered as a folklore tradition (see *http://www.paardevissers.be/* and *Provincie West-Vlaanderen 2008*, see theme **Maritime and coastal heritage**).

6.5 Sustainable use

6.5.1 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. It has to ensure that fisheries and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. Improving the scientific knowledge about fish stock conditions constitutes an important pillar of the CFP (see also *Verleye et al. 2015b*). An overview of the European legislation in the context of the CFP is given on this *website*.

The EC strives towards long-term management, and will draft multi-annual plans that will contribute to a sustainable exploitation of the concerned fish stocks and the protection of the marine ecosystems. A few objectives 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 (if possible by 2015), the implementation of transferable fishing concessions (member states' choice), and the focus on regional management by the Advisory Councils (ACs) (*website DG MARE*). The ecological, economic, social and governance impacts which are foreseen by this policy were investigated in the following study: *Europese studie (2010)*.

In order to achieve the goals of the CFP, the EU has introduced a number of conservation measures, which can be divided into 4 groups (*Adriansens 2009*, *website DG MARE*, *handleiding voor het GVB, 2009*):

- 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 following website: *website dienst Zeevisserij*. The quota can be swapped among the member states. During the *World Summit on Sustainable Development in 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 (*Adriansens 2009*, *handleiding voor het GVB, 2009*). At this moment, the MSY for certain species such as ray cannot be determined. *ICES* gives quantitative 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 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 when fishing boats are allowed to fish at sea. In addition, the fishing effort is reoriented by closing certain zones (temporarily) for fishing activities. In this regard, the Irish Sea was temporarily closed for the Belgian fishing fleet in January 2013, in line with the advice of the quota commission (ministerial decree of 21 December 2012).

- Fleet measures have been set with maximum capacities for every member state in kilowatts (kW) and Gross Tonnage (GT). For fleet segments with overcapacity, the member states have to take measures in an action plan. The efficiency of the EU measures dealing with the overcapacity of the fishing fleet was critically reviewed in the following study: *studie van de Europese Rekenkamer (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 a further elaboration of the union priorities as discussed in the regulation (see also **Sustainable use – Sustainable fisheries**). The EMFF wants the fisheries and aquaculture sectors to become ecologically sustainable, economically viable and socially responsible (*VIRA 2014*). Over the period 2014-2020, 41,746 million euros will be reserved for Belgium. This represents 0.73% of the total EMFF budget (5,749 billion euro) (see also *website*). An overview of the national evaluation reports of the former European Fisheries Fund (EFF) is given in *Interim evaluation of the European Fisheries Fund (2007-2013)*.

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. 2015b*) in order to prevent and eliminate IUU-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 and size of the catch for every species (*Visserijrapport (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 (*handleiding voor het GVB, 2009*).

6.5.2 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*) and 9 (polluting substances in marine organisms for human consumption, *Swartenbroux 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. More information concerning the MSFD is provided in *Verleye et al. (2015b)*.

6.5.3 Data collection in Europe and Belgium

In-depth research and scientific information are necessary to underpin the CFP. On the European level, the fisheries research is regulated by guidelines providing a framework for data collection (regulation (EC) No. 199/2008 and regulation (EC) No. 665/2008, Data Collection Framework (*DCF*)). The EC is currently reviewing the DCF and is working on an EU Master Data Register. The basic principles for data collection, as mentioned in the CFP (i.e. increase of scientific knowledge about the state of fish stocks), are an important basis throughout this reviewing process. The renewed DCF and the accompanying EU Master Data Register is a seven-year programme (2014-2020) wherein multiple activities, carried out in the member states, such as data collection, studies, etc. will be combined. The funding of the new DCF is covered by the EMFF. Advice regarding the CFP on the basis of scientific information is provided by several organisations (more information: *handleiding voor het GVB, 2009*):

- The International Council for Exploration of the Sea (*ICES*) gives biological advice for proper management of fisheries in Europe by means of international collaboration with fisheries biologists. The conclusions of the ICES working groups dealing with fish stock evaluation are processed in the deliberations of the Advisory Committee (ACOM).
- The Scientific, Technical and Economic Committee for Fisheries (STECF) is the regular advisory body of the EC with regard to fisheries. This committee was founded in 1993 (93/619/EC) and renewed in 2005 (2005/629/EC) and again in 2014 under the new CFP. The STECF consists of a group of independent scientists, established in order to advise the EC on all aspects of the fisheries policy.

The *ILVO* Fisheries Biology research group gives advice on the condition and management of Belgian and European fisheries. This research group also conducts research on fisheries biology, stock assessment methods, marine ecosystem dynamics and the potential consequences of fisheries management on the fish stocks and fisheries in itself. In order to realise these general objectives, the research activities mainly focus on data collection concerning the size of fish stocks and the exploitation pattern of the commercially important species. This results in scientific advice supporting the development and implementation of the CFP.

Furthermore, economic data from fisheries, the fish processing industry and aquaculture are inventoried and studied. This results in both scientific and economic advice which supports the development and implementation of the CFP.

The important challenges include: the evolution from a 'single species' towards a 'multi species' approach within the context of the ecosystem approach, the development and implementation of a métier oriented programme, the promotion of collaboration between the fisheries sector and scientists by means of fisheries-science partnerships, the socio-economic impacts of changes in the policy and the evolution towards an integrated chain policy.

6.5.4 Sustainable fisheries

Fisheries have gone through various years of crisis. The government has tried to respond to this crisis with specific measures. Hence, there is 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 (*Visserijrapport (VIRA) 2012*).

A number of initiatives to achieve a (more) sustainable fisheries sector are listed below:

Within the context of the European Maritime and Fisheries Fund (EMFF, the former EFF), every member state needs to develop an operational programme (EMFF) and a Strategic Environmental Assessment (SEA) of the operational programme (*Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische visserijsector 2014 - 2020*) (see royal decree of 18 May 2008). For the Belgian fisheries sector, a SWOT-analysis and a elaboration of the strategy have been carried out for 5 of the 6 priorities:

- 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 (increasing employment and territorial cohesion) will not be implemented in Belgium as Belgium has no fishing communities or outlying fishing grounds.

Within Axis 4 (sustainable development of fisheries) of the national operational programme (2007-2013), the EFF subsidised projects dealing with topics such as sustainable fishing methods, quality-oriented fish and fish chain management, sustainable market, innovation, equal opportunities and economic viability (*ontwikkelingsstrategie EVF As 4 Belgisch Kustgebied, 2011*). A Fisheries Local Action Group (FLAG) manages the funds and is responsible for project approvals. The FLAG is a partnership of regional socio-economic actors from the fisheries sector, NGOs and administrations. One of the most prominent and practicable results is the VALDUVIS method, which determines sustainability scores for each landed fish box, using different indicators for the three pillars of sustainability.

To be able to face the profitability problems of the fishing fleet, the Flemish government has developed a *global action and restructuring plan (Task Force Fisheries 2006)*, aiming towards sustainable Flemish fisheries by means of structural measures. This plan is part of the Belgian implementation procedure of the European regulation (EC) No. 744/2008, which allows temporary support for a scrapping programme and a modernisation scheme. These measures are financed by Flemish public resources from *FIVA* (decree of 13 May 1997).

- In 2005, the maximum engine capacity was raised to 1,200 kW and three fleet segments were defined. The

scrapping of vessels was temporarily supported by governmental intervention (ministerial decree of 2 June 2009 – see **Societal interest - The Belgian fleet**);

- The adapted Flemish quota policy (in force since 1 February 2006) should contribute to an optimum and efficient quota use (more information: *Adriansens 2009*);
- Research on alternative fishing techniques is carried out in order to transform the remaining vessels into a sustainable fleet.

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 proposed 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) (*Polet 2004*, *Van Craeynest 2009*, *Polet & 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*)).

Within the fisheries sector, a *societal covenant for sustainable fisheries (2011)* has been developed. 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 establishes a task force, a guidance committee and four working groups, i.e. WG Fisheries, WG Policy, WG Innovation and WG Coast. In 2012, the Flemish government already developed an action plan on selective fishing *Actieplan Selectief Vissen (2012)* in order to react pro-actively on a few topics of the reform of the CFP of 2013. In this action plan, 10 priorities were proposed which must lead towards more sustainable fisheries. In the publication *activiteitenverslag van de rederscentrale 2010 (Wintein & Brouckaert 2011)* reference is made to a few initiatives dealing with sustainability.

Legislation reference list

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations	Title	Year	Number
Directives			
Habitats Directive	Directive concerning the conservation of natural habitats and of wild fauna and flora	1992	43
Marine Strategy Framework Directive	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Regulations			
DCF	Regulation concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy	2008	199
Application of the DCF	Regulation laying down detailed rules for the application of Council Regulation (EC) No 199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy	2008	665
	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
	Regulation establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing, amending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999	2008	1005
	Regulation establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 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	2009	1224
Common Fisheries Policy	Regulation on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC	2013	1380
European Maritime and Fisheries Fund	Regulation on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council	2014	508
Andere (aanbeveling, communicatie, groenboek, witboek,…)			
	Commission Decision relating to the institution of a Scientific, Technical and Economic Committee for Fisheries	1993	619
	Communication from the Commission (COM): A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development	2001	264
	Council Decision establishing Regional Advisory Councils under the Common Fisheries Policy	2004	585

EUROPEAN LEGISLATION (continuation)			
Abbreviations	Title	Year	Number
	Commission Decision establishing a Scientific, Technical and Economic Committee for Fisheries	2005	629
	Green Paper (COM): Reform of the Common Fisheries Policy	2009	163
	Communication from the Commission (COM): Reform of the Common Fisheries Policy	2011	417

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 19 augustus 1891	Wet betreffende de zeevisserij in de territoriale zee	1891-08-19/30
Wet van 10 oktober 1978	Wet houdende vaststelling van een Belgische visserijzone	1978-10-10/30
Wet van 22 april 1999	Wet betreffende de exclusieve zone van België in de Noordzee.	1999-04-22/47
Royal decrees		
KB 21 december 2001	Koninklijk besluit betreffende de soortenbescherming in de zeegebieden onder de rechtsbevoegdheid van België	2001-12-21/72
KB van 18 mei 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
KB van 23 juni 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Decrees		
Decreet van 13 mei 1997	Decreet houdende oprichting van een Financieringsinstrument voor de Vlaamse visserij- en aquacultuursector	1997-05-13/31
Decreet van 28 juni 2013	Decreet betreffende het landbouw- en visserijbeleid	2013-06-28/15
Ministerial decrees		
MB van 2 juni 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
MB van 16 maart 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
MB van 21 december 2012	Ministerieel besluit houdende tijdelijke aanvullende maatregelen tot het behoud van de visbestanden in zee	2012-12-21/03
Others		
Besluit van de Vlaamse regering van 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

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
Besluit van de Vlaamse regering van 13 maart 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
Besluit van de Vlaamse regering van 3 juli 2015	Besluit van de Vlaamse Regering houdende de vaststelling van de verplichte bijdrage van de reders van Belgische vissersvaartuigen voor het jaar 2015 aan het Fonds voor Scheepsjongens	2015-07-03/04

7

Aquaculture

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In 2013, the worldwide production of fishery products (including aquatic plants) amounted to 191 million tons. Aquaculture accounted for 51% (97.2 million tons) 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 (*State of World Fisheries and Aquaculture, FAO 2014*, *FAO Fisheries and Aquaculture Information and Statistics Service 2015*). Aquaculture is globally the fastest growing food production sector with an annual growth of 6.6 % (compared to an annual growth of the human population of 1.8 %) (Figure 1). In 2013, the aquaculture production amounted to 46.6 million tons. The aquaculture sector of the European Union (EU) accounts for 1.27 million tons, while Europe produces 2.82 million tons in total, with Norway as the main producer (44%) (*FAO Fisheries and Aquaculture Information and Statistics Service 2015*).

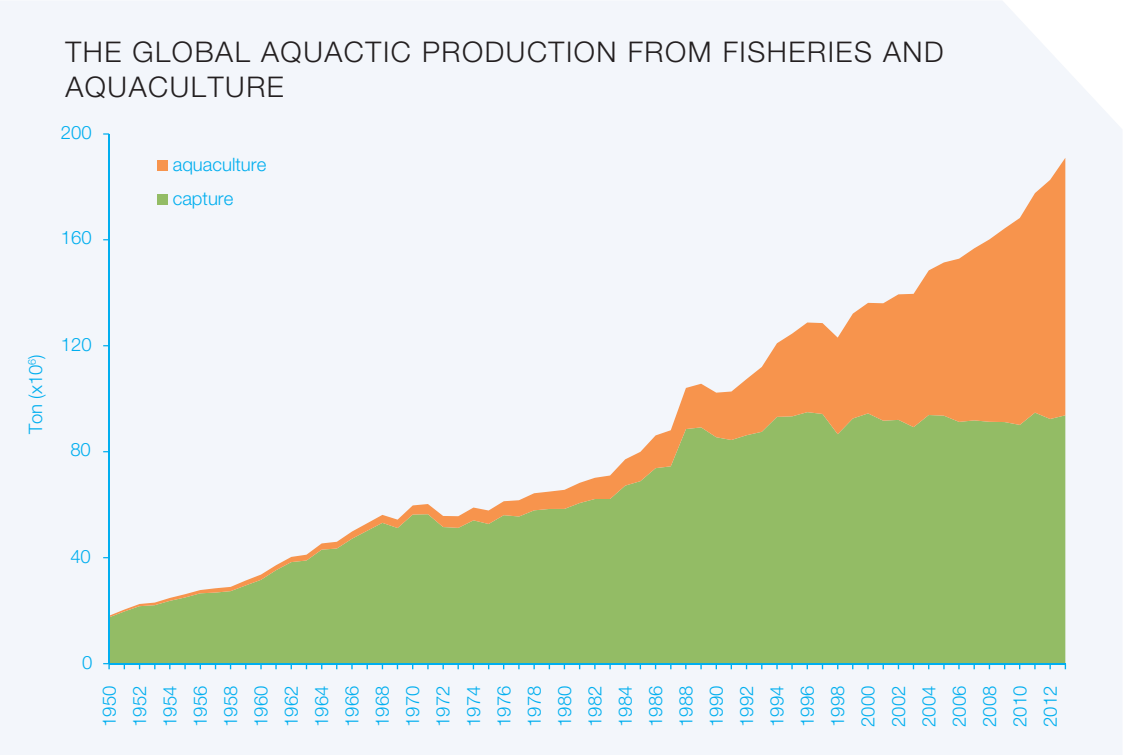

Figure 1. Global aquatic production from fisheries and aquaculture (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2015*).

The importance of the Belgian aquaculture production is rather limited and constitutes a very small part of the European production volume and 0.01% in terms of value (*Facts and figures on the Common Fisheries Policy, 2014*).

The current text will primarily focus on marine aquaculture (offshore aquaculture) in the Belgian Part of the North Sea (BNS), as well as on developments with regard to aquaculture in the coastal zone.

7.1 Policy context

At the European level, the policy concerning aquaculture (incl. mariculture) is included in the Common Fisheries Policy (CFP) (regulation (EC) No. 1380/2013). In September 2002, the European Commission (EC) published a communication concerning the strategy for a sustainable development of European aquaculture (COM (2002) 511). In 2009, this communication was renewed by communication COM (2009) 162 concerning a new impetus for the strategy for the sustainable development of European aquaculture. In communication COM (2013) 229, strategic guidelines have been published presenting common priorities and general objectives of European aquaculture. Furthermore, a sustainable aquaculture is one of the main priorities of the European Maritime and Fisheries Fund (EMFF, the former European Fisheries Fund (EFF)) (website *EMFF*, *Belgische Operationele Programma (EMFF) 2014-2020*).

Considering that mariculture is an offshore activity, it is a federal competence (minister or state secretary competent for the North Sea / *FPS Health, Food Chain Safety and Environment*). Aquaculture on land, however, is a Flemish

competence. In this regard, the division *Visserijbeleid en Kwaliteit Dier* of the department of Agriculture and Fisheries (*Departement Landbouw en Visserij*) is the management authority of the Operational Programme (EMFF) 2014-2020, which also includes measures to support aquaculture. The regulations and competent authorities for mariculture and aquaculture are discussed in the publication *Aquacultuur in Vlaanderen (2013)* and on the website of the *Flemish Aquaculture Platform* (more information: *Coppens & Stoop 2003*).

In 2011, a first attempt was made to develop a Flemish aquaculture policy (*Visserijrapport (VIRA) 2012*). In this context, the existing initiatives were mapped and a vision note was drafted by the Flemish government to better disclose the sector and the relevant research. In 2012, a *Flemish Aquaculture Platform* was established to create sufficient support from policy and research and to raise awareness to create synergies between research actors and to stimulate sustainable aquaculture.

7.2 Spatial use

7.2.1 Marine spatial plan and mariculture

The possibility for sustainable mariculture activities (under strict conditions) in the Belwind I and C-Power wind farms has been included in the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*) (figure 2). 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 fisheries in the wind farms has already been investigated in the context of the MARIPAS project (*Verhaeghe et al. 2011*). To date, no other areas in the BNS have been designated for mariculture. However, this situation might change during the next revision of the marine spatial plan. The *AquaValue project* investigates the integration of aquaculture with offshore structures such as wind farms and the energy atoll, but also with other functions such as coastal protection. Special attention goes to the possibility of a multitrophic integration (i.e. combination of multiple trophic levels) with supplementary species in the food chain. The project aims to develop a roadmap of integrated mariculture and to indicate what changes should be made during the next revision of the marine spatial plan regarding the available space for mariculture.

7.2.2 Restocking in the North Sea

Farm-raised turbot and sole were released in the coastal waters between Nieuwpoort and Bredene (westside of the Stroombank sandbank) in 1998 and 2000 respectively for the restocking of the fish population. Each time, this zone was closed for fisheries on a voluntary basis (*De Wachter & Volckaert 2005*, *GAUFRE project BELSPO*). The restocking of cultured turbot was continued in the *GAUFRE project (BELSPO)* in which the impact on the quality of the turbot was evaluated in view of the restocking success in the North Sea. In this context, the possibility to establish a turbot farm at the Belgian Coast was investigated (*Dierckens et al. 2004*, *project BELSPO*). Although the results were positive, both restocking programmes were stopped as most of the restocked animals were fished outside the BNS by foreign fishing vessels. This demonstrates that this kind of restocking programmes needs to be organised on a European level. Hence, a European Ecosystem-based Stock Enhancement Workshop was organised in Bruges in 2007, but has not been followed up.

7.2.3 Mussel farming in the North Sea

Between 1997 and 2011, a number of initiatives took place to cultivate mussels in the BNS. Several production systems and seed capture installations were tested in the 5b project *Vlaamse mosselkwekerij* (1998) and the PESCA project. From 2002 until 2006, the offshore mussel cultivation experiments were continued by private funding (José Versluys) and were scientifically supported by CLO-DVZ (now ILVO). Besides this private initiative, production of bivalve molluscs took place in the BNS between 2005 and 2010 using hanging structures in cages, spread over 4 zones (*Milieu-effectenbeoordeling Mosselcultuur 2005*, *Delbare 2005*, *Report of the Working Group on Marine Shellfish Culture (ICES WGMASC), 2011*). Those areas were planned as shellfish production areas based on the presence of obstacles (Z1: Wreck, Z2 and Z3: Towers, Z4: wind farm concession zone), and had respective surfaces of 0.21 km², 0.27 km², 0.23 km² and 277.14 km². The permit for the production of bivalve molluscs was granted by the ministerial decree of 7 October 2005, following the *environemental impact assessment* (EIA) cf. the law of 20 January

1999 and its royal decrees of 7 and 9 September 2003. The ministerial decree of 8 July 2005 stipulated a simplified procedure and a model form for the determination of the EIA. The foundation for Sustainable Fishery Development (SDVO) actively cultivated mussels within the 4 zones, while zone 1 was shared with Reynaert-Versluys. At the beginning of the construction of the C-Power wind farm (Thornton Bank), SDVO and the Management Unit of the North Sea Mathematical Models (BMM – MUMM) mutually decided to remove the cage in Z4 in order not to hinder the construction works. The mussel cultivation activities in the other three zones ended in 2011.

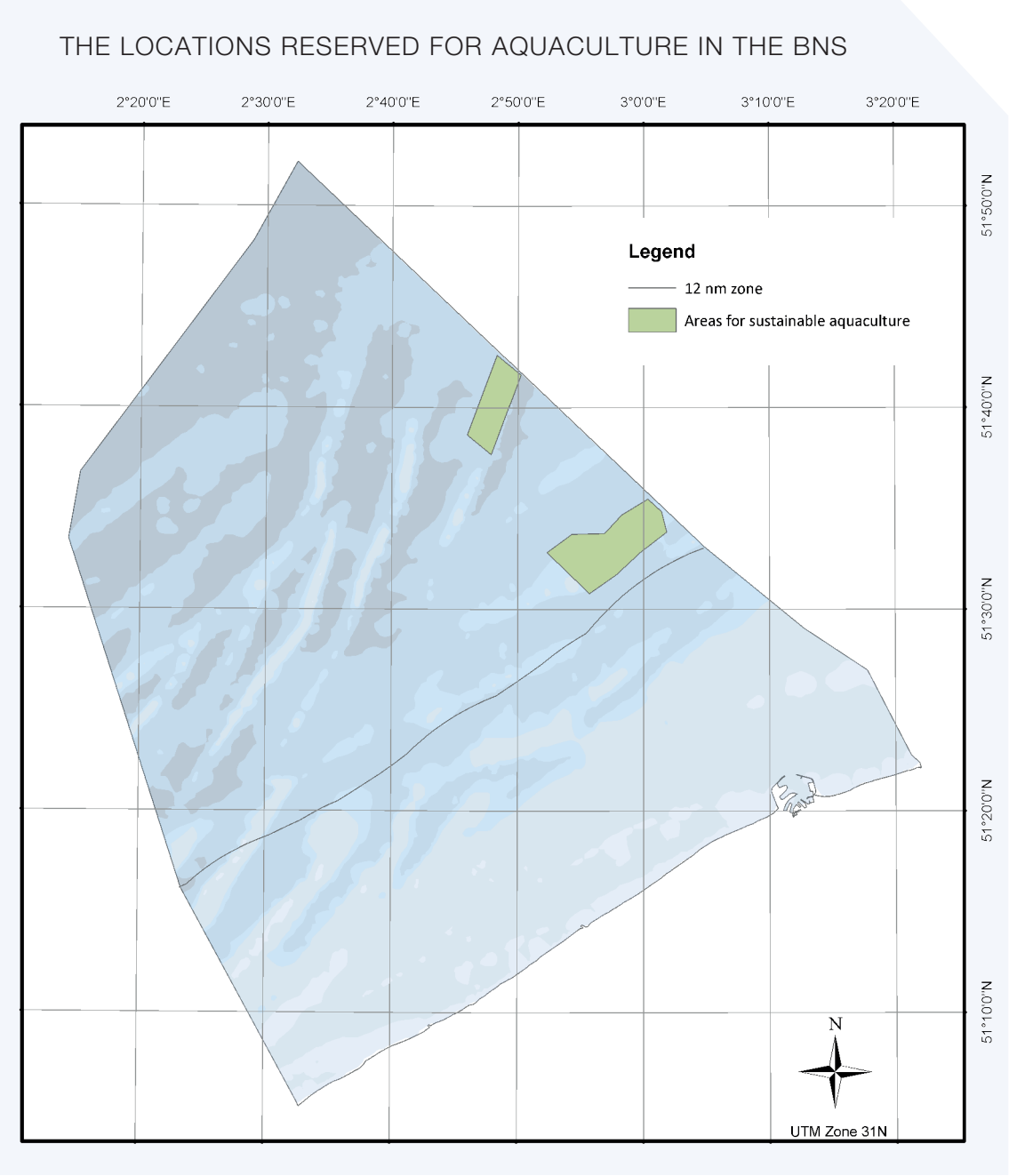

Figure 2. The locations reserved for aquaculture in the BNS (Source: RBINS/IRSNB, *marineatlas.be*, based on RD of 20 March 2014).

7.2.4 Aquaculture in the coastal zone

In the Belgian coastal zone, aquaculture can be found in the Sluice Dock of Ostend where the European flat oyster (*Ostrea edulis*) and the Pacific oyster (*Crassostrea gigas*) are farmed. 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 department 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*.

7.3 Societal interest

In 2012, 12,466 aquaculture companies were active within the EU, 90% of which counted less than 10 employees. These enterprises account for a total of 69,196 jobs (*EU Data Collection Framework*). In 2013, Europe produced 2.82 million tons of which the EU-Member States accounted for 45% (*FAO Fisheries and Aquaculture Information and Statistics Service 2015*). The European production of sea fish and diadromous fish (salmon, sea bass and seabream) together account for 83% of the total production. Shellfish represents 21% and fresh water fish (*inter alia* trout and carp) 9%. The aquaculture production in Europe accounts for 2.9% of the global production in terms of volume and 8% in terms of value (*FAO Fisheries and Aquaculture Information and Statistics Service 2015*).

In Belgium, the importance of aquaculture is rather limited. It mainly concerns the cultivation of freshwater species. Employment in the primary Belgian aquaculture sector is estimated at around 60 full-time equivalents (FTEs), while the supply sector accounts for an extra 78 FTEs (*VIRA 2014*). The production in 2011 was estimated at 50 tons with a corresponding value of 218,480 euros (*FOD Economie, KMO, Middenstand en Energie*) (see regulation (EG) No. 762/2008 regarding the data collection). The short revival in 2009 (575.9 tons) was the result of one extra aquaculture company, a tilapia farm, that ended its activities in 2010 (figures 3 and 4).

The Belgian aquaculture sector is mainly situated in Wallonia, which is not further discussed in the text. The Flemish aquaculture sector is represented by approximately 20 enterprises. The main species are the common carp, sturgeon (mainly production of caviar), oysters, angling fish and ornamental fish. New species are: pike-perch, omega perch and Penaeid shrimps (prawn) (*VIRA 2014*). An overview of the Flemish aquaculture companies is listed on the website of the *Flemish Aquaculture Platform*. Only two companies are situated in the coastal area, namely the oyster farm in the Sluice Dock of Ostend and the smokehouse of multinational Marine Harvest (farmed salmon).

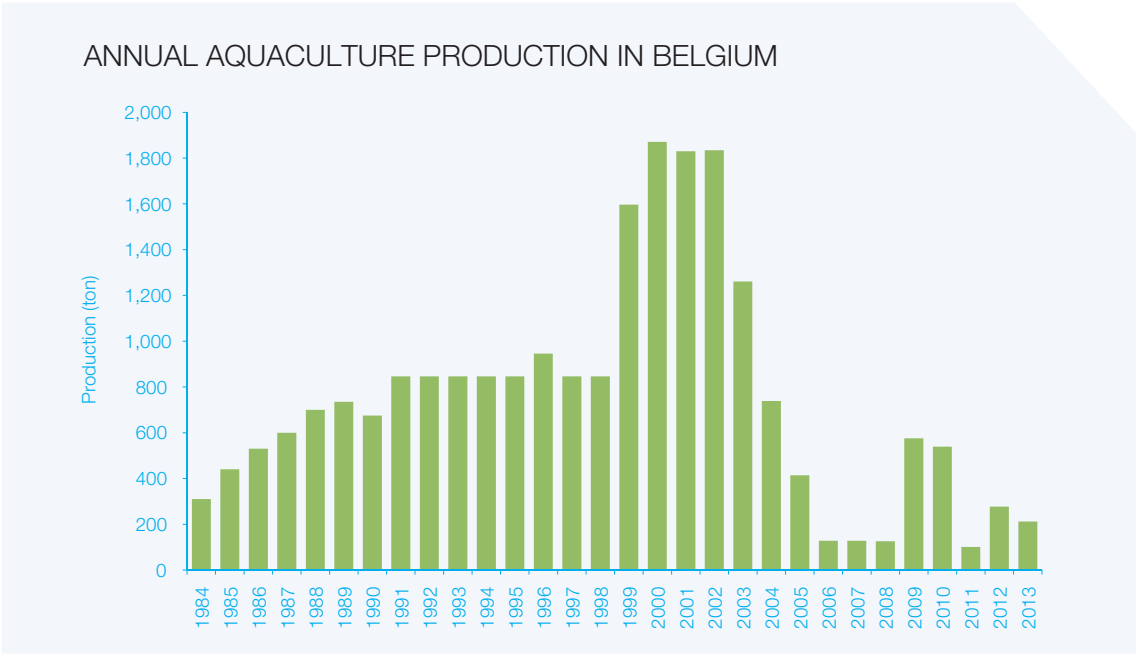

Figure 3. Annual aquaculture production in Belgium (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2015*).

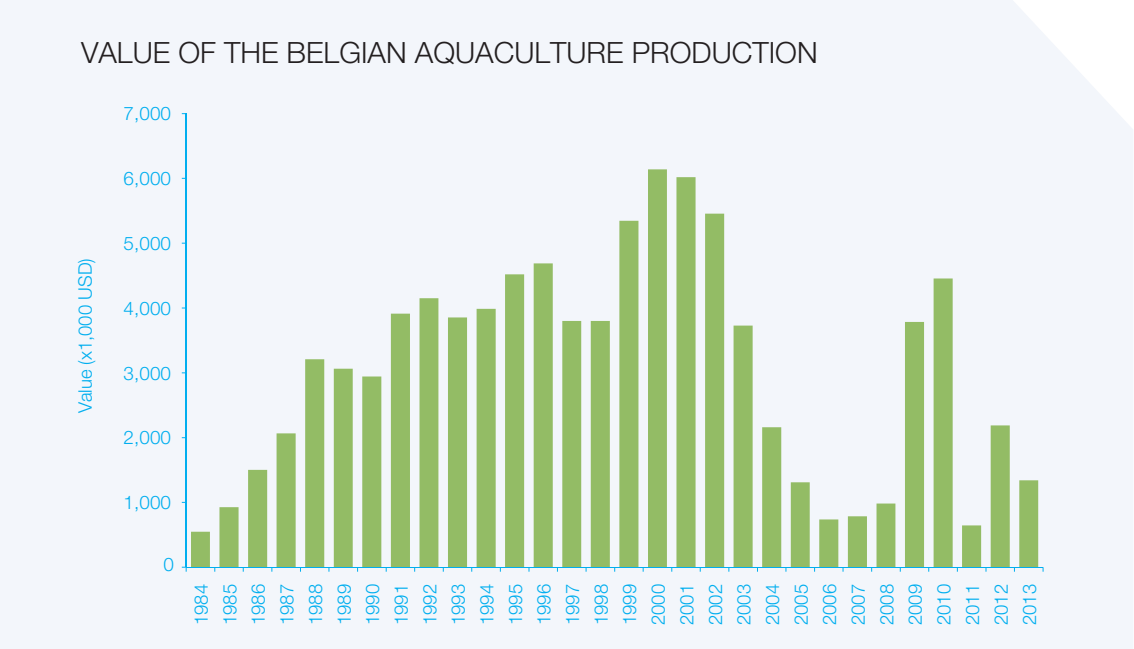

Figure 4. The value of the Belgian aquaculture production in the period 1984-2011 (Source: *FAO Fisheries and Aquaculture Information and Statistics Service 2015*).

From a historical perspective, the oyster farms along our coast were of significant commercial importance. In particular the 'Ostend Oyster' (l'Ostendaise or Royal Ostendaise) gained worldwide fame. Prior to the First World War, oyster farming reached a peak with 26 oyster farms along the Belgian coast. Every year, 30 to 35 million oysters were imported from England and further cultivated in the Belgian oyster farms (*Halewyck & Hostyn 1978*, *Polk 2002*). An overview of the history of the Belgian oyster farms is presented on the following website: *http://www.vliz.be/wiki/Historiek_van_de_Belgische_oesterkweek* (more information: *Pirlet 2012*). Since 1996, oysters have been commercially farmed in the Sluice Dock of Ostend (*Curé et al. 2000*) (see **Spatial use**).

7.4 Impact

Mariculture has a number of effects on the environment and the users of the sea (*Milieu-effectenbeoordeling Mosselcultuur 2005*, *De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Goffin et al. 2007*, *Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische visserijsector, 2007 - 2013*). In the *environmental impact assessment*, drafted prior to the installation of the offshore mussel cages, the following specific (local) effects on the marine ecosystem and users of the sea were listed:

- Effect on the quantity of suspended matter: mussels feed on suspended particles;
- Effect on the primary production: consumption of the phytoplankton;
- Effect on the secondary production: competition with other organisms;
- Modifications in the natural nutrients flux: excretion of organic nitrogen compounds (ammonium compounds);
- Transfer of material from the planktonic towards the benthic food web and the organic enrichment of sediments: excrements of mussels;
- Accumulation of mussel shells below the farm;
- Presence of a fouling community that settles on artificial hard structures;
- Attraction of birds, fishes and parasites;
- Diseases;
- Loss of parts of the mussel farm;
- Danger to shipping due to mariculture structures.

The impact of aquaculture on the ecosystem and other users strongly depends on the chosen technique. The potential effects are further elaborated in publications such as *State of World Aquaculture (FAO 2006)*, *OSPAR QSR (2010)*, *Report of the Global Conference on Aquaculture 2010 (FAO 2012)*, *Guidance on aquaculture and Natura 2000*

(2012), *Brenner et al. (2014)*, *Strategische Milieubeoordeling van het Nationaal Operationeel Plan voor de Belgische visserijsector, 2014 - 2020* and include:

- Eutrophication due to nutrient enrichment by food and excretion products of aquaculture organisms;
- Introduction of non-indigenous species;
- The demand for wild fish;
- Pollution of the bottom due to accumulation of organic material;
- Competition of escaped aquaculture species with wild fish;
- Use of chemicals;
- The impact on wild fish, seals, birds and other fauna as a result of the measures to prevent predation of aquaculture species;
- The alteration and destruction of natural habitats and ecosystem functions;
- Competition for the use of fresh water;
- Competition with livestock for food;
- Impact due to the collection of seed;
- The potential spreading of diseases and parasites in cultivated and wild stocks.

7.5 Sustainable use

7.5.1 Mitigation of the environmental impact

In COM (2009) 162 and COM (2013) 229, the European Commission (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. A selection of relevant European legislation with regard to a sustainable aquaculture.

EUROPEAN LEGISLATION	SUBJECT
Directive 91/676/EC	Nitrates Directive - The protection of water against pollution caused by nitrates from agricultural sources
Directive 92/43/EC	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 of 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
Directive 2006/113/EC	The quality required of shellfish waters
Regulation (EC) 708/2007	The use of alien and locally absent species in aquaculture
Regulation (EC) 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 2008/1/EC	Integrated pollution prevention and control
Directive 2009/147/EC	Birds Directive - The conservation of wild birds

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 of the protection goals, (2) promote good practices and (3) indicate how sustainable aquaculture and nature protection are compatible.

On the Belgian level, the mariculture activities have to comply with the law of 22 April 1999 (the EEZ law) concerning the exclusive economic zone (EEZ) of Belgium in the North Sea and the law of 22 April 1999 concerning the protection of the marine environment and the organisation of marine spatial planning in the BNS (see theme **Nature and environment**). Associated with these laws, a number of royal decrees are of specific importance for mariculture such

as the royal decree of 9 September 2003 in the context of the EIA, the royal decree of 7 September 2003 concerning the permit procedure, the royal decree of 23 June 2010 concerning the marine strategy and the royal decree of 23 June 2010 concerning the achievement of a good condition of the surface water. The royal decree of 18 May 2008 stipulates that in the context of the national operational plan, a strategic environmental impact assessment is required with regard to the mariculture activities in the BNS. For certain offshore activities, such as the production of bivalve molluscs by means of hanging structures, a simplified procedure may be applied (ministerial decree of 8 July 2005).

A list of the Belgian/Flemish regulations to minimise the environmental impact of aquaculture and mariculture installations is given in *Coppens & Stoop (2003)*, *Wettelijke Europese en Belgische regelgeving voor aquacultuurinrichting (2008)* and *Aquacultuur in Vlaanderen (2013)* (website *www.aquacultuurvlaanderen.be*).

7.5.2 A sustainable development of aquaculture

The FAO discusses the large contribution of environmentally friendly extractive aquaculture in Asia (removal of organic material by shellfish culture, removal of inorganic nutrients by macro-algae culture) to the total aquaculture production. It also highlights the possibilities of integrated (multitrophic) mariculture systems that aim for a more sustainable aquaculture and a reduction of the impact on the ecosystem (*Soto 2009*, *Report of the Global Conference on Aquaculture 2010 (FAO 2012)*, *Sorgeloos 2013*). Moreover, recent FAO publications express the need to shift from land-based and coastal aquaculture production to a sustainable offshore production to meet the demand for food and to reduce the competition for space and clean water (*Lovatelli et al. 2013*, *Kapetsky et al. 2013*). Within this context, it is recommended to make the effort to cultivate species of lower trophic levels and to optimise food and feeding in order to minimise the impact on the ecosystem and to pursue sustainability on the long term. Recommendations regarding offshore aquaculture, fish food and aquaculture technologies have also been formulated in the Bremerhaven Statements of 2012 (*Part I*, *Part II*) and 2013 (*Part I*, *Part II*).

Sustainable development and implantation of aquaculture facilities at sea and at the coast are discussed in the context of the Integrated Maritime Policy (COM (2007) 575). To unlock the potential of aquaculture in the EU and to counteract the stagnation, 4 priorities have been stipulated in COM (2013) 229:

- Simplification of administrative procedures;
- Coordinated spatial planning to reduce uncertainties and to facilitate investments;
- Enhancing the competitiveness of EU aquaculture;
- Promoting a level playing field for EU operators by exploiting their competitive advantages (e.g. high environmental, animal health and consumer protection standards).

The strengthening of the competitiveness needs to be done by a better market organisation and by an optimal use of the European Maritime and Fisheries Fund (EMFF, see also theme **Fisheries**) for production and sales plans and for a better relation between R&D and the sector. Union priority 2 of the EMFF aims at stimulating sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture.

A SWOT-analysis and draft policy priorities for the Belgian aquaculture sector have been included into the Operational Programme 2014-2020. The aquaculture strategy in the operational programme includes the following aspects:

- Stimulation of technological developments, innovation and knowledge transfer;
- Promotion of competitiveness and viability of aquaculture companies, including an improvement of safety and work conditions;
- Protection and recovery of aquatic biodiversity and aquaculture-related ecosystems and promotion of resource-efficient aquaculture;
- Promotion of aquaculture with a high level of environmental protection, animal welfare, public health and safety;
- Development of professional training and skills.

On a Flemish level, a bottleneck analysis as well as a recommendation to facilitate sector development, have been published by the Belgian Court of Audit (*Rekenhof*): *Aquaculture in Flanders (2013)*.

The *Flemish Aquaculture Platform* aims (1) to stimulate and facilitate the development of the Flemish aquaculture sector, (2) to map the aquaculture landscape (trends and developments) in Flanders and (3) to be the main communication channel concerning aquaculture for entrepreneurs and researchers. The *Flemish Algae Platform* is a network and innovation-stimulating project within the framework of *vzw FISCH*. The latter aims to identify, stimulate

and catalyse innovation for a sustainable chemistry in Flanders. Within this framework, research is conducted on microalgae as new providers of alternative resources, as a resource for waste disposal or for applications in cattle feed, chemicals and biofuel. The aim of this algae platform is to establish a facilitating framework, to inform about innovation possibilities and to create synergies between scientists and companies.

Several groups and institutes conduct research on the sustainable development of aquaculture in Flanders and in the BNS (see the list on the website *Flemish Aquaculture Platform* and *Visserijrapport (VIRA) 2012*). Specific examples are the MARIPAS project, which investigated the compatibility of mariculture and offshore wind farms (*Verhaeghe et al. 2011*), and the *Aquavalue project* (2014-2015), aiming to create a roadmap for integrated aquaculture in Flanders in order to optimally valorise the available expertise in Flanders. The final goal of this roadmap exercise is to initiate some promising pilot projects in consultation with all relevant stakeholders.

7.5.3 Monitoring in the BNS

A monitoring programme has been elaborated to review the environmental impact of the mussel farming installations (*Milieu-effectenbeoordeling Mosselcultuur 2005*). This monitoring programme was not retained in the permit and was therefore not executed.

Legislation reference list

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
Nitrates Directive	Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources	1991	676
Habitats Directive	Council Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
	Council 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 on the quality required of shellfish waters	2006	113
	Directive concerning integrated pollution prevention and control	2008	1
Marine Strategy Framework Directive	Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy	2008	56
Birds Directive	Directive on the conservation of wild birds	2009	147
Regulations			
	Council Regulation (EC) concerning use of alien and locally absent species in aquaculture	2007	708
	Regulation (EC) on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96	2008	762
Common Fisheries Policy	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
Other (Decisions, Communications, White Papers, etc.)			
	Communication from the Commission to the Council and the European Parliament - A strategy for the sustainable development of European aquaculture	2002	511
	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union	2007	575
	Communication from the Commission to the European Parliament and the Council - Building a sustainable future for aquaculture - A new impetus for the Strategy for the Sustainable Development of European Aquaculture	2009	162
	Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (29/04/2013): Strategic Guidelines for the sustainable development of EU aquaculture	2013	229

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 20 januari 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
Wet van 22 april 1999	Wet betreffende de exclusieve zone van België in de Noordzee.	1999-04-22/47
Royal decrees		
KB van 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
KB van 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
KB van 18 mei 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
KB van 23 juni 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
KB van 23 juni 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Ministerial decrees		
MB van 8 juli 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
MB van 7 oktober 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	

8

Agriculture

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Citation:

Van Bogaert, T., Danckaert, S., Demuynck, E., Maertens, E., Platteau, J., Pirlet, H., 2015. Landbouw. In: Pirlet, H., Verleye, T., Lescrauwaet, A.K., Mees, J. (Eds.), Compendium for Coast and Sea 2015: An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Ostend, Belgium, p. 165-174.

Agriculture constitutes an important economic sector in the coastal zone[1] and is, from a historical perspective, responsible for land reclamation. Over the last few years, the importance of agriculture as an employer in the European coastal regions has gradually decreased. Agriculture in the coastal zone is under pressure, mainly due to urban expansion (*Balancing the future of Europe's coasts, EEA 2013*). Between 1990 and 2000, 2,000 km² of farming land disappeared in the European coastal areas (first 10 km). In Belgium, the agricultural area decreased by 1.85% (*European Environment Agency (EEA) 2006*). Nevertheless, as an integral part of the agro-nutritional system, agriculture remains of significant economic importance with a small increase in Flanders over the last 10 year (*Landbouwrapport 2014*). Agriculture also has an impact on the marine environment *inter alia* due to the supply of nutrients such as nitrogen and phosphorus which can cause eutrophication of the coastal waters. Eutrophication especially constitutes a problem in the southern part of the North Sea and the Channel. 60% of the effluent nitrate and 31% of the effluent phosphorus derives from agriculture (*OSPAR QSR 2010*). However, these nutrients originate from the entire country and not only from agriculture in the coastal zone. Measurements by the Flemish Environment agency (*VMM*) indicate a reduction of the nitrate and phosphorus concentration in the surface water in Flanders. A further reduction of these nutrients from all sources remains important in order to achieve a good status of the ground water, surface water and coastal waters (see theme **Nature and environment**) (*Voortgangsrapport Mestbank 2013*).

8.1 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 (EC) (more information: *Brochure Europees Landbouwbeleid 2014*). For the period 2014-2020, the CAP is much more connected with and integrated into the overall EU 2020 Strategy. As in the previous period, the European agricultural policy is still embodied by two 'pillars': direct support and rural development (*Landbouwrapport 2014*).

At the Flemish level, the agricultural policy is developed by the Flemish minister of Agriculture and Fisheries (*beleidsnota Landbouw en Visserij 2014-2019*). The Agriculture and Fisheries department (*departement Landbouw en Visserij*) is responsible for the preparation, implementation and evaluation of the policy. The policy is supported by the Institute for Agricultural and Fisheries Research (*ILVO*), Flanders' Agricultural Marketing Board (*VLAM*) and the Strategic Advisory Council for Agriculture and Fisheries (*SALV*).

By means of research and information centres, the province plays an important role in the education 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 Provincie West-Vlaanderen*). 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 publication: *Landbouwrapport (2014)*. A broader overview of the legal context with regard to agriculture is provided in the *kustcodex thema landbouw*.

8.2 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. 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 (RUPs). However, this process has a serious delay.

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

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

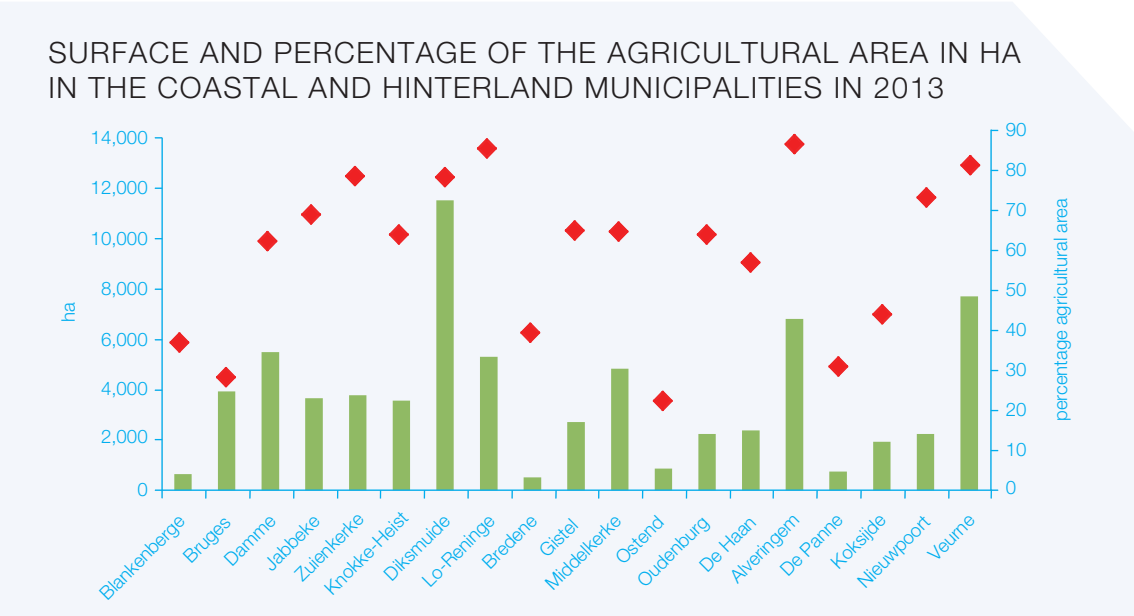

Figure 1. Surface of the agricultural area in the coastal and hinterland municipalities in ha in 2013 and the percentage of the agricultural area relative to the total area of the municipalities (Source: Agriculture and Fisheries department, based on FPS Economy – AD Statistiek).

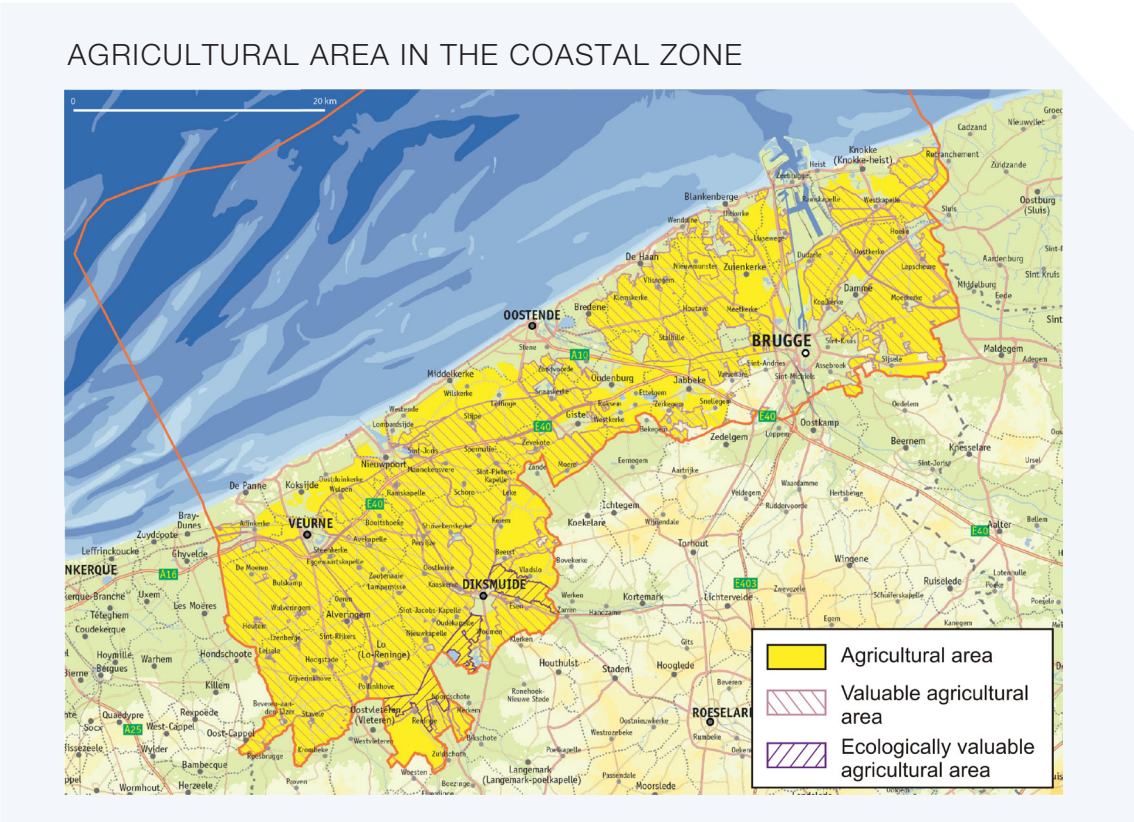

Figure 2. The agricultural area in the coastal zone (*Coastal Atlas*).

drafted which indicates the most important structures: connected areas prohibited for agriculture, valleys for nature development, etc. The consultation process finally resulted in 95,100 ha of reaffirmed agricultural area in the Coast-Polders-Westhoek region (*Danckaert 2013*). The regional spatial implementation plans (GRUPs) 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 Flemish government is also preparing a new policy *Beleidsplan Ruimte* that *inter alia* discusses food production (see also *Groenboek. Vlaanderen in 2050: mensenmaat in een metropool? Beleidsplan ruimte Vlaanderen (2012)*)

Parts of the agricultural structure are described in the spatial structure plan of the province of West Flanders (*PRS-WV*). For this publication, 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 (*Kustruimte*, *Westkustruimte*, *Oostendse ruimte* and a part of *Brugse ruimte*) due to the strong urban pressure, the economic developments (e.g. harbour of Zeebrugge) and the 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.

The agricultural area in the coastal zone constitutes a total surface of 71,154 ha (figures 1 and 2). This corresponds to 11.4% of the total agricultural area in Flanders (Source: Agriculture and Fisheries department based on the FPS Economy – AD Statistiek). All parcels registered by the Agriculture and Fisheries department, and their cultivation can be downloaded in GIS format on the Geopunt website (*www.geopunt.be*).

8.3 Societal interest

In 2013, 4,294 persons (3,130 full-time employees) were employed in 2,163 agricultural enterprises in the coastal and hinterland municipalities. This figure corresponds to 8.3% of all employees in agriculture and 8.7% of all agricultural enterprises in Flanders. Within the coastal area, agriculture represents about 2.5% of the workforce (source: *RESOC-dataset 2014* on *www.pomwvl.be*). The majority of the enterprises and employment in the coastal zone is located in the hinterland municipalities (see figure 3). The specialization of these enterprises, based on the standard output (more info: *Danckaert et al. 2009*), concerns primarily the cultivation of crops and the rearing of cattle, pigs and poultry (table 1) (Source: Agriculture and Fisheries department, based on FPS Economy – ADSEI, see also the specific theme agriculture and horticulture in the publication: *West-Vlaanderen ontcijferd 2014*).

The agricultural enterprises in the coastal zone account for 140,465 cows (figure of 2013), 696,485 pigs (figure of 2013), 9,597 sheep (figure of 2011), 2,760 goats (figure of 2011) and 1,809,905 heads of poultry (figure of 2011) (Source: Agriculture and Fisheries department, based on FPS Economy – AD Statistiek).

Table 1. Number of enterprises in the coastal area in 2013, broken down by specialisation (Source: Agriculture and Fisheries department, based on FPS Economy – AD Statistiek).

SPECIALISATION	NUMBER OF ENTERPRISES IN THE COASTAL ZONE (2013)
Agriculture	465
Horticulture	87
Milk production	236
Beef production	318
Mixed cattle breeding	207
Other grazing livestock (sheep, etc.)	115
Pigs and poultry	341
Mixed enterprises	394
Total of enterprises	**2,163**

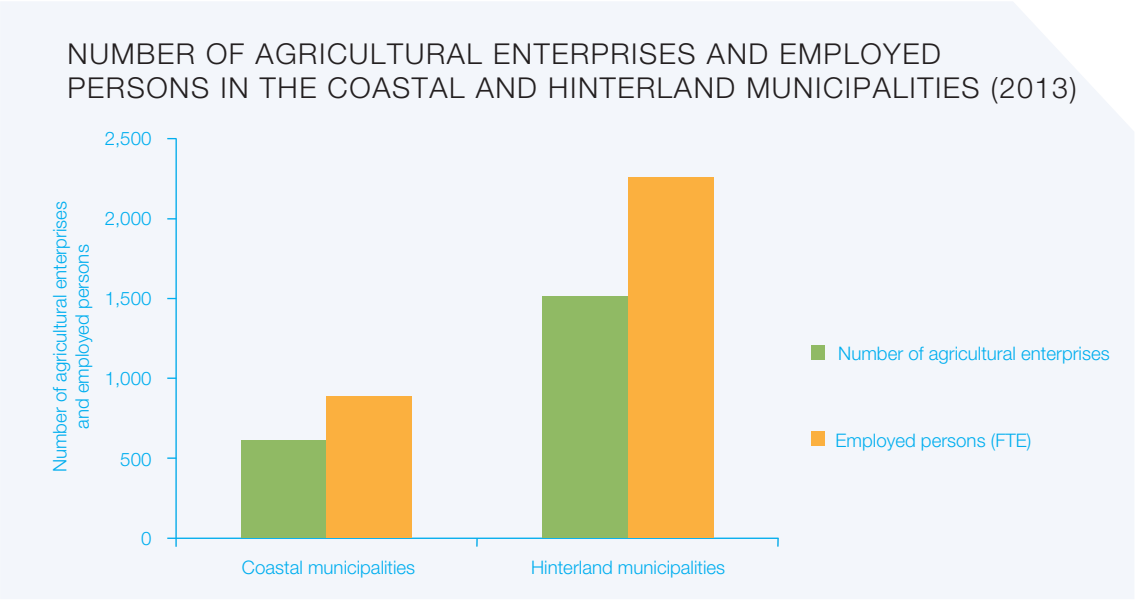

Figure 3. Number of agricultural enterprises and employed persons in the coastal and hinterland municipalities in 2013 (Source: Agriculture and Fisheries department, based on FPS Economy – AD Statistiek).

Besides the economic importance, agriculture also contributes to landscape creation, the management of open space (see also theme **Nature and environment**) and certain ecosystem services (e.g. water regulation, recharge of ground water, etc.) in the coastal zone.

8.4 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 mainly caused by other human activities, it has a considerable effect on the agricultural activities in the coastal zone.

8.4.1 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 the publications *Wustenberghs et al. (2009)*, *Van Steertegem (2012)* and *Landbouwrapport (2014)*. A description of the ecosystem of the polder area is discussed in the theme **Nature and environment**. The effects on the ecosystem are *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: **salinisation of the coastal area**, *Lenders et al. 2013*);
- The use of energy (more information: *Lenders et al. 2013*);
- The impact on the soil quality and erosion sensitivity;
- Fertilisation (more information: **eutrophication of the coastal waters**, *Voortgangsrapport Mestbank 2013*, *Overloop et al. 2011*, *Overloop 2013*);
- Acidifying emissions;
- The emission of particulates;
- Waste production;
- The impact on the spatial use.

8.4.2 Eutrophication of the coastal waters

Along with other factors, the use of fertilisers in agriculture has 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 supply of nutrients or 'eutrophication' amplifies the production of phytoplankton. A phytoplankton bloom can subsequently lead to changes in the structure of the ecosystems, habitat destruction and a decrease in biodiversity (*André et al. 2010*). Over the last 20 years, phosphorus concentrations have decreased in the sea water of the BNS, whereas nitrate concentrations have varied strongly and without any clear trend (*Goffin et al. 2007*). Besides the transport of nutrients by rivers, there is an increased awareness with regard to the atmospheric supply (*OSPAR QSR 2010*). The eutrophication of the coastal waters has been comprehensively studied 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 project) (more information: *Lancelot & Rousseau 2004*, *Rousseau et al. 2006*, *Lancelot et al. 2007*, *Lancelot et al. 2009*). The *ISECA project* aggregates the knowledge and information about the eutrophication in the southern part of the North Sea.

8.4.3 Salinisation of the coastal area

Salinisation has a considerable impact on agriculture in the coastal area. During this process, brackish or salt ground water can penetrate in the root layer of the soil. This causes an accumulation of salts (*Peeters 2013a*, *Peeters 2013b*). Naturally, there is a distribution of fresh and salt/brackish water in the coastal area. This distribution between fresh and salt water is the result of a complex history, influenced by human activities such as water extraction, infrastructure works (e.g. harbour expansion, tunnels, drainage, etc.) and interventions in the water management. These hydrological interventions in coastal areas may result in changes of the fresh-salt water distribution in the short or long term, possibly leading to salinisation (*Vanleberghe & Vanhoutte 2001*, *Van Houtte 2002*, *Vandenbohede et al. 2009*, *Vandenbohede et al. 2010*, *Vandenbohede et al. 2012*, river basin management plan for the Scheldt 2016-2021 - in preparation). Furthermore, sea level rise increases the salt pressure towards shallow groundwater and surface water. The fresh water lens in the dunes acts as a buffer against the intrusion of salt sea water in the hinterland (*Van den Eynde et al. 2011* (CLIMAR project *phase 1* and *phase 2* BELSPO) and the *CLIWAT project*).

8.5 Sustainable use

The international (WTO, climate conference of Copenhagen 2009, conference about sustainability in New York 2009, etc.) and European policy (the Treaty of Lisbon, the EU 2020 Strategy, the CAP, etc.) to maintain a sustainable agriculture is discussed in *Landbouwrapport (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 the environmental impact of agriculture in Flanders are listed in *Wustenberghs et al. (2009)* , *Van Steertegem (2009)* and *Van Steertegem (2012)*. *Gobin et al. (2008)* discusses the possibilities for the Flemish agriculture with regard to adaptations to climate change, whereas *Mathijs et al. (2012)* focuses more broadly on the sustainability of food production and consumption from a transition perspective. Furthermore, several studies have been conducted by the Agriculture and Fisheries department focusing on sustainable agriculture (*website Agriculture and Fisheries department*). These include *Bergen (2013)* (Agro ecology), *Danckaert et al. (2013)* (Food foodprint), *Dumez et al. (2014)* (new perspectives with regard to agriculture and policy) and *Bergen et al. (2014)* (Challenges for the Flemish agriculture).

The sustainable compatibility of several user functions in the coastal area (housing, tourism, recreation, agriculture, industry, nature, etc.) is discussed within the European recommendation for integrated coastal zone management (ICZM) (COM (2002) 413). The compatibility of different sectors in the polders 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.

8.5.1 Measures against eutrophication

In the Northeast Atlantic Ocean, OSPAR has created a *common procedure (2013)* for the identification of the eutrophication status (*Eutrophication Status of the OSPAR Maritime Area, 2008*). This procedure serves as a framework to identify the actions described in the *OSPAR Strategy (2010)*. This strategy includes a *eutrophication monitoring programme (2005 – updated 2013)* (see also *OSPAR website*).

At the European level, the issue of eutrophication is covered by several directives. The Nitrates Directive (91/676/EC) aims to reduce the leaching of nitrates from agriculture (*Goffin et al. 2007*). The Nitrates Directive is part of the Water Framework Directive (WFD) (2000/60/EC), which imposes an obligation to reach a good status of the surface and ground waters by 2015. In this context, the key chemicals contributing to eutrophication, such as nitrogen and phosphorus, have been included in the list of most important pollutants. There is also a link with eutrophication in other directives under the umbrella of the WFD, such as directive 91/271/EC on urban waste water and directive 2008/1/EC concerning integrated pollution prevention and pollution control. In the Marine Strategy Framework Directive (MSFD) (2008/56/EC), eutrophication is included as one of the descriptors for the environmental status of the marine environment. The criteria and methodological standards to determine this environmental status are described in *Ferreira et al. (2010)*.

On the Flemish level, the Nitrates Directive is implemented by the decree of 22 December 2006. This decree was originally approved on 23 January 1991 and was repeatedly modified afterwards. The decree of 22 December 2006 came into force on 1 January 2007. This associated fifth manure management plan (MAP-V) applies to the period 2015-2018 (for implementing decisions and modifications: *website VLM*). The WFD has been implemented on the Flemish level in the decree of 18 July 2003 on integrated water management (for implementing decisions and modifications: *website Coordination Committee on Integrated Water Policy*) and on the federal level in the royal decree of 23 June 2010 concerning the good status of surface waters (see *FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu 2009*). Furthermore, the MSFD has been incorporated in Belgian legislation by the royal decree of 23 June 2010 concerning the marine strategy for the BNS.

On 23 April 2014, the Flemish Government decided to establish a programmatic approach to address nitrogen depositions (*PAS*). PAS is a programme that aims to tackle the issue of nitrogen depositions in the special areas of conservation of the European Habitats 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).

VMM disposes of a monitoring network for the water quality that was expanded in 1999 with specific measuring points for agriculture (see water quality *geoportal*). In *Lancelot et al. (2011)* the costs and ecological efficiency of measures to prevent eutrophication in the Southern Bight of the North Sea have been modelled (see also AMORE III project *phase 1* and *phase 2* of the BELSPO project, and *TIMOTHY BELSPO project*).

8.5.2 Measures against salinisation

In COM (2012) 046 an overview is given of the implementation of the thematic strategy for soil protection since the establishment in COM (2006) 231. This strategy would be *inter alia* focused on the prevention of soil damage due to salinisation. Furthermore, intrusions of salt water have also been included in the WFD (2000/60/EC) as parameters for the quantitative status of ground water.

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 (in preparation), a number of measures have been included to prevent further salinisation. Furthermore, the WFD is also partially implemented in Belgian legislation by the royal decree of 23 June 2010 concerning the good status of surface waters. The quality of the surface and ground water is monitored by *VMM* (more information: *Vandenbohede et al. 2010*, the legislation is listed in the *coastal codex theme ground water extraction*).

In the study *ontwerpopgaven van Metropolitaan Kustlandschap 2100* two different development scenarios have been proposed for water management in the coastal polder (one integrated water system or partitioning). Within this context, the adaptation of agriculture to the increased saline seepage that may occur in the future is discussed.

8.5.3 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 characterized 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 authorization 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 Flemish government 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.

Legislation reference list

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
European Treaty			
	Treaty of Lisbon	2007	
Directives			
	Council Directive concerning urban waste-water treatment	1991	271
Nitrates Directive	Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources	1991	676
Habitats Directive	Council Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
	Directive concerning integrated pollution prevention and control	2008	1
Marine Strategy Framework Directive	Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy	2008	56
Other (Decisions, Communications, White Papers, etc.)			
	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
	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
	Report of the Commission (COM): The implementation of the Soil Thematic Strategy and ongoing activities	2012	46

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Royal Decrees		
KB van 23 juni 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
KB van 23 juni 2010	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
Decrees		
Decreet van 21 oktober 1997	Decreet betreffende het natuurbehoud en het natuurlijk milieu	1997-10-21/40
Decreet van 18 juli 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Decreet van 22 december 2006	Decreet houdende de bescherming van water tegen de verontreiniging door nitraten uit agrarische bronnen	2006-12-22/32

9

Maritime and coastal heritage

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Maritime and coastal heritage covers a very wide range of aspects. It includes maritime archaeological heritage in the sea as well as on 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, overview works 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. 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.

9.1 Current situation

9.1.1 Maritime 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;
- Settlements or other traces or remains of human activity in seas, rivers or other bodies of water and their paleo-environmental context (e.g. *Missiaen 2012*). 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 paleo-environmental context, which were entirely focused on the sea for their former operations such as lighthouses, fishing villages, shipyards, embankments, peat extraction, salt extraction, quays, drainage canals, etc.;
- Archaeological remains of sea fish that are also found far inland in archaeological research (e.g. *Van Neer & Ervynck 2006*);
- Paleontological bones of terrestrial fauna found at sea (for the Belgian part of the North Sea 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)).

For certain aspects of the maritime archaeological heritage (as mentioned above), there are (partial) overviews which cover 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 in a structured way about part of the heritage treated here, namely shipwrecks, without having an archaeological perspective:

- The wreck database of the Flemish Hydrography, *www.vlaamsehydrografie.be/wrakkendatabank.htm* 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 & Termote 2009*);

- The online database *www.wrecksite.eu* (private initiative), which has become an internationally respected and consulted database on shipwrecks.

Besides the three databases mentioned above, a number of reviews are available that cover part of the maritime archaeological spectrum. For example, in the so-called *onderzoeksbalans* of Flanders Heritage Agency (*https://onderzoeksbalans.onroerenderfgoed.be*), two 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 shipwrecks found on land, the research on the medieval shipwrecks in Doel is important in an international context (see also *http://www.kogge.be/en*, *Haneca & Daly 2014*, *Vermeersch & Haneca 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*).

Until now, little attention has been paid in the archaeological research field in Flanders to the other categories of maritime archaeological heritage on land such as embankments, harbour structures, lighthouses, salt extraction, etc.

In 2013, the IWT project 'Archaeological research in the North Sea: development of an efficient evaluation methodology and proposals for sustainable management in Belgium' (*SEARCH*) (2013-2016) was launched. This project aims to provide guidelines for a methodology with regard to buried shipwrecks and prehistoric relics in the North Sea. An efficient and low-cost methodology will be developed that will allow to detect the paleolandscapes, linked with prehistoric presence and buried archaeological remains, and manage them according to internationally accepted standards and protect them from uncontrolled destruction.

9.1.2 Historical fleet (including historical shipbuilding)

The historical fleet policy is relatively recent. In the early 1990s, increased attention was paid to the historical fleet by the industrial heritage cell within the former department of Monuments and Landscapes (the current Flanders Heritage Agency). The link between the historical fleet and the industrial heritage is obvious. Ships were built with materials used in other economic sectors. Initially, wood was the preferred material for ships. Depending on the type of vessel, the switchover to steel, the key product of the industrial revolution, was made sooner or later. 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*).

Two types of vessels are of great importance for the coast: fishing boats and sail yachts. In table 1, some of the most important historical fishing boats and their characteristics are presented. An overview of the fishing vessels from 1929 onwards is given 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 & Daems 2015*). The study outlines the history of shipbuilding on the coast and describes the development of the fishing boats between 1870 and 1970.

The Mercator ship is a special case which was protected as a monument in 1996. This steel barquentine of 78 m was built in 1932 according to the plans of Adrien de Gerlache (*VLIZ Wetenschatten 2012 – Adrien de Gerlache*, *VLIZ Wetenschatten 2015a*). The Mercator was used to train merchant marine officers. Since 1961, the ship 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.

Table 1. A selection of important historical fishing boats with their characteristics.

NAME OF THE SHIP	CHARACTERISTICS
Lorette de Gravelines	Year of construction: 1907, 17 m, oldest existing fishing sailboat of the Belgian coast, in restoration in France
Jacqueline-Denise	Shrimp fishing boat from Blankenberge, 17 m, based on the hull of a ship that was built in 1942 by Borrey in Ostend
OD.1 Martha	Year of construction: 1942, motor trawler, showpiece of the National Fisheries Museum (NAVIGO)
N.788 Moed en Vertrouwen	Year of construction: 1942, wooden motor trawler, 15 m, in very poor condition, along an access road to Oostduinkerke
O.305 François Musin	Year of construction: 1948, deep-sea trawler for Iceland fishing, shipyard: Belliard - Crighton in Ostend. Built for the NV Motorvisscherij. Restored in Antwerp by Werkvormm vzw. Protected as historical fleet
O.129 Amandine	Motor trawler, museum ship in Ostend about the history of the Iceland Fisheries (*Van Dijck 2012*)
O.148 Snipe	Year of construction: 1958, motor trawler, built by Loy, lies on dry land in Zandvoorde
O.116 Caroline	Year of construction: 1961, motor trawler, shipyard: De Graeve in Zeebrugge, still fishing
Crangon	Year of construction: 1965, motor trawler, shipyard: De Graeve in Zeebrugge, the first ship protected as historical fleet in 2007, tourist trips from Ostend

9.1.3 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 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 architectural heritage of the coastal zone has been gradually inventoried since 1977 (*Maelfait et al. 2012*). It was not until then that 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 3 parts of all protected monuments and sites in the province on 1 January 2001. 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 is discussed in the heritage magazine *In de Steigers*. 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 & Desnerck (1974)* and *Desnerck & Desnerck (1976)*. Pioneering work on the port of Antwerp was conducted by Albert Himler (see for instance *Himler 1993*, *Asaert et al. 1993* and *Himler & Moorthamers 1982*). The other Flemish ports have been far less studied. Also the industrial heritage linked to sea fisheries (fish smoking and processing plants) has been little explored up till now. An overview of the history of Belgian oyster farming is given by *Polk (2000)*, *Halewyck & Hostyn (1978)* and *Pirlet (2012)*, as well as on the following website: *http://www.vliz.be/wiki/Historiek_van_de_Belgische_oesterkweek* (see also theme **Aquaculture**).

9.1.4 Landscapes with heritage value[1]

The coastal landscape, bordered by the Pleistocene sand region, has been largely shaped by humans. Without embankments and drainage, this area would look completely different. There has been a significant human impact, although some areas such as De Grote Keignaard in Zandvoorde have a quite 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 (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* or on the geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be/*). 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* and in the geoportal of Flanders Heritage Agency.

9.1.5 Movable and intangible heritage[2]

The term 'movable heritage' covers historically valuable material 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 on the coast can be found on the provincial *museum map*. There are about twenty museums located in the coastal zone[3], some of them specifically focused on the coast (*www.erfgoedinzicht.be* for the digital disclosure of 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 following website (*collectiewijzer*) of the Flemish heritage library. The *VLIZ Library* of Flanders Marine Institute exclusively collects publications about the sea and coast. *The library and documentation centre of the National Fisheries Museum Oostduinkerke (NAVIGO)* focuses on the history of fisheries.

Furthermore, the archives of the various governments are often important sources for movable heritage and in the database, *Archiefbank*, private archives are inventoried, some of which are important for maritime heritage (e.g. the archives of fishing 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 (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 communities. The municipalities of De Panne, Koksijde and Nieuwpoort are included in the image bank *Westhoek verbeeldt* of the *Erfgoedcel CO7* and Ostend has its own *image bank.* The initiative '*a century of sea fisheries in Belgium*' of Flanders Marine Institute collects historical data about the landing, gross revenues and legislation of the Belgian fisheries (see also theme **Fisheries**). Finally, the local historical societies also preserve a lot of interesting materials. An overview of all societies 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.

Intangible heritage represents traditions, customs, knowledge and practices inherited or historically developed by a group of people. Dialects, processions or crafts are just some examples of intangible heritage. Recently, the Flemish government has launched the *Platform for intangible heritage in Flanders.* An overview of the intangible heritage is included in *the inventory of immaterial 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.

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

[2] Research on prehistoric heritage is included in maritime archaeology.

[3] It should be mentioned that certain actors (museums, libraries, archives, etc.) which are not located in the coastal zone do have interesting collections about maritime and coastal heritage.

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* 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.

9.2 Policy Context

On an international level, the policies related to cultural heritage are primarily defined by the United Nations Educational, Scientific and Cultural Organization (*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.

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 the 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. 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 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 *http://www.vondsteninzee.be/* for more information). This law implements the Belgian ratification of the UNESCO Convention for the protection of the underwater cultural heritage (2013) to a considerable extent.

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 & Derudder 2014*, *Derudder & Maes 2014*).

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

Within the policy domain Spatial Planning, Housing Policy and Immovable Heritage (*RWO*), *Flanders Heritage Agency* 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. The agency has carried out these tasks in an integrated way since 1 January 2013. The *RWO Inspection Agency* 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: *http://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 also manages several heritage sites and organises activities related to heritage (e.g. *Open Monumentendag*).

The policy note on immovable heritage (*beleidsnota onroerend erfgoed (2014 – 2019)*) and the policy note on culture (*beleidsnota cultuur (2014 – 2019)*) contain the strategic lines of the heritage and cultural policy in Flanders.

Since 1 January 2015, a new decree on immovable heritage has been in place (*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 decree of 6 July 2012 with regard to cultural heritage, the decree of 24 January 2003 concerning the protection of movable heritage of exceptional value and the decree of 29 March 2002 with regard to the protection of the historical fleet (*Province of West Flanders, 2008*). On 9 May 2014, the Flemish government revised the Historical Fleet Decree. However, the revised decree will only enter into force once there is an execution decision.

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*).

In the context of coastal heritage, the foundation of the heritage cell *KUSTERFGOED* in 2015 is important. Within this cell, 4 coastal municipalities (Middelkerke, Ostend, De Haan and Blankenberge) will collaborate on movable and intangible heritage at the coast.

9.3 Spatial use

9.3.1 Maritime archaeology

The geographical 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.

Concerning the BNS, there are three databases that provide structured information: *www.maritieme-archeologie.be*, *the wreck database of the Flemish Hydrography* and *www.wrecksite.eu*.

Within the *SEARCH* project, work has been done on an interactive geoportal concerning the underwater heritage (including prehistoric finds) in the BNS (*www.sea-arch.be*).

As far as maritime heritage in the BNS 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 recognized as cultural heritage underwater by the law of 4 April 2014 are listed in a register on the following website: *http://www.vondsteninzee.be/*. Since 2014, underwater cultural heritage has indeed received a spatial translation by the recent recognition of several ship wreck sites (e.g. HMS Wakeful, the lightship West-Hinder and an unknown 19th-century wreck site near Ostend (e.g. *Demerre et al. 2014*)).

In the marine spatial plan, the cultural and ecological importance of the more than 215 (ship)wrecks in the BNS is acknowledged in the annex of the royal decree of 20 March 2014 (*Maes & Seys 2014*).

9.3.2 Architectural heritage along the coast

The new geoportal of Flanders Heritage Agency (*https://geo.onroerenderfgoed.be*) provides an overview of the geographical location of the architectural heritage in the coastal area. Additional information can be obtained about the heritage elements.

9.3.3 Landscapes with heritage value

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

9.4 Societal interest

Despite the fact that the importance of heritage is generally recognised, the economic significance, benefits and societal return on investment are often unknown. The study by *De Baerdemaeker et al. (2011)* deals with the socio-economic impact of the immovable heritage (policy) in Flanders. 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.

With regard to the coastal zone, primarily the economic benefits related to coastal tourism are known (see the 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 on the coast accounts for more than 2 million visitors per year, whereas the total heritage-related tourism expenditure amounts to almost 60 million euro. In the publication *trendrapport Kust (2012-2013)* 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 and 2010 by the Flemish government for the restoration 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 (see also theme **Social and economic environment**). In De Panne, where 44% of the municipal area is protected (especially the landscape heritage is important in this regard), a property gets an added value of approximately 21,000 euro. In Knokke-Heist, the protected area amounts to 17% leading to an added value of property of approximately 8,300 euro (*De Baerdemaeker et al. 2011*);
- In a number of historic shipyards, social employment projects are developed;
- Museums are also involved in education. However, there are no data available regarding their impact;
- The development of Maasvlakte 2 in the Netherlands is an example of how economically driven projects like the expansion of the port of Rotterdam can take place in synergy with research about underwater heritage (see *inter alia* *Van Ginkel et al. 2014*, *Moree & Sier 2015*).

9.5 Sustainable use

9.5.1 Maritime archaeology

Until recently, the 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 finds in the BNS of which the finder may suspect that they are cultural heritage. Finds in the territorial sea, the exclusive economic zone or on the continental shelf have to be reported to the governor of West Flanders on the website, *http://www.vondsteninzee.be/*, where they are subsequently entered in a register. Archaeological finds on the beach should be reported to *Flanders Heritage Agency*. 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. 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 (royal decree of 20 March 2014) (*Maes & 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 a multiple use of certain marine areas.

9.5.2 Historical fleet (including historical shipbuilding)

Since 29 March 2002, there has been a decree that regulates the protection of the historical fleet. This decree on the historical fleet (decree of 29 March 2002) and the associated decision of 4 June 2004 provide support for owners of this kind of heritage to keep their vessel into service. A management plan can be drafted by the owner which covers the maintenance, restoration, budgeting and disclosure of the vessel over a period of several years. Based on this plan, a grant can be claimed. 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 2015, 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.

9.5.3 Architectural heritage along the coast

Due to the growing scarcity of open space at the coast, the remaining heritage comes increasingly under 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 (*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/*.

9.5.4 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/*), but only receives a legal status after the 'designation'. From then on, the local government is obliged to take it into account when drawing up a Spatial Implementation Plan (RUP). As soon as an anchorage area is included in a RUP, it is called a heritage landscape (Article 27 to 30). This means that the landscape values and characteristics of the anchorage area are converted into planning regulations. This way it is possible to ensure that the landscape heritage is dealt with in a sustainable way. More information about protected landscapes can be found in the following publication: *Landschappen: een kennismaking (2013)*.

9.5.5 Movable and intangible heritage

The list of objects and collections with an exceptional value (*topstukkenlijst*) contains several hundred pieces or (sub-) collections. Some of these are linked to the coast. It mainly concerns paintings from Ensor, Permeke and Spilliaert from the collection of Mu.Zee. 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 Flemish government (more information: *Steen & Van den Nieuwenhof 2008*). This policy focuses on two lines, the registration of movable heritage held by museums, local heritage societies and other heritage managers as well as the conservation and management of these pieces. To assist museums and heritage organisations in the registration of their collection, the heritage database *www.erfgoedinzicht.be* has been developed. In the longer term, regional depots should host documents or (sub-)collections of museums and local heritage associations.

The *inventory* of intangible heritage currently contains 40 elements, 2 of them are specific to the coast: the carnival of Blankenberge and horseback shrimp fishing in Koksijde. 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. Included elements must submit an annual progress report with information about the activities concerning the protection of the element. For now, the inclusion in the inventory only increases the visibility of the element. Being in the inventory is a prerequisite to be included in the *UNESCO list of intangible heritage*. In 2013, shrimp fishing on horseback in Koksijde was recognized by UNESCO as intangible heritage.

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
	Convention Concerning the Protection of the World Cultural and Natural Heritage	1972	1996 (ratification by Belgium)
UNCLOS	United Nations Convention on the law of the sea	1982	1994
	Convention on the Protection of the Underwater Cultural Heritage	2001	2013 (ratification by Belgium)
	Convention for the Safeguarding of Intangible Cultural Heritage	2003	2006 (acceptance by Belgium)

Table with legislation of the European Council.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
Granada Convention	Convention for the Protection of the Architectural Heritage of Europe	1985	1987
La Valetta Convention	Convention for the Protection of the Archaeological Heritage of Europe	1992	1995
Florence Convention	European landscape convention	2000	2004
Faro Convention	Convention on the Value of Cultural Heritage for Society	2005	2011

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 7 augustus 1931	Wet op het behoud van monumenten en landschappen	1931-08-07/30
Wet van 20 januari 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
Wet van 4 april 2014	Wet betreffende bescherming van het cultureel erfgoed onder water	2014-04-04/07
Royal Decree		
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Decrees		
Decreet van 3 maart 1976	Decreet tot bescherming van monumenten en stads- en dorpsgezichten	1976-03-03/30
Decreet van 30 juni 1993	Decreet houdende bescherming van het archeologisch patrimonium	1993-06-30/33
Decreet van 16 april 1996	Decreet betreffende de landschapszorg	1996-04-16/34
Decreet van 29 maart 2002	Decreet tot bescherming van varend erfgoed	2002-03-29/37

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
Decreet van 24 januari 2003	Decreet houdende bescherming van het roerend cultureel erfgoed van uitzonderlijk belang (topstukkendecreet)	2003-01-24/40
Decreet van 16 juli 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
Decreet van 6 juli 2012	Decreet houdende het Vlaams cultureel-erfgoedbeleid (erfgoeddecreet)	2012-07-06/31
Decreet van 12 juli 2013	Decreet betreffende het onroerend erfgoed (Onroerenderfgoeddecreet)	2013-07-12/44

10

Social and economic environment

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The European coastal areas are characterised by their increasing number of inhabitants and a population density that is on average 10% higher compared to the hinterland. Moreover, these regions are also subject to an expansion of infrastructure and economic activities (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*). Hence, the coastal zones are regions with a unique identity and specific challenges. The Belgian coastal area is characterised by a typical social environment, with a higher population density, a large ageing population, a high amount of second homes and high real estate prices. Furthermore, the coast constitutes a specific region from an economic perspective. On the one hand, large economic gateways (sea ports and airports) are present, but the region is also characterised by a higher unemployment rate, seasonal employment and a limited number of high-quality jobs for the highly educated (*Breyne et al. 2007*, *Maelfait et al. 2012*). In the current text, the Belgian coastal area is mainly compared to the province of West Flanders. In the publications mentioned below, the figures are also benchmarked within larger geographical areas, such as the Flemish region.

10.1 Policy context

Both federal and Flemish actors are involved in the Belgian policy concerning the economic environment. On the federal level, the following Federal Public Services (FPS) exist: *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*). Furthermore, there are the following Flemish policy domains: *Work and Social Economy* and *Economy, Science and Innovation* (see the Flemish policy notes *Sociale economie 2014-2019* and *Werk, Economie, Wetenschap en Innovatie 2014-2019*).

The housing policy and spatial planning belong to the Flemish policy domain of Spatial Planning, Housing Policy and Immovable Heritage (*RWO*) (see the *Omgeving 2014-2019* and the *Wonen 2014-2019*). Furthermore, the Flemish policy domains of *Wellbeing, Public Health and Family*, *Education* and *Culture, Youth, Sports and Media* are important as well with regard to the social environment.

The Province of West Flanders (see *streekhuis Kust*, *De Provincie aan de Kust. Beleidsbrief Kust 2011*) and the municipalities are involved in the translation of the economic policy, the housing policy and spatial planning (see below). The legal framework concerning spatial planning can be found in the *coastal codex, theme Spatial Planning*. The local legislation for inhabitants of the coast is listed as well (*coastal codex, theme Local Legislation*).

10.2 Spatial use

The actual spatial use has been determined by the regional spatial plans, drafted by the federal government. A regional spatial plan covers one or several districts, in which the space has been divided into areas dedicated to housing and services, industry, recreation, nature reserves as well as agriculture. A destination in a regional spatial plan is further refined by the municipality in urban plans (BPA). These plans have been created particularly in buildable areas. Therefore, differences exist today between several coastal municipalities concerning the specific interpretation, such as the heights and density of the apartment blocks.

The new Flemish decree on spatial planning (decree of 18 May 1999) has changed the planning system. The destinations on the regional spatial plan still remain valid until they are replaced by a new destination, through a spatial implementation plan (RUP). These RUPs can be elaborated by the municipalities, the provinces as well as by the Flemish Region. The drafting of a RUP is the implementation of a spatial vision described in a spatial structure plan. Three spatial structure plans exist: the Flemish spatial structure plan (*RSV*) (Flemish Region), the spatial structure plan of the province of West Flanders (*PRS-WV*) (Province of West Flanders) and the municipal spatial structure plans. These spatial visions determine the future spatial use. The regional spatial plans, RUPs and BPAs can be consulted on the following website: *http://www.giswest.be/gewestplan-rups-internet*.

In the *RSV*, the coast is regarded as an urban network and a tourist-recreational network. This means that a coherent urban policy for the coast should be in place, with opportunities for further tourist and recreational activities. In this context, the regional urban area of Ostend (consisting of parts of Middelkerke, Ostend and Bredene) serves to meet new needs with regard to housing and industry. Furthermore, Ostend and Zeebrugge are designated as economic gateways, which means that the ports of Ostend and Zeebrugge as well as Ostend Airport can benefit from opportunities for further development. This development is elaborated in regional spatial implementation plans

(GRUPs). The large connected nature areas such as *Zwin*, the beaches between coastal towns on the West Coast, etc. are also demarcated by the Flemish Region in GRUPs. The *RSV* and the GRUPs can be consulted on the following website: *www.ruimtelijkeordening.be*. Besides the further implementation of the Flemish spatial structure plan, the government of Flanders is preparing a new spatial policy plan (*Beleidsplan Ruimte*) (see *Groenboek. Vlaanderen in 2050: mensenmaat in een metropool? Beleidsplan ruimte Vlaanderen (2012)*).

The *PRS-WV* refines the spatial planning in the coastal zone. Every coastal municipality benefits from opportunities for further development. This needs to be concretised by the municipalities in municipal spatial structure plans and is concluded in the municipal spatial implementation plans. The province determines the possibilities for constructions on the beach and seawall in provincial spatial implementation plans. The PRS and RUPs can be found on the following website: *www.west-vlaanderen.be/ruimtelijkeordening*.

10.3 Current state

10.3.1 Social environment

THE COAST AND ITS INHABITANTS (more information: *demografische fiche Kust 2012*)

On 1 January 2014, the coastal area[1] numbered 418,558 inhabitants. This constitutes 35.6% of the total population of the province of West Flanders. In the period 2002-2014, the population in the coastal area increased by 4% (figure 1), a growth rate comparable to 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*). A detailed comparison of the population growth of the Belgian coast and the Côte d'Opale in Northern France is discussed in the following publication: *Grensoverschrijdende atlas: Van Berck tot Brugge, één grens, twee gebieden, één gezamenlijke horizon (2006)*.

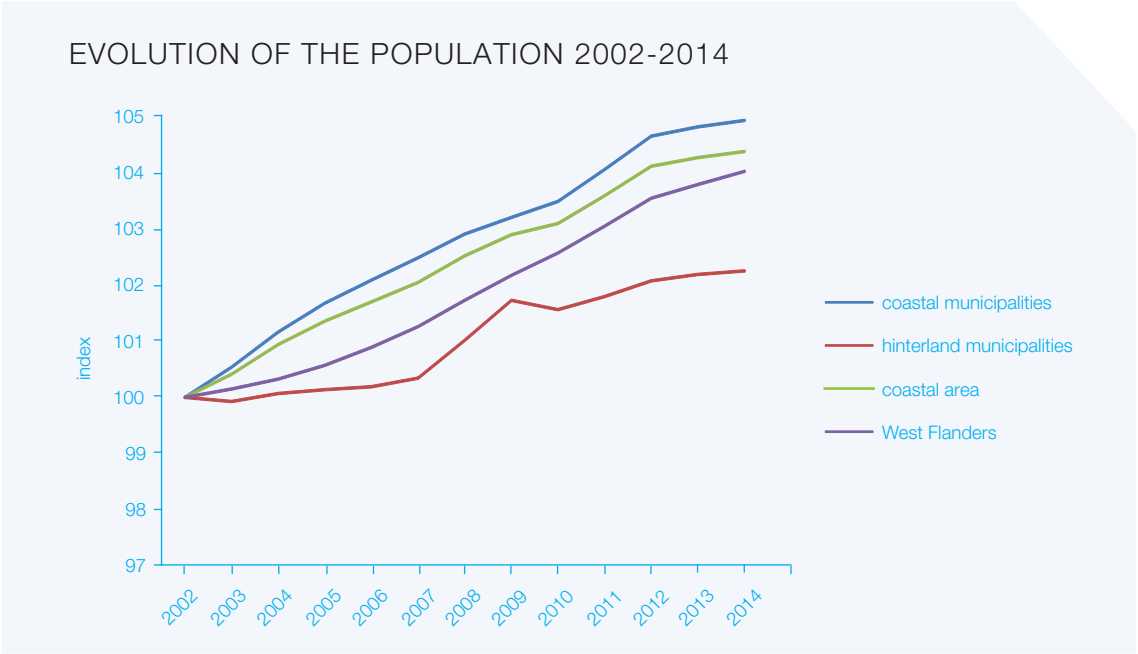

Figure 1. Evolution of the population in the coastal area (coastal municipalities + hinterland municipalities) and the province of West Flanders between 2002-2014 (Source: '*rijksregister*', population on 01.01 of each year, processed by the Province of West Flanders).

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

The coastal municipalities as well as the hinterland municipalities are characterised by population growth, although the increase is more evident at the coast than in the hinterland. The population growth in the coastal zone is stronger than the average in the province of West Flanders (Source: '*rijksregister*' population on 01.01 of each year, processed by the Province of West Flanders).

Recently, the research department of the government of Flanders have presented their new population forecasts (see figure 2). (*http://www4.vlaanderen.be/sites/svr/Pages/2015-01-29-projecties.aspx*). The projections show a further increase of the number of inhabitants in the coastal municipalities, although the population growth will be less pronounced (+2%) than the past 10 years. The population growth in the hinterland municipalities will stagnate between now and 2024.

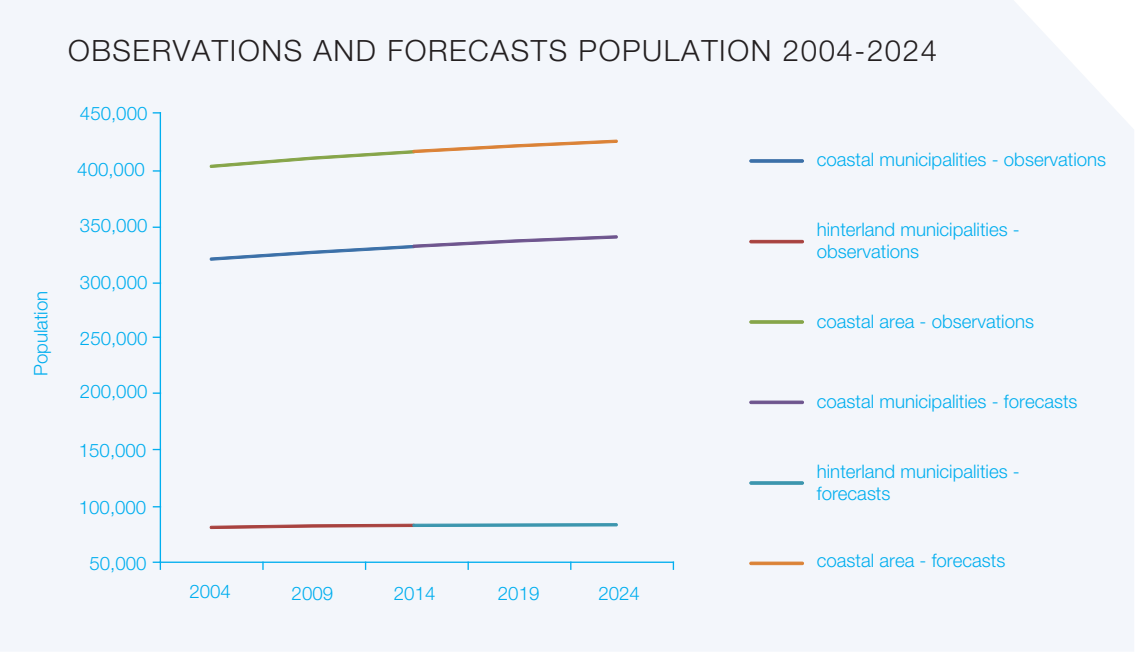

Figure 2. Observations and forecasts of the population in the coastal municipalities, hinterland municipalities and coastal areas (Source: research department of the government of Flanders).

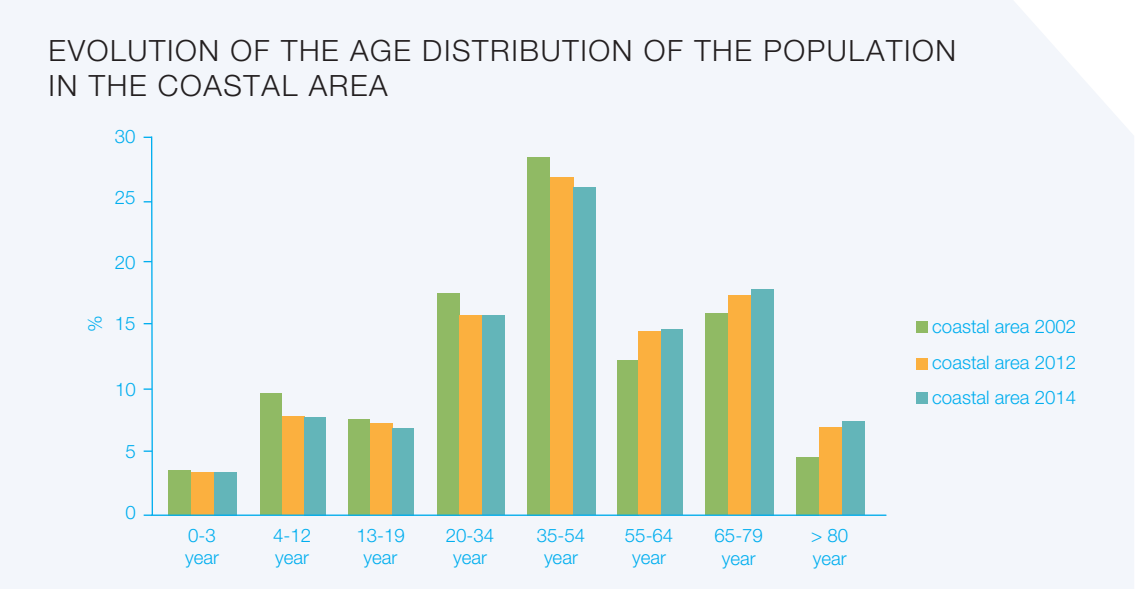

Figure 3. The evolution of the age distribution of the population in the coastal area, between 2002 and 2014 (Source: '*rijksregister*' on 01.01.2014, processed by the Province of West Flanders).

The Belgian coast as well as the Dutch coast and parts of the Northern French coast constitute the coastal area around the North Sea with the highest population density (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*). The average population density in the Belgian coastal area amounts to 368 inhabitants per km². This average masks certain differences: the population density of the coastal municipalities amounts to 696 inhabitants per km², while the population density of the hinterland municipalities is 129 inhabitants per km². 80% of the inhabitants of the coastal area live in a coastal town (Source: '*rijksregister*' on 01.01.2014, processed by the Province of West Flanders).

The coastal population has a few typical characteristics. According to the publication *Grensoverschrijdende atlas: Van Berck tot Brugge, één grens, twee gebieden, één gezamenlijke horizon (2006)*, the profile of the inhabitants of the Belgian coast strongly resembles the profile of the French Côte d'Azur. The dejuvenation and ageing processes are more pronounced in the Belgian coastal area than in the other parts of Flanders and West Flanders (Coudenys 2012 in *Maelfait et al. 2012*, *De Klerck 2011*). The age groups under 55 years decrease proportionally while the age groups above 55 years increase proportionally (see figure 3). Furthermore, the structural coefficients tell us something about the demographics (see table 1).

In West Flanders, for every 100 persons between 0 and 19 years old, there are 138 people aged 60+. In the coastal municipalities, this proportion increases to 199: for every 100 persons aged under 20, there are 199 people aged 60+, so the population aged 60+ is twice the population aged under 20. The so-called 'grey pressure' is 70 in the coastal municipalities: for every 100 persons in the professionally active age range (20-59 years) there are 70 people aged 60+. The internal ageing (the share of people aged 80+ within the group of 60+) amounts to 22 in the coastal municipalities. This figure is slightly lower than in the hinterland municipalities and West Flanders.

On 1 January 2014, 136,366 persons aged 60+ lived in the coastal area (Source: '*rijksregister*' on 01.01.2014, processed by the Province of West Flanders). The increase between 2002 and 2014 amounts to 28%, which means that the population of persons aged 60+ in the coastal area has increased with more than a quarter compared to 12 years ago. In the same period, the number of persons under 20 in the coastal area has decreased by 10% (from 84,219 in 2002 to 75,389 in 2014).

On 1 January 2014, 195,396 households were living in the coastal area. In the time range 2002-2014, the amount of households increased by 11%. The increase in the amount of households is stronger than the increase in the number of inhabitants. Hence, the coast was characterised by a continuing reduction in family size within the past 11 years.

When the features of the households are observed in detail, a distinction can be made with regard to the composition of the household: a household consisting of a single adult or of several adults living together, a household without children aged under 20 (family without children) or a household with one or more adults living together with one or more children aged under 20 (family with children). This last category also includes single-parent families.

The households in the coastal area comprise 37% singles, 41% families without children and 21% families with children (figure 4). The coastal municipalities are characterised by more singles and fewer families with children compared to the hinterland municipalities and less than the average of West Flanders. (Source: '*rijksregister*' on 01.01.2014, processed by the Province of West Flanders).

Table 1. The structural coefficients in the coastal area (coastal municipalities and hinterland municipalities) and the province of West Flanders on 1 January 2014 (Source: '*rijksregister*').

	STRUCTURAL COEFFICIENTS			
	coastal municipalities	hinterland	coastal zone	West Flanders
Ageing degree (60+/0-19 year)	199.44	122.36	180.88	138.19
Grey pressure (60+/ 20-59 year)	70.25	50.13	65.94	54.86
Internal ageing (80+/60+)	22.39	23.99	22.65	23.29
Family care index (80+/50-59 year)	50.72	41.99	48.96	45.66
Juvenile pressure (0-19 year/20-59 year)	35.22	40.97	36.45	39.70

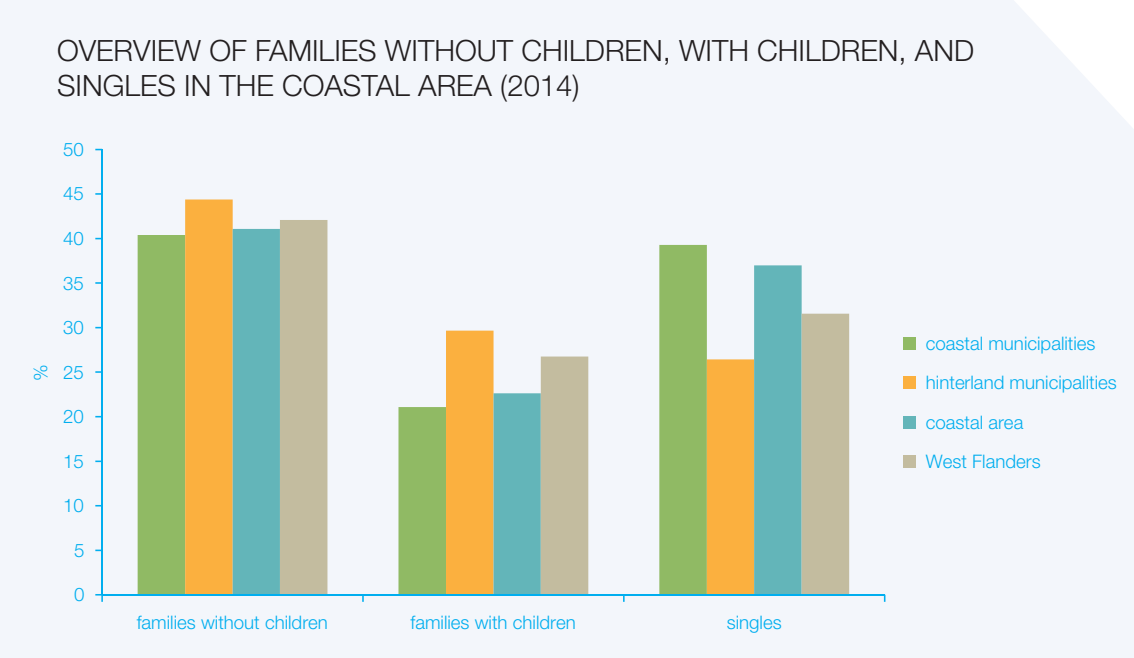

Figure 4. Overview of families without children, with children, and singles in the coastal area (coastal municipalities and hinterland municipalities) and the province of West Flanders on 1 January 2014 (Source: '*rijksregister*').

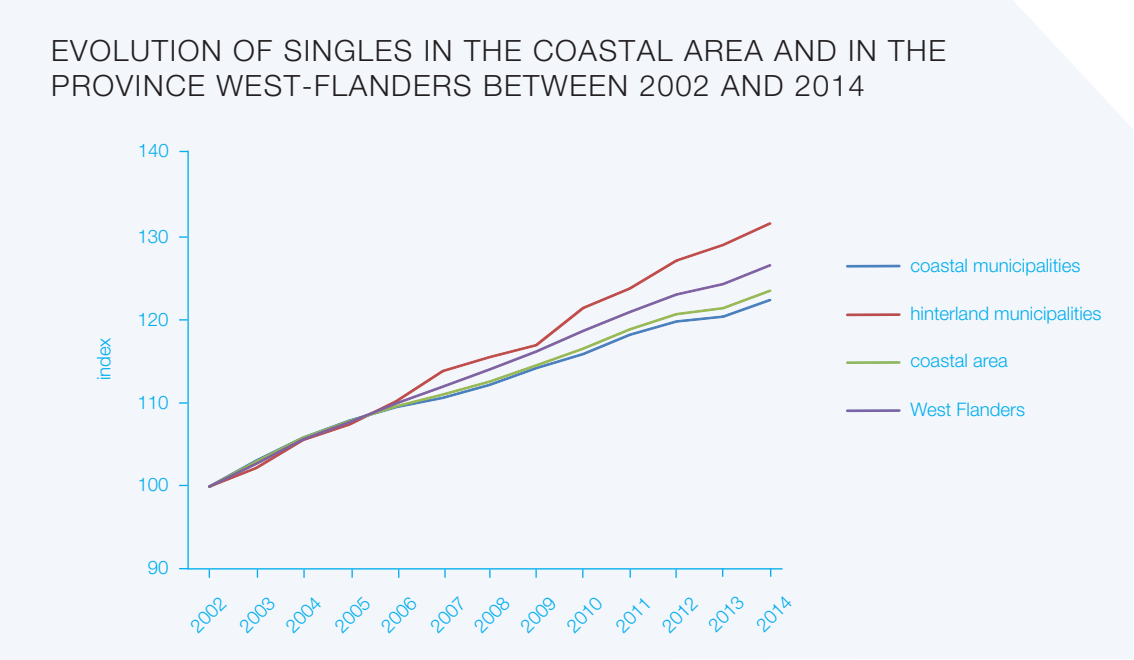

Figure 5. The evolution of singles in the coastal area (coastal municipalities and hinterland municipalities) and in the province of West Flanders between 2002 and 2014 (Source: '*rijksregister*', population on 1 January of each year, processed by the Province of West Flanders)

A distinctive feature of the coastal municipalities is the large number of singles. This group has grown a lot over the past 12 years (+23% in the coastal area, +26% in West Flanders) (see above: reduction in family size) (figure 5). The highest increase is observed in the hinterland municipalities.

When we observe the features of the population, a few indicators reveal the urban character of the coastal municipalities: an older population, a lot of singles and a higher population density. This urban profile first appeared

in the deprivation atlases (*Kesteloot et al. 1996*, *Kesteloot & Meys (2008)*) that contain an analysis on neighbourhood level. The neighbourhoods along the coast show a completely different profile than the neighbourhoods behind the coastal zone. The line of demarcation between more deprived quarters and less deprived neighbourhoods does not correspond to the borders of the municipalities. To determine the urban profile of the coastal zone and the related problems, an analysis on neighbourhood level is required.

The deprivation atlas of the province of West Flanders (*provinciebestuur West-Vlaanderen, Steunpunt Sociale Planning*, *Kansarmoede-atlas West-Vlaanderen 2014*) confirms the urban nature of the coastal municipalities and reveals that coastal towns are faced with deprivation more than average (*Kansarmoede-atlas West-Vlaanderen 2014*). In the coastal area, 19.7% of all families live in a deprived neighbourhood. The share of families living in a deprived neighbourhood is 8% higher than the average in West Flanders (12%). In the coastal municipalities, an average of 23% of families live in a deprived neighbourhood. For the hinterland municipalities, this share amounts to 4% of families (*Kansarmoede-atlas West-Vlaanderen 2014*, see also *kansarmoede-steekkaarten per gemeente*).

THE COAST AND ITS HOUSING (more information: *woonfiche kustzone 2012*)

The total surface of the coastal area is 1,183 km². The coastal municipalities account for 42% of this area, the hinterland municipalities for the other 58% (Source: FPS Economy - *Algemene Directie Statistiek en Economische Informatie*, based on the land register).

The Belgian coastal zone has the highest share of built-up area compared to the other European coastal zones (*The changing faces of Europe's coastal areas, EEA 2006*, *Balancing the future of Europe's coasts, EEA 2013*). In the publication: *Grensoverschrijdende atlas: Van Berck tot Brugge, één grens, twee gebieden, één gezamenlijke horizon (2006)* a detailed comparison between the habitation of the Belgian Coast and the Côte d'Opale (Northern France) is made. The built-up area in the Belgian coastal area amounts to 239 km². 7% of this built-up area in the coastal area serves housing. For the coastal municipalities, the area for housing constitutes 35% of the built-up area whereas in the hinterland municipalities this is only 4% (Source: FPS Economy - *Algemene Directie Statistiek en Economische Informatie*, based on the land register).

In 2014, 309,806 housing facilities were present in the coastal area (table 2). However, there is a significant difference in the types of housing. In the coastal municipalities, 54% of the housing facilities are situated in an apartment (block) compared to 8% in the hinterland municipalities. In the hinterland municipalities, 87% of the housing facilities are ordinary houses (*Kadasterkubus* of Province West Flanders).

The total amount of housing facilities in the coastal municipalities is slightly higher than the amount of homes needed for housing its inhabitants. An average of 38% of the housing facilities in the coastal area is not used as a permanent home (figure 6). In other words, housing facilities often serve other functions: second homes, some sort of industry, or sometimes they remain tenantless houses (Coudenys 2012 in *Maelfait et al. 2012*).

The use of the housing facilities for other functions than permanent habitation might have negative consequences for the community, such as an increased feeling of insecurity and a lack of social cohesion. On the other hand, a large amount of second homes is one of the preconditions for the tourism industry (see theme **Tourism and recreation**). Figure 6 clearly shows a large housing surplus. This phenomenon is typical for the coast given that the hinterland municipalities only have 10% housing facilities which are used for other purposes than permanent habitation.

Table 2. An overview of the housing facilities in the coastal area, divided into hinterland municipalities and coastal municipalities (Source: Province of West Flanders, *kadasterkubus*, situation on 01.01.2014).

Housing facilities	COASTAL ZONE		HINTERLAND MUNICIPALITIES		COASTAL MUNICIPALITIES	
	Total		Total		Total	
Total number housing facilities	309,806	100%	38,125	100%	271,681	100%
• Residential houses	149,182	48%	33,256	87%	115,926	43%
• Commercial premises	9,919	3%	1,693	4%	8,226	3%
• Apartments and buildings	150,705	48%	3,176	8%	147,529	54%

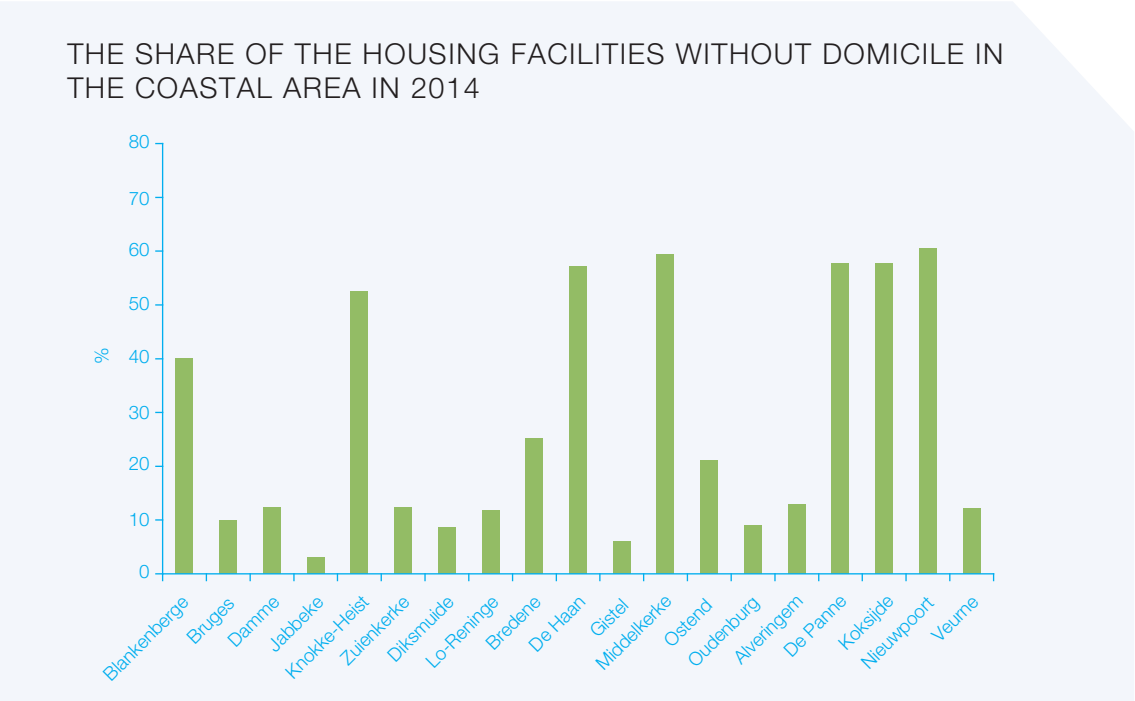

Figure 6. The share of the housing facilities without domicile in the coastal area, during the past 5 years (Source: *Kadasterkubus* province of West Flanders, situation on 01.01.2014; methodology: Coudenys 2012 in *Maelfait et al. 2012*).

10.3.2 Economic environment

THE COAST AND ITS LABOUR MARKET

In 2012, there were 169,121 professionally active persons in the coastal area (employees, self-employed and helpers) aged between 18 and 64 years. Hence, the coastal area constitutes 33.5% of the total number of working persons in West Flanders. There were 142,170 employees in the coastal area at the end of 2012, which represents 34.8% of the total of West Flanders. Moreover, 36,928 self-employed and helpers (excluding the self-employed as a secondary activity) were active in the coastal area, which equals 35.1% of the total number in West Flanders (Source: *RESOC-dataset 2014* on *www.pomwvl.be*).

The coastal area is characterised by a very weak industrial basis. The share of the industry within salaried employment was only 9.4% at the end of 2014, compared to 20.7% in West Flanders. In the coastal area, 85.5% of salaried employment is situated in trade and services, of which tourism and the hotel and catering industry constitute a major part. In the latter sector, a large number of the jobs are seasonal employment. In West Flanders, 71.8% of all employees are active in trade and services (Source: *RESOC-dataset 2014* on *www.pomwvl.be*).

In 2012, 181,306 inhabitants of the coastal area belonged to the professionally active population (working people and non-working jobseekers) aged between 18 and 64 years. This is 33.9% of the total number in West Flanders. The degree of activity – the proportion of the professionally active population compared to the total population aged between 18 and 64 – in the coastal area equalled 73.1% (2012), which is less than in West Flanders (75.7%). The employment rate – the proportion of the number of working people compared to the total population aged between 18 and 64 – is lower as well in the coastal area (68.1%) than in West Flanders (71.3%) (figure 7). The unemployment rate – the number of non-working jobseekers compared to the professionally active population aged between 18 and 64 – in the coastal area amounts to 6.7%, which is higher than the average of West Flanders (5.5%) (Source: *RESOC-dataset 2014* on *www.pomwvl.be*).

In 2013, 13,430 non-working jobseekers were present in the coastal area, which represents 41.1% of the total in West Flanders. Furthermore, the older jobseekers amount to 3,051 or 44.5% of the total in West Flanders. The unemployment pressure – the proportion of the number of non-working jobseekers and the older jobseekers compared to the potential professionally active population (18-64 years) – is higher in the coastal area (6.7%) than

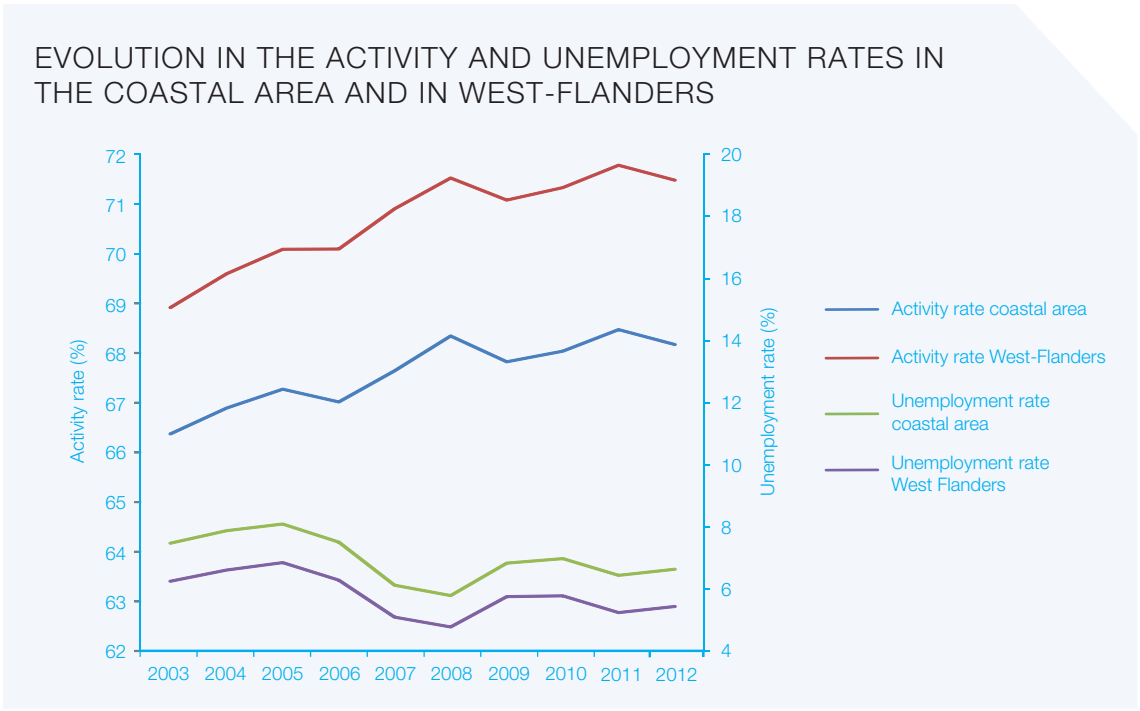

Figure 7. The evolution of the activity and unemployment rates in the coastal area and in West Flanders, 2003-2012 (Source: *Steunpunt WSE*, Processing: *Afdeling DSA*, West Flanders Development agency).

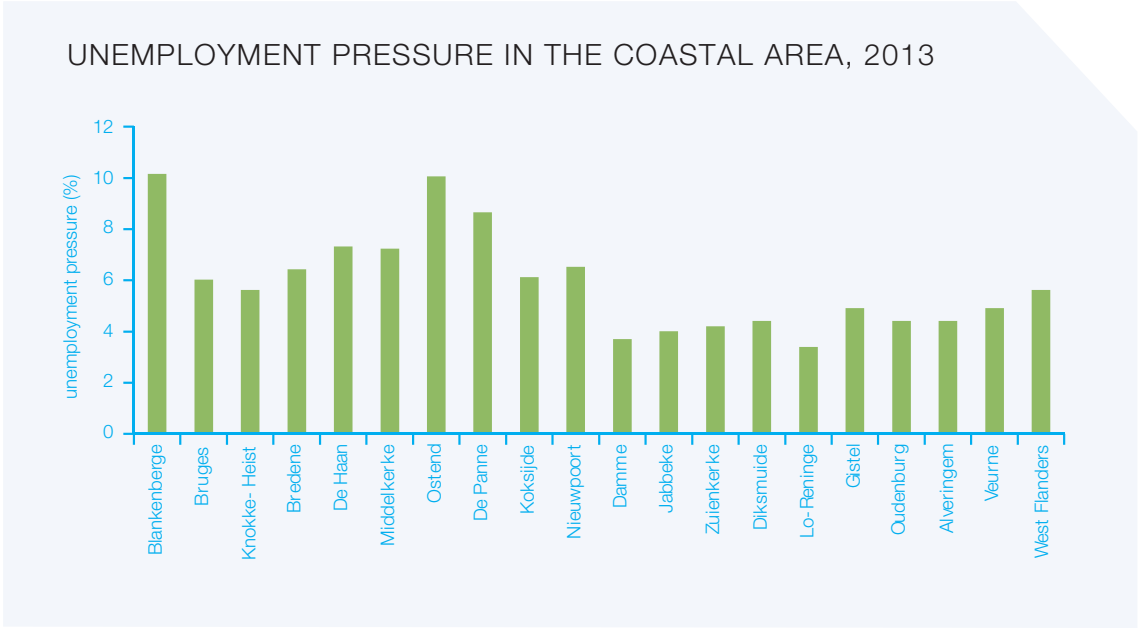

Figure 8. Unemployment pressure in the coastal zone, 2013 (Source: *West-Vlaanderen Ontcijferd editie 2014*, processing: *Afdeling DSA*, West Flanders Development agency).

in West Flanders (5.6%). In the coastal municipalities, the unemployment pressure is considerably higher than in the hinterland municipalities (figure 8) (Source: VDAB and RVA in *West-Vlaanderen Ontcijferd editie 2014*).

In 2012, only four coastal municipalities (Bruges, Knokke-Heist, Ostend and Nieuwpoort) had a positive commuting balance for employees. In these municipalities, the number of employees who work in the cities but live elsewhere exceeds the number of inhabitants working outside of the municipality (Source: *West-Vlaanderen Ontcijferd editie 2014*).

In the following information sources: *West-Vlaanderen Ontcijferd editie 2014*, *Gemeentelijke Steekkaarten* and the *RESOC-dataset*, statistics about the labour market are available on the level of municipalities, districts and the province of West Flanders.

ENTREPRENEURSHIP AT THE COAST

In 2012, the produced wealth measured on the basis of the Gross Domestic Product (GDP[2]) per capita, was lower in West Flanders than in the Flemish region or in Belgium. The district of Bruges (also including municipalities that are not part of the coastal area) is the only coastal district where the GDP per capita is higher than the average of West Flanders. During the 2003-2012 period, the GDP per capita in the district of Bruges grew by an average of 3.5% per year; in West Flanders, the average increase of the GDP per capita was limited to 3.0% per year. Hence, the district of Bruges widened the gap with the province of West Flanders. In the other coastal districts of Ostend and Veurne (also including municipalities that do not belong to the coastal zone), the GDP per capita grew by an average of 2.7% and 2.4% respectively. The latter increase did not allow to close the gap with West Flanders (Source: NBB in *West-Vlaanderen Ontcijferd editie 2014*).

With regard to the realised gross value added[3], the district of Bruges ranks second after Kortrijk, with a share of 25.6% of the gross value added that was realised in West Flanders in 2012. In the other coastal districts of Ostend and Veurne the gross value added amounted to 10.4% and 4.9% respectively. In 2012, the gross value added per employee in West Flanders was 82,915 euros. This means that the province remains well below the Flemish average (88,636 euros). The coastal districts of Veurne and Ostend, as well as the district of Diksmuide and Tielt, have a gross value added per employee that exceeds the Flemish average (Source: INR in *RESOC-dataset 2014*).

In 2013, 35,706 active enterprises were present in the coastal area, which equals 33.8% of the total in West Flanders. 26,719 of the active enterprises are situated in the coastal municipalities, 8,987 in the hinterland municipalities. In the coastal areas, 69.3% of the active enterprises belong to the tertiary sector of the economy[4], and 6.9% to the quaternary sector[5]. In West Flanders, the share of active enterprises in these sectors is lower (62.9% in the tertiary sector and 5.4% in the quaternary sector). Also, the number of founded and disappeared enterprises in the tertiary and quaternary sector is notably higher in the coastal area compared to West Flanders. The economic dynamics in the coastal zone are relatively high. In 2014, both the foundation ratio (proportion of the number of foundations in comparison to the number of active enterprises) (coastal zone: 6.9%, coastal municipalities: 7.2%, hinterland municipalities: 6.0%) and the retirement ratio (proportion of the number of shutdowns and bankruptcies compared to the number of active enterprises) (coastal area: 6.8%, coastal municipalities: 7.1%, hinterland municipalities: 5.7%) were higher in the coastal area than in the province of West Flanders as a whole in 2013. The turbulence ratio (sum of the foundation and retirement ratios) is therefore considerably higher (coastal area: 13.7%, coastal municipalities: 14.3%, hinterland municipalities: 11.7%) than the figure for West Flanders (12.8%). These observations can be entirely attributed to the coastal municipalities, as the ratios of the hinterland municipalities are always below the ratio for West Flanders. Urban centres usually have more foundations and shutdowns. This is inherent to the opportunities these centres offer. The higher turbulence at the coast can also be partly explained by the nature of the activities. The hotel and catering sector, which is abundantly present in the coastal area, is characterised by a large number of foundations and shutdowns. In 2013, 4,022 active enterprises were present in the hotel and catering sector in the coastal area (coastal municipalities: 3,432 active enterprises, hinterland municipalities: 590 active enterprises), equalling 50.5% of the province of West Flanders. The coastal area alone accounts for 43.1% of the total number of catering businesses in West Flanders. (Source: FPS Economy (ADSEI), processing: *Afdeling DSA*, West Flanders Development agency).

The coastal area covers 36.2% of the total surface of West Flanders. With regard to the surface used for economic activity, the coastal area only constituted 22.5% of the total in West Flanders on 1 January 2013. In West Flanders, 17.8% of the built-up area is used for economic activity whereas this figure is 14.4% in the coastal area. In the coastal municipalities, the share of the built-up area that is used for economic activity is larger than in the hinterland municipalities (16.0% and 11.7% respectively) (Source: *RESOC-dataset 2014* on *www.pomwvl.be*).

[2] The GDP is the market value of all officially recognised final goods and services produced 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] 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.

In 2012, the spatial productivity in the coastal area equalled 45.1. This means that in the coastal area, there were 45.1 persons working per hectare of economically occupied surface. In the coastal municipalities, this number amounted to 56.1 compared to 23.2 in the hinterland and 32.6 in the entire province. These differences are caused by the different morphology and the economic structure of these regions. In urbanised regions, the economic use of space is totally different as a result of a different sectoral structure: on the one hand relatively little industry and fewer users of large spaces, and on the other more trade and services with offices and high-rises and more employees per surface unit. Until 2008, the spatial productivity of West Flanders remained at the same level. After 2008 the indicator revealed a decreasing evolution. In the other regions, the spatial productivity already started to decrease in 2006. These decreases are the result of a growing spatial dispersion of living and working. In this regard, the commercial suburbanisation or the migration from municipalities towards the surrounding countryside has strongly increased over the past five years. Up till now, the Flemish spatial structure plan (*RSV*) could not reverse this trend (Source: *RESOC-dataset 2014* on *www.pomwvl.be*).

In the following information sources: *West-Vlaanderen Ontcijferd editie 2014*, *Gemeentelijke Steekkaarten* and the *RESOC-dataset* statistics about entrepreneurship are available on the level of municipalities, districts and the province of West Flanders.

10.4 Sustainable use

10.4.1 Sustainable living at the coast

In the coastal zone, few ingredients for a balanced, sociologically healthy social environment are present. The continued ageing, the high amount of singles, the numerous relocations and the strong pressure caused by tourists and second homes cause an unbalanced social and demographic situation. This disrupted social climate appears mostly in the neighbourhoods close to the coast (*Meire & Bracke, 2005*, Coudenys 2012 in *Maelfait et al. 2012*).

The ageing of the coastal population results in an unbalanced demographic mix, which causes a different model of society. On the coast, there are proportionally much more elderly people compared to the rest of West Flanders. This feature is amplified by the second home owners, who are nearly always older than 45 years and do not have children under 18 living at home. 75% of second home owners are at least 55 years old and live together with their partner. More than half of them are retired. Hence, the ageing process is amplified by the nearly 124,500 second home owners aged 50+, who reside on average 82 nights a year in their second home (WES 2008, second homes at the coast, *part 1* and *part 2*).

The Province of West Flanders is investing in a programme where the coast is considered to be a test case for the future ageing of the population in Flanders (*Programma Vergrijzing aan de kust*). Hence, in the note *Vergrijzing aan de Kust: Lust of last (2012)* (Province of West Flanders), the situation of the ageing population at the coast is described and a number of barriers and challenges are listed. Furthermore, in *Vandekerckhove et al. (2015)*, a study commissioned by the Province of West Flanders, the relocation movements of people aged 80+ has been analysed. The research includes the consequences for the housing market and health care in the coastal region. The analysis has revealed a number of trends: the retired migrant is insufficiently prepared for growing older, a personal social network is important and the housing accommodations at the coast are not adapted. Furthermore, a number of challenges and recommendations have been formulated: consider the situation as an asset (e.g. voluntary work opportunities, economical opportunities, etc.), go for adapted and self-reliant living and raise awareness (see *De Klerck 2011*).

The importance of a personal social network is also addressed in *Meire & Bracke (2005)*. For the many singles and retired migrants at the coast who left their social environment, social isolation is a realistic problem. It is therefore essential to repair and strengthen this social network as much as possible. A study about the liveability at the coast (*Meire & Bracke, 2005*) has revealed that the mutual involvement of inhabitants is indeed weak along the coast, especially in neighbourhoods close to the sea.

A good physical environment and good living conditions are also essential for a sustainable living environment and the wellbeing of the inhabitants of the coast. The urban profile and the high deprivation rate indicate the many challenges of the coastal area (*Maelfait et al. 2012*).

10.4.2 Economic development at the coast

In '*West Deal*' the strategic lines for the economic policy of West Flanders are outlined for the next five years (2013-2018). Some of the policy lines are specifically relevant for the coastal area such as cooperation concerning Blue Energy (*Fabriek voor de Toekomst*), the possibilities for Ostend as an industrial port for offshore developments, the expansion of the harbour of Zeebrugge, tourism-related opportunities for Bruges-Ostend airport, etc. In the study *West-Vlaanderen Groeit – Ambitie 2030*, an investigation has been conducted into the status of the West-Flemish economy as well as its prospects. In this context, five visions for the future and five specific construction sites for West Flanders have been addressed, including certain aspects of the economy in the coastal area (blue energy, ports, healthcare economy at the coast, etc.).

Legislation reference list

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Decrees		
Decreet van 18 mei 1999	Decreet houdende de organisatie van ruimtelijke ordening	1999-05-18/33

11

Tourism and recreation

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According to a *study (2013)*, coastal and maritime tourism (including the cruise sector) is the biggest maritime sector in Europe with regard to the added value and employment. European coastal tourism generates 183 billion euro of added value and creates jobs for 3.2 million people. Moreover, about half of the tourist overnight stays are booked in coastal areas (*Eurostat Regional Yearbook 2014* and COM (2014) 86).

The Belgian coast is a popular holiday destination as well. Residential tourism accounted for 5.0 million arrivals and 28.4 million overnight stays in 2013. The number of day trippers varies between 16 and 19 million annually. The total spending of coastal tourists amounts to approximately 2.7 billion euro (*Strategisch beleidsplan voor toerisme en recreatie aan de kust 2015-2020*).

Besides coastal tourism, tourism in the hinterland accounts for a considerable number of arrivals and overnight stays as well. The tourist and recreational regions of Bruges Woodland and the Westhoek area accounted for about 500,000 arrivals and almost 1.3 million overnight stays in 2013 (*Westtoer, Trendrapport Brugse Ommeland 2012-2013*, *Westtoer, Trendrapport Westhoek 2012-2013*). World War I tourism in the Westhoek area has led to a significant increase in 2014 of nearly 800,000 memorial tourists (numbers *Westtoer*). It should be mentioned that the borders of these regions extend further than the hinterland communities (the strategic policy plans for tourism and recreation: *Bruges Woodland (2013-2018)* and *Westhoek (2008-2013)*).

11.1 Policy context

At the European level, the policy relating to tourism is stipulated by *DG Growth* of the European commission. However, maritime and coastal tourism is included in the so-called Blue Growth-policy (COM (2012) 0494) established by *DG MARE*. In this context, a strategy was developed to increase growth and employment in coastal and maritime tourism (COM (2014) 86).

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 of Tourism (Flemish level, *beleidsnota toerisme 2009-2014*), and '*Westtoer*' (provincial level). 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 Bruges Woodland (*Bruges Woodland (2013-2018)*) and the Westhoek area (*de Westhoek (2008-2013)*).

In the past, the Flemish government and the minister of tourism provided funding in the framework of the Coastal Action Plan I (*Kustactieplan*) (1997-2002), II (2000-2004) and III (2005-2009)) and the 'Coastal Impulse Programme' (*Impulsprogramma Kust*) (2010), to invest in certain coastal-related projects. Since 2015, tourism leverage projects (*toeristische hefboomprojecten*) have been incorporated within the impulse programmes which apply for Flanders (and not only for the coastal region). Furthermore, a permanent measurement and monitoring system has been developed (KiTS, Coastal-Indicators-Tourist-Statistical) that publishes numbers with respect to the tourist activities along the coast biannually. These statistics are annually bundled in a trend report (*Westtoer, Trendrapport Kust 2012-2013*). More information on the sectoral legislation with regard to tourism can be found on the website of Tourism Flanders (*Toerisme Vlaanderen*) and in the *coastal codex, theme tourism and recreation*.

For water recreation on the coast, the royal decree of August 4, 1981 regarding the Police and Shipping Regulations for the Belgian territorial sea, coastal ports and beaches is of interest (more information: *website FOD Mobiliteit 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 the DG Maritime Transport (*DG Maritiem Vervoer*, FPS Mobility and Transport) and is discussed in the following documents: *Vademecum van de pleziervaart in België (2014)*, *De pleziervaart op de bevaarbare waterwegen in Vlaanderen (2011)* and *Wijzer op het water (2010)*.

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 *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 coastal codex, themes *tourism and recreation*, *coastal zone management* and *local legislation* and is also discussed by *Derous (2005)* and *De Wachter & Volckaert (2005)* (*GAUFRE project BELSPO*).

11.2 Spatial use

The areas for tourism and recreation are primarily steered by spatial planning (see also theme **Social and economic environment**). Instruments such as the spatial structure plans, spatial implementation plans (RUP) and regulations, on a Flemish, provincial and municipal level, indicate the possibilities for the future tourist-recreational developments of 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 recognized as a tourist-recreational network which requires a policy on a Flemish level. This policy was *inter alia* developed in the framework of initiatives and studies such as the Masterplan Coastal Safety (*Masterplan Kustveiligheid*), Flemish Bays (*Masterplan Vlaamse Baaien 2014*) and *Metropolitaan Kustlandschap 2100* (*fase 1* / *fase 2* / fase 3 part *1*, *2* and *3*). 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)*) 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 (GRUPs) can be consulted on: *www.ruimtelijkeordening.be*. Besides the further implementation of the Flemish spatial structure plan, the Flemish government is preparing a new spatial policy plan (*Beleidsplan Ruimte*) (see *Groenboek. Vlaanderen in 2050: mensenmaat in een metropool? Beleidsplan ruimte Vlaanderen (2012)*).

The Flemish government is the owner of almost all beaches along the coast. 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*). The Coastal division also distributes the concessions for the beach and seawall in consultation with the municipalities, other public councils, contractors, 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. Furthermore, an action plan for the '*Koninklijke Baan (N34)*' road has been discussed in the provincial spatial structure plan (more information: *Waarheen met de Koninklijke Baan? 2008*). The *PRS-WV* also demarcates outdoor recreational green domains, amusement parks and tourist-recreational linear elements (watercourses, railway track, seawall and road infrastructure). Furthermore, a number of strategic project areas have been selected with important touristic and recreational aspects (*PRS-WV*, *strategisch beleidsplan voor toerisme aan de kust 2009-2014*): the mouth of the river Yser in Nieuwpoort, the area east of Blankenberge, the area south of the railway station of Knokke, the military base in Koksijde and the east bank of Ostend. In addition, the *provincial spatial implementation plans* (in particular the provincial RUPs for beach and seawall) are of significant importance for the planning of the tourist-recreational functioning of the coastal zone.

At the municipal level, processes are under development that create new possibilities for tourism and recreation within the municipal structure 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.

11.3 Societal interest

11.3.1 Coastal tourism

The tourist-recreational sector is of crucial importance for the coastal economy. In 2013, the coast accounted for 4,950,446 arrivals and a total of 28,356,924 overnight stays (table 1 and figure 1). Commercial accommodation constitutes 44.0% of these stays and second home tourism 56.0%. In addition, 16,930,000 day trippers arrived at the coast in 2013 (*Westtoer, Trendrapport Kust 2012-2013*, more information, *Vakantieganger in commercieel logies aan de Kust in 2011*, *Westtoer 2010*). Furthermore, the presence of an airport in Ostend and the harbors of Ostend and

Table 1. Arrivals and overnight stays (excl. marinas) on the coast in 2013 (*Westtoer, Trendrapport Kust 2012-2013*).

	ARRIVALS (2013)		OVERNIGHT STAYS (2013)	
Commercial accommodation (holiday houses, hotels, camping grounds, holiday centers and holiday parks)	2,402,175	48.5%	12,489,687	44.0%
Second home tourism (holiday houses)	1,944,291	39.3%	12,347,824	43.5%
Second home tourism (on camping grounds)	603,980	12.2%	3,519,413	12.4%
Total	4,950,446		28,356,924	

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

Zeebrugge are important for the inflow of foreign tourists towards the Belgian coastal area. In *Merckx & Neyts (2015)* figures on the arrival of passengers in the coastal harbours are mentioned. The traffic figures for Ostend Airport are available on the following web page: *http://www.ost.aero/passagiers/voorstelling-luchthaven/trafiekcijfers*.

The total direct spending generated by residential tourism (commercial accommodation, second home tourism and mooring in marinas) and day trippers amounted to more than 2.7 billion euros in 2013 (table 2 and figure 2). In this context, residential tourism represents 2.1 billion euros in direct spending whereas the day trippers account for 629.0 million euros (*Westtoer, Trendrapport Kust 2012-2013*, more information: *Westtoer, Vakantieganger in commercieel logies aan de Kust in 2011*, *Westtoer 2010*). The direct turnover of the construction sector as a result of the construction of second homes amounted to 367 million euros in 2007 (*IDEA consult 2009*). Recent research on the meeting industry at the coast reveals that this sector has a turnover of 60 million euro (*Westtoer, onderzoek Meeting aan Zee 2015*).

The activities of the Belgians during day trips (*inter alia* to the coast) have been examined in detail in the following study: *pilootonderzoek naar daguitstappen van de Belg (2010-2011)*. This report shows that the majority of day trips to the coastal region are focused on visiting the sea, beach and dunes (76.6%), followed by amusement parks (7.8%), sightseeing (2%) and other activities such as hiking, gastronomy, shopping, events, museums, etc. According to the trend report (*Westtoer, Trendrapport Kust 2012-2013*), 26 water sport clubs and 13 yacht clubs (3,553 moorages) were active along the coast in 2013. The spending at the yacht clubs amounted to 21.1 million euros. The economic benefits of these recreation and sport activities on the coast (without indirect effects) are also discussed in *De Wachter*

& Volckaert (2005) (*GAUFRE project BELSPO*). In the *Seaconomics project* (2011-214) the economic importance of yacht clubs was further investigated (*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 euros.

According to statistics of the research department of the Flemish government (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 on 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 study (Westtoer), the direct employment related to coastal tourism in 2013 was estimated at more than 27,000 fulltime equivalents (assuming 1 fulltime equivalent of direct employment for every 100,000 euros of direct spending) (*Westtoer, Trendrapport Kust 2012-2013*). Employment in the construction sector related to second home tourism was estimated at 1,814 jobs in 2007 (*IDEA consult 2009*).

11.3.2 Hinterland tourism

In addition to coastal tourism, tourism in the Westhoek area, Bruges Woodland and Bruges is of significant importance. Bruges Woodland accounted for 133,861 visitors and 322,934 overnight stays in 2013 (*Westtoer, Trendrapport Brugse Ommeland 2012-2013*). The arrivals and overnight stays in the Westhoek area amounted to 368,413 and 945,869 respectively (*Westtoer, Trendrapport Westhoek 2012-2013*). Bruges accounted for 1.03 million arrivals and 1.87 million overnight stays in 2013. These are arrivals and overnight stays in commercial accommodations (excl. second home tourism) (Source: *Westtoer, Kerncijfers West-Vlaanderen 2013*). In these trend reports, spending and employment are discussed as well.

Table 2. The direct spending of coastal tourism per type of tourism in 2013 (*Westtoer, Trendrapport Kust 2012-2013*).

TYPE OF TOURISM	DIRECT SPENDING OF TOURISTS IN MILLION EUROS	PERCENTAGE OF DIRECT SPENDING
Commercial accommodation	766.4	28.1
Second home tourism	1,251.2	45.9
Mooring in marinas	21.1	0.8
Day trippers	629.0	23.1
Meeting industry	60.0	2.2
Total	**2,727.7**	**100**

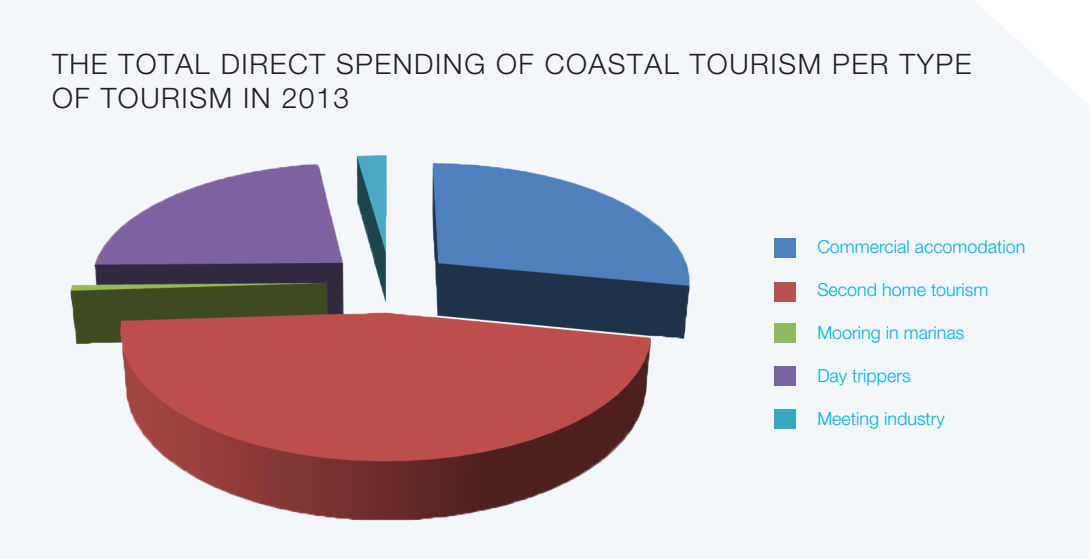

Figure 2. The total direct spending of coastal tourism per type of tourism in 2013 (*Westtoer, Trendrapport Kust 2012-2013*).

11.4 Impact

As mentioned above, coastal tourism has a significant economic and societal value and creates a number of facilities such as the coastal tram. 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 fabric, mobility problems, etc. (Coudenys 2012 and Keunen & Hoornaert 2012 in *Maelfait et al. 2012*, *Meire & Bracke 2005*, *Goffin et al. 2007* (see also 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 tourism 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 urbanization 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*, *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 zone during the high season has some direct and indirect ecological effects (see table 3).

Also, recreation and sport activities on the beach and in the dunes have direct and indirect ecological effects (table 4).

Table 3. An overview of the ecological effects caused by the high concentration of tourists and residents in the coastal area.

IMPACT	LITERATURE
Increased consumption of energy and water	*Vanlerberghe & Vanhoutte 2001*, *Goffin et al. 2007* (see theme **Agriculture**, salinisation)
Problems with waste processing	*Goffin et al. 2007*, De Groof in *Maelfait et al. 2012*, *kustactieplan OVAM*
Contribution of coastal tourism to the eutrophication of the coastal waters	*Maes et al. 2004* (*MARE-DASM project BELSPO*) (see theme **Agriculture**, eutrophication)
Pollution caused by traffic	*Goffin et al. 2007*

Table 4. An overview of the ecological effects caused by recreation and sport activities on the beach and in the dunes.

IMPACT	LITERATURE
Trampling and disruption of the beach and dune ecosystem	*Vincx et al. 2001*, *Maes et al. 2004* (*MARE-DASM project BELSPO*), *Goffin et al. 2007*, *Derous 2005* (*GAUFRE project BELSPO*), *Welkom in de duinen 2008* (see theme **Nature and environment**)
Litter on the beach	*Lescrauwaet et al. 2006*, *Goffin et al. 2007*, *Maelfait 2008*, *Doomen et al. 2009*, *André et al. 2010* (see theme **Nature and environment**)
Mechanical cleaning of the beaches and its associated ecological effects	*Belpaeme 2003*, *Goffin et al. 2007*, *Doomen et al. 2009* (marine litter, see theme **Maritime transport, shipping and ports**)
Pollution by recreational boating	*Maes et al. 2004* (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* (*GAUFRE project BELSPO*), *Lescrauwaet et al. 2006*, *Goffin et al. 2007*
Sport fisheries	see theme **Fisheries**

11.5 Sustainable use

11.5.1 Sustainable development of coastal tourism

The sustainable co-existence of the various users and sectors of the coastal areas (*inter alia* tourism and recreation) is discussed in the European recommendation on integrated coastal zone management (ICZM) in Europe (2002/413/EC). In *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 on 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**. More recently, a communication concerning European maritime and coastal tourism (COM (2014) 86) proposed 14 actions that can contribute to a sustainable growth in the sector and can provide an extra boost to the European coastal areas.

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 investment 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 above mentioned strategic objectives, tourism leverage projects (*toeristische hefboomprojecten*) can be used within the impulse programmes. 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 **Spatial use**).

Furthermore, there are several visions and policy initiatives (e.g. *Metropolitaan Kustlandschap 2100 fase 1* / *fase 2* / fase 3 part *1*, *2* and *3*, *Masterplan Vlaamse Baaien 2014*, *Masterplan Kustveiligheid*, etc.) and studies (eg. *Kindvriendelijkheid aan de Vlaamse kust 2008*, *De Waegemaeker 2012*, an *analysis of the accessibility along the coast by npo Westkans* with an *interactive map*, the project 120 km coastal quality with studies such as *van Meenen 2009*, *Pijpers 2009*, *kansen aan de kust 2009*, etc.)) (indirectly) discussing the (sustainable) development of coastal tourism. Besides, several labels (such as *Blauwe vlag* of *Bond Beter Leefmilieu*, the *Q-label* for tourism entrepreneurs, *Groene Sleutel*, *het toegankelijkheidslabel* of the *npo Westkans*, etc. (more information: *website Toerisme Vlaanderen*)) and awards (*De Kust Kijkt Verder 2012*) contribute to a sustainable (coastal) tourism.

11.5.2 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)*, *Uitkerkse polder, een recreatieve meerwaarde voor de Vlaamse kust (2007)*, *Welkom in de duinen (2008)* and *Doomen et al. (2009)*.

The (bathing) water quality of the coastal zone is managed on the European level by directive 91/271/EC concerning urban waste-water treatment, the Water Framework Directive (WFD) (2000/60/EC) and directive 2006/7/EC concerning

the bathing water quality. On the federal level, these European measures are implemented by the royal decree 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*, *Rapport Kwaliteit van het Zwemwater 2014*). 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

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
	Council Directive concerning urban waste-water treatment	1991	271
Water Framework Directive	Directive establishing a framework for Community action in the field of water policy	2000	60
Bathing Water Directive	Directive concerning the management of bathing water quality and repealing Directive 76/160/EEC	2006	7
Other (Decisions, Communications, White Papers, etc.)			
	Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe	2002	413
	Communication from the Commission (COM): Blue Growth opportunities for marine and maritime sustainable growth	2012	494
	Communication from the Commission (COM): A European Strategy for more Growth and Jobs in Coastal and Maritime Tourism	2014	86

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 20 januari 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
Royal Decrees		
KB van 4 augustus 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
KB van 23 juni 2010	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
Decrees		
Decreet van 18 juli 2003	Decreet betreffende het integraal waterbeleid	2003-07-18/72
Other		
Besluit van de Vlaamse Regering van 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

12

Safety against flooding

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Verwaest, T., DeWolf, P., Mertens, T., Mostaert, F., Pirlet, H., 2015. Safety against flooding. In: Pirlet, H., Verleye, T., Lescrauwaet, A.K., Mees, J. (Eds.), Compendium for Coast and Sea 2015: An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Ostend, Belgium, p. 211-222.

In the 20th century, the average annual sea level increase was 1.7 mm. Since the 1950s, a significant acceleration of the global sea level rise has been observed. Currently, the annual sea level increase amounts to 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*). 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 2013 was significantly higher than at the start of the measurements. In Ostend the trend line increased by 115 mm between 1951 and 2013 (figure 1). Significant increases have been recorded in Zeebrugge and Nieuwpoort as well. However, this increase does not seem to have continued in the last few years (*Brouwers et al. 2015*). Recent studies concerning extreme high water in Ostend reveal that the storm surge, regardless of the increase of the annual average sea level, does not seem to show an exceptional or additional increase (*Willems 2014*). 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*). In *Brouwers et al. (2015)* an overview is given of scenarios regarding the sea level rise and storm surges for the Belgian coast.

The above-mentioned factors imply an increased flood risk in low-lying coastal areas. The Netherlands and Belgium belong to the most vulnerable countries of the European Union, given that the elevation of more than 85% of the Belgian and Dutch coastal area is lower than the level of a yearly storm (+ 5 m TAW) (*EEA Report 2006*, *Eurosion*, *Balancing the future of Europe's coasts, EEA 2013*). In Flanders, 15% of the area is situated below 5 meters above the average sea level. Moreover, the Belgian coast has the highest proportion of built-up area of all European coasts: in 2000, more than 30% of the coastal strip of 10 km wide was built-up area. This figure amounted to 50% of the coastal area when considering the first kilometer inland of the coastline. 33% of citizens living in West Flanders reside in the low-lying polders which are prone to flooding from the sea (*Brouwers et al. 2015*). Besides housing, intense economic activities take place in the coastal areas of the Netherlands and Belgium, *inter alia* due to the presence of harbours. Hence, the loss of life and material damage in case of a flood may be quite high (*The European environment: state and outlook 2010. Adapting to climate change 2010*, *Kellens, 2011*).

An analysis of the Flemish sea barrier in 2007 and 2008 revealed that about one third of the coast and coastal ports need additional protection against the impact of super storms. The *Masterplan Coastal Safety* (approved by the

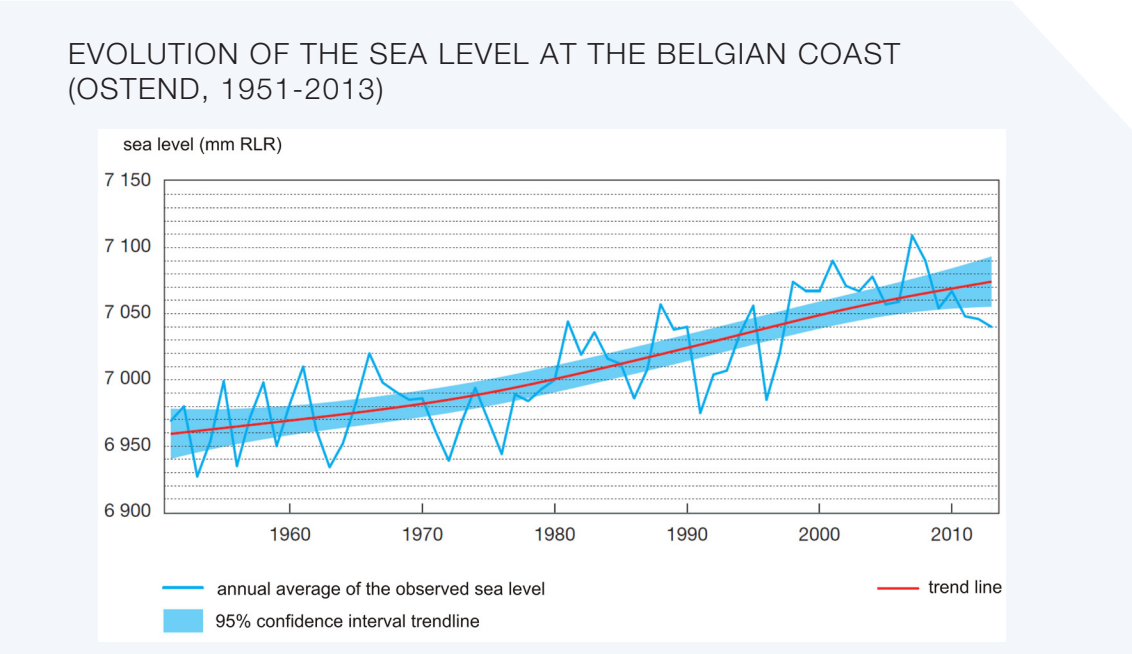

Figure 1. Evolution of sea level on the Belgian coast (Ostend, 1951-2013) (Source: *Brouwers et al. 2015*, MIRA based on PSMSL and agency for Maritime and Coastal Services, more information: *www.milieurapport.be*). Note: The sea level is expressed in mm RLR (Revised Local Reference). Data relating to a local reference level (for the Belgian coast this is TAW) was converted to the international reference level.

Flemish government on 10 June 2011) defines the measures required for a sufficient protection of the coastline, coastal harbours and the adjacent low-lying polders against super storms by 2050. To achieve this both 'soft' measures (beach nourishment, dune nourishment, etc.) and 'hard' coastal protection measures (seawall, flood barriers, etc.) are included in the masterplan. In Nieuwpoort the realization of a storm surge barrier is investigated. Measures include the reinforcement of locks, dams and discharge constructions that constitute the connection with rivers and canals in the hinterland. 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 chance of rainfall may be 10% higher in the coastal area compared to the hinterland (*Van Steertegem 2009*). However, this type of floods will not be discussed in the current text.

12.1 Policy context

In 2007, the *Directorate-General for the Environment* of the European Commission issued the *Floods Directive* (2007/60/EC) to counter the harmful consequences of floods on humans, nature, heritage, economy, etc. and the potential increase in the number of floods in the context of climate change. The directive is valid for all European coastal and inland waters. Since 2013, Europe has a strategy for adapting to climate change (COM (2013) 216, *website Climate Adapt*) which includes the impact on coastal areas.

Since 1980, the policy concerning water management has been a competence of the regions (law of 8 August 1980). The most important legislative component of this policy is the *Integrated Water Policy of 18 July 2003* that deals with the Flemish implementation of the European Floods Directive from 2010 onwards. The *Coordination Committee on Integrated Water Policy* hosts the deliberation in Flanders between the various policy domains and levels of government responsible for 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 2016-2021 (in preparation).

The *Coastal division* (part of the agency for Maritime and Coastal Services – *MDK*, which in turn is part of the policy domain of Mobility and Public Works – *MOW*) is responsible for the safety of the Flemish coast and more specifically for flooding by the sea. Every 6 years, the Flemish authorities submit the entire sea barrier to a safety test. This test aims to guarantee the basic safety in all coastal zones. This basic safety concerns the protection against a super storm with a statistic return period of 1,000 years. In the framework of the *Masterplan Coastal Safety*, the *Coastal division* elaborated a flood risk management plan for the coastal area in collaboration with *Flanders Hydraulic Research*. This *Masterplan Coastal Safety* is discussed in more detail in the section **Sustainable use**. Besides this masterplan, the *Sigmaplan* of the Flemish government should be mentioned. This plan addresses the protection against flooding from the Scheldt and its tributaries, but will not be further elaborated in the current text (theme **Scheldt Estuary**).

In order to realize the coastal protection measures, the environmental legislation needs to be respected by the drafting of Environmental Impact Assessments (EIAs). Besides, building permits have to be requested for so-called hard protection measures. This requires collaboration, in particular with the Agency for Nature and Forest (*ANB*) of the Flemish policy domain of Environment, Nature and Energy and with the Flemish policy domain of Spatial Planning with regard to the building permits.

100% safety can never be guaranteed. Hence, emergency plans remain necessary. All coastal towns need to elaborate a municipal emergency plan against floods (so-called 'BNIP floods'). The provincial level is responsible for the coordination between the municipalities in case of super storms. Furthermore, the *Province of West Flanders* is competent for the elaboration and coordination of a provincial BNIP floods. When cross-border problems occur in case of a super storm, the crisis centre of the FPS Home Affairs will take over the coordination, *inter alia* by the implementation of the National Emergency Plan 'Floods and High Water'.

12.2 Spatial use

In the *Masterplan Coastal Safety* the demarcation of areas of particular attention along the Flemish coast is discussed, as well as the necessary protection measures for each of these areas. The status of the works in these zones can be found on the following website: *www.kustveiligheid.be*.

The spatial distribution of the flood hazards (the physical characteristics of floods such as the extent and depth) and the flood risks (potential negative consequences for humans, environment, heritage, etc.) are available for Flanders on the following *geoportal* (waterinfo.be).

The protection of the coast is also discussed in the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*). The plan stipulates some spatial policy choices with regard to coastal safety. In the context of the implementation and support of the Masterplan Coastal Safety, sufficient sand and gravel extraction areas are demarcated with an eye to 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.

12.3 Societal interest

12.3.1 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 has been investigated for a range of super storms. Table 1 summarizes the results. Moreover, the ongoing spatial developments in the coastal areas further increase the potential economic and human losses. Hence, this increases the damage a storm may cause with a certain probability of occurrence (*Plan-MER voor het Geïntegreerd Kustveiligheidsplan: kennisgeving 2009*, *Kellens 2011*).

Table 1. An overview of the flood risks (for conditions in 2006) in the Belgian coastal area for different storm surge levels and return periods, with the associated deaths and the direct economic damage (*Meire et al. 2011*).

FLOOD RISKS IN THE BELGIAN COASTAL ZONE			
Storm surge level	Return period	Deaths	Direct economic damage
+ 6.5 m TAW	~100 year	41	0.67 billion euro
+ 7.0 m TAW	~1,000 year	251	2.1 billion euro
+ 7.5 m TAW	~4,000 year	885	3.9 billion euro
+ 8.0 m TAW	~17,000 year	3,297	6.5 billion euro

In the context of the *Masterplan Coastal Safety* a map has been drafted with the distribution of the flood in case of a 1,000-year storm under the conditions present in 2006 (figure 2). The largest risk of damage is situated in the four ports, which are also the weakest areas when considering coastal safety. With regard to the coastal municipalities, special attention needs to be paid to the zones Ostend centre, Ostend-Raversijde, Ostend-Mariakerke, Ostend-Wellington and De Haan-Wenduine. Also, the damage risk in Middelkerke is relatively high. Moreover, the expected number of casualties in these zones is not socially acceptable (*Masterplan Coastal safety*).

A study in the context of the *CLIMAR project (BELSPO)* has selected three indicators quantifying the risks of climate change with regard to floods in the coastal zone: the loss of beach and dune areas due to erosion (1), modelling of the economic damage (2) and the number of casualties (3) in case of a storm surge level of + 8.00 m TAW in two long-term climate scenarios (2100) (*Van der Biest et al. 2009*). In this study, the focus is on the issues in coastal municipalities. Harbours have not been taken into consideration, while sandy coasts without dykes have.

Flanders Hydraulic Research (department of Mobility and Public Works of the Flemish government) and Ghent University have developed LATIS software which calculates both risk and damage for Flanders. This instrument allows to determine the economic and human losses in case of a flood. These calculations cover the entire Flemish region. The software is currently being extended with new modules (expected in 2016), enabling the calculation of the social, cultural and ecological impact of floods (*Brouwers et al. 2015*).

The potential economic loss and flood risks of can be consulted for the Flemish region using the following *geoportal* (waterinfo.be).

CALCULATION OF THE DISTRIBUTION OF THE FLOOD OF A 1,000-YEAR STORM, UNDER THE CONDITIONS PRESENT IN 2006

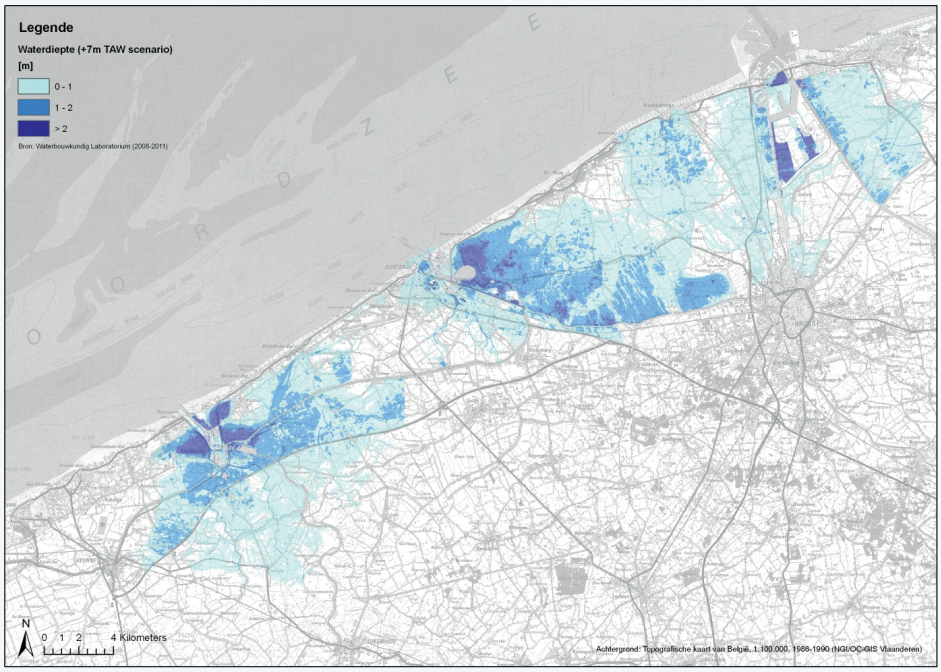

Figure 2. Calculation of the distribution of the flood of a 1,000-year storm, under the conditions present in 2006 (*Masterplan Coastal Safety*).

Global long-term climate scenarios are published by the Intergovernmental Panel on Climate Change (*IPCC*). Such estimates clearly illustrate the societal interest of sea barriers and safety against floods in general.

12.3.2 Investments in coastal safety

In Europe, a total of 15.8 billion euro was invested in coastal protection and climate adaption 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, the associated costs have been calculated using different future scenarios (*Brown et al. 2011*).

The total cost of 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 for maintaining the new beaches amounts to a yearly average of 600,000 to 700,000 m³. Prior to the *Masterplan Coastal Safety*, the Flemish beaches were replenished with a yearly average of 550,000 m³ of sand (both by means of pressure pipes and trucks) (*Maelfait & Belpaeme 2007*, *Vandewalle et al. 2008*, *Masterplan Coastal Safety*).

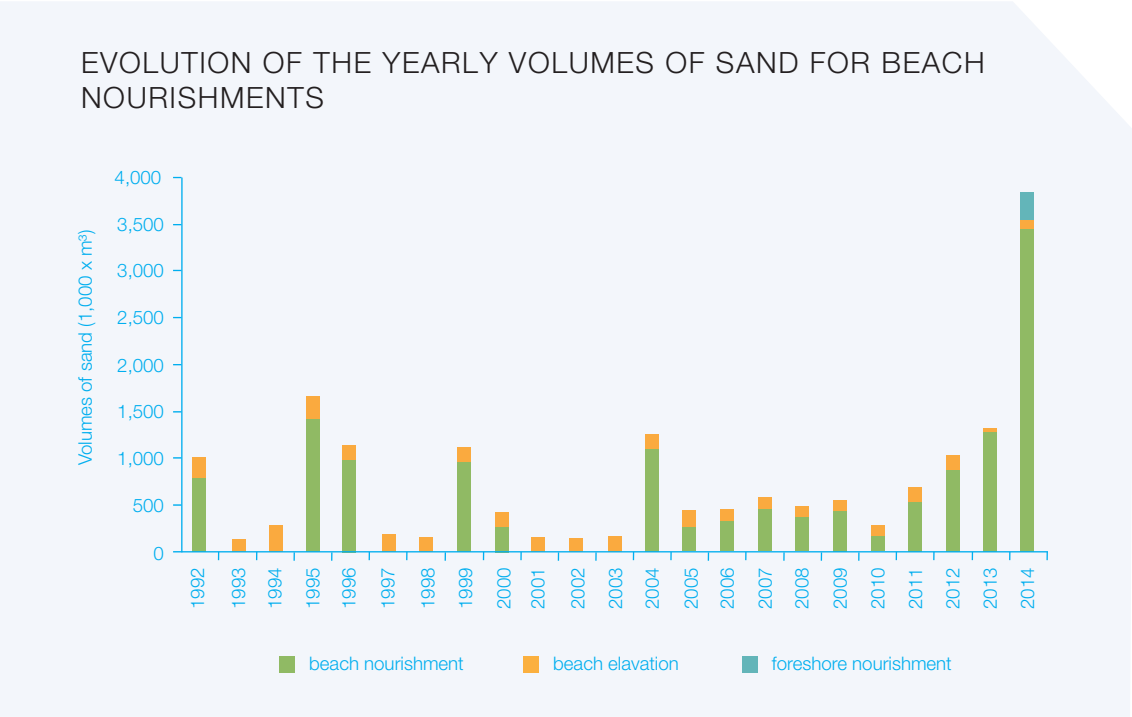

Figure 3. Evolution of the yearly volumes of sand for beach nourishments and beach elevations (Source: Coastal division). The sand for beach nourishments is supplied by dredgers, while the sediment for beach elevations is supplied by lorries.

12.4 Impact

The coastal protection works and infrastructure along the Flemish coast have an impact on some environmental aspects, depending on the technique used. The hard as well as the soft protection works are therefore subject to the European *EIA Directive* (85/337/EEC), which implies that an environmental impact assessment (EIA) 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. Therefore, 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 gives 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)*.

Besides a general EIA plan that maps the total environmental effects of the measures of the *Masterplan Coastal Safety*, a project EIA may be needed in order to evaluate the local effects of the different projects. 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*
Seabed	• 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*, *Janssens et al. 2013* (*QUEST4D project BELSPO*), *Houthuys et al. 2014*
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 & Rozemeijer 2009*, *Braarup Cuykens et al. 2010*, *Vanden Eede & Vinckx 2011*, *Vanden Eede 2013*, *Van Tomme 2013*, *Van Tomme et al. 2013*, *Vanden Eede et al. 2014*
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*

12.5 Sustainable use

12.5.1 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 these directives. In the case of Flanders, these maps can be consulted on the following *geoportal* (waterinfo.be).

Since 2015, the member states also need to elaborate flood risk management plans at a river basin level, focusing on the prevention of and protection against floods. These flood risk management plans are integrated into the river basin management plans that have to be 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 *inter alia* the Flemish coastal area are integrated in the river basin management plan of the Scheldt 2016-2021 (in preparation).

An additional challenge in the coastal area is the integration of flood risks from inland waters (such as the Yser) on the one hand, and from the sea on the other. 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 contributes to the preventive reduction of the damage caused by floods.

12.5.2 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) in 2002. In this context, deliberations between services with competences with regard to the coastal zone are organized by the *Coastal Territorial Cooperation* of the Province of West Flanders (the former Coordination Centre for ICZM) (i.e. agency for Maritime and Coastal Services, agency for Nature and Forest, Flanders Marine Institute, Province of West Flanders and Federal Public Service Health, Food Chain Safety and Environment). The following section will elaborate on policies, studies, projects and initiatives which deal with coastal safety in an integrated way.

MASTERPLAN COASTAL SAFETY

By means of 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 *European recommendation on integrated coastal zone management*). Since its approval by the Flemish government on 10 June 2011, the plan has been gradually implemented. The website *www.kustveiligheid.be* gives a description of the measures for each of the attention zones along the coast. The website also provides a status of the progress of the works (see also table 3).

Table 3. An overview of the selected protection measures for each zone of particular attention (*Masterplan Coastal Safety*).

ZONE OF PARTICULAR ATTENTION	SELECTED MEASURES
De Panne - section 8	Dune nourishment
De Panne – centre (section 13 to 18)	Beach nourishment with an elevated beach
St. Idesbald - Koksijde-centre (section 21 to 31)	Beach nourishment with an elevated beach
Koksijde - section 39	Raising the road by the replenishment of the dune passage in combination with the reconstruction of the road
Port of Nieuwpoort	Construction of a storm surge barrier
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
Raversijde – Ostend Wellington (section 97 to 108)	Beach nourishment with a low-lying beach in combination with a high stormwall or adapted seawall ramp and wave absorbing expansion or widening of the seawall at Raversijde
Ostend centre (section 109 to 117) + Port of Ostend + Ostend-East (section 118 tot 120)	OW-Plan Ostend
Ostend-East (section 121)	Beach nourishment in connection with the OW-plan, subplan for integrated coastal zone management at *Oosteroever* (section 119 and 120)
De Haan - Wenduine (section 172 to 176)	Beach nourishment with a low-lying beach in combination with stormwalls at *De rotonde* and the seawall/widening of the seawall
Port of Blankenberge	Construction of a storm wall at + 8 m TAW in combination with anti-erosion protection around the port
Blankenberge (section 185 to 195)	Beach nourishment with a low-lying beach
Port of Zeebrugge	Construction of a storm wall at + 8 m TAW around the *Prins Albert I* dock and connected to the locks in combination with anti-erosion protection around the port
Knokke-Heist (section 225 to 243)	Beach nourishment (profile between steep and low-lying beach)
Zwin (section 250 to 255)	Zwin project
Renovation of weirs and locks	Ports of Blankenberge, Ostend and Zeebrugge

VISIONS, PROJECTS AND INITIATIVES FOR AN INTEGRATED APPROACH TO COASTAL SAFETY

In the project 'Flemish Bays' (*Vlaamse Baaien*) of the Flemish government, a plan has been developed for coastal development which comprises three tracks (*Masterplan Vlaamse Baaien 2014*). For each of these tracks, a set of measures has been elaborated from an overarching vision, in the short (2020), medium (2050) and long (2100) term.

1. A robust coast with an accelerated implementation of the Masterplan Coastal Safety (decided policy) in the short term, alternative feeding methods in the short and medium term and innovative sea barrier techniques and spatial vision in the long term.
2. The development of the port of Zeebrugge in conjunction with the adjacent coastal zone, with the optimization of the accessibility of the port (through a pilot project with a local deepening of the port entrance and potentially an expansion of the western jetty) in the short term, an investigation to assess the possibility of inland shipping along de coast in the short term and its implementation in the medium term (also see *Delecluyse et al. 2014*) as well as the expansion of the port in the long term.
3. Streamlining of all stakeholders on the cross-border aspects of the Flemish Bays project (*Vlaamse Baaien*), but also alignment on external aspects that influence the project. An example might be how to use the Dutch dredged material released during the construction of an alternative fairway in the Scheldt Estuary.

A few other relevant studies, projects and initiatives are given in table 4.

Table 4. An overview of studies, projects and initiatives in the framework of an integrated approach to coastal safety.

STUDIES, PROJECTS AND INITIATIVES	EXPLANATION
Kappa plan	Natuurpunt proposes one integrated plan that elaborates on climate adaption in combination with the natural environment along our coast: the so-called Kappa plan provides a sustainable vision on coastal safety with natural climate buffers.
CcASPAR (Climate change and changes in spatial structures in Flanders) project (*Allaert et al. 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 (*verkennende en methodologische analyse van de Belgische Kust*, *ontwerpopgaven* and *exploratief ontwerpend onderzoek deel 1*, *2* and *3*)	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 den Eynde et al. 2009*, *Van den Eynde et al. 2011*)	This project aims to develop 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	This project aims to inform stakeholders in coastal areas about climate change and its effects on the coast (erosion, floods, etc.).
Provoost et al. 2014	In this ecosystem service report of the nature report (NARA) 2014, the protection against floods from the sea by means of natural sea barrier elements is elaborated.
New Ecosystem Vision Coast (*Ecosysteemvisie Kust*)	ongoing

Legislation reference list

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
EIA Directive	Council Directive on the assessment of the effects of certain public and private projects on the environment	1985	337
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
Floods Directive	Directive on the assessment and management of flood risks	2007	60
Other (Decisions, Communications, White Papers, etc.)			
Recommendation for integrated coastal zone management	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
	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

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen	1980-08-08/02
Royal decrees		
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Decrees		
18 juli 2003	Decreet (betreffende het) Integraal Waterbeleid	2003-07-18/72

13

Military use

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Wouters, B., Depoorter, P., Pâris, T., Pirlet, H., 2015. Military use. In: Pirlet, H., Verleye, T., Lescrauwaet, A.K., Mees, J. (Eds.), Compendium for Coast and Sea 2015: An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Ostend, Belgium, p. 223-232.

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 the 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 (*Maes et al. 2005*, *GAUFRE project BELSPO*, *Berichten aan Zeevarenden 2015 nr. 1*). 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 munitions dump sites are located in the North Sea and the northeastern part of the Atlantic Ocean (*OSPAR QSR 2010*).

13.1 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 *coastal codex, theme military activities*.

13.2 Spatial use

In the BNS, a number of zones reserved for military activities are indicated on the nautical charts (*Vermeersch & Desnouck 2009*). The coordinates of these areas are communicated in the Notices to Mariners (*NtM*) at the beginning of each year (*NtM 2015 nr. 1*). Some military zones have been adjusted in view of the shipping traffic and wind farms.

The zones for military use are also demarcated in the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*) (figure 1). The compatibility with other (potential) users such as the zone for an energy atoll is taken into account (see theme **Energy (including cables and pipelines)**).

13.2.1 Military exercises in the coastal zone and the BNS

In the BNS and the coastal zone, military activities and exercises regularly take place (*NtM 2015 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. The practice area (D07) is divided into three sectors (K-small, M-medium and G-Large), depending on the weapons used. Every year, the practice area is available for military activities for approximately 150 days. The K-sector is used about 60 days, the M-sector 40 days, and the G-sector 20 days per year. These numbers may vary depending on the operational requirements of the Belgian Defence.
- Detonation exercises with practice mines. These exercises take place in the circular area in the southeastern part of the BNOM zone (zone Thornton Bank-Gutter Bank). After the exercises, the practice mines are removed.
- The QZR 040 zone is a practice area used by the international naval mine warfare school of Eguermin in Ostend for Naval Mine Counter Measures (NMCM) training.
- Detonation of historical real mines. Very occasionally, a real war mine is found by ships, fishermen or dredgers. Such mines are also detonated in the circular area, unless in case of an emergency.
- Exercises to lay, search and sweep mines. These exercises take place in two smaller areas, more precisely NB-01 (between Goote Bank 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 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.
- 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.

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).

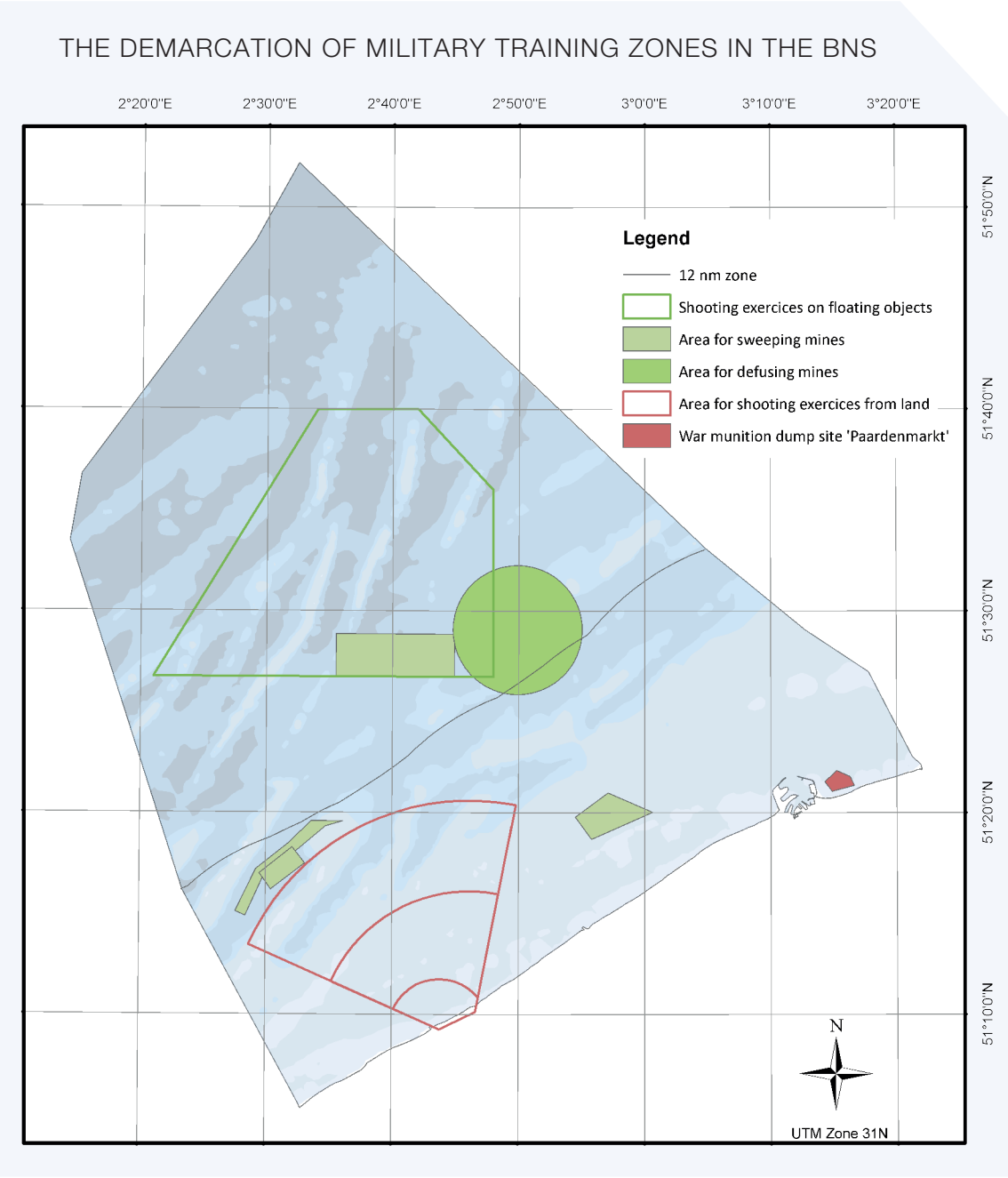

Figure 1. The demarcation of military training zones in the BNS (source: KBIN/IRSNB, *marineatlas.be*, based on the royal decree of 20 March 2014).

The Belgian Defence also takes part in the SAR (Search and Rescue) organisation by means of helicopters and boats under the leadership of the Maritime Rescue and Coordination Centre (*MRCC*) (theme **Maritime transport, shipping and ports**). The frequency of the SAR activities depends on the incidents which occur in the BNS.

Additionally, in cooperation with other national governments, military infrastructure is deployed for security reasons in the framework of existing agreements.

13.2.2 Military bases

The following military bases are located in the coastal area:

- 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 (Brugge).

(*website Belgian Defence*)

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);

13.2.3 Munitions dump site

After WWI, the Belgian Defence dumped German munitions a few kilometres off the coast of Knokke-Heist on a shallow sandbank called *De Paardenmarkt*. There are at least 35,000 tons of munitions. Until recently, it was assumed that about one third consisted of poison gas shells. However, new indications reveal that this percentage may be significantly higher (*Missiaen 2013*). The exclusion zone is a pentagon of about 3 km² (*Missiaen et al. 2002*). The official coordinates of the pentagon are included in the marine spatial plan (royal decree of 20 March 2014, see also *Van de Velde et al. 2014*). In this pentagon, bottom-disturbing activities are prohibited (royal decree of 20 March 2014).

13.3 Societal interest

The Belgian Defence is not only responsible for the military tasks within the BNS. In case of an emergency in the North Sea, the Belgian army offers help and assistance and provides *inter alia* helicopters (*website airbase Koksijde*), 'ready duty ships' and divers (*website coastguard*, 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 Navy is responsible for the detection of violations in the Belgian Exclusive Economic Zone (EEZ) (law of 22 April 1999, law of 20 January 1999). There is a collaboration with the scientific service 'Management Unit of the Mathematical Model of the North Sea' (MUMM) of the Royal Belgian Institute of Natural Sciences (*RBINS*) in the framework of detecting and combating pollution at sea. Thus, support is provided in the detection of polluters. The regent decree of 30 March 1946 grants other specific competences to the Belgian Navy regarding marine and coastal demining and the surveillance of fisheries. In this context, the 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 *structure Coast Guard* (theme **Maritime transport, shipping and ports**). The organisation and responsibilities of MIK are stipulated in the royal decree 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: Admiralty List of Radio Signals – Maritime Radio Stations). The Belgian Defence also intervenes in case of pollution in the North Sea and in case of the detonation of explosives at sea (*website Coast Guard*).

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*). The 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.

Finally, Belgian Defence is involved in a project about archaeological heritage in the North Sea (*Search project*). The aim is that the users of the North Sea – such as the Belgian Defence – disclose information related to heritage to the other partners involved (see theme **Maritime and coastal heritage**).

EMPLOYMENT

With several bases along the coast, the Belgian Defence is responsible for significant direct and indirect employment. In 2015, direct employment in the coastal region amounted to 2,945 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 2015 (source: Belgian Defence).

BASE	EMPLOYMENT (2015)
Zeebrugge (naval base, including crew)	1,480
Ostend (naval mine warfare school)	130
Lombardsijde (practice area + medical detachment)	400
St-Kruis (training navy, including Dutch colleagues in the context of binational activities)	430
Koksijde (airbase)	365
Poelkapelle (dismantling of munitions)	140
Total	**2,945**

13.4 Impact

13.4.1 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 NBH-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*).

Munitions that end up on the seabed during exercises are not cleared. 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 *De IJzermonding* nature reserve (Estuary of the Yser) and near the Ramsar and habitats directive area of the Flemish Banks. Furthermore, there are two marine birds directive areas (special protection area 1 and 2) in the vicinity of the target practices. The negative impact on fauna can be partially reduced by a proper timing that takes into account the presence of large concentrations of marine mammals and seabirds which are highly sensitive to disturbance (*Degraer et al. 2011*).

MUNITIONS DUMP SITE

The release of chemicals that were used in the munitions of the Paardenmarkt site, such as mustard gas and Clark components (see among others *Missiaen & Moerkerke 2002*, *Francken & Ruddick 2003*, *Francken et al. 2006*, *Francken & Ruddick 2007*, *Francken & Hafez 2009*, *Missiaen & Henriet 2010*, *Missiaen 2013*), may lead to pollution of the sediment and the water column, and to disturbance of the food chain (*OSPAR QSR 2010*, *Goffin et al. 2007*, *André et al. 2010*). A synthesis of the scientific research conducted on the impact of the munitions storage on the Paardenmarkt sandbank is available in *Missiaen & Henriet (2010)*. A summary is given of the studies with regard to the topography, localisation of munitions, characterisation of the subsurface, sampling and chemical monitoring, security, distribution of toxic components, biomonitoring and possible technical solutions. Furthermore, this report also makes recommendations for possible investigations and / or actions to be undertaken in the future.

13.4.2 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 *NtM 2015 nr. 1* 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.

13.5 Sustainable use

13.5.1 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. The periods when the target practices are suspended, are shown in the NtM (*NtM 2015 nr. 1*). Infringements and complaints relating to the target practice rules can be submitted to the Federal Police (website *Belgian Defence*).

The target practices take place near the nature reserve *De IJzermonding* (Estuary of the Yser) and in the marine areas of the western coastal zone which are protected by the EU Birds and Habitats Directives (see also theme **Nature and 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*).

13.5.2 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* (even though a call for mitigating measures has been included in the *ASCOBANS resolution 2006*) and the European Marine Strategy Framework Directive (MSFD). 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 (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*).

On the Belgian level, 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 submitted to a permission or authorisation as a result of a common proposal by the minister whose authority includes the protection of the marine environment and by the minister of Defence. In the latter case, the permission or authorisation is granted by both ministers. The law of 20 January 1999 does, however, state that the military authorities, in consultation with the minister (whose task it is to protect the marine environment), need to make every effort to prevent damage and environmental disturbance, without affecting the preparedness of the military force. 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.

The current trend for navy ships is to set an example on the ecological level. Within NATO, a special task force exists for this purpose (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 adapted them to the specific demands of navy ships. This has resulted in a series of publications such as the Allied Maritime Environmental Protection Publication (AMEPP). These publications each 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 navy systems. 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. 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 (*Maes et al. 2005*, *GAUFRE project BELSPO*).

13.5.3 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 & Moerkerke 2002*). Subsequently, OSPAR published a recommendation for the reporting of conventional and chemical ammunition in the OSPAR area (*OSPAR recommendation 2010/20*).

On the European level, the dumping of ammunition is discussed in decision 2850/2000/EC, which establishes a common framework for collaboration in case of accidental or deliberate marine pollution. Moreover, the dumping site of the Paardenmarkt sandbank is located in the birds directive area (SBZ 3). Furthermore, the Marine Strategy Framework Directive (MSFD) constitutes an important framework for measures against pollution from ammunition in offshore dump sites. One of the descriptors in the MSFD to determine a Good Environmental Status (GES) concerns the concentration of polluting matters (*Law et al. 2010*). 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 royal decree of 23 June 2010 - *oppervlaktewatertoestand* and the royal decree of 23 June 2010 - *mariene strategie*.

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 (SBZ 3), it is crucial to monitor the ammunition dump site on a regular basis (e.g. *Missiaen et al. 2002*, *Missiaen & Moerkerke 2002*, *Martens 2005*, *Missiaen & Henriet 2010*, *Missiaen 2013*, *website MUMM*). The contingency plan for the North Sea (ministerial decree of 19 April 2005 – will be replaced by the ANIP North Sea in 2015) also takes the Paardenmarkt sandbank into account. The publication *Missiaen & Henriet (2010)* provides an overview of the conducted research and gives recommendations concerning further research and monitoring of the Paardenmarkt site. The condition of the potential leakage of chemical compounds in the sediment and water column is monitored and modelled in the following studies: *Francken & Ruddick (2003)*, *Francken et al. (2006)*, *Francken & Ruddick (2007)* and *Francken & Hafez (2009)*. In *Degraer et al. (2011)*, it is recommended not to intervene in the Paardenmarkt site at this moment. *Missiaen et al. (2013)* formulates recommendations about the geochemical monitoring of the Paardenmarkt site.

13.5.4 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 januari 2004)). The internal environmental care within the Belgian Defence is mentioned in *André et al. (2010)*. Two military domains in the coastal area 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 & 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

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
MARPOL Convention	International Convention for the prevention of pollution from ships, as modified by the Protocol of 1978 relating thereto	1973	1978
UNCLOS	United Nations Convention on the law of the sea	1982	1994
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR Convention	Convention for the protection of the Marine Environment of the North-East Atlantic	1992	1998
Chemical Weapons Convention (*CWC*)	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction	1993	1997

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
Habitats Directive	Council Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
Marine Strategy Framework Directive	Directive 2008/56/EC establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Birds Directive	Directive on the conservation of wild birds	2009	147
Other (Decisions, Communications, White Papers, etc.)			
	Decision of the European Parliament and of the Council of 20 December 2000 setting up a Community framework for cooperation in the field of accidental or deliberate marine pollution	2000	2850

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databases*.

BELGIAN AND FLEMISH LEGISLATION		
Date	Title	File number
Laws		
Wet van 20 januari 1999	Wet ter bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België	1999-01-20/33
Wet van 22 april 1999	Wet betreffende de exclusieve zone van België in de Noordzee	1999-04-22/47
Royal Decrees		
Besluit van de Regent van 30 maart 1946	Besluit betreffende oprichting en organisatie van de Marine	

BELGIAN AND FLEMISH LEGISLATION (continuation)		
Date	Title	File number
KB van 6 februari 2009	Koninklijk besluit tot oprichting en organisatie van het maritiem informatiekruispunt	2009-02-06/39
KB van 23 juni 2010 - oppervlaktewatertoestand	Koninklijk besluit betreffende de vaststelling van een kader voor het bereiken van een goede oppervlaktewatertoestand	2010-06-23/04
KB van 23 juni 2010 - mariene strategie	Koninklijk besluit betreffende de mariene strategie voor de Belgische zeegebieden	2010-06-23/05
KB van 20 maart 2014	Koninklijk besluit tot vaststelling van het marien ruimtelijk plan	2014-03-20/03
Ministerial Decrees		
MB van 19 april 2005	Ministerieel besluit tot vaststelling van het Rampenplan Noordzee	2005-04-19/40

14 Scheldt Estuary

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Goffin, A., Van den Bergh, E., Meire, P., Mostaert, F., Lescrauwaet, A., Pirlet, H., 2015. Scheldt Estuary. In: Pirlet, H., Verleye, T., Lescrauwaet, A.K., Mees, J. (Eds.), Compendium for Coast and Sea 2015: An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Ostend, Belgium, p. 233-242.

The Sea Scheldt and its tidal tributaries (Durme, Rupel with the Zenne, Dijle and Netes), the Western Scheldt and the mouth of the Scheldt together constitute the Scheldt Estuary. The water bodies and flood plains are subject to the tides from the North Sea. Hence, a strong interaction exists between the Scheldt Estuary and the North Sea (exchange of water masses, dissolved substances, sediments, fauna & flora etc.). Given the importance of the relationship between the user functions of both areas (fisheries, shipping, dredging and dumping, recreation, etc.), the Compendium for Coast and Sea also covers the Scheldt Estuary. The current text is largely based on the contents of *ScheldeMonitor*. This is a Flemish-Dutch knowledge and information portal for research and monitoring in the Scheldt Estuary, which offers information (expertise, literature, projects, etc.), data (datasets, measurements, etc.) and data products (maps, graphs, indicators, etc.).

Besides the Scheldt Estuary, a number of other important estuaries are situated in the North Sea area. 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*). The 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, the estuaries face common challenges such as increasing flood risks, issues with regard to 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. *FLOODSCAPE*, *FRaME*, *HARBASINS*, *TIDE*, *SEDNET*, *SCALDWIN*, *EMOVE*, etc., see also *list of projects* in ScheldeMonitor). The Scheldt Estuary is unique in northwestern Europe because a tidal regime is preserved along the entire fresh-salt water gradient in the river with the typical tidal habitats and communities (*Directie Zeeland & AWZ 2001*).

14.1 Policy context

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 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 not only involve Flanders and the Netherlands, but also the Walloon Region, the Brussels-Capital Region and France (see table 1 and *website International Scheldt commission*). An overview of historical treaties and agreements is available in *van Langenhuysen & 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 was composed of Dutch and Belgian/Flemish officials and was responsible for studies about the Scheldt (e.g. the Deltaplan, the Scheldt-Rhine connection, Long Term Vision (LTV) and the Development sketch 2010 for the Scheldt Estuary). After 2008, the TSC was succeeded by the Flemish-Dutch Scheldt Commission (*VNSC*), as stipulated in the Scheldt Treaties that were concluded on 21 December 2005 in Middelburg. The VNSC consists of a political and an official college and promotes the collaboration between Flanders and the Netherlands in the field of the policy and management of the Scheldt Estuary (the preparation and establishment of plans, programmes and projects, the establishment and guidance of a common programme for monitoring and research, etc.). Depending on the policy and management questions, the official college can establish a permanent or temporary working group to perform specific tasks. The two permanent working groups are ‘Research and monitoring’ and ‘Communication’. In 2015, four temporary working groups were active: ‘Development sketch 2010 for the Scheldt Estuary’, ‘The new sluice of Terneuzen’, ‘Inland navigation in the Scheldt Area’, and ‘Policy and management evaluation’.

On a sectoral level, Flanders and the Netherlands collaborate as well. Both countries ensure the organisation of smooth and safe shipping from and to the Scheldt ports by means of the Common Nautical Management (*CNM*). The *permanent committee of supervision on Scheldt navigation*, that was founded pursuant to article 9 of *the treaty of 19 April 1839* concerning the separation between the Netherlands and Belgium, is the highest body in the organisation of the CNM. The Common Nautical Authority (*CNA*) ensures the daily nautical management, supervised by the permanent committee. The CNA provides information about radar systems and shipping guidance by the Vessel Traffic Services (VTS), as well as information about regulations and procedures. The monitoring of shipping on the Scheldt is mainly performed by the Scheldt Radar Chain (SRC), a shipping guidance system used by the Flemish and Dutch governments. The operational, functional and technical management of the systems of the SRC is executed by the *management and exploration team*.

Table 1. Overview of transborder treaties and memoranda for the Scheldt Estuary (*website VNSC*, *website International Scheldt Commission*).

FLANDERS – THE NETHERLANDS (FROM 1960)	
Scheldt treaties	Memoranda of Understanding (MoU)
Pilot rates (*Loodsgeldtarieven*) (2005)	MoU The Hague (*MvO Den Haag*) (2005)
Common nautical management (*Gemeenschappelijk Nautisch Beheer*) (2005)	First MoU Vlissingen (*Eerste MvO Vlissingen*) (2002) Second MoU Vlissingen (*Tweede MvO Vlissingen*) (2002)
Common policy and management (*Gemeenschappelijk beleid en beheer*) (2005)	MoU Kallo (*MvO Kallo*) (2001)
Development sketch 2010 for the Scheldt Estuary (*Ontwikkelingsschets 2010 Schelde-estuarium*) (2005)	
Scheldt Treaty (*Scheldeverdrag*) (2002)	
Widening of the channel 48/43/38 feet (*Verruiming vaargeul 48/43/38 voet*) (1995)	
Improvement of the waterway at Walsoorden (*Verbetering vaarweg te Walsoorden*) (1970)	
Scheldt-Rhine connection (*Schelde-Rijnverbinding*) (1963)	
Canal Ghent-Terneuzen (*Kanaal Gent-Terneuzen*) (1960) • Protocol Canal Ghent-Terneuzen (*Protocol Kanaal Gent-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)

The objective of the International Scheldt Commission (*ISC*) is to improve the cooperation between riparian states (France, Belgium and the Netherlands) and regions of the Scheldt, in order to achieve a sustainable and integrated water management of the international Scheldt river basin district. Since 2000, attention has also been paid to the common aspects of the river basin management plan for the Scheldt Basin (report 2016-2021, in preparation) in the context of the goals of the Water Framework Directive (WFD).

In the current policy concerning the Scheldt Estuary, particular attention is being paid to the Long Term Vision for the Scheldt Estuary (LTV, *Directie Zeeland & AWZ 2001*). This vision was established in 2001 by the Netherlands and Flanders, and approved by the governments and parliaments of both countries. The LTV constitutes the basis for the development of a trans-border and integrated policy for the estuary. The vision was conceived from the idea that the different functions of the Scheldt Estuary (within the three main themes of safety, nature and accessibility as well as other functions such as fisheries, tourism and recreation) have to be taken into account, in a sustainable way in the future. In the LTV, a 'Target 2030' has been formulated, listing the goals to be achieved by 2030. The *Development sketch 2010 for the Scheldt Estuary (Proses 2005)* indicates which measures and policy efforts are needed in order to achieve the objectives of 'Target 2030'. The challenges for policy makers and managers with regard to the Scheldt Estuary are nowadays included in the *Agenda for the Future*. In 2014, a research programme was established in the context of this agenda.

The *Research and Monitoring* working group is a permanent working group of the Flemish and Dutch Scheldt Commission (VNSC), established in the context of the LTV for the Scheldt Estuary. The Research and Monitoring working group coordinates a long-term monitoring and research programme (MONEOS, *Meire & Maris 2008*) to support the policy and management of the Scheldt Estuary. In this context, an evaluation of the Scheldt Estuary is conducted every six years (evaluation methodology: *Holzhauer et al. 2011*, T2009 report: *Depreiter et al. 2014*) (see **Indicators for a sustainable management**).

In 2003, *ScheldeMonitor* was launched in the context of VNSC as an information system with regard to research and monitoring in the Scheldt Estuary. In addition to the disclosure of information, data and data products related to

the Scheldt Estuary have also been included since 2010. Special attention is paid to the disclosure and archiving of datasets from the MONEOS programme.

In Flanders, two of the themes which are covered by the LTV - safety and nature - are commonly implemented by means of the *updated Sigmaplan (2005)*. Hence, the measures set in this plan serve both the safety and nature function of the estuary. The objectives of the LTV with regard to nature in the Sea Scheldt have been further refined in the context of the updated Sigmaplan (*Adriaensen et al. 2005*). Furthermore, a series of measures has been proposed to realise these goals. Three types of measures are important in this regard: the development of mud flats and salt marshes by allowing controlled reduced tides in a controlled floodplain (CFP), the renewal of dikes or depolderisation, and the development of wetlands in the valley, whether or not as a CFP. The goals and measures are part of the *updated Sigmaplan (2005)*, as approved by the Flemish government (22 July 2005).

The policy and management with regard to the Scheldt Estuary are largely driven by international and European legislation such as the Birds and Habitats Directives, the Water Framework Directive (WFD), the Floods Directive (see also *http://www.scheldemonitor.be/nl/monitoring-en-beleidskader*) and the national and regional policy instruments that have to ensure the local implementation of these measures (see also theme **Nature and environment**) by means of concrete goals such as the good ecological and chemical condition (WFD) and the conservation objectives of the natura 2000 areas in and around the estuary. An overview of the policy framework for the Scheldt Estuary is given in *Debergh et al. (2009)* and on the following webpage: *http://www.scheldemonitor.be/nl/monitoring-en-beleidskader*

14.2 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. Furthermore, the upper limit of the highest high water is regarded as a border (figure 1).

The LTV (*Directie Zeeland & AWZ 2001*) applies to a specific geographical 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 mouths of the tributaries. The downstream border of the estuary contains the Scheldt and its estuaries, 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

THE AREA OF THE SCHELDT ESTUARY

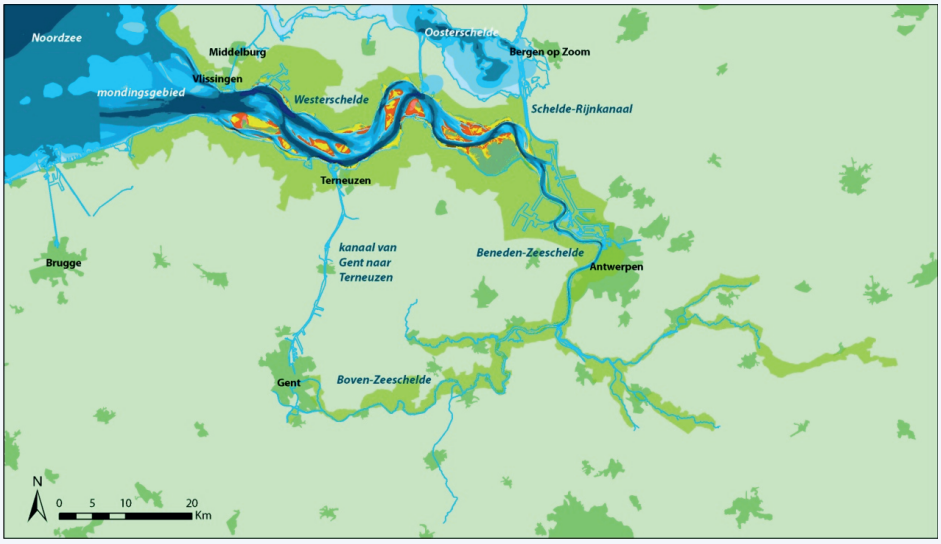


Figure 1. The area of the Scheldt Estuary, with an indication of the estuary, the Western Scheldt, the Lower Sea Scheldt and the Upper Sea Scheldt (Source: VNSC Communication).

its waterway *Pas van het Zand* are not included in the area demarcated for the LTV. The LTV also covers the banks up to the principal weirs.

The spatial division which is presented in the evaluation methodology for the Scheldt Estuary (*Holzhauer et al. 2011*) is based on the division in OMES/MOSES compartments which are related to the salinity and residence times (figure 2). These zones can be subdivided or combined depending on the desired detail. Four different scales can be distinguished:

- Level 1: Estuary
- Level 2: Western Scheldt – Sea Scheldt - Tributaries
- Level 3: Mouth zone – 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: OMES/MOSES compartment

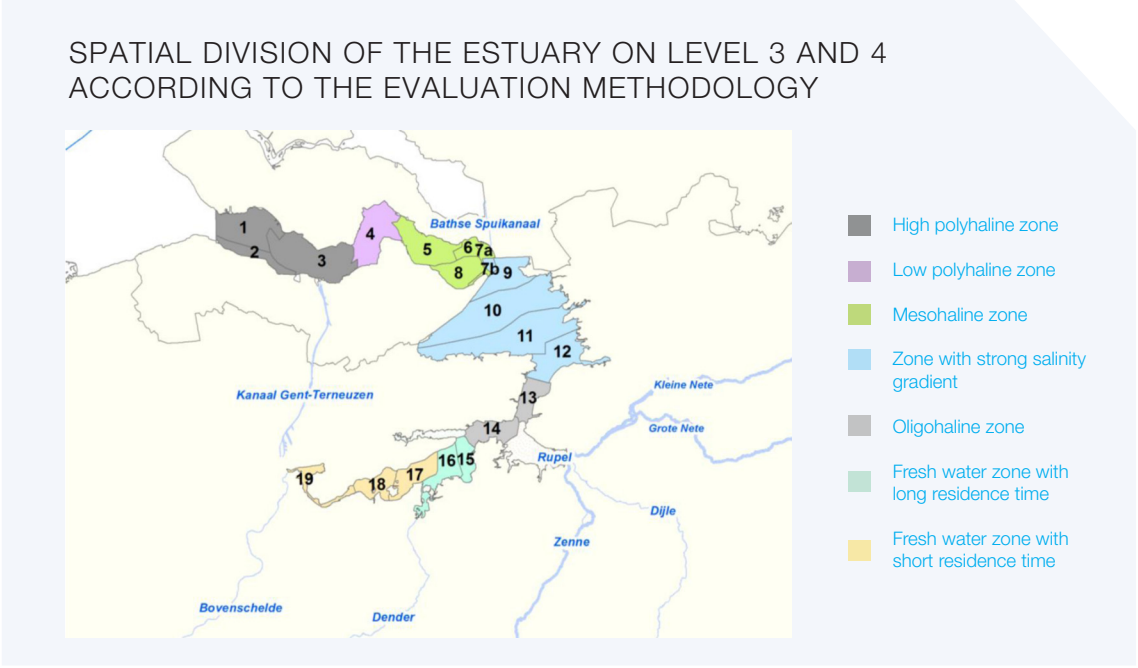


Figure 2. The spatial division of the Scheldt Estuary on level 3 and 4 according to the evaluation methodology (Source: *Maris et al. 2014*).

14.3 The ecosystem of the Scheldt Estuary

The Scheldt Estuary is an area with unique natural values. It is one of the most important European estuaries where the tidal regime has been preserved along the entire fresh-salt water gradient with the typical tidal habitats and communities (*Directie Zeeland & AWZ 2001*).

The Scheldt Estuary is by nature a very dynamic system. Mud flats, salt marshes, sandbanks and gullies are constantly subject to tidal and salinity changes. The low-dynamic (with a low water velocity) shallow water areas, the intertidal areas (mud flats, sandbanks) and salt marshes constitute ecologically valuable habitats in the Scheldt Estuary. The mudflats and sandbanks are usually rich in benthos and constitute important feeding grounds for waders and other birds. In general, the areas with an average exposure rate (the percentage of time the mud flats are surfaced) are the most attractive areas from an ecological point of view (*MER Verruiming vaargeul Beneden-Zeeschelde en Westerschelde 2007*, *Wetsteijn et al. 2007*, *Depreiter et al. 2014*). Low-dynamic shallow water areas are essential for the reproduction and growth (nursery function) of fishes, crustaceans and molluscs. Salt marshes provide a suitable nesting area for several bird species and serve as a refuge during high water. In addition, these intertidal areas have an important regulating function as a source or sink of certain substances such as nutrients and silica (see *inter alia Struyf et al. 2006* and *Jacobs et al. 2008*).

Table 2. Overview of the available information, data and data products about the ecosystem which are present in ScheldeMonitor.

THE ECOSYSTEM OF THE SCHELDT ESTUARY	
Topic	Subtopic
Habitats diversity	
Species diversity	
Ecological functioning	
Physico-chemistry	• *Physical parameters* • *Light climate* • *Pollution* • *Bottom water quality* • *Water quality*
Hydrodynamics	• *Waves* • *Water balance* • *Water level and tide*
Morphodynamics	*Geomorphology*

Flanders and the Netherlands collaborate on an ecotope system (i.e. a (hierarchical) classification of ecotopes of habitats) for the Scheldt Estuary. This type of system is used to track changes in different habitats throughout time, to predict the impact of certain variations in the system on the present habitats and to evaluate the effects on the communities (*Arcadis 2014*).

Table 2 gives an overview of the available information (expertise, literature, projects, etc.), data (datasets, measures, etc.) and data products (maps, graphs, projects, etc.) in *ScheldeMonitor* regarding the different aspects of the ecosystem. Important information concerning the ecosystem of the Scheldt Estuary is also available in reports of the Research and Monitoring working group (see reports on the websites of *ScheldeMonitor* and *VNSC*).

14.4 The use of the Scheldt Estuary

The Scheldt Estuary is not only an important ecosystem, but also hosts several user functions such as shipping, dredging, sand extraction, recreation, protection against floods (e.g. flood control areas), fishing, etc. Table 3 gives an overview of the available information (expertise, literature, projects, etc.), data (datasets, measures, etc.) and data products (maps, graphs, indicators, etc.) in *ScheldeMonitor* concerning these user functions. Certain users functions are also discussed in reports of the Research and Monitoring working group (see reports on the websites of the *ScheldeMonitor* and *VNSC*).

Table 3. Overview of the available information, data and data products about the different user functions of the estuary which are present in ScheldeMonitor.

THE USER FUNCTIONS OF THE SCHELDT ESTUARY	
Topic	Subtopic
Morphodynamics	• *Dredging and dumping* • *Sand extraction*
Shipping	
Safety	
Fisheries	
Administration and law	
Socio-economics	

14.5 Indicators for a sustainable management

Flanders and the Netherlands have decided to conduct a common evaluation of the functioning of the Scheldt Estuary and the activities in the estuary in the framework of the Research and Monitoring working group (VNSC), every six years. This reporting aims to evaluate the three principal functions: nature, safety and accessibility by means of seven indicators for a sustainable management (see table 4). In 2011, an evaluation methodology was developed which describes how each indicator should be evaluated (*Holzhauer et al. 2011*). Every indicator has a pyramid structure which includes the relevant benchmark parameters, calculation parameters and explanatory parameters. The evaluation methodology is a dynamic document which is reviewed after each evaluation report. Hence, a first update became available in 2014: *Maris et al. 2014*. The *Evaluation and Reporting project group* coordinates the different evaluation reports (see explanation on *website ScheldeMonitor*).

Prior to evaluation, a baseline has to be clearly defined based on the evaluation methodology (*Holzhauer et al. 2011*). 2009 is used as a reference (T2009) (*Depreiter et al. 2014*). In the aforementioned report, the baseline situation of the system of the Scheldt Estuary is described (the year 2009) as well as the trends and historic developments until 2009. The next evaluations will be conducted in 2016 and 2022.

Prior to the evaluation methodology mentioned above, a set of indicators was selected in the context of the LTV goals and aligned with the complete transboundary Scheldt Estuary in consultation with scientists and policy makers (see *Indicators for the Scheldt Estuary 2011* and *website ScheldeMonitor*).

Tabel 4. 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*).

OVERVIEW INDICATORS EVALUATION SCHELDT ESTUARY			
Principal function	**Indicator**	**Methodology**	**Report appendix**
Safety	Water movement dynamics	*version 2011* *version 2014*	*Appendix T2009*
Accessibility	Navigability	*version 2011* *version 2014*	*Appendix T2009*
Nature	Water Quality	*version 2011* *version 2014*	*Appendix T2009*
	Flora & Fauna	*version 2011* *version 2014*	*Appendix T2009*
	Ecological functioning	*version 2011* *version 2014*	*Appendix T2009*
	Habitat	*version 2011* *version 2014*	*Appendix* & *Addendum T2009*
	Bank-gully system	*version 2011* *no pyramid 2014*	

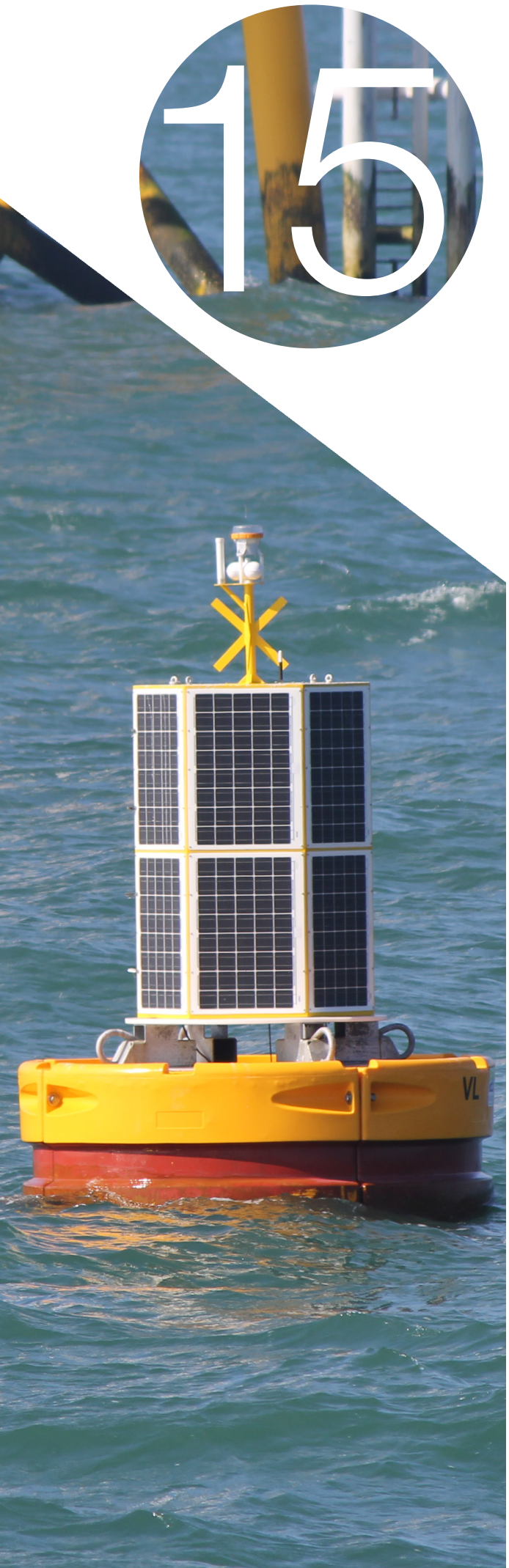
Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
	Canal Ghent-Terneuzen (*Kanaal Gent-Terneuzen*) Protocol Canal Ghent-Terneuzen (*Protocol Kanaal Gent-Terneuzen*)	1960 1985	
	Scheldt-Rhine connection (*Schelde-Rijnverbinding*)	1963	
	Improvement of the fairway at Walsoorden (*Verbetering vaarweg te Walsoorden*)	1970	
RAMSAR Convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat	1971	1975
	Treaty of Charleville-Mézières (*Verdrag van Charleville-Mézières*)	1994	
	Widening of the channel 48/43/38 feet (*Verruiming vaargeul 48/43/38 voet*)	1995	
	Scheldt treaty (*Scheldeverdrag*)	2002	
	Treaty of Ghent (*Verdrag van Gent*)	2002	
	Pilot rates (*Loodsgeldtarieven*)	2005	2008
	Common nautical management (*Gemeenschappelijk Nautisch Beheer*)	2005	2008
	Common policy and management (*Gemeenschappelijk beleid en beheer*)	2005	2008
	Development sketch 2010 for the Scheldt Estuary (*Ontwikkelingsschets 2010 Schelde-estuarium*)	2005	2008
Memoranda of Understanding			
	MoU Kallo (2001)		2001
	MoU Vlissingen (2002) (2 MoUs)		2002 (2)
	MoU Den Haag (2005)	2005	2005
Ministerial Decrees			
	Ministerial conference in Middelburg (*Ministersconferentie te Middelburg*)	1998	
	Ministerial declaration of Liège (*Ministeriële Verklaring van Luik*)	2001	

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
Habitats Directive	Council Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive 2000/60/EC establishing a framework for Community action in the field of water policy	2000	60
Floods Directive	Directive 2007/60/EC on the assessment and management of flood risks	2007	60
Birds Directive	Directive on the conservation of wild birds	2009	147



Marine data and information

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15.1 Introduction

Few marine areas in the world are that well investigated as the Belgian part of the North Sea (BNS). This is partly due to a deep-rooted tradition and expertise in marine research in Belgium (**Chapter 1**), but is also a response to the intense use of the BNS (**Chapter 2**). This intensive use of space by a variety of economic activities results in new opportunities, which, however, are related to legislation, monitoring, enforcement and reporting. The policy instruments dealing with the protection of marine ecosystems (Marine Strategy Framework Directive (MSFD), *OSPAR Convention*, etc., see theme **Nature and environment**) increasingly determine the framework in which the maritime sectors can develop in these areas (*Verleye et al. 2015*, *Juridische Codex Kustzone*). The use of space in the BNS is regulated by the Marine Spatial Plan (MSP, RD of 20 March 2014, see also *Van de Velde et al. 2014*). By implementing the MSP and the MSFD, Belgium complies with the European guidelines for the Integrated Maritime Policy (IMP, COM (2007) 575) and lays the foundation for an ecosystem approach to the management of the BNS. Cooperation and coordination between the competent authorities, policy areas and sectors take place in terms of operational tasks, monitoring, enforcement, reporting, use of infrastructure, data collection, etc., within the BNS as well as across the borders (land-sea boundary included).

As one of the cornerstones of the IMP, the Marine Knowledge 2020 strategy (COM (2010) 461) is even more ambitious about an integrated approach. With Marine Knowledge 2020, the European Commission (EC) aims to centralise as well as disclose marine data from different sources. The ultimate goal is to increase efficiency in services to the industry, policy makers and scientists in order to develop new products and services and to deepen the marine knowledge.

15.2 Marine data and information management: infrastructures in Belgium

For Flanders and Belgium, the integration and harmonisation of existing scientific marine/maritime knowledge is not a new concept. The infrastructure for the management of marine research data in Belgium is based on two complementary centers:

- The Belgian Marine Data Centre (*BMDC*): part of the Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature, MUMM) (since 1997);
- The *VLIZ data centre*: part of the Flanders Marine Institute (VLIZ) (since 1999).

Both centres have been appointed as National Oceanographic Data Centres (NODC) in the programme for International Oceanographic Data and Information Exchange (*IODE*) of the IOC-UNESCO. They are international players in the collaboration concerning the management and exchange of oceanographic data and information. For these tasks, the BMDC and the VLIZ data centre rely on a set of data and information systems for the collection, storage, description, exploration, integration, redistribution and access to data, focussing on the BNS and adjacent areas (table 1).

These systems represent the infrastructural backbone for the management of data and information in the BNS and adjacent areas, and take care of the numerous Flemish and Belgian contributions and their inflow in European and global marine data systems. Some examples include: the IODE *Ocean Data Portal* (IOC-UNESCO); the global Ocean Biogeographic Information System (*OBIS*) and its European pillar (*EurOBIS*), which includes the biogeographical data for the BNS; SeaDataNet with its European catalogues for marine environmental datasets (EDMED) and research projects (*EDMERP*); and the European Marine Observation and Data Network (*EMODnet*). EMODnet is a cornerstone of the European Marine Knowledge 2020 strategy. The web portal unites marine metadata, data and data products in a standardised manner and has a data policy based on Open Access (OA). It focuses on data sources and information flows collected by EU Member States in a coordinated way, following legally anchored reports and other formal activities.

15.3 Marine data and information for the BNS and adjacent areas

Data collection is achieved through a wide range of research and monitoring activities with different objectives: single samplings within the frame of brief research projects (e.g. doctoral thesis); collection of economic and social data (port policy, recreational navigation, aquaculture, etc.); environmental impact assessments (EIAs) for interventions in the BNS (e.g. offshore wind farms); regular monitoring under formal reporting requirements (*Bonn Agreement*, *ASCOBANS*, OSPAR Coordinated Environmental Monitoring Programme (*CEMP*), Common Fisheries Policy (CFP),

Table 1. Overview of data and information systems managed by the Belgian NODC, concentrated on the BNS and adjacent areas. Note: Non-exhaustive list, focusing on publicly accessible data and information systems concerning marine research and management in the BNS and adjacent areas.

NAME (ACRONYM)	DESCRIPTION	SOURCE
Integrated Marine Information System (IMIS)	Marine expertise: institutes, people, publications, projects and datasets	VLIZ • *http://www.vliz.be/imis*
Marine Information and Data Acquisition System (MIDAS)	Data linked to scientific surveys and sampling: navigation, meteorology and underway oceanographic parameters measured aboard the RV Zeeleeuw and RV Simon Stevin	VLIZ • *www.vliz.be/vmdcdata/midas*
Oceanographic Data Acquisition System (ODAS)	Physicochemical parameters, measurements of currents and waves and CTD-profiles measured aboard the RV Belgica	RBINS, OD Nature (MUMM) • *http://odnature.naturalsciences.be/belgica/en/odas/1293*
Integrated Dynamical Oceanographic Data Management (IDOD) Data and Information Tracking System (DITS)	Data on the quality of the marine environment: concentrations of substances in water, air, sediments and biota; includes selection and analysis tools Metadata and data related to projects and datasets	RBINS, OD Nature (MUMM) • *www.mumm.ac.be/datacentre* • *http://dits.bmdc.be*
Integrated Marine Readings and Samples (IMERS)	Data on sampling campaigns and measurements (in water column, sediment and biota), linked to IMIS, *MIDAS* and *Aphia*	VLIZ • *www.vliz.be/vmdcdata/imers*
Aphia World Register of Marine Species (WoRMS)	Taxonomic register of all known marine species worldwide, including the European (ERMS) and Belgian platform (BeRMS)	VLIZ • *www.vliz.be/en/taxonomic-register-marine-species* • *www.marinespecies.org* • *www.marinespecies.org/berms*
Marine Data Archive (MDA)	Online platform for archiving data files in the context of data management within a project, institute or individually (private, shared and public)	VLIZ • *http://www.vliz.be/en/marine-data-archive*
ScheldeMonitor	Data and information portal for the Scheldt Estuary: provides access to information, measurements and data products (commissioned by the Flemish-Dutch Scheldt Commission-VNSC)	VLIZ (commissioned by VNSC) • *www.scheldemonitor.org*

MSFD, etc.); as well as extensive operational data streams regarding shipping movements (Scheldt Radar Chain (*SRC*) and Vessel Traffic Services (VTS), Dredging Information System (Baggerinformatiesysteem (*BIS*)), wave and tidal climate (Flemish Banks Monitoring Network)).

The ex post gathering and integration of data and information from various sources is not self-evident. It relies on cooperation for the development of standards, agreements and harmonisation for the benefit of interoperable data infrastructures (*inter alia* INSPIRE Directive 2007/2/EG), and a clear data policy (*Aarhus Convention*, Open Access movement). Despite the increased collaboration in order to efficiently collect data and make it available, it is not evident for professional users to get an overview of the available, digitally accessible data and information concerning the coast and sea. A non-exhaustive list of publicly accessible socio-economic, ecological and environmental data relevant to the BNS and the adjacent estuaries and coastal areas, is available in the annex. This list is largely classified according to the themes discussed in **Chapter 2 'Use of the sea'**.

15.4 Access and use

The extent to which information is freely available, can vary widely depending on the context and the purposes for which the data collection is intended. With the Marine Knowledge 2020 strategy, the EC strives for an *Open Access* policy (OA). OA means free online access to (scientific) information and data (Open Data). OA publications and data can easily be found online and are therefore readily available to researchers and other users, without requiring them to pay a fee. For marine scientists in Belgium, VLIZ manages the Belgian marine repository for literature: the Open Marine Archive (OMA). The Belgian Marine Bibliography[1] (*BMB*) is the reference list for all publications focussing on

[1] The definition of the BMB collection is more comprehensive than the publications of the marine research groups (MRGs) (see **Chapter 1, Inventory marine research**).

the Flemish coast and the BNS and all other marine, estuarine and coast related publications from Belgian authors and scientists, and from foreign scientists affiliated to a Belgian institute. About 60% of the publications in the BMB collection (34,225 records total) are digitally available through OMA (situation on 30/10/2015).

The most powerful model of OA publishing, however, is the fully digital and 100% OA journal title, for which the publication costs are taken on by the publisher and the authors. Analyses carried out in the Web of Science database based on the BMB collection, demonstrate that OA publishing presents the best result in terms of visibility and impact (Analysis VLIZ Information Management 2015).

In addition to publications, data should be made available as much as possible for scientific research, both on a national and an international level (Marine Knowledge 2020). When only limited access can be granted, the public disclosure of data descriptions allows an exploration of the existing datasets.

In line with the BMB collection, VLIZ also works on a collection of Belgian Marine Datasets (BMD)[2]. A first subset was disclosed as the datasets '*Belgian coast and sea*', an inventory of datasets specifically focussing on the Flemish coast, estuaries and the BNS. This collection provides access to 522 thematically searchable datasets (situation on 30/10/2015).

Scientific data are unique and valuable and must be preserved from loss. To this end, VLIZ developed the Marine Data Archive (*MDA*), a secure online system where researchers can archive and, if desired, publish their data files in a well-documented manner. Publishing data sets is increasingly taken into account as a citable contribution to the research curriculum. Citing research data is important, *inter alia* for the traceability and crediting (impact) of data. The VLIZ data centre provides assistance to researchers with regard to the publication of their data and to assign a DOI (Digital Object Identifier) under the care of *DataCite*, which develops guidelines and standards for the traceable and citable publication of data (DOI *Manual* - *http://www.vliz.be/en/data-submission*).

Internationally accepted data standards and policies (*IOC data policy*, *Ocean Data standards*, ICSU World Data System, *EU Open research data pilot*, etc.) are also used as a base for the further promotion of efficient data streams. These data policies constitute the core service of the NODCs with regard to making data and information, provided by third parties, publicly available.

Table 2. List of data sets (situation on 30/10/2015) for the BNS and adjacent estuaries and coastal areas, which are disclosed in the BMD.

THEME	NUMBER
Species diversity	291
Physico-chemistry	126
Morphodynamics	89
Ecological functioning	81
Diversity habitats	49
Hydrodynamics	41
Fisheries	23
Methods and techniques	10
Shipping	4
Meteorology	3
Safety	3
Marine waste	2
Recreation and tourism	2
Socio-economic system	2

[2] The reference list of datasets on the Flemish coast and the BNS, and all the other marine, estuarine and coastal datasets of Belgian authors and scientists and foreign scientists affiliated to a Belgian institution.

This kind of immediate and unrestricted access to scientific publications and data promotes innovation, adds value to research, the economy and society in general and complies with the intentions of the European and international policy regarding marine knowledge.

15.5 Annex

Table. Data and information sources focussing on the Belgian part of the North Sea and adjacent areas, by topic. A non-exhaustive list of digital and open sources, acknowledging the respective information managers and web page.

THEME	DESCRIPTION	INFORMATION MANAGER	SOURCE
General			
Geography, location and administration	Marine Atlas: Geographical information on the BNS and the user functions	RBINS, OD Nature (MUMM)	*http://odnature.naturalsciences.be/marine-atlas*
Geography, location and administration	The Coastal Atlas: geographic and administrative information on the BNS and the adjacent estuaries and coastal zones	Province of West Flanders – Coastal Territorial Cooperation	*www.kustatlas.be*
Place names and geo-terms (sea)	Marine Regions, VLIMAR Gazetteer and VLIZ Maritime Boundaries Geodatabase: geographic descriptions and place names, including coordinates (sandbanks, areas, estuaries, exclusive economic zone (EEZ), etc.), with an initial focus on the BNS and adjacent areas	VLIZ	*http://www.marineregions.org/about.php*
General indicators administration, population, economy	National Statistics: economy, population, use of space, energy, etc. Local Statistics Flanders: population, economy, use of space, etc., at the municipal level, including coastal and polder municipalities	Directorate-General Statistics (ADSEI), Studiedienst van de Vlaamse Regering (SVR), in cooperation with the *Agentschap voor Binnenlands Bestuur* (ABB) and local authorities	*http://statbel.fgov.be/en/statistics/figures/* *www.lokalestatistieken.be*
Meteo-Physico-Hydro			
Meteorology and hydrology	Flemish Banks Monitoring Network - oceanographic parameters: tide and tidal height, currents, waves and water temperature	Agency for Maritime and Coastal Services (MDK) - Flemish Hydrography	*www.meetnetvlaamsebanken.be*
Meteorology and hydrology	Operational models hydro-meteo	RBINS, OD Nature (MUMM)	*http://www.mumm.ac.be/EN/Models/Operational/index.php*
Characteristics of sea water	Flemish Banks Monitoring Network - temperature, salinity, oxygen concentrations and acidity	Agency for Maritime and Coastal Services (MDK) - Flemish Hydrography	*www.meetnetvlaamsebanken.be*
Historical time series	4 decades of Belgian marine monitoring - 4DEMON: data concerning water quality, eutrophication, ocean acidification, etc., collected over the past four decades in the BNS	BELSPO, Institute for Agricultural and Fisheries Research (ILVO), RBINS, OD Nature, VLIZ	*http://4demon.be/* *http://4demon.be/data-products*
	Historical temperature and salinity measurements in the BNS and adjacent areas	ICES, VLIZ, RBINS	*http://www.vliz.be/en/imis?module=dataset&dasid=5096*
Sea level and water levels	Operational data about tides, precipitation, water flows, water levels and drought, floods, sediment amounts based on field measurements (WISKI database); predictions concerning water levels and flow rates based on these data Time series and historical sea level compared to a reference level on land: real-time monitoring of the sea level in monitoring stations in collaboration with GLOSS (Global Sea Level Observing System) and IOC (Intergovernmental Oceanographic Commission): station Ostend	Flanders Hydraulics Research – *Hydrologisch Informatie Centrum* (HIC) MDK, LOSS (IOC-UNESCO) (VLIZ)	*http://www.waterinfo.be/* Ostend: *http://www.ioc-sealevelmonitoring.org/station.php?code=oste*
Climate, wind climate, solar energy	Climate atlas: temperature (air), pluviometry, solar radiation, duration of sun shine	Royal Meteorological Institute of Belgium (RMI)	*http://www.meteo.be/meteo/view/nl/16788784-klimaatatlas.html*

THEME	DESCRIPTION	INFORMATION MANAGER	SOURCE
Use of space			
Marine Spatial Plan (MSP) for the BNS	Overview of zoning and use of space in the BNS	RBINS, OD Nature (MUMM)	*http://odnature.naturalsciences.be/marine-atlas/data*
Spatial plans – coastal zone	Spatial Implementation Plans (RUPs), maps and instructions available for coastal municipalities, including the RUPs 'beach and dike' Spatial vision for agriculture, nature and forest for the region 'Coast, Polders and Westhoek area'	Province of West Flanders RWO Flanders	*http://www.west-vlaanderen.be/kwaliteit/Leefomgeving/rup/Paginas/default.aspx* *http://rsv.vlaanderen.be/RSV/RuimtelijkStructuurplanVlaanderen/Planningsprocessen/Landbouwnatuurenbos/KustPoldersenWesthoek*
Use of space and development projects (land)	Use of space all sectors – Overview of development projects: overall projects, rural projects, land development projects, land consolidation projects and nature development projects	Flanders Geographical Information Agency (FGIA – AGIV) Flemish Land Agency (VLM)	*http://www.geopunt.be/* *https://www.vlm.be/en*
Nature and environment			
Species Register BNS	Belgian Register of Marine Species (BeRMS): full list of species, taxonomic information and sources for all known species	VLIZ	*www.marinespecies.org/berms*
European Habitats and Birds Directives	Estuaries, mud flats and salt marshes, dune areas, polders and polder complexes	Environment, Nature and Energy department (LNE)	*https://www.natura2000.vlaanderen.be/* *http://bd.eionet.europa.eu/activities/Natura_2000/index_html*
LifeWatch	The Belgian LifeWatch project is part of the European LifeWatch infrastructure and was established as part of the European Strategy Forum on Research Infrastructure (ESFRI) and can be viewed as a virtual laboratory for biodiversity research	VLIZ, INBO, Hercules Foundation	*http://www.lifewatch.be/*
Invasive species	List of non-indigenous species in the BNS and adjacent estuaries, indicating the distribution and the year of the first observation	VLIZ Alien Species Consortium	*http://www.vliz.be/en/non-indigenous-species*
Biological valuation - sea	Biological valuation map for the BNS	BELSPO project consortium: Marbiol (UGent), INBO, Renard Centre of Marine Geology (RCMG) (UGent), ILVO and VLIZ	*http://www.vliz.be/projects/bwzee/atlas.php*
Biological valuation (habitat and species) – coastal zone (land)	Biological valuation map – land side, including dune areas, mud flats and salt marshes	INBO	*http://www.geopunt.be/catalogus/applicationfolder/biologische-waarderingskaart*
Ecosystem services and products (land)	Nature value explorer: importance and economic valuation of ecosystem services for Flanders	Environment, Nature and Energy department (LNE), Flemish Institute for Technological Research (VITO), Antwerp University, Agency for Nature and Forest (ANB)	*http://natuurwaardeverkenner.be/nwv2/*
Good environmental status (GES) of the marine waters (MSFD)	MSFD - Belgian marine monitoring programme aimed at MSFD descriptors and indicators for monitoring the GES: online search tool for all components of the monitoring programs of the Belgian coastal waters, as reported to the EC	RBINS, OD Nature (MUMM) With the support of the EU project JMPS-NS, and in broader collaboration with experts in Flanders and Belgium	*http://www.msfd-monitoring.be/2014/public/explorePgms.xhtml*
Good ecological and chemical status of the marine waters (Water Framework Directive, WFD)	WFD - focused on the monitoring of the good ecological and chemical status. For the good ecological status in marine waters, the WFD reaches to 1 nautical mile seawards of the low water mark. For the good chemical status, the the WFD reaches to 12 nautical mile seawards of the low water mark.	Coordination Committee on Integrated Water Policy (CIW)	*www.integraalwaterbeleid.be/en*

THEME	DESCRIPTION	INFORMATION MANAGER	SOURCE
Water quality surface waters and nutrients	Measurements of nitrate and phosphate concentrations in surface waters in Flanders in the monitoring network for the observation of water quality (monitoring network in the framework of the Manure Action Plan)	Flanders Environment Agency	*http://geoloket.vmm.be/Geoviews/*
Bathing water quality	Quality of the swimming water in bathing areas of the coast during bathing season, according to bacteriological standards of the European Bathing Water Directive	Flanders Environment Agency	*www.kwaliteitzwemwater.be*
Dredging and dumping			
	Evolution of the amount of dumped dredged material in the BNS since 1991 Location of the dumping ground for dredged material and the intensity of dredging in the BNS (see MSP)	RBINS, OD Nature (MUMM) Maritime Access division (aMT)	*http://www.mumm.ac.be/NL/Management/Sea-based/table4.php*
Fisheries			
Belgian commercial fisheries activities	Supply and revenue Fisheries: Year reports and results of data collection in line with the Common Fisheries Policy (CFP): supply (ton), revenue (euros)	Agriculture and Fisheries department, Sea Fisheries service	*http://lv.vlaanderen.be/nl/visserij* *jaarlijkse overzichten*
Belgian fleet	Size and characteristics of the commercial fishing fleet Results of the fleet	FPS Mobility and Transport	Official list of the Belgian fishing fleet *http://mobilit.belgium.be/nl/scheepvaart/zeevisserij*
History of the Belgian commercial fleet	An overview of the fishing vessels from 1929 onwards, at the level of individual vessels	VLIZ	*www.vliz.be/cijfers_beleid/zeevisserij/fleet.php*
Total allowable catch and quota	The Flemish fisheries quota	Agriculture and Fisheries department, Sea Fisheries service	*http://lv.vlaanderen.be/en/nieuws/visserij*
Historical timelines fisheries	Historical landings, revenue, fishing grounds, fleet, etc. since 1929	VLIZ, 'A century of sea fisheries in Belgium'	*www.vliz.be/cijfers_beleid/zeevisserij/*
State of the fish stocks	Fish stock assessment and biological advice for EU fisheries management	ILVO – research group Fisheries biology, in cooperation with ICES	*http://www.ices.dk/community/advisory-process* Versions advice for non-experts: *http://www.ices.dk/publications/our-publications/Pages/Popular-advice.aspx*
Tourism			
	Arrivals and overnight stays Residential tourism, day trippers and tourist spending	Westtoer Tourism Flanders	*http://www.westtoer.be/nl/kenniscentrum* *www.toerismedatabank.be*
Aquaculture			
Aquaculture areas	Areas reserved for aquaculture in the BNS	RBINS, OD Nature (MUMM)	See Use of space at sea
Sluice dock Ostend	Monitoring of the quality of shellfish waters (also see Nature and environment)	VLIZ	*www.vliz.be/spuikom/doelstelling.php*
Aquaculture production	Annual aquaculture production in Belgium	FAO	*http://www.fao.org/fishery/statistics/global-aquaculture-production/en*
Historical aquaculture production	History and production of the Belgian oysters farms	VLIZ	*www.vliz.be/wiki/Historiek_van_de_Belgische_oesterkweek*
Offshore energy			
Offshore wind energy	Overview of the sites and used area of the domain concessions for wind turbines in the BNS	FPS Economy RBINS, OD Nature (MUMM) and Belgian Offshore Platform (BOP)	*www.mumm.ac.be/NL/Management/Sea-based/windmills_table.php* *www.belgianoffshoreplatform.be/nl/projects*

THEME	DESCRIPTION	INFORMATION MANAGER	SOURCE
Sand and gravel extraction			
Sand and gravel extraction	Amount of mined sediment and location of the domain concessions	FPS Economy, Continental Shelf Service	*http://economie.fgov.be/en/entreprises/particular_domains/Marine_sand_and_gravel_extraction/*
Maritime and coastal heritage			
Maritime archaeological heritage	Shipwrecks (and their contents) in the North Sea and in Flanders, loose objects found at sea and maritime sites on land such as fishing villages and lighthouses	Flanders Heritage Agency Flemish Hydrography	*www.maritieme-archeologie.be* *www.vlaamsehydrografie.be/wrakkendatabank.htm* *www.wrecksite.eu*
Historical fleet	Inventory historical fleet	Flanders Heritage Agency	*https://inventaris.onroerenderfgoed.be/ivm/varend/zoeken*
Architectural heritage	Inventory immovable heritage Geoportal immovable heritage: an overview of the spatial distribution of the protected architectural heritage along the coast	Flanders Heritage Agency	*https://inventaris.onroerenderfgoed.be* *https://geo.onroerenderfgoed.be*
Underwater heritage	Geographic information system with the position of underwater cultural heritage in European seas Interactive geoportal with respect to the underwater heritage (including prehistoric finds) in the BNS (under development)	*Archaeological Atlas of the 2 Seas* *SEARCH* project consortium	*http://www.atlas2zeeen.eu/* *www.sea-arch.be/en*
Legal information			
	Legal Codex Coastal zone: Coastal Codex	MDK – Coastal Devision	*http://www.kustcodex.be/kustcodex-consult/*
	Manual 'Marine policy instuments and legislation for the Belgian part of the North Sea'	VLIZ	*www.compendiumkustenzee.be/en*
Operational data streams: (*) non-public data			
Shipping movements (*)	Scheldt Radar Chain (*SRC*) and Vessel Traffic Services (VTS)	Agency for Maritime and Coastal Services (MDK)	*http://www.scheepvaartbegeleiding.be/en/vts/tasks*
Dredging (*)	Dredging information system (Baggerinformatiesysteem (*BIS*))	Maritime Access division (aMT)	*http://www.maritiemetoegang.be/het-baggerinformatie-systeem*
Satellite observations	REMSEM remote sensing and ecosystem modelling tools, focused on the BNS: long time series of chlorophyll-a, total suspended matter, and surface water temperature, based on satellite observations MODIS, MERIS and SeaWiFS	RBINS, REMSEM-OD Nature	*http://odnature.naturalsciences.be/remsem/software-and-data/timeseries*
LifeWatch – Bird migrations	Real-time tracking data of large sea birds (European herring gull and lesser black-backed gull)	VLIZ	*http://www.lifewatch.be/en/real-time-data-birds*

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ETC.			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
Bonn Agreement	Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances	1983	1989
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994
OSPAR Convention	Convention for the protection of the Marine Environment of the North-East Atlantic	1992	1998
Aarhus Convention	Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters	1998	2001

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
Habitats Directive	Directive on the conservation of natural habitats and of wild fauna and flora	1992	43
Water Framework Directive	Directive establishing a framework for Community action in the field of water policy	2000	60
Bathing Water Directive	Directive concerning the management of bathing water quality and repealing Directive 76/160/EEC	2006	7
INSPIRE Directive	Directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)	2007	2
Marine Strategy Framework Directive	Directive establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
Birds Directive	Directive on the conservation of wild birds	2009	147
Regulations			
Common Fisheries Policy	Regulation on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC	2013	1380
Other (Decisions, Communications, White Papers, etc.)			
Integrated Maritime Policy	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union	2007	575
Marine Knowledge 2020	Communication from the Commission to the European Parliament and the council: Marine Knowledge 2020 - marine data and observation for smart and sustainable growth	2010	461