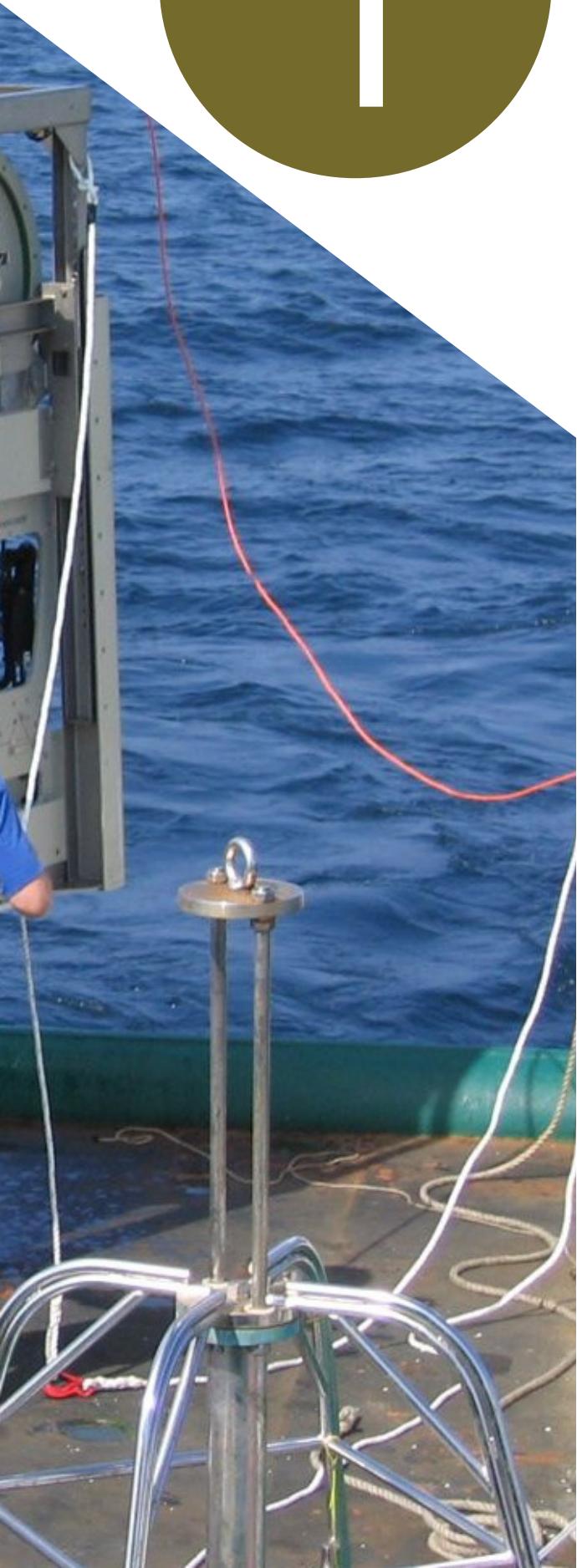




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Chapter 1

Marine research



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Foreword



The marine sciences in Flanders and Belgium stand out as a diverse and complex landscape, characterised by a broad range of expertise. Over 80 different research groups - with more than 1,000 marine scientists and specialised staff - are dedicated to coastal and marine research. Within this landscape, Flanders Marine Institute (VLIZ) acts as a coordination and information platform for marine and coastal research in Flanders, and supports and promotes the visibility and international impact of Flemish marine research and international marine education.

To receive guidance with regard to its science-supporting tasks, VLIZ consults 4 times per year with a team of scientists in the Scientific Committee, which advises the Board of Directors on all scientific and research-support activities of VLIZ. This committee represents *inter alia* the marine research groups associated with the Flemish universities and scientific institutes. The Scientific Committee consists of three bodies: the Scientific Board provides science-based advice to the Board of Directors; the

Guidance Committee meets annually in a plenary meeting open to a broad group of marine scientists to discuss relevant new and planned activities; the thematic Expert Working Groups consist of relevant experts from Belgium and abroad and may be established for a limited or an extended period of time. Through these structures, VLIZ provides a platform to the wider network of marine scientists and experts from Flanders and Belgium, and also abroad.

The Compendium for Coast and Sea aggregates up-to-date information and data from Flemish and Belgian marine research. It is an objective knowledge document that integrates the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. Developing a Compendium is in line with the strategic objectives of VLIZ, as stipulated in its statutes and in the agreement between the Flemish Government and VLIZ.

The present chapter 'Marine Research' focuses in particular on an inventory and description of marine research - including a brief history - in Flanders and Belgium, and presents this in a broader European context. In the chapter 'Marine Research', objective figures are reported in a replicable way so that trends can be detected and new developments can be mapped. In the future, the current inventory can be expanded with additional measurements in terms of institutional capacities, bibliometric indicators, financial resources, emerging issues in research, etc. In this context, all research conducted in the marine, estuarine and coastal domain, including policy-supporting research and research focused on practical applications and sectors, is covered under the common denominator of 'marine' research. The results of the inventory were examined and validated by an Expert Panel of marine scientists and representatives of the research field. The Expert Panel thus supports - together with the Expert Group 'Compendium for Coast and Sea 2013' - the results of the present mapping of the marine research landscape. Along with the brochure 'Belgian Marine Research - an overview', it maps the organisation and dimension of marine research, its research resources and knowledge output. The results of this inventory and qualitative description may be used in the future to identify knowledge gaps, bottlenecks and opportunities for marine research.

As coordinator of the initiative, VLIZ aims to contribute with the Compendium for Coast and Sea 2013 to an efficient communication within the network of marine scientists, policy makers and experts, and to increase the visibility and accessibility of marine research in Flanders and Belgium.

dr. Jan Mees

Director of VLIZ

1 Marine research

1.1 Introduction

Seas and oceans play a crucial role in the overall functioning of the earth. As a storage of energy, the oceans have a major impact on the climate and water cycle. Oceans absorb a large part of the atmospheric carbon dioxide, and one third of the oxygen that is available for life on the earth, is produced by the world's oceans. Moreover, the seas and oceans contain a significant part of the biological diversity on the planet. In terms of economy, the importance of the seas is still growing: maritime transport and ports, tourism, the applications in the field of renewable energy and marine biotechnology, the exploitation of living and non-living resources, as a source of food, etc. Nevertheless, seas and oceans are the least explored and studied areas on earth. Research does not only play a role in unveiling this knowledge, or to use this knowledge for the purpose of economic and social development; research at sea and on marine ecosystems is essential to understand global processes and ecosystem functioning and manage them in view of a sustainable future.

The chapter 'Marine research' in the Compendium for Coast and Sea provides an overview of marine research in a global, European and local context. It maps the marine research landscape in Flanders and in Belgium on the basis of quantitative measurements related to research capacities, research resources and knowledge output. A description of the research themes and contents and the nature of the research partnerships, provides a review of the expertise and diversity of the marine research community.

1.2 Marine research: the global context

Research on seas and oceans has a distinct and global dimension. It is therefore not surprising that several initiatives and organisations make the efforts to coordinate their marine research programmes at an international level. The United Nations (UN) play an important role in this global context, with the Intergovernmental Oceanographic Commission ([IOC](#)) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) being mandated for the coordination and execution of programmes for research and observation of the oceans, exchange of oceanographic data and information, services and training. In the Ocean Science Section, research is conducted on [ocean acidification](#), climate change ([WCRP](#)) and its effects on ecosystems and coral reefs ([GCRMN](#), [GLOBEC](#)), climate change and adaptation in (Western) Africa ([ACCC Africa](#), [ACCC-WAfrica](#)), the ecology and effects of harmful algal blooms ([IOC-HAB](#), [GEOHAB](#)), global nutrient supply from river and water catchment areas toward seas and oceans ([Global NEWS](#)), marine spatial planning ([IOC MSP](#)) and coastal zone management ([ICAM](#), [SPINCAM](#)). The Ocean Science Section also provides support to the UN Regular Process and [Assessment of Assessments](#).

Programmes and services for operational data and monitoring of oceans include the Global Ocean Observing System ([GOOS](#)), the Joint Technical Commission for Oceanography and Marine Meteorology ([JCOMM](#), in joint cooperation with [WMO](#)), the International Oceanographic Data and Information Exchange ([IODE](#)), the International Ocean Carbon Coordination Project ([IOCCP](#)) and the Global Ocean Ship-Based Hydrographic Investigations Programme ([GO-SHIP](#)).

The IOC is – together with the other UN entities that develop ocean-related activities – part of the [UN-OCEANS](#) network, promoting a higher level of cooperation on ocean and coastal issues at the global level. Within this network, the *Convention on Biological Diversity* ([CBD](#)), the International Maritime Organisation ([IMO](#)), the UN Environmental Program ([UNEP](#)) and the UN Development Program ([UNDP](#)) are of particular relevance to marine and coastal research (see also Chapter 3 for an overview of UN entities and mandates). The 'Oceans Compact initiative' ([Ki-Moon 2012](#)²²⁹¹⁸⁷) of the UN secretary-general sets out a strategic vision for the UN system with regard to its ocean-related mandates, consistent with the [Rio+20 agenda \(2012\)](#)²²⁹¹⁸⁹. 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 Oceans and Seas.

Several other international scientific networks and programmes focus on marine research, such as the Partnership for Observation of the Global Oceans ([POGO](#)), World Association of Marine Stations ([WAMS](#)), Census of Marine Life ([CoML](#)), Global Ocean Ecosystem Dynamics ([GLOBEC](#)), Integrated Marine Biogeochemistry and Ecosystem Research ([IMBER](#)), Variability and Predictability of the Ocean-Atmosphere System ([CLIVAR](#)), International Study of Marine Biogeochemical Cycles of Trace Elements and their Isotopes ([GEOTRACES](#)) and the International Council for Science (ICSU) [Future Earth Programme](#). The international research programme [DIVERSITAS](#) integrates research on biological diversity at the global level and collaborates with a wide range of partners, including the UN, to address

these issues. The International Council for the Exploration of the Sea ([ICES](#)) is a cooperation of 19 countries bordering the North Atlantic Ocean and adjacent seas with the aim to exchange scientific information and provide expert advice to governments and commissions of the European Union (EU) and Regional Sea Conventions. Finally, the Organisation for Economic Co-operation and Development ([OECD](#)) works on oceans and seas related topics, e.g. on Marine or Blue Biotechnology ([OECD 2013](#) ²²⁹⁰²²).

In May 2013, the EU, the US and Canada launched a joint alliance on Atlantic Ocean research through the transatlantic [Galway Statement on Atlantic Ocean Cooperation \(2013\)](#) ²²⁹²²⁹. The goal is to connect the ocean observation efforts of the three partners in the Atlantic Ocean and study the interplay with the Arctic Ocean in view of a sustainable use of resources.

Other research and development (R&D) is conducted to support the tasks of international organisations responsible for the implementation of the international conventions on maritime transport, prevention and control of (oil) pollution, dumping of waste at sea and safety and environmental protection. An overview of these organisations, bodies and treaties is available in [Chapter 3](#).

1.3 Marine research: the European context

EUROPEAN POLICY AND PLATFORMS FOR RESEARCH AND INNOVATION

EU science policy and organisation

Within the European Commission (EC), several agencies are responsible for (marine) science policy. The Directorate-General for Research and Innovation ([DG Research & Innovation](#)) is responsible for the development and implementation of 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 Research & Innovation is also responsible for financing and for establishing financial instruments for scientific research, such as the European Framework Programmes (FPs, see below).

The seventh Framework Programme (FP7) is aimed at financing both competitive and cooperative research in the context of the EU goals for employment, competitiveness, living standards and the EU leadership in the global knowledge economy (Europe 2020 strategy). The goal is to achieve a European Research Area ([ERA](#)) (COM (2000) 6) in which free exchange of scientists and knowledge is stimulated.

The European Research Council ([ERC](#)) is an independent entity within the DG Research & Innovation, and finances ground-breaking research by outstanding scientists from FP7. The European Research Executive Agency ([REA](#)) of the EC is a funding body responsible for managing large parts of FP7 (2007-2013). Independent entities conducting specific research for the EC include e.g. 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](#)).

Investments in international networks and cooperation

In Europe, the research agendas are mainly determined by the competent governmental bodies of Member States (for Belgium, see [Policy context for scientific research in Flanders/Belgium](#)). 88% of all public investments in research and development are designed, financed and evaluated at the national and local levels ([Acheson et al. 2012](#) ²²⁹⁰⁰⁸). Research on oceans and seas, however, is in particular need of a coordinated European strategy and an active partnership between European Member States because of the inherently high costs associated with marine research and the fact that it relies on research facilities which are not always accessible to all European researchers. Aligning objectives and pooling available financial resources and capacities allow addressing the challenges in terms of protection, sustainable use and management of European marine waters in an effective and coordinated way. Moreover, it stimulates the conversion of scientific information and knowledge into innovation and research applications ([Navigating the Future IV, European Marine Board, 2013](#) ²²⁶⁸⁷⁴).

The FP7 specific programme (SP) 'COOPERATION' enhances transnational research cooperation between universities, industry and research centres on the one hand and governmental bodies on the other, both in the EU and with third countries. Furthermore, this programme focuses on joint activities such as the horizontal ERA-NETs, on projects in

the context of [Article 185¹](#) (the former Article 169) of the EU Convention and on joint technological initiatives and platforms. The [ERA-NET projects](#) (since FP6) provide a formal platform to develop networks and co-operations in research and technology, both at the European level and in international partnerships. A number of these ERA-NET projects are situated in the marine field, e.g. [MarinERA](#), [AMPERA](#), [MariFish](#) and [SEAS-ERA](#). Complementary to the SP Co-operation (SP1), IDEAS (SP2) is focused on supporting excellent ‘frontier research’; ‘PEOPLE’ (SP3) is focused on the support of training and career development of researchers, and ‘CAPACITIES’ (SP4) is focused on fostering the improvement of research capacities and environment across Europe (i.e. infrastructures, research for the benefit of SMEs, international cooperation, etc.).

The FP7-OCEAN programme ‘Ocean of Tomorrow’ is oriented towards multidisciplinary marine research in preparation of Horizon 2020 ([COM \(2011\) 808](#)), a programme to facilitate multidisciplinary research and innovation in different fields, technologies and disciplines. Horizon 2020 aligns the ‘FP for research’ with the targeted innovation measures of the Competitiveness and Innovation Framework Programme ([CIP](#)) and the European Institute of Innovation and Technology ([EIT](#)).

Joint Programming (JP) offers an integration and coordination platform for European Member States in order to make efficient use of the available national budgets and organisational resources for research by, e.g., drafting joint research agendas and aligning priorities for co-operation in the long term. Contrary to the FP, JP is a bottom-up approach and the JP Initiatives (JPI) offer ways to initiate the process of JP. Since 2009, 10 JPIs have been launched, including the initiative for ‘Healthy and Productive Oceans and Seas’, also referred to as [JPI-Oceans](#).

Cooperation in research is also stimulated through the European Innovation Partnerships ([EIP](#)), Joint Technology Initiatives ([JTI](#)), Coordination and Support Actions ([CSA](#)) and the co-operation 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, and facilitates initiatives leading to a better use and development of this infrastructure at the European and international level. Two initiatives within ESFRI are of particular relevance to marine research: the Integrated Carbon Observation System ([ICOS](#)) and the E-Science European Infrastructure for Biodiversity and Ecosystem Research ([Lifewatch](#)).

There are several examples of partnerships between research institutes at the European level such as 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](#)), Marine Genomics Europe ([MGE](#)) and Marine Biodiversity and Ecosystem Functioning ([MarBEF](#)) (now operating jointly as [EUROMARINE](#)), the EU Technology Platform [Waterborne](#) and [EurOcean](#). Marine research is also an important component in support of the operational tasks of different European and regional organisations: e.g. the EU Management Committee for Marine Pollution (MCMP), the European Maritime Safety Agency ([EMSA](#)) and the Central Dredging Association ([CEDA](#)).

Strategic research agendas and visions for the future

A number of networks and consortia with a strong representation in 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 up Position Papers on research priorities and strategies for European marine research such as [Navigating the Future IV \(2013\)](#)²²⁶⁸⁷⁴ (figure 1).

The [EurOCEAN conferences](#) offer a platform for those involved in the research-policy interface, both at the European level and in Member States. These conferences allow the European research community to participate in shaping the European vision for marine research through the ‘[Galway Declaration \(2004\)](#)⁷⁰⁷²⁰’, the ‘[Aberdeen Declaration \(2007\)](#)²²⁹⁰⁰⁵’ and the ‘[Ostend Declaration \(2010\)](#)²⁰⁴⁸⁶⁷’. The ‘[Brest Declaration \(2011\)](#)²²⁸⁸¹⁴’ specifically deals with marine research infrastructure (figure 1).

¹ Article 185 (ex. Article 169) of the Lisbon Treaty allows the European Union to participate in research programmes financed by different European Member States, including participation in structures associated with the implementation of national research programmes. An example is the BONUS programme for the Baltic Sea.

OVERVIEW OF SOME OF THE IMPORTANT DEVELOPMENTS IN THE EU MARINE SCIENCE POLICY (2004 - 2013)

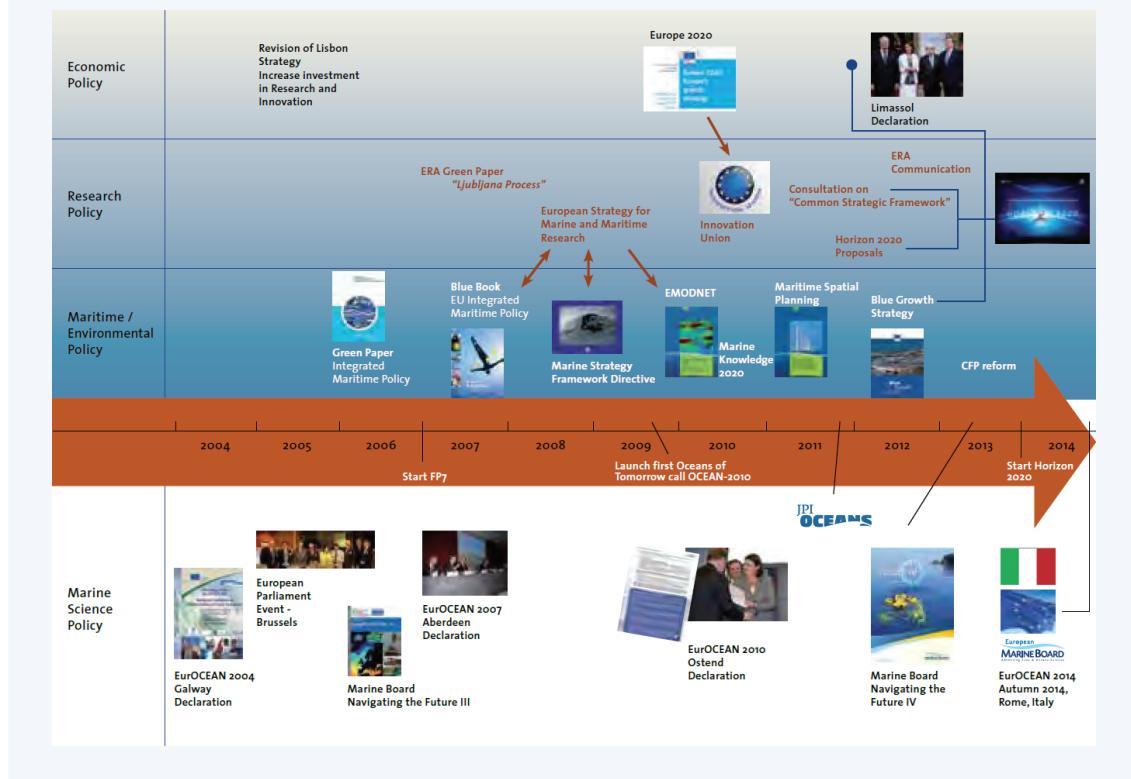


Figure 1. Overview of some of the important developments in the EU marine science policy between 2004 and 2013 (source: [Navigating the Future IV \(European Marine Board, 2013\)](#) 226874).

EUROPEAN POLICY INSTRUMENTS AS DRIVERS FOR MARINE RESEARCH

Different policy domains of the EC with regard to coasts, seas and oceans affect marine research in Europe 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 issues and a higher degree of coordination between the different policy domains involved. The *IMP* integrates a number of transversal policy instruments in the fields of Blue Growth (COM (2012) 494), Marine Knowledge (COM (2010) 461) (see below), Maritime Spatial Planning (COM (2013) 133), Integrated Maritime Surveillance (COM (2009) 538) and Sea Region Strategies (figure 1 and Chapter 3). In the *Limassol Declaration* (2012), the European ministers of maritime affairs reaffirm the importance of a coherent approach to develop blue growth in Europe and to ensure the health of oceans and seas. The *EU Marine Strategy Framework Directive (MSFD, 2008/56/EC)* addresses the environmental aspects of the *IMP*, and provides a joint framework and goals for the protection and conservation of the marine environment (see Chapter 2 - theme Nature and environment, and Chapter 3).

The European strategy for marine and maritime research (COM (2008) 534) was drafted within the *IMP* and following the *Aberdeen Declaration (2007)* 229005 (see above and 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 Research & Innovation](#)).

Marine Knowledge 2020 (COM (2010) 461) is considered by the EC as an important component within the *IMP* for centralising marine data from different sources. The aim is to:

- Reduce operational costs for data users;
- Provide wider access to quality-checked marine data to industries, policy makers and scientists in an efficient way so they can develop new or improved products and services;
- Reduce uncertainty in our knowledge of the oceans and the seas as a sound basis for managing future changes.

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 2371/2002) and its reform, 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. Information systems in support of these policy instruments include the Shared Environmental Information System (*SEIS*), the Water Information System for Europe (*WISE*) and *WISE-marine*, the Biodiversity Information System for Europe (*BISE*), the European Climate Adaptation Platform (*CLIMATE-ADAPT*), the Data Collection Framework for the *CFP* (Regulation 1343/2007), and *My Ocean*, the marine component of the Global Monitoring for Environment and Security Initiative (GMES). The research-policy interface within the framework of these policy instruments is discussed in more detail in Chapter 3 of the Compendium for Coast and Sea.

REGIONAL SEA – NORTH SEA

A number of policy instruments and entities are specifically focused on the level of regional seas, e.g. the North East Atlantic Region and/or the North Sea. Recently (May 2013), the EC drafted an Action Plan for a Maritime Strategy in the Atlantic region. Similar to the Europe 2020 strategy, the Action Plan focuses on establishing smart, sustainable and inclusive economic growth (COM (2013) 279). This plan refers to the developments in marine research that are necessary for a sustainable growth of the economic activity in the Atlantic region and discusses insights into processes that determine the climate in the Atlantic Ocean. As the first step in a series of regional research strategies, '*A draft Marine Research Plan for the European Atlantic Sea Basin - Discussion Document (2011)*'²²⁹²⁴⁴ was developed by the SEAS-ERA project (FP7).

Conventions at the level of regional seas exist e.g. for the Baltic Sea (*Helsinki Convention* (HELCOM)), the Mediterranean Sea (*Barcelona Convention* (UNEP-MAP)) and the Black Sea (*Bucharest Convention*). The *BONUS programme* for research and development is designed to meet the specificities of the Baltic Sea.

The *Convention for the Protection of the Marine Environment of the North-East Atlantic* (*OSPAR*) offers a framework for addressing pollution and protection of the marine environment in the North East Atlantic Region, with specific measures for the North Sea (OSPAR Region II). Within this scope, the *Ministerial North Sea Conferences and Declarations* played an important role in the proposal of measures to reduce marine pollution of the North Sea from rivers, estuaries and the atmosphere.

An extensive overview of the relevant entities and legal instruments for the Belgian part of the North Sea (BNS) is given in Chapter 3.

EU FINANCIAL INSTRUMENTS FOR MARINE RESEARCH

Overview and history of EU financial instruments for research

The EU offers several instruments for financing research, depending on the goals, partnerships, structural embedding, budget requirements, etc. Currently the five most important financial mechanisms include (*New practical guide to EU funding opportunities for research and innovation 2012*)²²⁹⁰⁰⁷:

- The Seventh Framework Programme for Research and Technological Development (*FP7*, 2007-2013) and its precursors MAST and FP5 and FP6 (figure 2). FP7 is followed by *Horizon 2020* (2014-2020);
- The Competitiveness and Innovation Framework Programme (*CIP*), continued under the Programme for the Competitiveness of enterprises and SMEs (*COSME*) (2014-2020);

- The *Structural Funds*, including the European Regional Development Fund (*ERDF*) that finances the INTERREG programme (III, IV, 2 Seas);
- The European Agricultural Fund for Rural Development (*EAFRD*);
- The European Fisheries Fund (*EFF*) (2007-2013), continued as from 2014 as the European Maritime affairs and Fisheries Fund (*EMFF*) (2014-2020) to support the *CFP* and *IMP*.

OVERVIEW OF INSTRUMENTS FOR CO-OPERATION AND FINANCING OF RESEARCH IN THE EU

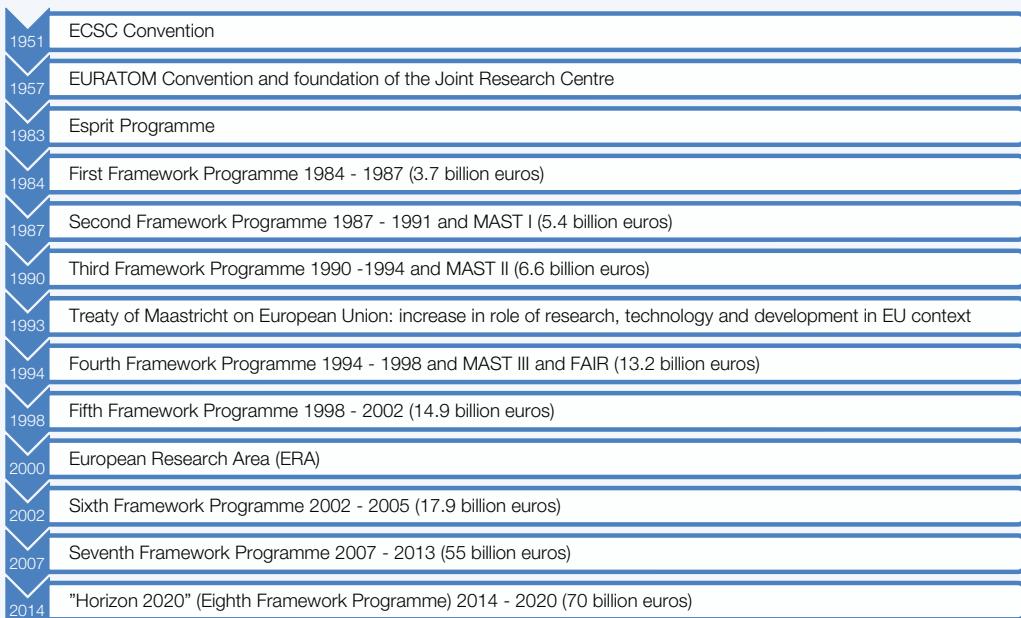


Figure 2. Chronological overview of instruments for cooperation and financing of research in the EU, with an indication of the available budget (source: DG Research & Innovation).

Besides the aforementioned financial instruments, there are other mechanisms within the community programmes (*Marco Polo II*, Financial Instrument for the Environment (*LIFE+*), Trans-European Transport Networks (*TEN-T*), Trans-European Energy Networks (*TEN-E*), etc.), and other instruments for external support (Development aid), regional support and support for maritime affairs and fisheries. Also worth mentioning are the *EUREKA network*, *EUROCORES* and the European Co-operation in Science and Technology (*COST*), and *Regions of Knowledge*. An overview of the European financial instruments and mechanisms is available on the website: www.eutrainingsite.com/eu_funds.php.

Europe and the EC have always conducted an active policy for international co-operation in research. After the Treaty establishing the European Coal and Steel Community (ECSC) in 1951, the precursor of the European Union we know today, the Joint Research Centre (*JRC*) was established under the *EURATOM Convention* in 1957. This basis for co-operation can be found in article 130 of the Treaty for the European Union (http://europa.eu/abc/treaties/index_en.htm) that calls for a reinforcement of science and technology as one of the foundations of the European industry. The following FPs (figure 2, from 1984) were in fact implemented according to the founding principles of the Treaty, as they were aimed at increased competitiveness at the international level and highlighted the need for research to underpin other EU policy goals.

An analysis of the EU *DG Research & Innovation* shows that since FP1 in 1984, the available EU budgets for research (FPs and other EU-financed programmes e.g. CERN, COST, ESF, ESO, EUREKA, etc.) have gradually increased, also in comparison with dedicated resources from Member States for research and development at a national level (DG Research 2005). The first three FPs had an average annual budget of approximately 1 billion euros, rising gradually from FP4 onwards to 4 billion euros per year during FP6, and again to 7.8 billion euros during FP7 (figure 2).

The numbers also show that in the 1980s the FP budgets made up about 2% of the dedicated national budgets for research and development of Member States. Together with other EU-financed programmes, the EU financial resources added up to an average of 8% in comparison to the national budgets. In the 2002-2005 period, the EU share in financing research slowly increased to an average of 15.3% compared to national research budgets (Acheson et al. 2012²²⁹⁰⁰⁸).

FP7 had a budget of over 50 billion euros in the timeframe 2007-2013. The forthcoming financial instrument 'Horizon 2020' (COM (2011) 808) runs from 2014 to 2020 with an approved budget of 70 billion euros.

Relative importance of the European financial instruments for marine research

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. It was not until FP2 that the first dedicated 'Marine Science and Technology Programme (MAST)' was established which continued in MAST II under FP3, and subsequently in MAST III and FAIR (Agriculture and Fisheries) under FP4, with dedicated 'marine' budget lines. FP5, FP6 and FP7 – except for Ocean of Tomorrow – did not include specific budgets for marine research. Dedicated efforts to inventory marine research projects, however, allow quantifying the budgets spent on marine research (EUROCEAN Marine Knowledge Gate). *Ocean of Tomorrow* (total budget of 134 million euros) is a special programme within FP7 in which multidisciplinary projects addressing great challenges for marine research are financed. Horizon 2020 will address marine research as a crosscutting activity (Source: *EUROCEAN Marine Knowledge Gate*, Santos et al. 2007²²⁹⁰⁰⁰, Jagot et al. 2012²¹⁶⁰⁵⁴).

The EU-wide inventory of marine knowledge output, *EUROCEAN Marine Knowledge Gate*, provides an overview of marine research projects by programme and by budget size (figure 3).

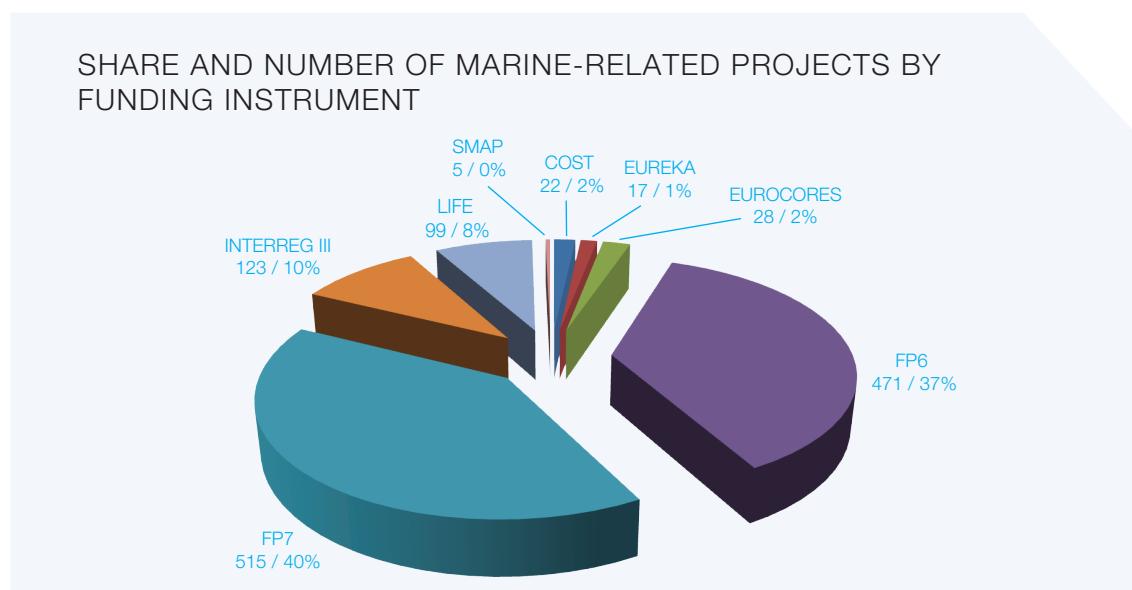


Figure 3. Share and number of marine-related projects by funding instrument, relative to the total inventoried marine-related projects (1.280) in the *EUROCEAN Marine Knowledge Gate*.

The *EUROCEAN* data also show an increase in the share of the total FP budgets assigned to financing marine-related projects, in comparison with the total budget available in the FPs: this 'marine share' increased from 1% at the start of the FPs (1987-1991) to 4.9% during FP6 (2002-2006). Preliminary data (31/10/2012) for FP7 (2007-2013) yield a share of 3.5%. These preliminary numbers do not include the budgets for the last calls of FP7 (Source: data 31/10/2012 2012 *EurOcean Marine Knowledge Gate*) (figure 4).

SHARE (%) OF THE EUROPEAN RESEARCH BUDGET DEDICATED TO MARINE-RELATED PROJECTS, FROM FP2 TO FP7

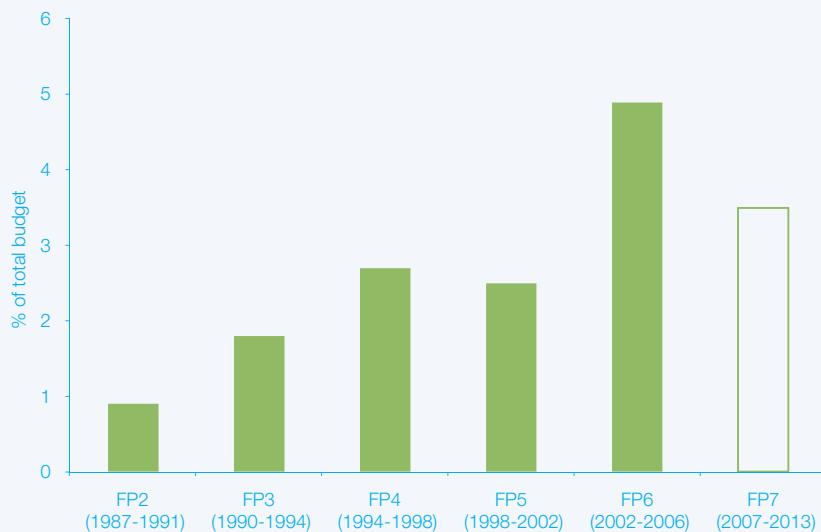


Figure 4. Share (%) of the European research budget dedicated to marine-related projects, from FP2 to FP7 (source: EUROCEAN 2006, completed with provisional figures of EUROCEAN (31/10/2012)).

Financing of data collection and data management

In the context of the initiative Marine Knowledge 2020 (COM (2010) 461), it is estimated that the total cost of the collection of marine data by public institutes of the EU Member States is more than 1 billion euros annually. Besides financing marine/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) and 70 million euros for spatial research. A specific additional annual effort of 18.5 million euros in the period 2011-2013 focuses on data collection and data integration at the scale of regional seas, in support of the requirements of the MSFD. The efforts related to the initial assessment required by the MSFD in the 22 coastal Member States and Croatia amounted to 45-55 million euros, with another estimated 45-52 million euros for the annual cost of assembling data from existing monitoring programmes. The annual cost of new monitoring programmes for the MSFD in these coastal states is estimated at approximately 20 million euros (COWI; Ernst&Young 2013²²⁹³⁶⁷).

2 Marine research in Flanders/Belgium

2.1 Policy context for scientific research in Flanders/Belgium

DIVISION OF COMPETENCES

The division of competences for scientific research and innovation in Belgium is stipulated in the *Special law of 8 August 1980 on Institutional Reforms*. Article 6bis of this law establishes that the federal government, the Communities and the Regions are responsible for scientific research, including research within the framework of the execution of international or supranational conventions and treaties. The Communities carry the responsibility for scientific research, mainly through universities (Article 127 of the Belgian constitution), while the Regions are responsible for research in the fields of economy, energy, public works, environment, transport etc., including technological and industrial fundamental research and technological innovation. Moreover, the federal government is responsible for the implementation and organisation of the exchange of data between scientific institutes at national and international level, the space research in the framework of international or supranational institutes, agreements or instruments,

the federal scientific and cultural institutes, programmes and actions that require a homogeneous implementation at national or international level and for keeping a permanent inventory of the scientific potential of the country. Co-operation between these different policy levels is coordinated through the Interministerial Conference for Science Policy ([IMCWB](#)) (figure 5).

There is an effort throughout the different policy levels in Belgium to systematically increase the public budgets for research and technological development (R&D) as a basis for economic growth, echoing the Barcelona goals of spending 3% of the gross domestic product (GDP) on R&D in 2010 ([COM \(2002\) 499](#)). Although the public R&D



Figure 5. 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).

investments increased from 0.55% to 0.67% of the GDP in the period 2000-2010, the total share of the R&D budgets remained the same (1.99%). Private investments decreased from 1.42% to 1.32% of the GDP in this timeframe ([EU Research Country Profile 2013](#) ²²⁹¹⁹¹).

FEDERAL SCIENCE POLICY

The Federal Public Planning Service Belgian Science Policy ([BELSPO](#)) is responsible for the science policy of the federal government (figure 5).

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 of society. Of particular importance for the marine research field is the Science and Sustainable Development programme ([SSD](#)) which includes the [Belgian Federal North Sea Research Programme](#). Furthermore, marine research is financed by the thematic programmes on climate, biodiversity, transport, the Belgian Polar Platform (Antarctic) and the STEREO programme. The SSD programme recently finished. Marine research will be financed by means of the new programme 'Belgian Research Action through Interdisciplinary Networks' ([BRAIN-be](#)). In addition, marine research is financed by multidisciplinary programmes such as the Interuniversity Attraction poles ([IAP](#)). The implementation of IAP and SSD 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 5).

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).

The national research network, [BELNET](#), offers fast internet access to Belgian universities, colleges, research centres and government departments. The Scientific and Technical Information Service ([STIS](#)) provides support for information exchange to the scientific community, the socio-economic sectors and government departments. BELSPO is also responsible for coordinating research efforts of all governments of the country, and ensuring that Belgian researchers can participate in international research networks.

SCIENCE POLICY IN THE WALLONIA-BRUSSELS FEDERATION

In Wallonia and the Wallonia-Brussels Federation (formerly the 'French Community of Belgium'), the preparation and implementation of the science policy is regulated by the Directorate for Scientific Research ([Direction de la Recherche Scientifique](#)) of the Directorate-General for Non-Obligatory Education and Scientific Research (Direction Générale de l'Enseignement Non Obligatoire et de la Recherche Scientifique (DGENORS)), which itself is part of the General Administration for Education and Scientific Research (Administration Générale de l'Enseignement et de la Recherche Scientifique (AGERS)) of the Federation. This directorate is responsible for financing universities, financing non-targeted scientific research (Fonds de la Recherche Scientifique (FNRS) and associated funds), and special funds for research in universities. It also coordinates co-operation in science policies at the regional, federal and international level. The [FNRS](#) is the entity that provides funding for research programmes, infrastructure and activities in the French-speaking research community. The board of directors of FNRS is *inter alia* composed of representatives from the French-speaking universities as well as the permanent secretaries of the Royal Academy for Science, Literature and Fine Arts, and the Belgian Royal Academy of Medicine.

Since 2007-2008, the French-speaking Universities in Belgium have merged into three 'Académies universitaires' (university academies) in response to changes in the subsidy regulations of the French Community: the Académie Universitaire Wallonie-Europe (ULg, FUSAGx), the Académie Universitaire Louvain (UCL, UNamur, FUSL and FUCaM) and the Académie Universitaire Wallonie-Bruxelles (UMons and ULB) (figure 5).

The Walloon government body *Direction Générale Opérationnelle de l'Économie, de l'Emploi et de la Recherche* (Operational Directorate-General for Economy, Employment and Research) ensures the support of research centres within the scope of (applied) research and technological development in collaboration with the agency *Agence de Stimulation Technologique* (AST). To this end they put grants at the disposal of companies, universities, colleges and research centres.

THE FLEMISH POLICY FRAMEWORK FOR RESEARCH AND INNOVATION

The Flemish Science policy is *inter alia* established by law in the *Decree of 30 April 2009* on the organisation and financing of the science and innovation policy. Several entities in the policy domain of Economy, Science and Innovation (*EWI*) are involved in preparing, implementing and evaluating science policy:

- The department of Economy, Science and Innovation (*EWI*) is responsible for the preparation, follow-up and evaluation of concrete action plans, policy research and regulations in the policy fields of economy, science and innovation;
- The Agency for Innovation by Science and Technology (*IWT*) stimulates innovation with an added economic and societal value in Flanders through the provision of financial support, advice and coordination to companies, research institutes, the government and other entities;
- The task of the Agency for Scientific Research Flanders (*FWO-Vlaanderen*) is to stimulate and support fundamental scientific research at the universities of the Flemish Community, including partnerships between Flemish universities and other research institutes;
- The *Hercules Foundation* was established by the Flemish government as the agency for financing medium-scale and large-scale infrastructure for fundamental and strategic research;
- The Flemish High Council for Science and Innovation (*VRWI*) is a strategic advisory board for science and innovation policies.

The Information Guide for Entrepreneurship and Innovation (*Van der Weken et al. 2013* ²²⁹²⁶⁶) provides an overview of the total budget for science and innovation in Flanders. In 2013, the budget amounted to 1.979 billion euros, 1.271 billion euros of which is spent on research and development in the thirteen policy domains of the Flemish government. An overview of all actors in the Flemish research landscape is available on the [website of the department EWI](#).

The research is conducted in the first place by the universities (*Hogeschool-Universiteit Brussel, University of Leuven, University of Antwerp, Ghent University, Universiteit Hasselt, Vrije Universiteit Brussel*), the *Flemish Scientific Institutes* (*INBO, ILVO, KMSK, Flanders Heritage Agency*), the Strategic Research Centres (*SOC*), (*VITO, IMEC, VIB, IBBT*) and other research institutes (*ITG, KMDA, Botanic Garden*, managementschools, university associations) (figure 5). The 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 in the policy with regard to the coast and sea is available in [Chapter 3](#).

The Flemish Interuniversity Council (*VLIR*) is an autonomous advisory platform aiming to improve the communication and co-operation between the Flemish universities. The Flemish university colleges are also organised under the umbrella organisation of the Flemish University Colleges (*VLHORA*). Moreover, there is communication between all actors in the Flemish higher education (*VLIR, VLHORA, university associations, etc.*) through the Flemish Council for Universities and Colleges (*VLUHR*) (see below, [Financing](#)).

MARINE RESEARCH IN FLANDERS AND BELGIUM: GENERAL POLICY CONTEXT

Marine research in Flanders and Belgium is mainly guided and financed within the framework of the science policy of the Communities and the federal and regional governments (see [Policy context for scientific research in Flanders/Belgium](#)). Because of the growing importance of science in response to the increasing societal challenges, research is extended to a greater number of policy domains and several applications, as support is raised for the authorities involved. The responsible governmental entities and the division of competences in the coastal zone, marine waters and adjacent estuaries are described in [Chapter 3](#) of the Compendium for Coast and Sea.

Traditionally, sectoral legislation and policy instruments that play an important role in fundamental research as well as in applied and policy-oriented marine research include fisheries and aquaculture, sand and gravel extraction, dredging and dumping, shipping and ports. Over the past years, offshore energy production has also gained importance as a

research field. The societal challenges also result in a greater demand for research on conservation and management of nature and environment as well as heritage and culture. A detailed overview of all user functions is provided in Chapter 2 of the Compendium for Coast and Sea.

2.2 History of marine research in Flanders/Belgium

PIONEERS AND GROUNDBREAKING RESEARCHERS

Belgium has a long standing tradition in marine sciences (*Charlier & Leloup 1968* ¹¹²⁹¹⁴, *Houvenaghel 1980* ²¹²¹⁸⁷, *Godeaux & Voss 1985* ¹³¹²⁷, *Godeaux 1990* ²⁰⁵⁷³⁶, *Decler et al. 1990* ²⁰⁸⁴⁷⁶, *Charlier 2004* ⁷⁰⁹⁰⁵, *Seys et al. 2009* ¹⁴¹⁸¹⁰). Prior to the introduction of a more systematic approach to marine research in the early 20th century, research was conducted by scientists individually. Notwithstanding the small size of its marine territory, Belgium has a long and productive history in the field of marine research. Besides those who acquired international fame because of their groundbreaking achievements in the field of marine sciences prior to the 18th century such as the cartographer *Gerardus Mercator* ²¹⁴⁵⁸³ (Rupelmonde, 1512-1594) and the mathematician and natural scientist *Simon Stevin* ²⁰⁶⁵³⁵ (Bruges, 1548-1620), there are the pioneers of marine research such as 'abbé' *Théodore-Augustin Mann* ²¹⁷²⁸³ (1735-1809) and Jean-Baptiste de Beunie (1717-1793). These pioneers in marine sciences already provided advice to their governments on issues such as overfishing, mussel poisoning, tides and meteorology through studies for the Royal Academy. Later on, their work was adopted by trailblazers such as *Pierre-Joseph Van Beneden* ¹⁴²⁴⁴⁷ (1809-1894), his son *Edouard Van Beneden* ²⁰⁶⁶⁰⁶ (1846-1910), *Alphonse Renard* ²⁰⁶⁵³⁶ (1842-1903) and *Gustave Gilson* ²⁰⁶⁵³⁷ (1859-1944). The merits of marine researchers and experts such as Louis Verhaeghe (1811-1870), Auguste Stessels (1826-1875), *August de Maere-Limnander* ¹²⁶⁶¹³ (1826-1900), Charles Van Bambeke (1829-1918), *Philippe Dautzenberg* ¹⁴²⁴⁷⁷ (1849-1935), Julius Mac Leod (1849-1935), *Alphonse Meunier* ¹²⁶⁶¹² (1857-1918), *Paul Pelseneer* ²⁰⁷²⁹⁶ (1863-1945), Auguste Lameere (1864-1942), *Jean Massart* ¹⁴²⁴⁷⁹ (1865-1925), Désiré Damas (1877-1959), Louis Stappers (1883-1916) and many others are essential in the further evolution of marine sciences in Belgium. The second half of the 19th century was marked by fast developments in science and technology, especially influenced by two milestones: the start of multidisciplinary oceanographic research with the Challenger expedition (1872 – 1876) and the publication of 'On the Origin of Species' (1859) by Charles Darwin. 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 marine research', VLIZ).

A FIRST MARINE STATION IN OSTEND

Pierre-Joseph Van Beneden ¹⁴²⁴⁴⁷ (1809-1894), professor at the Catholic University of Leuven, built a modest laboratory on the east bank of the Ostend harbour in 1843 with his own means (*Breyne et al. 2010* ¹⁹⁸⁴²³). In the following decades, marine biological research was conducted in this 'Laboratoire des Dunes' ('Dune Laboratory'), installed at the oyster farm of Valcke-De Knuyt, and Van Beneden received visits from famous local and foreign scientists (*Decler 1989* ²⁰⁵⁴⁰⁹). This marine station in Ostend was operational in the years prior to the foundation of renowned European marine stations such as Concarneau (1859), Roscoff (1872), Naples (1872), Wimereux (1875) and Den Helder (1876/1890), *Van Bennekom 2001* ²¹³⁴⁰) which only appeared in the 2nd half of the 19th century. His son *Edouard Van Beneden* ²⁰⁶⁶⁰⁶ (1846-1910), who gained a reputation as the discoverer of meiosis, followed in his father's footsteps and became the driving force behind oceanographic research at the University of Liège. He founded his own research centre in Ostend (1883), close to his father's.

THE START OF SYSTEMATIC MARINE RESEARCH WITH AN INTERNATIONAL DIMENSION

In 1897, *Adrien de Gerlache* ²²⁰⁸⁶⁷ (1866-1934) set sail for Antarctica with the RV Belgica to conduct multidisciplinary research, supported by an international team of scientists. The attention for the expedition stimulated renewed interest in marine research and highlighted the importance of multidisciplinary research in Belgium. Between 1898 and 1913 - and also after WWI - *Gustave Gilson* ²⁰⁶⁵³⁷ who was professor at KULeuven, director of the Royal Natural History Museum (the current Royal Belgian Institute for Natural Sciences, RBINS, *Vivé & Versailles 1996* ³⁰⁰⁶⁰) and successor of *Edouard Van Beneden* ²⁰⁶⁶⁰⁶, undertook a number of campaigns in the southern North Sea. These campaigns led to a collection of more than 14,000 samples which are still used as reference material for present research 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. In 1937 ZWI became an ‘institution of public utility’. The institute’s research focus was mainly on fisheries, inventorying the fauna and flora of coastal waters, and statistical data collection of sea fisheries. The latter was taken over by the Experimental Station for Sea Fisheries (*Proefstation voor de Zeevisserij*) in 1963, later known as the National Station for Sea Fisheries (*Rijksstation voor Zeevisserij*), now part of the Institute for Agricultural and Fisheries Research (*Instituut voor Landbouw en Zeevisserij (ILVO)*) of the Flemish government. Gilson was also the driving force behind the ‘First International Congress of the Sea’ which took place in Ostend in 1936 and was organised again in 1939, 1946 and 1951. Together with his assistant Charles Gillis, he played a role in the foundation of the international programme for data collection on sea fisheries in the Northern Atlantic Region and the North Sea, through the International Council for the Exploration of the Sea ([ICES](#)).

The infrastructure of ZWI was intensively used by researchers from the Flemish universities. After WWII, marine research in Flanders took a new start with Eugene Leloup (1902 – 1981) as director of ZWI. Under his direction, hydrographic reference stations were surveyed *inter alia* aboard the Westhinder, with an important scientific input from the Belgian universities. ZWI was closed in 1967 due to a lack of financial resources ([Decler 1989](#)²⁰⁵⁴⁰⁹, [Seys et al. 2009](#)¹⁴¹⁸¹⁰).

While the French-speaking universities focused on marine research in the Mediterranean Sea, the main study areas for Flemish institutes were the BNS and the southern North Sea. This led to the foundation of a number of dedicated marine research groups at the State University of Ghent. For internships and practical fieldwork, however, researchers were still depending on foreign marine research stations (e.g. Wimereux and Roscoff).

In October 1970, the Institute for Marine Research (*Instituut voor Zeewetenschappelijk Onderzoek (IZWO)*) was founded by the Flemish universities, the Province of West Flanders and private initiatives involved in marine research activities. Under the leadership of E. Jaspers (°1941) IZWO supported co-operation between several marine research disciplines and the management of laboratory facilities at the Ostend Sluice Dock, a pool of brackish water systematically used for research by university groups since the 1940s ([Leloup & Miller 1940](#)⁵²⁸⁸). When IZWO was dissolved in 2000, its tasks, staff and infrastructure were taken over by the current Flanders Marine Institute (*Vlaams Instituut voor de Zee (VLIZ)*) ([IZWO 1991](#)²⁵⁵⁷⁸, [IZWO 1993](#)⁶⁵⁹⁶², [Seys et al. 2009](#)¹⁴¹⁸¹⁰). VLIZ is a platform for marine and coastal research in Flanders, coordinating the scientific programme and the ship time of the research vessel of the Flemish government, RV Simon Stevin, and manages its research equipment. Flanders Marine Institute is also part of several projects and networks, and supports and promotes the international appeal of Flemish marine research and international marine education.

RESEARCH PROGRAMMES FOR THE NORTH SEA

In 1970, the Belgian government initiated ‘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). 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 in both a qualitative and a quantitative way. Between 1971 and 1976, 200 researchers

Table 1. Period and budget of the various phases of the research programme for the North Sea.

PHASE	NAME	PERIOD	BUDGET
I	Project Sea	1971 – 1976	4.4 million euros
II	Concerted Research Action Oceanology	1977 – 1981	3.4 million euros
III	Concerted Interuniversity Research Action North Sea	1982 – 1993	5.3 million euros
IV	Impulse programme Marine Sciences	1992 – 1996	4.6 million euros
V	Sustainable Management of the North Sea (SPSD I)	1997 – 2003	10.3 million euros
VI	Sustainable Management of the North Sea (SPSD-II)	2002 – 2006	10.9 million euros
VII	North Sea Research (SSD)	2006 – 2010	8.3 million euros
VIII	Marine Research (BRAIN-be)	2012 – 2017	

from 40 university laboratories and scientific institutes and from multiple disciplines cooperated in the project. 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 Direction Natural Environment of the RBINS.

Since Project Sea there have been 7 consecutive phases in the research programme for the North Sea (table 1). A new phase was recently initiated in the framework of the research programme: BRAIN-be. The goals of these programmes include:

- The development and consolidation of the scientific expertise with regard to the ecosystem of the North Sea;
- Scientific support for policy makers in matters of the North Sea;
- The promotion of multidisciplinary research (in natural and social sciences);
- The encouragement of interactions between scientists, policy makers and other involved parties at the national, European and international level;
- The stimulation of participation of scientists in international research and international programmes.

RESEARCH VESSELS

At the start of the 20th century, [Gustave Gilson](#) ²⁰⁶⁵³⁷ used several vessels for his sampling campaigns in the North Sea: the *Sleper nr. 1*, the *Ville d'Anvers* (a vessel for surveillance of fisheries) and the *Narval* (a steamship). As early as 1914, Gilson highlighted the importance of a national oceanographic research vessel ([Noël 1994](#) ⁶⁶²⁷¹).

In the 1970s, sampling campaigns at sea were conducted with converted minesweepers of the Belgian Navy, such as the *Mechelen* ([France et al. 1992](#) ⁷⁹²⁸⁹, [Noël 1994](#) ⁶⁶²⁷¹). It was not until 1984 that the Belgian scientific community finally had its own vessel: the *RV Belgica*. The RV Belgica is owned by the Belgian State and falls under the responsibility of [BELSPO](#). The Direction 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 operation and the dock in Zeebrugge, the home port of the Belgica ([website MUMM](#)).

In 2000, 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, which is mainly used for coastal oceanographic research in the Southern Bight of the North Sea and the eastern part of the Channel ([website VLIZ](#)). The operation and crew 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](#)).

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

METHODOLOGY

The inventory of marine research in Flanders/Belgium intends to map the marine research landscape in an objective and coherent way. This first inventory effort addresses the 2008 – 2012 period. In the future, the inventory will be updated annually. Within this scope, objective definitions, preconditions and replicable methods are necessary in order to compare and monitor evolutions in the long term (table 2). These are discussed more thoroughly below.

Research domain, research discipline and marine expertise

To enable a comparison of the inventory on an international level, the definition of research domains and disciplines was based on the international FRASCATI-model (Revised field of science and technology (FOS) classification in the Frascati manual, version 2006). The division of the research disciplines was adapted to marine research based on the division used by the Australian Bureau of Statistics (table 3). The content of the research disciplines is defined by a third hierarchical level, using specific marine expertise (key words, thesauri, 'Aquatic Sciences and Fisheries Abstracts' (ASFA) terminology, etc.). While the first two levels follow the international standards, the third level allows a more flexible and more specific approach to the description of marine research in Belgium. This division in research domains and disciplines is used for the actual description of marine research ([Qualitative description](#)).

Table 2. Overview of the terminology and definitions which were used for the inventory of the marine research landscape in Flanders and Belgium.

TERM	DEFINITION
Marine research group (MRG)	An MRG has to meet all 4 criteria listed below: <ul style="list-style-type: none"> • The research group is established in Flanders or in 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 are included in the list of institutes recognised for scientific research, as established in the <i>Royal Decree of 22 August 2006</i> and the subsequent modifications of this royal decree. • The research group focuses on marine research, or research which is relevant for the aforesaid research. In case of doubt, the measurable marine research output of the group over the last 5 years is checked. This output is defined as 'more than one peer-reviewed or VABB publication (definitions of peer-reviewed and VABB publications) the first author of which is affiliated to the research group'.
Types of scientific institutes	4 types of scientific institutes are distinguished in this inventory: <ul style="list-style-type: none"> • Flemish universities • Universities of the Wallonia – Brussels Federation • Flemish scientific institutes • Federal scientific institutes
The Belgian Bibliography (BMB)	<p>Marine The BMB is the reference list of all publications on the Flemish coast and the Belgian part of the North Sea (BNS), and of all other marine, estuarine and coastal publications of Belgian authors and scientists and of foreign scientists affiliated to a Flemish/Belgian institute.</p> <p>The BMB includes:</p> <ul style="list-style-type: none"> • Books • Reports • Proceedings and Abstracts • Theses • Articles, including peer-reviewed publications • Atlases and maps • Multimedia
Peer-reviewed publications	Marine publications included in the BMB which belong to one of the following categories: <ul style="list-style-type: none"> • A1: Publications included in one of the ISI Web of Science databases: 'Science Citation Index', 'Social Science Citation Index' or 'Arts and Humanities Citation Index'. Limited to publications of the type: article, review, letter, note, proceedings paper. • A2: Publications in an international scientific journal with peer review, not included in (A1) • A3: Publications in a national journal with peer review, not included in (A1) • P1: Proceedings included in one of the ISI Web of Science databases: 'Conference Proceedings Citation Index - Science' or 'Conference Proceedings Citation Index - Social Science and Humanities'. Limited to publications of the type: article, review, letter, note, proceedings paper, except for publications of the type (A1)
VABB publications	A publication included in the list of the Flemish Academic Bibliographic Database for Social Sciences and Humanities (VABB-SHW) (includes both peer-reviewed and non-peer-reviewed publications (definition of peer-reviewed publications)).
Marine publication (MPub)	A publication included in the BMB (definition of BMB).
Peer-reviewed Marine Publication (MPub_pr)	A marine publication published in a peer-reviewed journal (definition of peer-reviewed publication) and included in the BMB
Non peer-reviewed Marine Publication (MPub_non-pr)	A marine publication included in the BMB, except for those published in a peer-reviewed journal
Marine researcher	A person affiliated to an MRG (definition of MRG) who is a (co)author of one or more marine publications (definition of MPub).
Specialised personnel	A person affiliated to an MRG (definition of MRG) who contributes to the development and support of marine research, but without measurable output as publications in the BMB (definition of BMB).

Process

VLIZ is responsible for the mapping of the marine research landscape, as commissioned by the Flemish government (EWI dept.). Based on the daily operations of VLIZ, research groups at universities and scientific institutes with a marine research focus are identified as a so-called MRG (definition of MRG). Moreover, additional systematic efforts have been carried out to identify additional MRGs which have not yet been identified through the regular channels used by VLIZ.

Table 3. Overview of the research domains and disciplines which are used in the inventory and description of the marine scientific landscape in Flanders and Belgium.

RESEARCH DOMAIN	RESEARCH DISCIPLINE
Agricultural and veterinary sciences	Fisheries and aquaculture sciences Veterinary sciences Other Agricultural and veterinary sciences
Engineering and technology	Civil engineering Electrical and electronic engineering Mechanical engineering Information and computer sciences Geomatics Biotechnology Other Engineering and technology
Humanities	History and archaeology Other humanities
Medical and health sciences	Medical and health sciences
Natural sciences	Mathematics Physical sciences Chemical sciences Earth sciences Biological sciences
Social sciences	Economics and business Sociology Law and legal studies Political sciences and policy Communication and media Other Social sciences

The process to inventory the marine research landscape is based on the regular operation of VLIZ, complemented with an annual systematic survey of literature databases. In the inventory of 2013 these databases are 'Web of Science' (through the ISI-Web or Knowledge) and the Flemish Academic Bibliographic Database for the Social Sciences and Humanities ([VABB-SHW](#)). The surveys are based on marine keywords in publications as well as journals (figure 6; methods and files in online annex). This selection of publications is subsequently checked on its marine focus and affiliation with a Belgian research group. Next, the publications are added to the Belgian Marine Bibliography ([definition of BMB](#)) in the integrated marine information system ([IMIS](#), VLIZ), in which a link is made between the author(s), the institute and the publication. Based on these links, new or additional MRGs ([definition of MRG](#)) are identified, provided they have more than one marine peer-reviewed or VABB publication as a first author in the past 5 years.

The completeness of the inventoried marine publications is verified for all MRGs ([definition of MRG](#)) from at least 2008 onwards. The links between marine publications, author(s) and institutes in the database serve as a basis to count the number of marine publications and authors of the MRGs. The inventory of the staff of the MRGs (marine researchers and specialised personnel, definitions) is based on a survey of the MRGs and their information products (brochures, websites). This survey was performed by VLIZ in 2012-2013 (example file will be provided on [www.compendiumcoastandsea.be](#)).

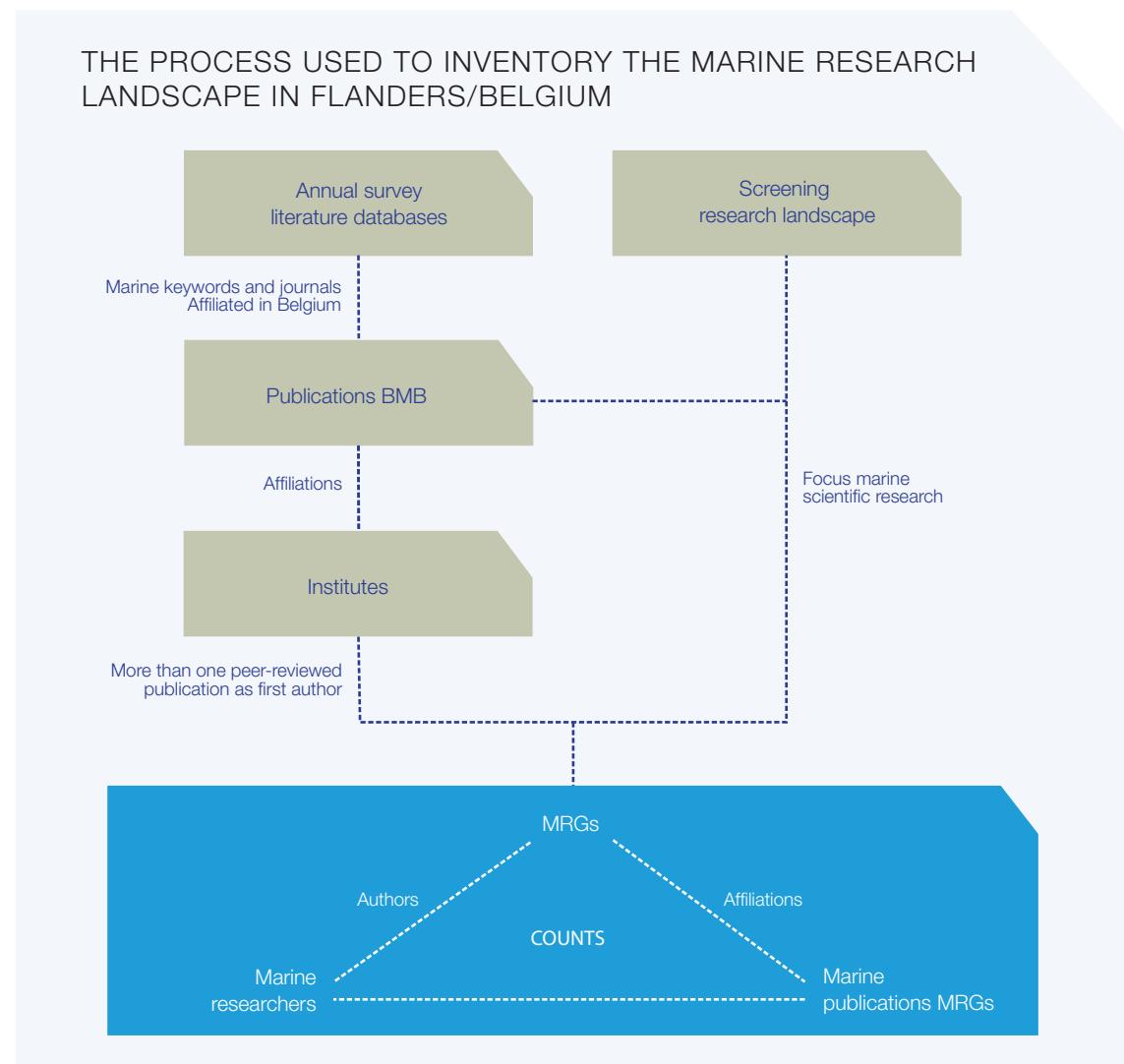


Figure 6. The process used to inventory the marine research landscape in Flanders/Belgium.

From 2013 onwards, the counts and the survey of literature databases will be annually performed by VLIZ for the preceding five years, with a benchmark in July. The benchmark for the present inventory was 19 July 2013.

Consequences and limitations of the definitions and methodology used

The current inventory addresses MRGs at universities and scientific institutes in Flanders and Belgium. Marine research not performed at universities or scientific institutes is not included in the present inventory. This may concern administrations, public and private non-profit organisations, companies, consultancies, port and fish market operators, museums and organisations with educational goals. The marine research results of these bodies are discussed in Chapter 2 (Use of the Sea) of the Compendium for Coast and Sea.

In this first version of the inventory of marine research in Flanders and Belgium, the objective counts are focused on peer-reviewed publications and publications included in the Flemish Academic Bibliographic Database for the Social Sciences and Humanities ([VABB-SHW](#)). A significant part of the scientific output is available in types of publications which are not included in the counts of the current inventory (e.g. theses, books, scientific advice, project reports, etc.) (figure 7). The collection of publications included in the inventory is to some extent determined by the surveyed databases (Web of Science and [VABB-SHW](#)), in which certain fields of science, such as engineering sciences, are less represented. This implies a potential incompleteness or underestimation of the scientific output of the MRGs.

OVERVIEW OF VARIOUS TYPES OF MARINE SCIENTIFIC PUBLICATIONS IN THE BMB WITH INDICATION OF THE ONES INCLUDED IN THE COUNTS AND TREND MEASUREMENTS

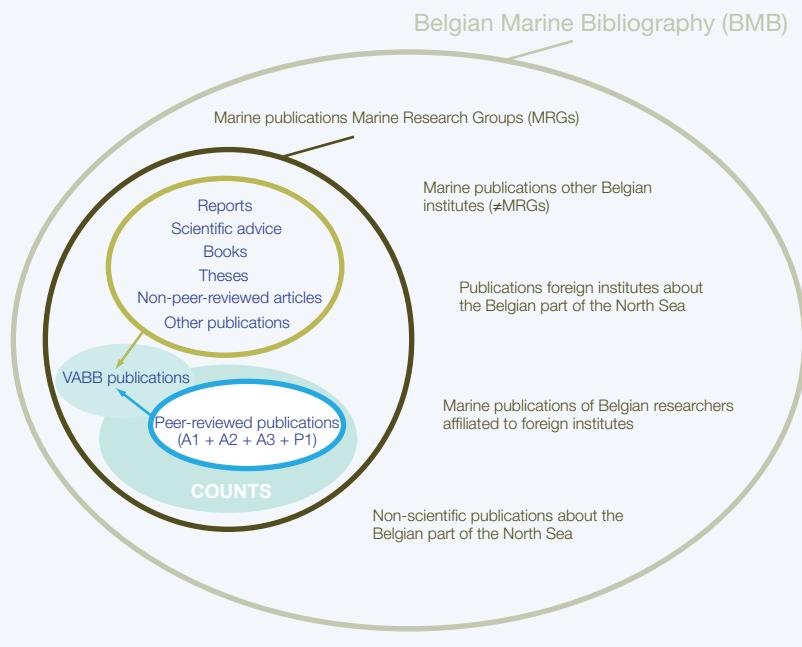


Figure 7. Overview of various types of marine scientific publications in the BMB with indication of the publications included in the counts and trend measurements (VLIZ, 2013).

This limitation is a direct consequence of the specific character of the available information sources. Nevertheless, the survey can be expanded to new and/or more complete information sources such as the [INSPEC](#) database (focus on engineering and technology) when available. In addition, important developments occur in the field of citability of data sets and other scientific knowledge output (projects, datasets, maps, models, etc.), which will receive the appropriate attention in this inventory in the future.

The methodology used, aims to exhaustively inventory the MRGs and their publications. This may lead to a degree of incompleteness which is hard to quantify. In the following years, the inventory will be completed further, which may result in small changes to the current figures.

Given that the affiliation of the authors is used to link institutes, authors and publications, it may be that the inventory counts do not include publications with an incomplete or incorrect affiliation (e.g. 'Ghent University' instead of 'Marine Biology Section').

In literature databases, new publications are included and described with a certain delay, meaning that the statistics for publications in 2012 in the current inventory are incomplete for the Web of Science database while they are not yet available for the [VABB-SHW](#). More reliable figures for 2012 will be available in the next edition of the inventory.

MARINE RESEARCH GROUPS AND RESEARCH CAPACITY

A total of 82 marine research groups (MRGs) had been identified on the benchmark date of 19 July 2013. Scientific institutes are counted on an institute level (e.g. Research Institute for Nature and Forest, INBO) whereas university groups are counted on a laboratory, unit, or research group level (e.g. Ecosystems management Research Group) (figure 8). A list of all MRGs on the date of the count is available in the annex.

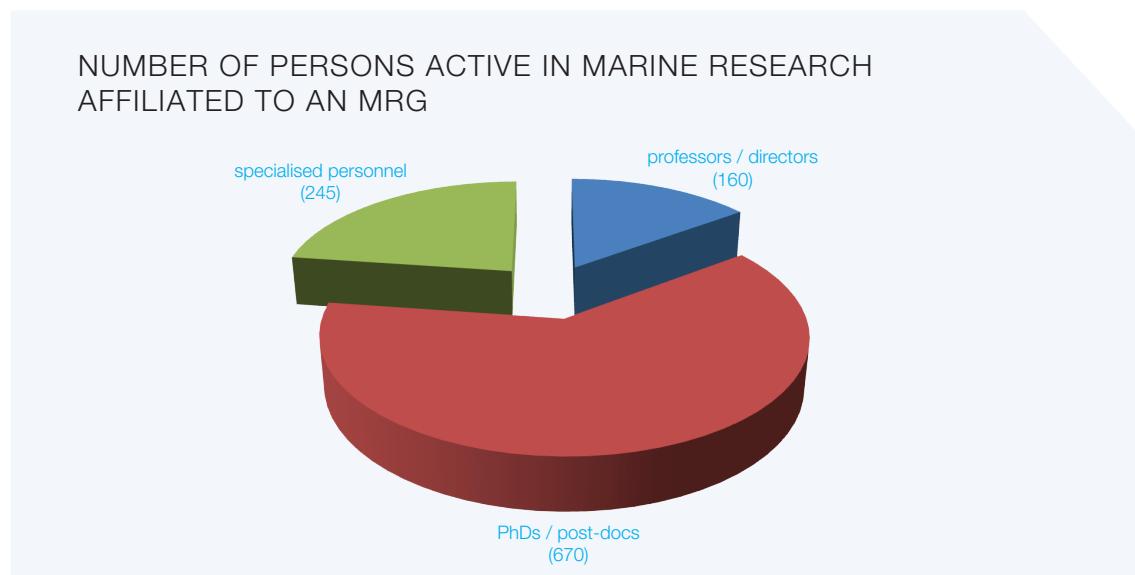


Figure 8. Number of persons active in marine research which were affiliated to an MRG on 19 July 2013 (Source: VLIZ survey 2012-2013).

A total of 1,075 persons active in the field of marine research were counted in these MRGs. This corresponds to 1.7% of the total staff in the Research and Development (R&D) sector in Belgium and 3.9% of the R&D staff in higher education and the government (source: Commissie Federale Samenwerking, Overleggroep CFS/STAT; calculations Federal Science Policy (BELSPO)).

The Flemish MRGs account for 67% of the marine research staff in Belgium (725 out of 1,075). R&D indicators ([Debackere & Veugelers 2011](#) ²²⁸⁷⁵⁷) show that 15,500 people worked full-time in the non-profit segment of the R&D sector (government and higher education) in 2009. This means that the marine research potential at the MRGs in Flanders accounts for an estimated 4.7% of the total non-profit R&D sector in Flanders.

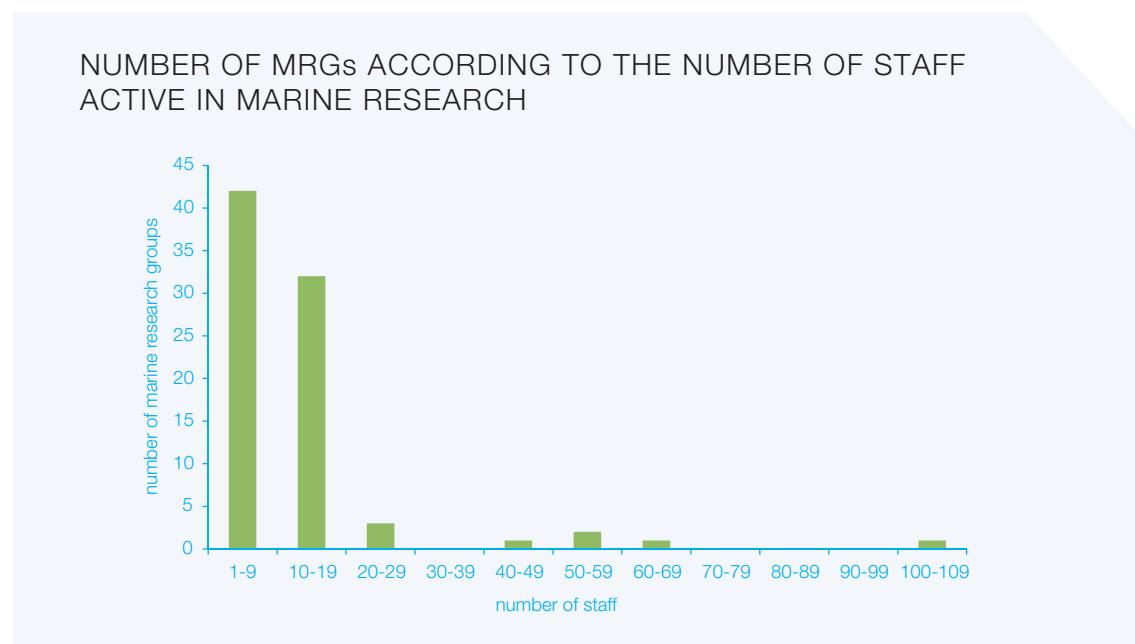


Figure 9. Number of MRGs based on 'the number of staff active in marine research (marine researchers and specialised personnel, definitions)' (Source: VLIZ survey 2012-2013).

The staff of the MRGs can be further categorised into professors, heads of department and directors of research groups and institutes (160 persons); researchers in a PhD programme or continued research (670 persons); and specialised personnel in marine research (245 people). It should be mentioned that not all marine researchers and specialised personnel work full-time on marine topics.

The number of staff per research group is rather limited, with a median of 9 people active in marine research per MRG (figure 9). Only 5 out of 82 groups have more than 30 staff members active in marine research. In 4 out of 5 cases it concerns a scientific institute.

Research capacity by type of institute

The Flemish universities and the universities of the Wallonia – Brussels Federation account for 48 and 26 MRGs respectively. There are 6 MRGs in the Flemish scientific institutes and 2 in the federal scientific institutes.

The number of staff active in marine research provides a better view on the actual research capacity of the different types of institutes, showing that the Flemish universities employ about half of the marine researchers and specialised personnel (521 persons), followed by the universities of the Wallonia – Brussels Federation (238 marine staff members), the Flemish scientific institutes (204 marine staff members), and the federal scientific institutes (112 marine staff members) (figure 10).

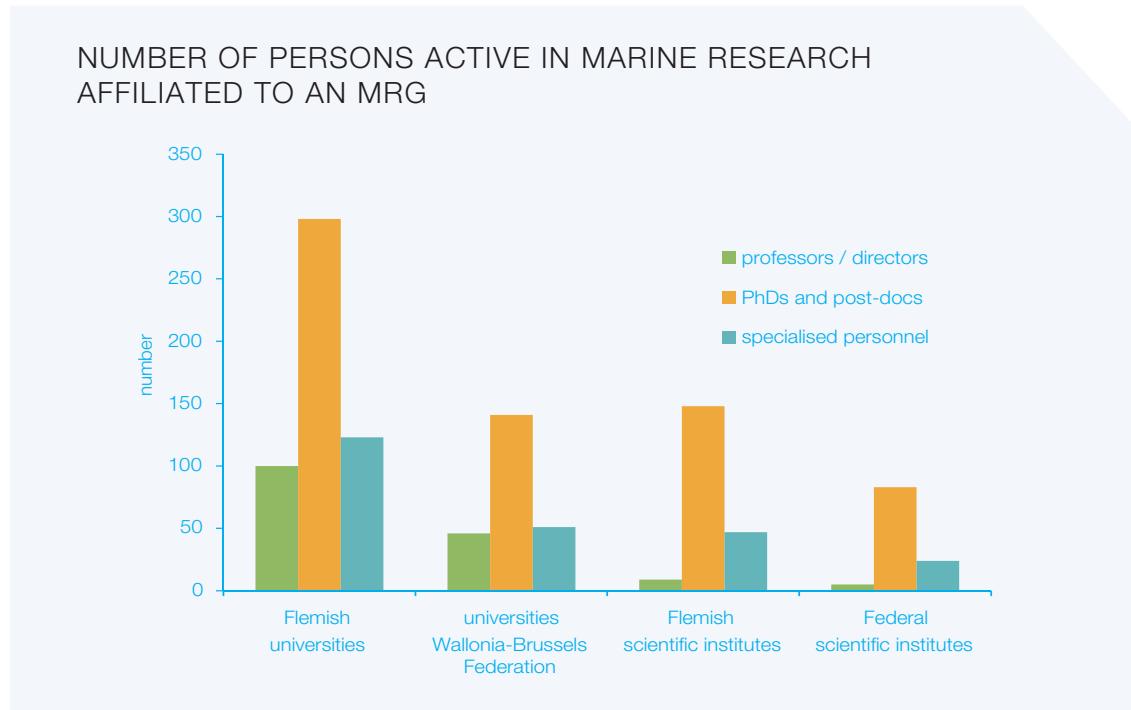


Figure 10. Number of persons active in marine research affiliated to an MRG on 19 July 2013, by type of institute (Source: VLIZ survey 2012-2013).

Research capacity by research domain and discipline

The bulk of marine research at the MRGs is carried out within the research domain of Natural Sciences with 57 MRGs (out of the 82 inventoried MRGs) and 826 marine staff members (out of a total of 1,075; source: VLIZ survey 2012-2013). In addition, the MRGs have a considerable research capacity in the domain of engineering and technology (16 MRGs; 285 staff members), agricultural and veterinary sciences (9 MRGs; 134 staff members) and social sciences (7 MRGs; 111 staff members). The human sciences and the medical and health sciences are represented by four MRGs / 24 staff members and two MRGs / 11 staff members respectively (figure 11).

NUMBER OF PERSONS ACTIVE IN MARINE RESEARCH, AFFILIATED TO AN MRG, BY RESEARCH DOMAIN OF THE MRG

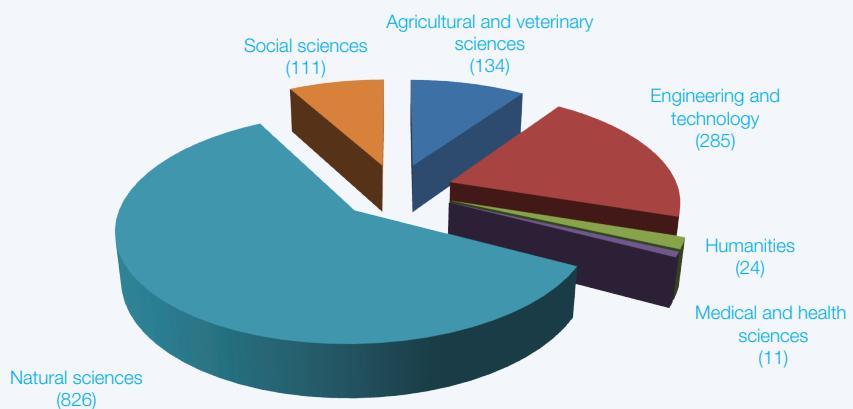


Figure 11. Number of persons active in marine research who were affiliated to an MRG on 19 July 2013, by research domain of the MRG. Research groups (and the associated staff) can be allocated to several research domains and disciplines (Source: VLIZ survey 2012-2013).

The research domains can be subdivided into several research disciplines, in which the biological sciences (33 MRGs; 524 marine staff members) and earth sciences (24 MRGs; 347 marine staff members) account for the majority of the research capacity (figure 12). Additionally, research groups belong to a number of research disciplines ranging from fisheries and aquaculture sciences, civil engineering, history and archaeology to law and legal studies. This diversity is also demonstrated by the qualitative description of the research topics of the MRGs (see Qualitative analysis).

NUMBER OF MRGs BY RESEARCH DISCIPLINE

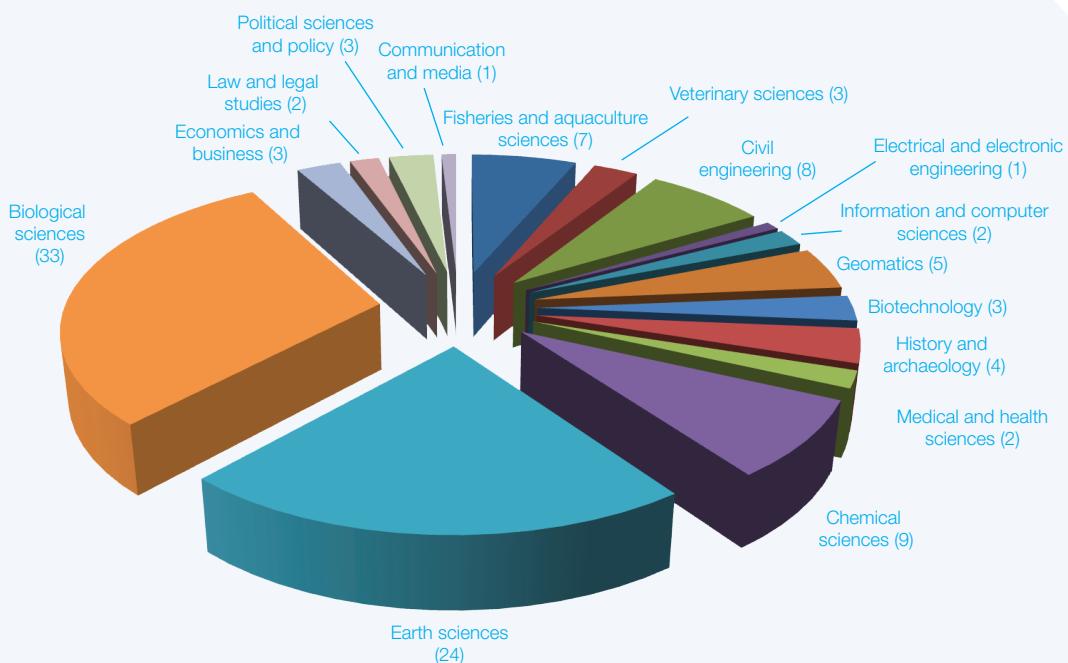


Figure 12. Number of MRGs by research discipline on 19 July 2013. MRGs (and the associated staff) can be allocated to several research domains and disciplines (Source: VLIZ survey 2012-2013).

SCIENTIFIC OUTPUT

The scientific output of the MRGs is diverse and includes peer-reviewed publications, books, (project) reports, proceedings, scientific advice, theses, etc. In the following, only the output of peer-reviewed and VABB publications is taken into account (definitions and figure 6). It is not the intention to value different types of publications in this context. The methodology and its consequences and limitations are explained more thoroughly in the methodology section.

Peer-reviewed publication

Between 2008 and 2011, the 82 MRGs published an average of 372 marine peer-reviewed publications every year (figure 13). As explained in the methodology section, this number is a minimum estimate. The marine output of the MRGs constitutes approximately 1.5% of the peer-reviewed publications of institutes located in Belgium (Belgian research groups but also European institutes such as JRC, etc.) in 'Web of Science' (25,154 peer-reviewed publications: articles, proceedings, reviews, meeting abstracts, etc. in 2012). Besides, approximately hundred marine peer-reviewed publications of institutes not recognised as an MRG are annually included in the BMB (figure 13). These are publications by Belgian researchers affiliated to foreign institutes, publications of Belgian institutes which do not meet the definition of an MRG, and publications on the BNS by foreign research institutes.

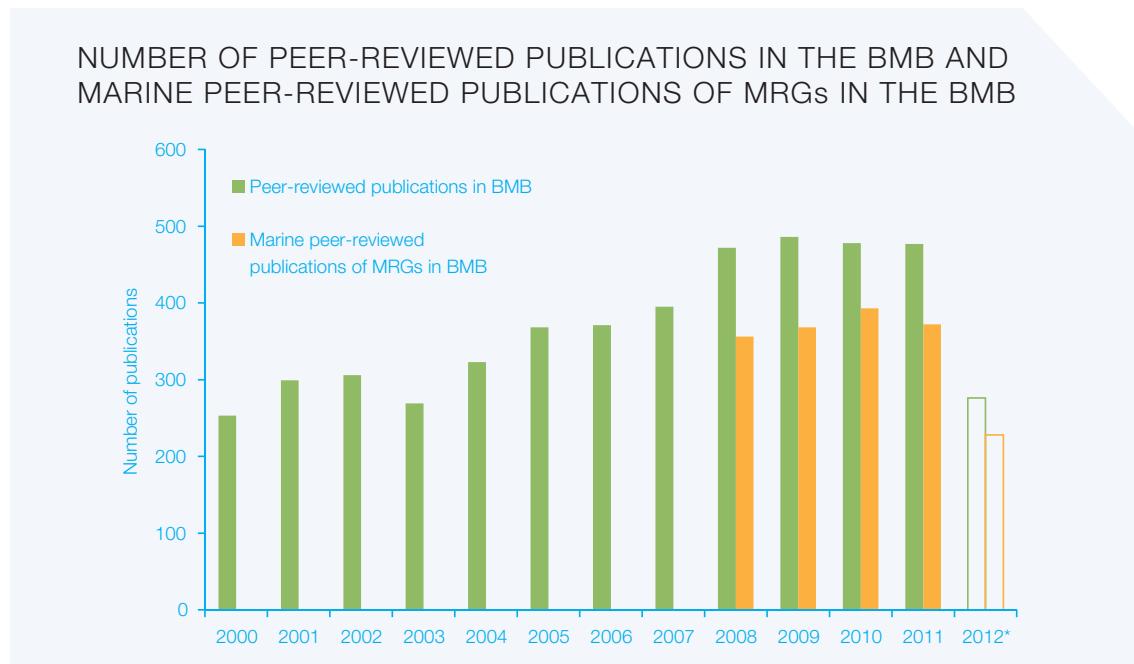


Figure 13. Number of peer-reviewed publications in the BMB and marine peer-reviewed publications of MRGs in the BMB. *The figures for 2012 are less complete, (see Methodology; source: IMIS, VLIZ 2013).

In line with the research capacity, the majority of marine peer-reviewed publications was published by Flemish universities and universities of the Wallonia – Brussels Federation, with an annual average of 248 and 105 marine peer-reviewed publications respectively in the 2008-2011 period (figure 14). The Flemish scientific institutes publish an average of 27 marine peer-reviewed publications and the federal scientific institutions an average of 55 marine peer-reviewed publications per year. It is important to mention that scientific institutes mainly focus on knowledge output such as scientific advice, project reports, monitoring and evaluation of policy goals, etc., which are often not suitable for publication in peer-reviewed journals.

The majority of marine peer-reviewed publications is published by MRGs active in the research domain of natural sciences, with an annual average of 328 publications in the 2008-2011 period (figure 15). This is in line with the aforementioned research capacity, but is also a consequence of the nature of the database surveyed (Web of Science, see **Methodology**) and of the tradition in the domain of natural sciences to publish in peer-reviewed journals. The prevalence of natural sciences in the peer-reviewed output also shows in the list of journals in which MRGs publish

NUMBER OF MARINE PEER-REVIEWED PUBLICATIONS AFFILIATED TO AN MRG, BY TYPE OF MRG

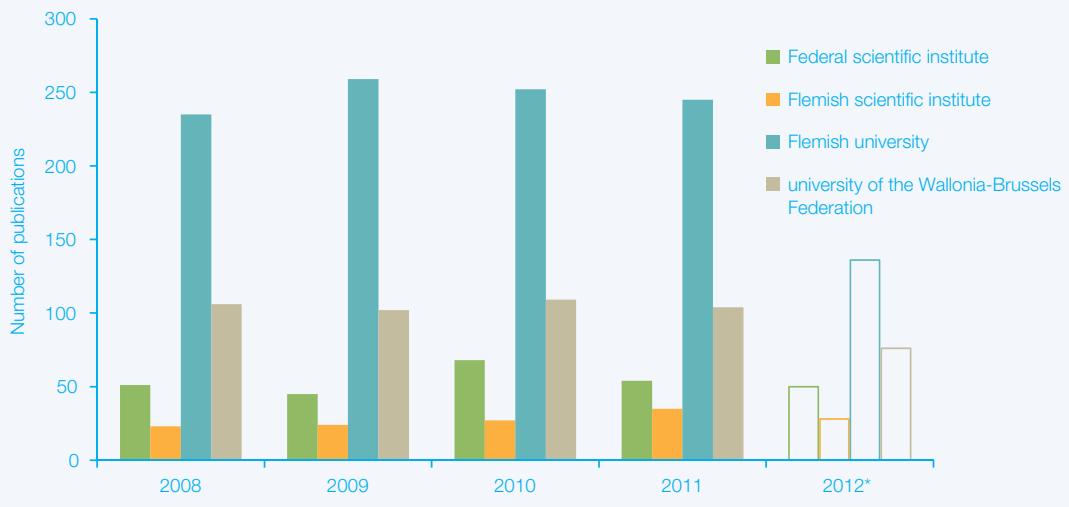


Figure 14. Number of marine peer-reviewed publications affiliated to an MRG, by type of MRG. In case of cooperation between several institutes, a publication can be allocated to more than one type of institute. *The figures for 2012 are less complete (see Methodology; source: IMIS, VLIZ 2013).

NUMBER OF MARINE PEER-REVIEWED PUBLICATIONS AFFILIATED TO AN MRG, BY RESEARCH DOMAIN OF THE MRG

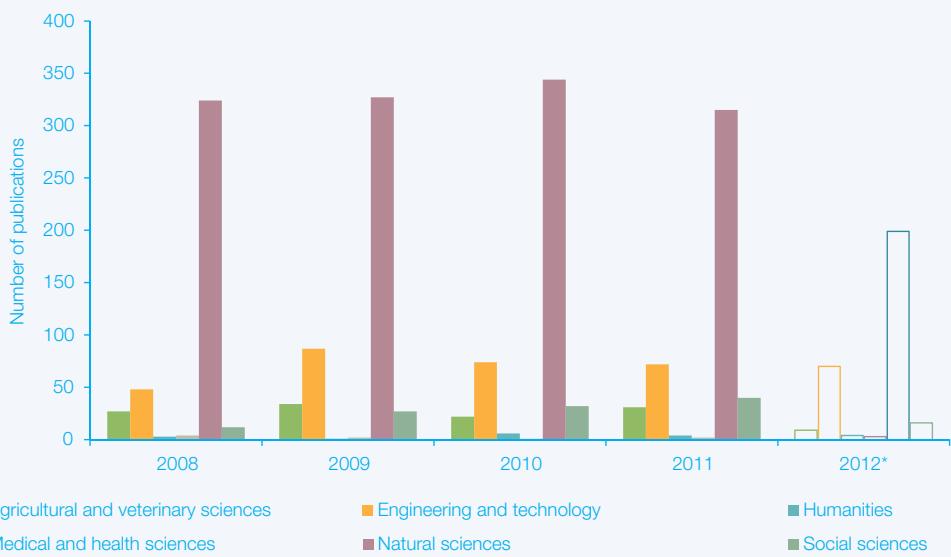


Figure 15. Number of marine peer-reviewed publications affiliated to an MRG, by research domain of the MRG. In case of cooperation and multidisciplinary research, a publication can be attributed to several research domains. *The figures for 2012 are less complete (see Methodology; source: IMIS, VLIZ 2013).

most often (table 4). On the other hand, the fact that publications were published in 499 different peer-reviewed journals between 2008 and 2011, gives an indication of the diversity of the research conducted by the MRGs. The research domain engineering and technology accounts for an average of 70 peer-reviewed publications per year (2008-2011), followed by agricultural and veterinary sciences (yearly average of 29 peer-reviewed publications) and social sciences (yearly average of 28 peer-reviewed publications). As scientific output is often published outside of the peer-reviewed publications system in certain research domains such as human and social sciences, marine publications which are included in the **VABB-SHW** have also been taken into account (see below, **VABB publications**).

Table 4. Overview of the number of marine peer-reviewed publications affiliated to an MRG, on the basis of the journals in which MRGs most frequently publish (2008-2012).

NUMBER OF PUBLICATIONS (2008-2012)		JOURNAL
1	75	Geophysical Research Abstracts. Copernicus: Katlenburg-Lindau. ISSN 1029-7006
2	64	Marine Ecology Progress Series. Inter-Research: Oldendorf. ISSN 0171-8630
3	57	Estuarine, Coastal and Shelf Science. Academic Press/Elsevier: Amsterdam. ISSN 0272-7714
4	37	Marine Geology. Elsevier: Amsterdam. ISSN 0025-3227
	37	Deep-Sea Research, Part II. Topical Studies in Oceanography. Pergamon: Oxford. ISSN 0967-0645
6	32	Marine Pollution Bulletin. Macmillan: Oxford. ISSN 0025-326X
	32	Ocean Dynamics. Springer-Verlag: Berlin. ISSN 1616-7341
8	29	Belgian Journal of Zoology. Koninklijke Belgische Vereniging voor Dierkunde = Société royale zoologique de Belgique: Gent. ISSN 0777-6276
9	28	Marine Biology. Springer: Berlin. ISSN 0025-3162
10	26	PLoS One. Public Library of Science: San Francisco. ISSN 1932-6203
11	23	Coastal Engineering: An International Journal for Coastal, Harbour and Offshore Engineers. Elsevier: Amsterdam. ISSN 0378-3839
	23	Continental Shelf Research. Pergamon Press: Oxford. ISSN 0278-4343
	23	Geologica Belgica. Geologica Belgica: Brussel. ISSN 1374-8505
	23	Journal of Marine Systems. Elsevier: Amsterdam. ISSN 0924-7963
15	22	Aquaculture. Elsevier: Amsterdam. ISSN 0044-8486
16	21	Geochimica et Cosmochimica Acta. Elsevier: Oxford. ISSN 0016-7037
	21	Journal of Coastal Research. Coastal Education and Research Foundation: Fort Lauderdale. ISSN 0749-0208
18	20	Hydrobiologia. Springer: Berlin. ISSN 0018-8158
	20	Journal of Experimental Marine Biology and Ecology. Elsevier: Amsterdam. ISSN 0022-0981
20	19	Bulletin van het Koninklijk Belgisch Instituut voor Natuurwetenschappen. Aardwetenschappen = Bulletin de l'Institut Royal des Sciences Naturelles de Belgique. Sciences de la Terre. KBIN: Brussel. ISSN 0374-6291
	19	Journal of Geophysical Research. American Geophysical Union: Washington DC. ISSN 0148-0227
	19	Marine Ecology (Berlin). Blackwell: Berlin. ISSN 0173-9565
23	18	Aquatic Botany. Elsevier Science: Amsterdam. ISSN 0304-3770
	18	Journal of the Marine Biological Association of the United Kingdom. Cambridge University Press/Marine Biological Association of the United Kingdom: Plymouth. ISSN 0025-3154
	18	Ocean Modelling. Elsevier: Amsterdam. ISSN 1463-5003
26	17	Gattuso, J.P.; Kesselmeier, J. (Ed.) Biogeosciences. Copernicus Publications: Katlenburg-Lindau. ISSN 1726-4170
	17	Zootaxa. Magnolia Press: Auckland. ISSN 1175-5326
28	16	Eos, Transactions, American Geophysical Union. American Geophysical Union: Washington DC. ISSN 0096-3941
29	15	Maritime Policy and Management. Taylor & Francis: London. ISSN 0308-8839
30	13	Journal of Experimental Biology. Cambridge University Press: London. ISSN 0022-0949
	13	Marine Policy. Pergamon: Amsterdam. ISSN 0308-597X
	13	Palaeogeography, Palaeoclimatology, Palaeoecology. Elsevier: Amsterdam. ISSN 0031-0182

On the benchmark date of 19 July 2013, the integrated marine information system ([IMIS](#), database of VLIZ) contained 674 marine peer-reviewed publications affiliated to an MRG (2008-2012) with a Web of Science (WoS) code. This code was inserted during the survey of the WoS database and can be used to analyse the number of citations in the WoS database. These 674 marine peer-reviewed publications (2008 – 2012) with a WoS code constitute a representative sample of the total peer-reviewed output of the MRGs to analyse the number of citations. The total annual average of citations of the analysed publications is 1.86 citations each year (figure 16). It should be mentioned that the annual average number of citations of a publication increases as the publication is included in the WoS database for a longer period of time. Eleven publications have an average of more than 10 citations per year.

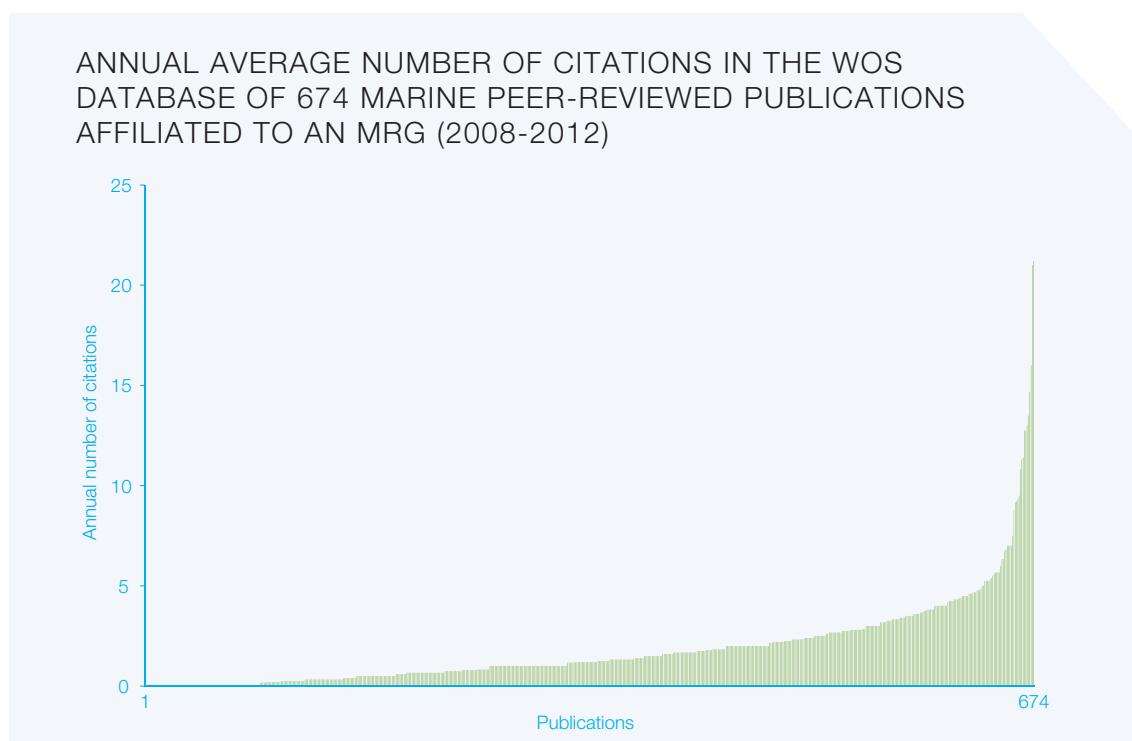


Figure 16. Annual average number of citations in the WoS database of 674 marine peer-reviewed publications affiliated to an MRG (2008-2012) (Source: Web of Science, survey VLIZ July 2013).

VABB publications

For a more complete view of the scientific output of MRGs in research domains which often publish outside of peer-reviewed journals (e.g. human and social sciences), [VABB-SHW](#) has been surveyed as well. This database was established to better assess the output in this kind of research domains and contains books, (peer-reviewed) journals, proceedings, abstracts, etc. The conditions a publication needs to meet to be included in the VABB are elaborated on the website <http://www.ecoom.be/en/vabb>. It should be mentioned that this database focuses on Flemish universities, and that the output of other types of institutes is less well represented.

Table 5. Number of marine VABB publications affiliated to an MRG on the basis of the journals in which MRGs most frequently publish (2008-2011).

	NUMBER OF PUBLICATIONS (2008-2011)	JOURNAL
1	11	Maritime Policy and Management. Taylor & Francis: London. ISSN 0308-8839
2	6	Maritime Economics & Logistics. Palgrave Macmillan: Basingstoke. ISSN 1479-2931
3	5	Journal of Transport Geography. Butterworth-Heinemann: Oxford. ISSN 0966-6923
4	3	Marine Policy. Pergamon: Amsterdam. ISSN 0308-597X
	3	Nieuw Juridisch Weekblad. Kluwer: Mechelen. ISSN 1378-8914

On average, 31 marine publications of MRGs are included in the VABB database every year (2008-2011) (figure 17). Given the specific character of the database, it is not surprising that the marine VABB publications are mainly published by Flemish universities (an annual average of 31 publications between 2008 and 2011) and in the domain of social sciences (an annual average of 20 publications between 2008 and 2011). This last fact is also apparent in the list of journals in which MRGs publish most often (table 5).

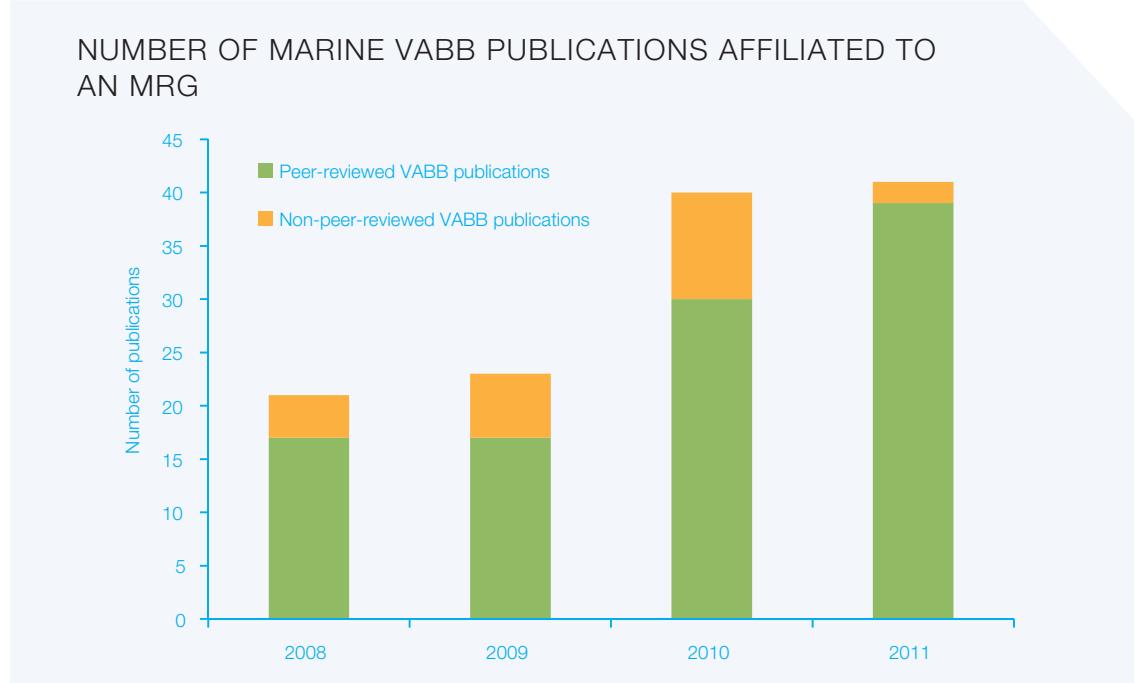


Figure 17. Number of marine VABB publications affiliated to an MRG (2008-2011) (Source: VABB and IMIS, VLIZ 2013).

Authors

In the 2008-2012 period, a total of 1,089 unique persons affiliated to an MRG were (co)author of a marine peer-reviewed or VABB publication. The yearly average amounts to 466 unique authors (2008-2011) (figure 18). In line with the research capacity, most authors are affiliated to MRGs of Flemish universities (648 unique authors) and of universities of the Wallonia – Brussels Federation (270 unique authors). Additionally, 114 unique authors of a peer-reviewed or VABB publication were affiliated to a Flemish scientific institute, and 119 to a federal scientific institute (2008-2012).

922 unique authors of marine peer-reviewed or VABB publications are affiliated to an MRG in the research domain of natural sciences. In addition, the research fields of engineering and technology (218 unique authors), agricultural and veterinary sciences (110 unique authors) and social sciences (58 unique authors) account for a considerable number of authors as well (figure 19). Given that this count encompasses a period of 5 years (2008-2012), a number of these authors may be no longer affiliated to an MRG at the time of the count. The current situation with regard to staff composition is discussed in the section about the research capacity of the MRGs.

STUDY AREAS OF THE MRGs

An analysis of the location of the study areas was conducted on the basis of the inventoried marine peer-reviewed and VABB publications of the MRGs of 2010. In the case 144 publications, a study area could not be determined. Examples of these kinds of publications are conceptual modelling studies and experimental studies in laboratories. Of the remaining publications, 78 can be categorised as 'regional research' (29% of publications with a study area). This concerns studies with a study area in the River Scheldt, the Flemish coastal zone or the Southern Bight of the North Sea (figure 20). Within the study area of the Southern Bight of the North Sea, a further selection is made

NUMBER OF UNIQUE AUTHORS AFFILIATED TO AN MRG BETWEEN 2008 AND 2012, BY TYPE OF INSTITUTE

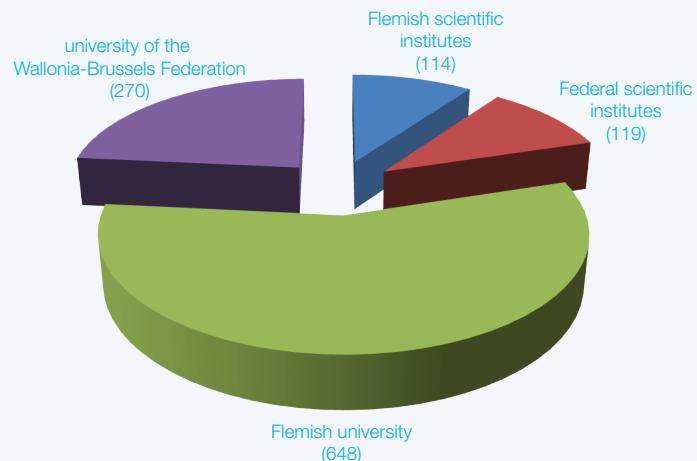


Figure 18. Number of unique authors of marine peer-reviewed or VABB publications affiliated to an MRG between 2008 and 2012, by type of institute. An author can be affiliated to several types of institutes (Source: IMIS, VLIZ 2013).

NUMBER OF UNIQUE AUTHORS AFFILIATED TO AN MRG (2008-2012), BY RESEARCH DOMAIN OF THE MRG

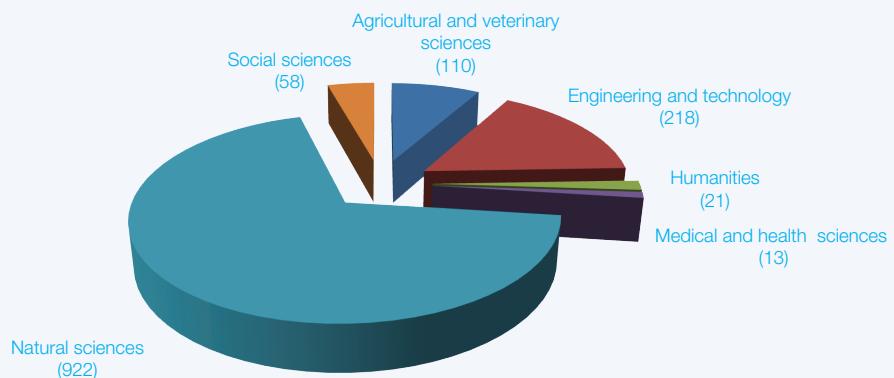


Figure 19. Number of unique authors of marine peer-reviewed and VABB publications affiliated to an MRG (2008-2012), by research domain of the MRG. The authors may belong to several research domains (Source: IMIS, VLIZ 2013).

for research conducted exclusively in the Belgian part of the North Sea. Studies located in Flanders which also include measurements in the coastal zone are classified as 'Flanders'. Within regional research, the River Scheldt (27 publications) and the Belgian part of the North Sea (24 publications) are the most important study areas. The other 190 publications (71% of publications with a study area) are categorised as international research. This international research can be divided into the following regions: Arctic Region, Atlantic Region, North Sea and Baltic Sea, Mediterranean and Black Sea, Pacific Region, Antarctic Region, Indian Ocean, Global, and European Seas and Oceans (measurements in all European seas and oceans, usually for European policy purposes). The most frequently studied areas are the Atlantic Region (56 publications), the Pacific Region (35 publications) and the Mediterranean and Black Sea Region (22 publications) (figure 20).

MARINE PEER-REVIEWED AND VABB PUBLICATIONS AFFILIATED TO AN MRG (2010) ACCORDING TO THE GEOGRAPHICAL LOCATION OF THE STUDY AREA

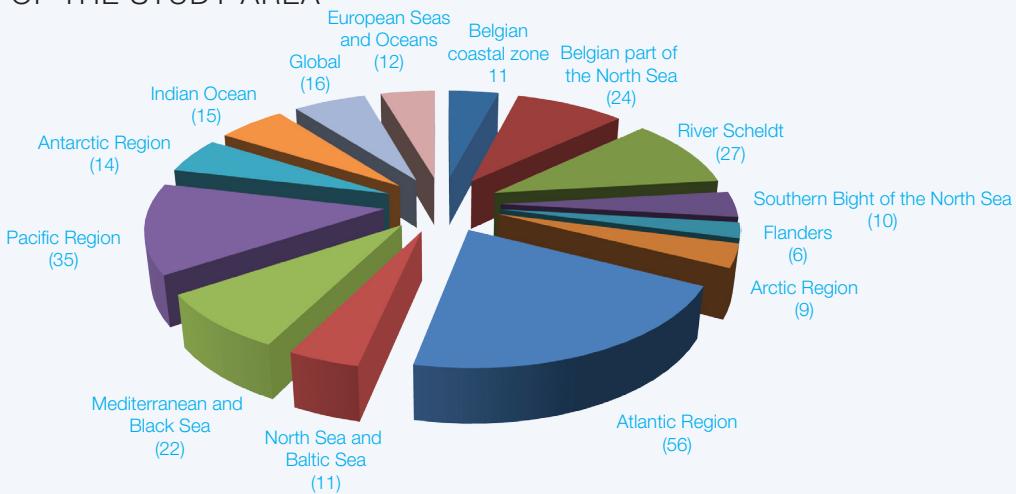


Figure 20. Marine peer-reviewed and VABB publications affiliated to an MRG (2010) on the basis of the geographical location of the study area. A publication is always attributed to one specific geographical area, except if several areas are explicitly mentioned (source: IMIS, VLIZ 2013).

A similar analysis for the year 2008 confirms the international character of the research conducted by the MRGs. In 2008, 27% of the publications with a study area indication (64 publications) were classified as regional research, while 73% (173 publications) were classified as international research.

COLLABORATION

Collaboration between MRGs

In the 2008-2012 period, 523 peer-reviewed and VABB publications resulted from collaboration between at least two MRGs (figure 21), which corresponds to 30% of the total number of inventoried marine peer-reviewed and VABB publications affiliated to an MRG. This number is indicative for the level of collaboration between the MRGs. In addition, there are also a range of partnerships in projects, education, etc., which do not necessarily result in a joint publication.

The collaboration between the different MRGs with regard to marine peer-reviewed and VABB publications between 2008 and 2012 mainly occurred through cooperation of different MRGs within the Flemish universities (184 publications) and universities of the Wallonia – Brussels Federation (88 publications), as well as through cooperation of MRGs from the universities in Flanders and Wallonia and Brussels (93 publications). There is also a considerable number of publications resulting from the collaboration between MRGs from Flemish universities and federal (106 publications) or Flemish scientific institutes (83 publications). With respect to the research domains, joint publications of MRGs mainly occurred within the domain of natural sciences (421 publications) and between MRGs of the domain of natural sciences on the one hand and MRGs of the domain of engineering and technology on the other (172 publications) (2008 and 2012). A total of 53 marine peer-reviewed and VABB publications resulted from cooperation between MRGs in the domain of agricultural and veterinary sciences and MRGs in the domain of natural sciences. The aforementioned numbers are to a large extent a consequence of the research capacities in the different types of institutes and research domains.

International collaboration

An analysis of the affiliations of (co)authors of the inventoried marine peer-reviewed and VABB publications of the MRGs in 2010 revealed that 264 of the 388 (68 %) publications analysed have at least one foreign (co)author. A total

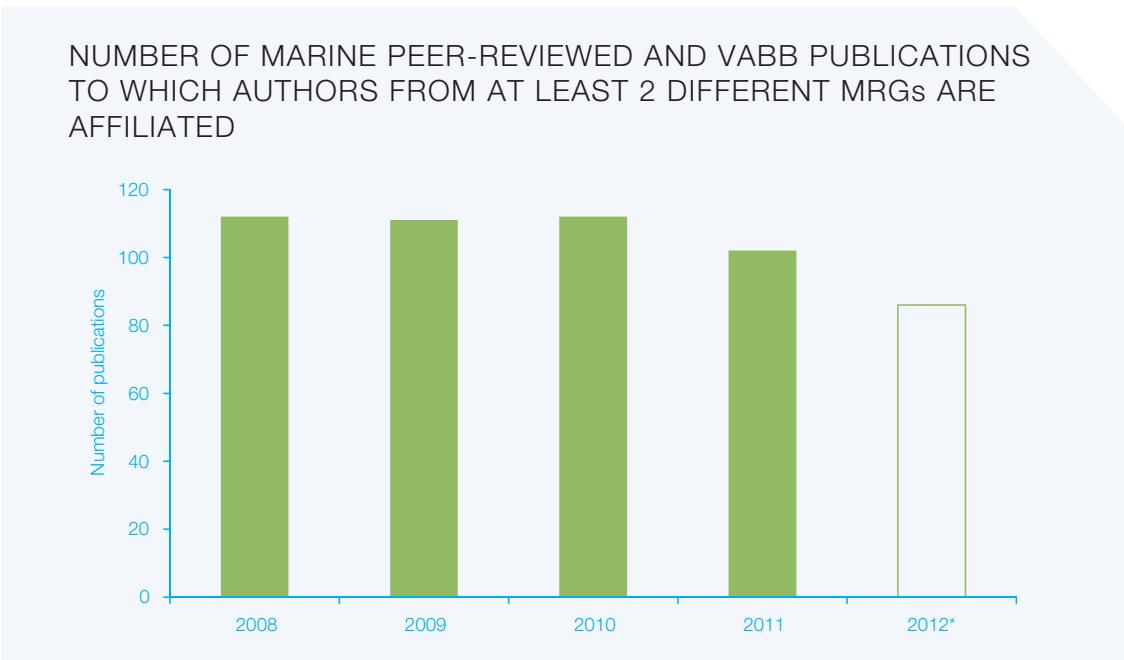


Figure 21. Number of marine peer-reviewed and VABB publications to which authors from at least 2 different MRGs are affiliated (2008-2012). *The figures for 2012 are less complete, (see Methodology, source: IMIS, VLIZ 2013).

of 57 different nationalities were present (excluding Belgium). Collaboration mainly occurred with the neighbouring countries of France (70 publications), Germany (62 publications) and The Netherlands (59 publications), as well as with the USA (53 publications) and the UK (46 publications) (figure 22). A researcher of a Belgian research group acts as first author in 267 of the 388 publications analysed. A marine researcher affiliated to an MRG is listed as the first author in more than half of the publications (54%) with at least one foreign co-author (143 publications). Foreign first authors come from 29 different countries. The majority of the foreign first authors are found in Germany (18 publications), the USA (14 publications), France (12 publications) and the UK (10 publications).

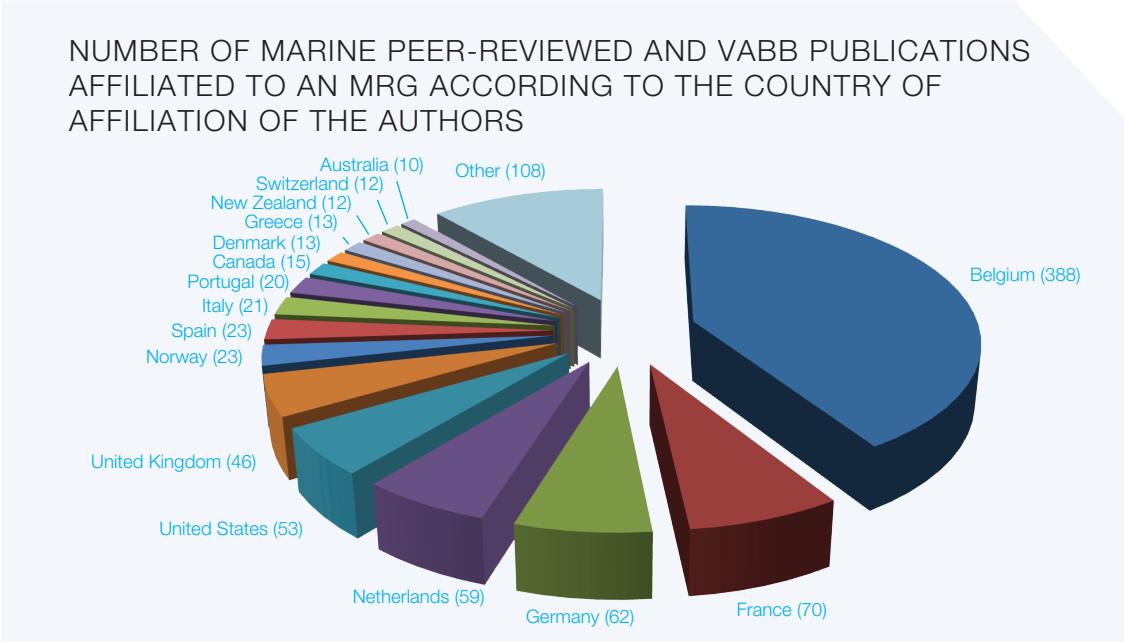


Figure 22. Number of marine peer-reviewed and VABB publications affiliated to an MRG on the basis of the country of affiliation (research institute) of the authors (2010). A country is only counted once per publication (Source: IMIS, VLIZ 2013).

RESEARCH VESSELS

The marine peer-reviewed and VABB publications of the MRGs in 2010 (403 publications) were screened on the use/mention of a research vessel. In 140 publications (35%), a research vessel was used for sampling or for data collection; 67 of these publications specifically mentioned the name of the ship whereas 73 publications do not refer to any ship(s). These publications constitute the sea-going research of the MRGs (figure 23). The other publications (263) mainly concern coastal and estuarine research, modelling studies, experimental studies in laboratories, social and economic studies, etc. However, many of the aforementioned studies directly rely on sea-going research (e.g. for the validation of models or experiments).

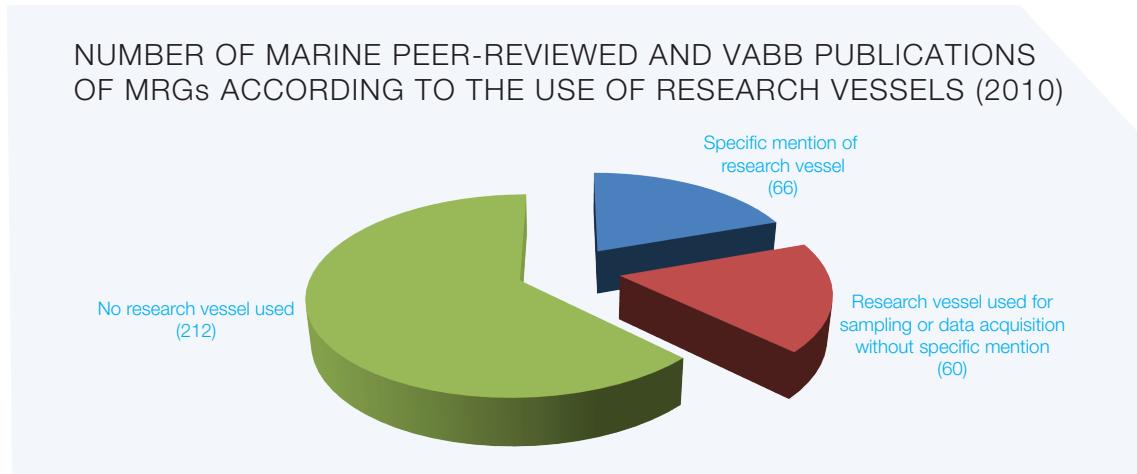


Figure 23. Number of marine peer-reviewed and VABB publications of MRGs on the basis of the use of research vessels for the year 2010 (Source: IMIS, VLIZ 2013).

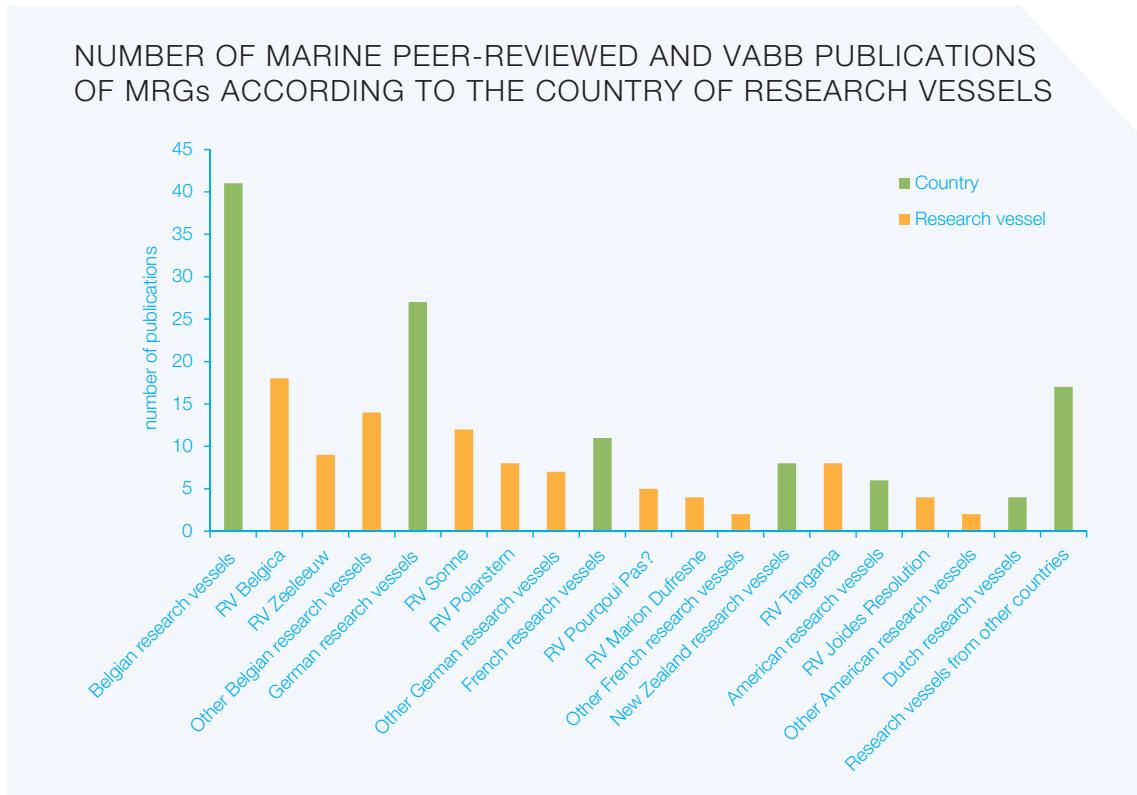


Figure 24. Number of marine peer-reviewed and VABB publications of MRGs on the basis of the research vessel and its country (2010). Several research vessels may be mentioned in one publication (Source: IMIS, VLIZ 2013).

A total of 41 different research vessels from 15 different countries are mentioned in the peer-reviewed and VABB publications of MRGs in 2010. The majority is from Belgium (41 publications), Germany (27 publications), France (11 publications) and New Zealand (8 publications) (figure 24).

RV Belgica (18 publications), RV Sonne (12 publications), RV Zeeleeuw (9 publications), RV Tangaroa (8 publications) and RV Polarstern (8 publications) are the ships which are most often mentioned. The relatively high number of publications which mention the RV Sonne and the RV Tangaroa is due to an international research project on methane sources on the Hikurangi Margin off the coast of New Zealand, in which an MRG participated. The scientific cruises within the scope of this project also explain the intensified cooperation with authors from New Zealand (International Collaboration) and contribute to the relatively high share of the Pacific Region in the study areas of the MRGs (Study areas of the MRGs). The scientific results of these cruises are measurable over several years in different publications.

FUNDING

In order to finance their research, the different research institutes and universities in Flanders have several mechanisms and funds at their disposal in addition to the fixed working budgets which also finance higher education. Depending on the type and objectives of the research, several resources can be addressed (table 6). A definition and division of the different types of research are provided in the following publication: [Soete \(2012\)](#) ²²⁹¹⁹⁰.

Apart from some exceptions, the present funding instruments do not include a specific budget for marine research. Financial information sources are incomplete and scattered, and overlap occurs in the reported numbers as a result of the different types of information gathering. The current effort to quantify the funding of marine research in Flanders and Belgium will be completed further in a later phase. Together with other European Member States, Belgium addresses this challenge with an eye on an efficient use of research funds in the context of the current and future (science) policy.

Table 6. Overview of the research funding and the most important funding resources for marine research (International, federal and Flemish).

Funding by Universities	International-European <ul style="list-style-type: none"> • European Framework Programmes <i>FPs</i> and <i>Horizon2020</i> • Programmes of the Directorates-General of the European Commission: <i>EMFF</i>, <i>ERDF</i>, <i>EUREKA</i>, etc. • Flanders-UNESCO Science Trust Fund (<i>FUST</i>) • International Foundation for Science (<i>IFS</i>)
Flanders	Federal <ul style="list-style-type: none"> • Belgian Science Policy (<i>BELSPO</i>) • Research programmes (SSD, BRAIN-be, STEREO, Interuniversity Attraction Poles (<i>IAP</i>)) • The <i>RV Belgica</i> (<i>BELSPO</i>) • Other funding by the federal government
Financing through Sustainable Development Aid	'Science and Society' <p>Societal valorisation of scientific research and communication</p>
Science awards	Foundations <ul style="list-style-type: none"> • University Foundation • Francqui Foundation • Biotechnology Funds (FBBF) Research Awards • Royal Flemish Academy of Belgium for Science and the Arts (KVAB) • King Baudouin Foundation • Foundation against Cancer (<i>Stichting tegen Kanker</i>)

Funding instruments for marine research (Flanders and Belgium)

Bijzonder Onderzoeksfonds (BOF) is an important funding source for academic research in Flanders. BOF resources include calls for mandates, fellowships, scholarships and initiatives such as 'Methusalem', which are granted according to the regulations stipulated by EWI (Flemish Government). The allocation of BOF resources is based on scholarly results and the academic publication output. From 2003 onwards, part of the BOF resources have been attributed on the basis of the publication and citation output (with a weighing factor of up to 35%) aiming at a qualitative policy. The new BOF resolution (1 January 2013) stipulates a number of conditions on strategic policy, good governance, science communication and diversity. Since 2013, the Flemish Government has provided a total of at least 150 million euros to Flemish universities through BOF, which is a sevenfold increase over a period of 20 years (21.1 million euros in 1995). There are currently no specific numbers available for the funding of marine research with BOF resources.

Research Foundation Flanders (*FWO-Vlaanderen*) finances fundamental scientific research at universities through PhD fellowships, post-PhD research, temporary and fixed mandates, individual research grants, research projects, participations in congresses and symposia, knowledge exchange networks, and excellence programmes (such as the Methusalem and Odysseus programmes). FWO is mainly financed by the Flemish Community as well as by the Federal Government, companies and foundations. The annual investment of the Flemish Government in FWO amounts to 172 million euros (2012). A first estimation, based upon the numbers (mandates, scholarships, stays, congresses) indicates an annual average of 1.9 million euros in funding for marine research since 2000 (source: database FWO, processed by the VLIZ, 2010). An *inventory* of finished and ongoing research projects is available on the website of FWO.

The agency for Innovation by Science and Technology (*IWT*) focuses on specialised scholarships and on projects in the Strategic Basic Research (*SBO*). The average annual funding of scholarships for marine researchers is estimated at 0.5 million euros (source: database IWT, processed by the VLIZ, 2010).

The *Hercules Foundation* is a structural funding channel of the Flemish government for investments in medium-scale and large-scale research infrastructure for fundamental and strategic research in all scientific disciplines. An *inventory* of all financed projects since the start of the programme (2007) is available online.

Part of the institutional funding granted to the Flemish scientific institutes and strategic research centres (figure 5; *The Flemish policy framework for research and innovation*) is reserved for personnel and means for marine research and monitoring. The scientific institutes complement their resources for marine research with external local/regional and European funding.

The policy fields of Economy, Science and Innovation (EWI), Environment, Nature and Energy (LNE), Mobility and Public Works (MOW), Foreign Affairs (IV), Agriculture and Fisheries (LV), etc. provide resources for (policy) research and monitoring, for which the MRGs of universities and research institutes can apply.

A number of funding instruments are focused on research valorisation and are also used by (marine) research groups at universities. The Industrial Research Fund (*IOF*) finances research mandates and projects focused on the valorisation of academic knowledge in the form of community and/or commercial applications. In addition, IWT manages the *TETRA fund* for technological research at colleges and the SOC fund for the spin-off policy of the Strategic Research Centres. IWT also participates in the Flemish Innovation Network (VIN), which is structured around the Flemish Cooperative Innovation Networks (VIS) and the innovation centres, which are under provincial control. Development aid projects can be funded by sources at different levels: the Flemish Interuniversity Council (*VLIR*), the Flemish Department of Foreign Affairs (*DIV*), the Directorate-General for Development Cooperation, the Belgian Development Agency, and international cooperation (UNESCO, UN).

The Centre for Research & Development Monitoring (*ECOOM*) is an interuniversity consortium in which all Flemish universities participate. ECOOM supports the Flemish Government by mapping the innovation and R&D efforts in Flanders. No specific numbers for marine research are available.

The Belgian Science Policy (*BELSPO*) provides the institutional resources of the Direction Natural Environment – RBINS. Furthermore, BELSPO is an important actor in the field of marine research project funding with *inter alia* the North Sea Research Programme. A new phase in these programmes was initiated recently, in the framework of the BRAIN-be programme. The earth observation programme STEREO II also finances marine projects. Between

2005 and 2012, approximately 6 million euros were annually invested in marine programmes through SSD and other BELSPO programmes. About half of the amount was granted to Flemish universities and scientific institutes (source: BELSPO, 2013). The Interuniversity Attraction Poles (IAP) programme provides support to networks of excelling research teams performing fundamental research at universities and scientific institutes in Belgium. The current phase (VII) runs from 2012 to 2017 and has a budget of 156 million euros.

The federal government also provides additional resources for research and monitoring through federal government departments. An important aspect in this regard is research funding in support of the policy field of the FPS Public Health, Food Chain Safety and Environment, and more specifically the marine research assignments of the Marine Environment Department (DMM). The procurements of this department accounted for an annual average of 0.1 million euros (source: DMM, processed by VLIZ, 2010).

Support of marine research

In addition to the direct funding of marine research, an important part of the resources is provided by the systematic support of this research. Resources in support of the operation of research vessels are crucial in this regard (see **Research vessels**). The Flemish Government (VLOOT) annually spends 0.9 million on the operation of RV Zeeleeuw and its successor RV Simon Stevin. RV Simon Stevin entered into service in May 2012. The cost amounted to 11.5 million euros (including taxes), and 1 million euros were spent on scientific equipment. The federal agency BELSPO takes care of RV Belgica, with an annual operational budget of approximately 2 million euros (source: BELSPO). Both ships are annually deployed for 200 sailing days to support research, monitoring, and educational objectives.

VLIZ annually receives 1.7 million euros in subsidies (2012) from the Flemish government to support marine research and science education. The organisation receives an additional 0.9 million euros for international assignments of the Flemish government in the field of marine research and data management (IODE Project Office IOC-UNESCO, EMODNET Project Office and JPI-Oceans). The Province of West Flanders supports marine research with an annual allowance of 0.15 million euros as a partner in VLIZ ([Mees et al. 2013](#) ²²⁵⁶⁷⁸).

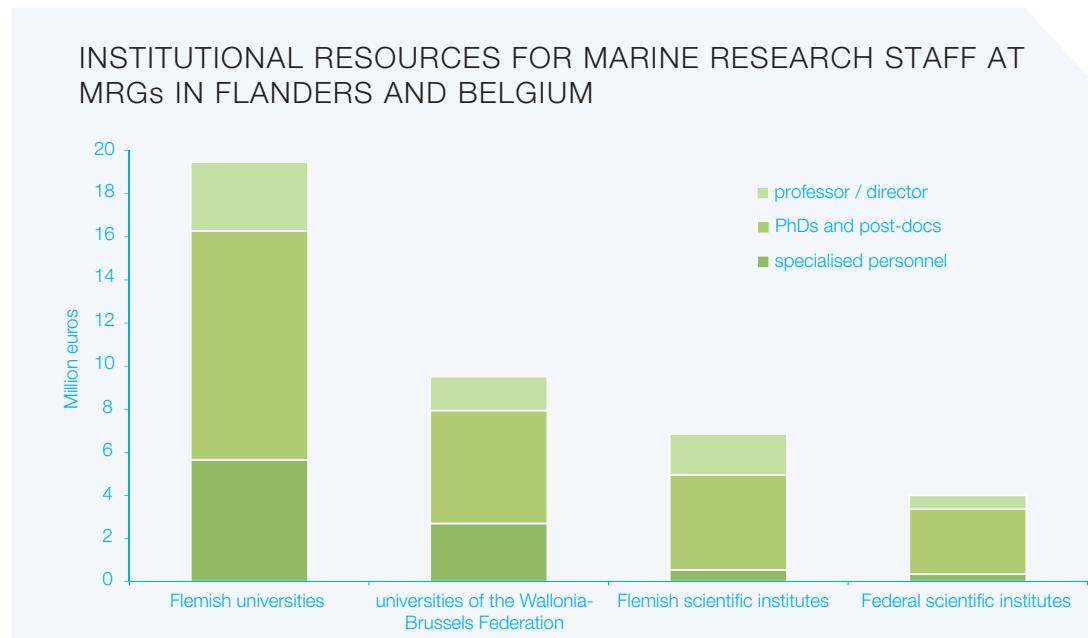


Figure 25. Institutional resources for marine research staff at MRGs in Flanders and Belgium. The estimation is based on the inventory of the number of employees and a differential salary scale. These numbers do not include investments and operational costs (Source: VLIZ survey 2012 – 2013).

Marine research staff

Given the incompleteness of the financial information sources, an indirect estimation of the financial resources for marine research staff was made, taking into account both fixed institutional resources and national and European competitive resources. This estimation was based on the inventory of the marine research capacity at the MRGs in Flanders and Belgium (survey of VLIZ 2012-2013; Inventory of Marine Research). A different salary scale was used for heads of department, (post-)doctoral employees and specialised personnel (figure 25). This estimation did not take into account investments, administrative support and operational costs; consequently, it does not provide an accurate representation of the total resources for marine research.

Based on this indirect approach, the MRGs in Flanders and Belgium had a budget of approximately 40 million euros at their disposal for funding marine research staff in 2012. 19.5 million euros went to staff affiliated to MRGs of Flemish universities, 9.5 million to universities of the Wallonia – Brussels Federation. The Flemish and federal scientific institutes complete the personnel budget with 6.8 and 4 million euros respectively. These results are directly related to the result of the inventory of marine personnel, and are also influenced by the definitions used ([Inventory of Marine Research](#)).

European projects

Although marine research in Flanders and Belgium is mainly funded by fixed and competitive resources on a national level (Flemish, Walloon, federal and provincial government resources, see [Policy context for scientific research in Flanders/Belgium](#)), an increasing part of the funding comes from international and European funding mechanisms. Europe is an important actor in guiding and enabling marine research. A variety of programmes exists, such as the 6th and 7th Framework Programme for Research and Technological development of the European Directorate-General for Research and Innovation, the European CO-operation in Science and Technology ([COST](#)), [LIFE](#) (European instrument supporting environmental and nature projects), [EUREKA](#) (a Europe-wide network for industrial research and development) and INTERREG (strengthening of regional cooperation through projects). Information on the framework programmes ([DG Research & Innovation](#)) is available through the Community Research & Development Information Service ([CORDIS website](#)). An overview of the European funding instruments, including the programmes of the directorates-general of the EC, is available on http://www.eutrainingsite.com/eu_funds.php ([European financing instruments](#)).

An overview from the EUROCEAN database ([Knowledge Gate](#), EUROCEAN) indicates that 130 European marine projects in which at least one scientific institute from Flanders/Belgium participated received European funding prior to FP7 (FP6, COST, EUREKA, EUROCORES, INTERREG III, LIFE, SMAP). Approximately one hundred of these projects were funded by FP6. This is a significant increase compared to the previous period, during which the Belgian participation in European marine research and innovation projects accounted for 31 projects, mainly MAST III and specific programmes of [DG Environment](#).

During FP5 and FP6, Belgium took part in 3 of the largest European marine research projects: DAMOCLES, aimed at developing arctic modeling and observing capabilities for long-term environmental studies (16 million euros); ENSEMBLES, aimed at predicting of climate change and its effects (15 million euros); and HERMES, aimed at deep-sea ecosystems in the European Seas (15 million euros). During FP6, a total of 600 million euros was spent on marine research themes (DG Research and Innovation, 2012). One of the requirements of FP6 is transnational co-operation in project consortia. Belgium participated in 101 projects during FP6, of which 21 were coordinated by Belgian partners (source: EUROCEAN 2012), managing 32.19 million euros. In comparison, the UK accounted for the highest number of participations during FP6 with 282 projects, and France managed the highest amount of money, namely 166.29 million euros (EUROCEAN 2012). For the COST, EUREKA, LIFE, INERREG III and SMAP programmes there are no specific analyses available with regard to marine research.

Belgian participation in marine FP7 projects

During FP7, Belgian partners participated in 178 projects with a total budget of 38 million euros. MRGs accounted for 79 of these project participations, with a total budget of 20 million euros. In the majority of the cases it concerned an MRG affiliated to a university (50 projects and a total budget of 15 million euros) (table 7. Source: EWI 2013, processed by VLIZ. Figures for 2007-2012).

Table 7. Overview of the Belgian participation in marine FP7 projects (EWI 2013, processed by VLIZ).

PROJECT PARTNERS	Number of FP7 projects	FP7 budget (in euros)	Average budget per partner (in euros)
Organisations located in Belgium	178	38,363,485	215,525
Belgian Marine Research Groups	79	19,922,230	252,180
MRG affiliated to a university	50	14,940,498	298,810
Flemish universities	30	10,076,921	335,897
Universities of the Wallonia – Brussels Federation	20	4,863,577	243,179
Flemish scientific institutes (MRGs)	19	3,197,641	168,297
Federal scientific institutes (MRGs)	10	1,784,090	178,409

Participation of Flemish MRGs in marine FP7 projects

The MRGs of the Flemish scientific institutes and universities participated in 49 projects with a total project partner budget of 13 million euros. This is a significant increase compared to FP5, when the number of participations was 13 and the total partner budget amounted to 1.8 million euros (table 8, figure 26).

Table 8. Overview of the Flemish participation in marine projects from FP5 until FP7 (EWI 2013, processed by VLIZ).

Flemish scientific institutes and universities	NUMBER OF PARTICIPATIONS	BUDGET OF THE PROJECTS (IN EUROS)	AVERAGE BUDGET PER PARTNER (IN EUROS)
FP5	13	1,778,901	136,838
FP6	18	5,767,766	320,431
FP7	49	13,274,562	270,909

NUMBER OF PARTICIPATIONS IN MARINE PROJECTS AND THE TOTAL BUDGET ALLOCATED TO FLEMISH MRGS



Figure 26. Number of participations in marine projects and the total budget allocated to Flemish MRGs, from FP5 to FP7 (Source: EWI 2013, processed by VLIZ).

Additionally, an annual average of 0.35 million euros over the past 10 years from competitive resources from European financing instruments for regional development (INTERREG) was spent on marine research with societal relevance. Between 2011 and 2013, total funding from the *European Fisheries Fund – Axis 4* for the sustainable development of Belgian fisheries areas amounted to about 4 million euros. Axis 4 is focused on a broad range of project objectives ranging from promotion, education, development of new economic carriers to applied fisheries research.

Other institutes involved in the funding of marine research

During policy preparation, implementation and evaluation, the competent government instances and administrations also conduct applied research that is directly or indirectly related to marine waters and coastal zones. In the case of Flanders, these policy areas are Economy, Science and Innovation (EWI), Environment, Nature and Energy (LNE), Agriculture and Fisheries (LV), Mobility and Public Works (MOW), Spatial Planning, Housing Policy and Immovable Heritage (RWO), Work and Social Economy (WSE), Foreign Affairs (IV), and Welfare, Public Health and Family (WVG). On the federal level, the major competent government instances are the FPS Public Health, Food Chain Safety and Environment, FPS Economy, SMEs, Self-Employed and Energy, FPS Mobility and Transport, FPS Finances, FPS Internal Affairs, PPS Science Policy, the Ministry of Defence and the Federal Police. An overview of the competent bodies of the Flemish and federal government with regard to the coast and sea is available in **Chapter 3 – Division of Competences**.

COMPANIES AND EDUCATION

Flanders in Action (ViA), the programme of the Flemish government, stipulates that Flanders will spend 3% of its GDP on research and development in 2014. The marine sector also promotes this exchange between knowledge-generating research and its commercialisation in the business world. '*Flanders Maritime Cluster*' vzw, which represents the Flemish marine and maritime scientific institutes and companies, plays a facilitating role in the sustainable growth of the Flemish knowledge-based economy. This cluster represents companies in maritime transport (42%), research and development such as consultancies (26%), services for the maritime sector (26%) and dredging and extraction (20%).

A list of companies in the marine - maritime sector is available in the *business catalogue – maritime industry in Flanders*²²³⁸⁴⁸ and on the website of *Flanders Maritime Cluster*.

There is also a broad offer of marine and maritime education in secondary and higher education at universities, university colleges and secondary schools.

Table 9. Overview of maritime technical (TSO) and vocational (BSO) education in secondary education.

DIPLOMA	SCHOOL	STAGE
TSO Maritime education - Deck TSO Maritime education - Engine Room	<i>Koninklijk Werk IBIS</i> Bredene	2 nd stage and 3 rd stage
TSO Maritime education - Deck TSO Maritime education – Engine room BSO Rhine and Inland Navigation Shortsea Shipping	KTA Zwijndrecht - Cenflumarin	2 nd stage and 3 rd stage, as well as a specialisation year
TSO Maritime Education - Deck TSO Maritime Education – Engine room BSO Fisheries BSO Shipmaster - Engine Room	Maritime Institute 'Mercator' Ostend	2 nd stage and 3 rd stage, as well as a specialisation year

The publication '*Koers naar Zee*' provides an overview of educational tools and activities at the coast on the themes of nature, environment, science and technology (*Copejans et al. 2011*²⁰⁹⁷⁰⁹). Last but no least, Flanders boasts 26 maritime museums, centres, study groups and non-governmental organisations which fulfil important socio-economic functions in addition to their work with regard to seas and coasts.

Table 10. Overview of the most important marine-related master degrees in higher education.

MASTER DEGREE	UNIVERSITY	DURATION	LANGUAGE
Marine and Lacustrine Science and Management, 'Oceans and Lakes'	Ghent University, University of Antwerp, Vrije Universiteit Brussel	2 years	English
Nautical Sciences	Antwerp Maritime Academy	1 year	Dutch / English
Marine Biodiversity and Conservation, Erasmus Mundus	Ghent University and 5 European partners	2 years	English
Maritime Sciences (interuniversity programme)	Ghent University University of Antwerp	1 year	Dutch / English
Océanographie	University of Liège	2 years	French / English
Aquaculture (international)	Ghent University	2 years	English
Master of Science in Electromechanical Engineering (Maritime Engineering)	Ghent University	2 years	Dutch / English

2.4 Marine research in Flanders and Belgium: a qualitative analysis

Based on a survey of the 82 Marine Research Groups (MRGs), the diversity of the current marine, coastal and estuarine research was mapped and described qualitatively for the different research domains. Figure 27 provides

NUMBER AND LOCATION OF THE MRGs ACCORDING TO THEIR RESEARCH DOMAINS

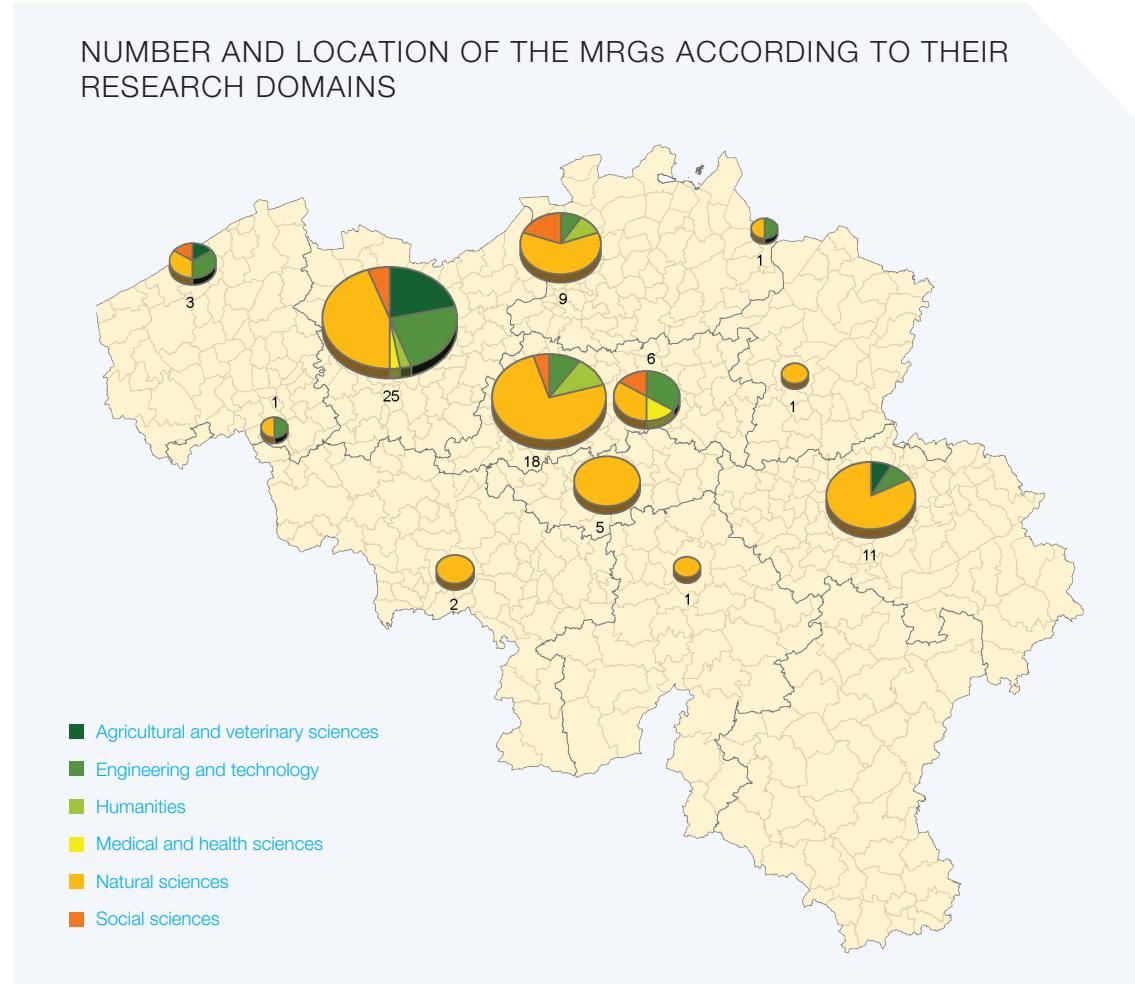


Figure 27. Number and location of the MRGs according to their research domains.

an overview of the geographic distribution of the expertise of the MRGs. Comparable to the inventory of the research capacity (Inventory of Marine Research), the qualitative description demonstrates the diversity of the research conducted by the MRGs. The description below also indicates that the MRGs have extensive expertise in research fields put forward by the (European) scientific community as challenges for future research (cf. *Navigating the Future IV (European Marine Board, 2013)*²²⁶⁸⁷⁴ and the communication on a European strategy for marine and maritime research (COM (2008) 534)).

The division below is somewhat artificial, which can lead to overlap between the different research domains. The research domain natural sciences is further divided into disciplines (biological, chemical and earth sciences).

RESEARCH DOMAIN AGRICULTURAL AND VETERINARY SCIENCES

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DOMAIN OF AGRICULTURAL AND VETERINARY SCIENCES AND THE NUMBER OF PUBLICATIONS

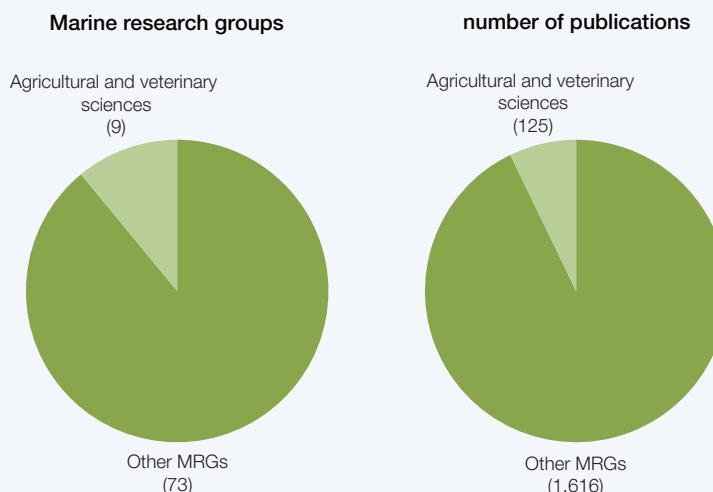


Figure 28. Number of MRGs in Flanders and Belgium active in the research domain of agricultural and veterinary sciences as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research domain (Source: IMIS, VLIZ 2013).

Within the research domain of agricultural and veterinary sciences, the MRGs (9, figure 28) conduct research on several aspects of fisheries, aquaculture, aquatic veterinary medicine, food safety and consumption of fish and shellfish. The fisheries research supports a fisheries management based on scientific information about fish stocks and their position in the ecosystem, a thorough knowledge of the efficiency and effects of different fishing methods, and insight in the socio-economic aspects of the fisheries sector. The aquaculture sector is currently the fastest growing producer of animal nutrition (COM (2012) 494). Scientific information on environmental effects, the different aquaculture techniques and breeding species, and the quality and safety of the products is necessary to achieve a sustainable aquaculture (COM (2009) 162). In *Navigating the Future IV (European Marine Board, 2013)*²²⁶⁸⁷⁴, sustainable fisheries and aquaculture are identified as key points for future marine research (Chapter 2, themes *Fisheries and Aquaculture*).

The fisheries research of the MRGs covers a range of aspects. The biological aspects of fisheries research are mainly focused on the collection of biological and ecosystem data, fish stock evaluations and catch predictions to support the European *Common Fisheries Policy* (CFP) and environmental impact assessments (EIAs). In this regard, the impact of fishing activities on the marine environment is studied extensively. Research is conducted on sustainable fishing techniques so as to reduce the environmental impact and optimise the catch. This primarily encompasses adaptations of existing fishing techniques such as beam trawling, but also includes research on alternative fishing techniques such as handline fishing, gillnetting, Scottish seining and electrotrawling ('Hovercram').

There is also research on **social, economic and historical aspects** of the fisheries sector. Evidently, fisheries research has a certain overlap with biological research conducted in the research domain of natural sciences, but it also has links to research domains in the social sciences (fisheries policy and legislation), and human sciences (history and archeological research).

In the field of **aquaculture**, MRGs address biological, ecological (cf. research discipline biological sciences) and technical aspects. This does not only concern aquaculture on land, but also mariculture with offshore farms and mussel culture, and the application of **integrated multi-trophic aquaculture systems** (IMTA). An important aspect concerns the study of the **impact** of aquaculture activities on the (marine) environment. Research is furthermore conducted on **different breeding species** such as sea bass, turbot, bream, halibut, cod, black tiger shrimp, mussels, etc. The immunological aspects of this research are addressed as well and have a strong link with veterinary research (see below). The **food sources** for aquaculture such as Artemia species (brine shrimp), micro-algae and rotifers constitute a research subject of their own: biological cultures, natural occurrence, production techniques, strain-typing, nutritional value and enrichment, the impact of a diet on the breeding species, etc. Technical aquaculture research on new integrated water systems supports the development of research and industry in this field.

Besides fisheries and aquaculture, there is also research on **food safety and consumption of fish and shellfish** as well as on the quality and freshness of fish products. Research is performed on chemical contaminants in the sediment, in suspended material and in biota, and on the biological effects of these chemical contaminants on marine organisms (link with veterinary, biological and chemical sciences). Additionally, microbial ecology and viruses in fish products are studied with a view to food safety, and strategies for preservation and intelligent packaging are developed further. The toxicological risks associated with the consumption of fish products are addressed in the research domain of medical and health sciences. Finally, some research groups study consumer behaviour and the marketing of fish products.

Veterinary research conducted by the MRGs is closely related to research on fisheries and aquaculture, as well as to biological and chemical (toxicological) research in the research field of natural sciences. This research *inter alia* addresses the diagnosis of diseases and mortality and the influence of pollutants on marine organisms and on marine mammals in particular. Research is furthermore performed on the interaction between micro-organisms with a probiotic function and their hosts (larvae of marine fish species (sea bass/sole) and nauplii of brine shrimps). Finally, the potential injuries and physiological consequences of electric pulse fishing and other forms of anthropogenic stress on marine organisms are studied.

RESEARCH DOMAIN OF ENGINEERING AND TECHNOLOGY

The MRGs (16, figure 29) with expertise in the field of engineering and technology are active in research concerning: coastal protection and the construction of ports; ship design and hydrodynamics; offshore energy systems; management of research vessels and their equipment, data and information management; research on remote sensing; and marine biotechnology. At the European level, the societal relevance of this research is highly valued. The economic value and importance of research on several offshore energy technologies, blue biotechnology, maritime transport and ship construction is specifically highlighted in the communication on blue growth (COM (2012) 494) and the communication on a European strategy for marine and maritime research (COM (2008) 461). This last communication also emphasises the importance of specialised marine research facilities. These facilities encompass, *inter alia*, research vessels and their equipment ([EU-FP7 project Eurofleets](#)), satellites, buoys, deep sea observatories, and data and information systems (COM (2010) 461). [Navigating the Future IV \(European Marine Board, 2013\)](#)²²⁶⁸⁷⁴ further discusses the importance of research on new and existing forms of energy production from seas and oceans, blue technology and ocean observation.

In the field of **coastal protection**, the research of the MRGs mainly focuses on innovative coastal protection systems, fundamental research on coastal protection works for sandy beaches, and hydraulic aspects of the design of hydrological structures (locks, weirs, bank and seabed protection, etc.). The interaction between coastal protection and port structures on the one hand and the marine environment on the other is also studied closely. Both the hydrodynamic and the sedimentological field are addressed by the MRGs in this regard. Given the frequent use of hydrodynamic and sediment transport models in this research, domain overlap occurs with the morphological and modelling studies conducted in the research discipline of earth sciences.

Notwithstanding the fact that no major shipyards remain in Belgium, there is still research on certain facets of **ship-building** and the **hydrodynamic aspects of ships**. An integrated software package for ship-building is being

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DOMAIN OF ENGINEERING AND TECHNOLOGY AND THE NUMBER OF PUBLICATIONS

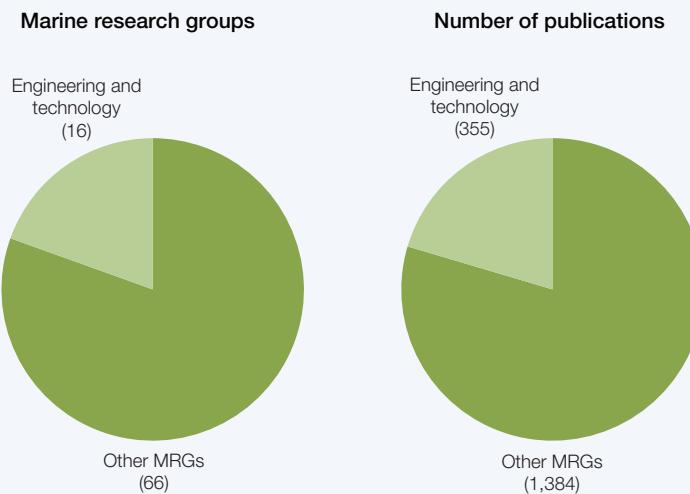


Figure 29. Number of Marine Research Groups (MRGs) in Flanders and Belgium active in the research domain of engineering and technology as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research domain (Source: IMIS, VLIZ 2013).

developed, and research is being conducted on the influence of wave forces, the corrosion of ballast tanks, and the phenomenon of brittle fracture in the steel structure of ships. Additionally, several MRGs study the behaviour of ships in shallow waters, such as ship-ship interactions, bank effects and the nautical bottom. Studies related to ship-building address the presence of toxic fumes aboard chemical tankers, electronic navigation devices for ships, acoustic submarine communication, and the financial aspects of shipping (cf. research domain social sciences) (Chapter 2, theme **Maritime transport, shipping and ports**).

The MRGs in Belgium have broad expertise in the field of offshore energy systems. Several groups are conducting research on the technical aspects and economic feasibility of different offshore technologies for renewable energy, energy storage and energy transport. Research themes such as wind and wave conditions and protection against erosion of offshore wind turbines are discussed. Modelling studies and techniques from the earth sciences discipline are used within this scope. Specific research is being conducted on wave energy conversion systems: optimisation of point absorber systems, farm modeling of wave energy convertors, and overtopping wave energy convertors. The materials for wind turbines and the behaviour of the construction, as well as management and maintenance of offshore turbines are also studied. Within the research disciplines of earth sciences and biological sciences, research is being performed on the effects of offshore wind turbines on marine ecosystems (Chapter 2, theme **Energy (including cables and pipelines)**).

Marine biotechnology is the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services (definition of the Organisation for Economic Co-operation and Development, [OECD](#)). Marine biotechnology is a research field with a strong multidisciplinary character. In Belgium, there are research groups in several disciplines (biological sciences, medical and health sciences, biotechnology, fisheries and aquaculture sciences, veterinary sciences, chemical sciences, etc.) whose expertise covers different aspects of marine biotechnology. The expertise of these groups is addressed in more detail in the relevant research fields. A number of these MRGs collaborate in the framework of [the Flemish Marine Biotechnology Platform](#).

In the context of logistic and operational activities (a broader scope than engineering and technology), Belgium puts 2 seagoing research vessels at the disposal of the marine scientific community: RV Belgica and RV Simon Stevin. The Royal Belgian Institute of Natural Sciences (RBINS, [Direction Natural Environment](#)) is responsible for the coordination and management of the oceanographic research vessel Belgica. This encompasses the preparation of

scientific programmes, budget control and the management of scientific instrumentation (purchase, operation and data supervision). The Flanders Marine Institute ([VLIZ](#)) is responsible for the coordination of ship time for RV Simon Stevin and manages a pool of common research equipment and infrastructure.

There are two marine data centres in Belgium: the Belgian Marine Data Centre ([BMDC](#), RBINS), and the Flanders Marine Data and Information Centre ([FMDC](#), VLIZ). These data centres provide a wide range of data (physical, chemical, taxonomical, biogeographical, ecological, geological, hydrometeorological, toxicological, etc.) to a broad group of experts on a national, European and international level. In addition, these groups are involved in the development of international standards for the management and exchange of data and information and for the integration in international networks. The [VLIZ-library](#) is specifically dedicated to marine, estuarine and coastal scientific literature and multimedia.

Remote sensing through satellites and (unmanned) planes allows to study certain parameters, processes and phenomena on a larger spatial scale. The MRGs use these observations for different goals, ranging from the monitoring of human activity at sea (fisheries, pollution, etc.) over the studying of certain parameters (chlorophyll-a, SPM) to spatial environmental aspects (water quality, eutrophication, etc.). These observations are closely related to the research conducted in other scientific disciplines, such as earth sciences and biological sciences. Remote sensing is often combined with models and *in situ* measurements.

RESEARCH DOMAIN HUMANITIES

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DOMAIN OF HUMANITIES AND THE NUMBER OF PUBLICATIONS

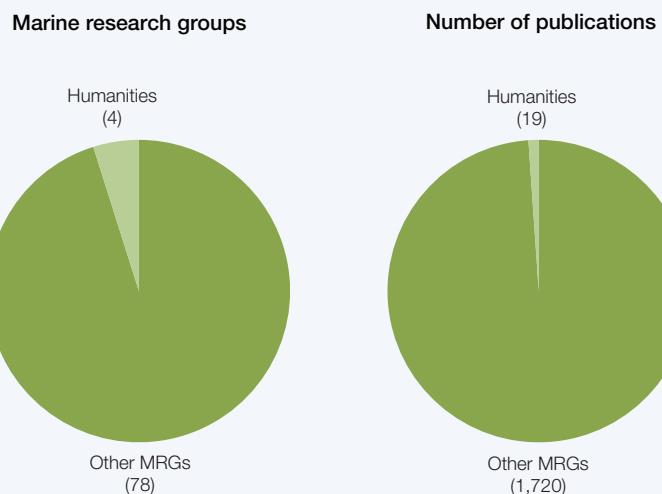


Figure 30. Number of MRGs in Flanders and Belgium active in the research domain of humanities as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research domain (Source: IMIS, VLIZ 2013).

Humankind has undeniably influenced the development of the coastal landscape. Hunting and agriculture already occurred in the coastal zone in the Neolithic. In the Middle Ages, the impact of humankind increased as a result of dike construction, dune fixation and increasing agricultural activity, which increasingly determined the landscape. The coastal zone was also where important economic activities such as fishery, shipping and ports as well as military activities took place. Hence, it is not surprising that research is carried out on different aspects of these historical human activities in the coastal zone. This research is not only conducted on land. As a result of the *Convention on the Protection of the Underwater Cultural Heritage* (UNESCO, 2001), there has been an increased interest in submerged landscapes on and under the seabed in recent years.

The historical and archaeological research of the MRGs (4, figure 30) is principally concentrated on the Middle Ages, studying different aspects: research on rural society, demographic research, research on water management and floods in the coastal plain and neighbouring estuaries, research on the development of the medieval coastal and polder landscape (historical geography), research on fishing settlements, research on medieval cogs, etc. Furthermore, there is archeological research in the Belgian part of the North Sea. This encompasses both surveys for new information as well as the inventory of archaeological finds. Aspects of conservation and preservation are also considered in the research on maritime heritage and maritime archaeology. The historical maritime research addresses the history of maritime economy (importance of ports, trading relations, etc.) and maritime migrations. Last but not least, naval heritage is also studied. This includes the inventory of naval heritage, information on ships and their history, and research on the history of shipyards. Some of the aforementioned research themes have a strong relation with other research disciplines, such as earth sciences (e.g. geological development of coastal zones) and biological sciences (e.g. identification of fish remains from archaeological sites).

RESEARCH DOMAIN OF MEDICAL AND HEALTH SCIENCES

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DOMAIN OF MEDICAL AND HEALTH SCIENCES AND THE NUMBER OF PUBLICATIONS

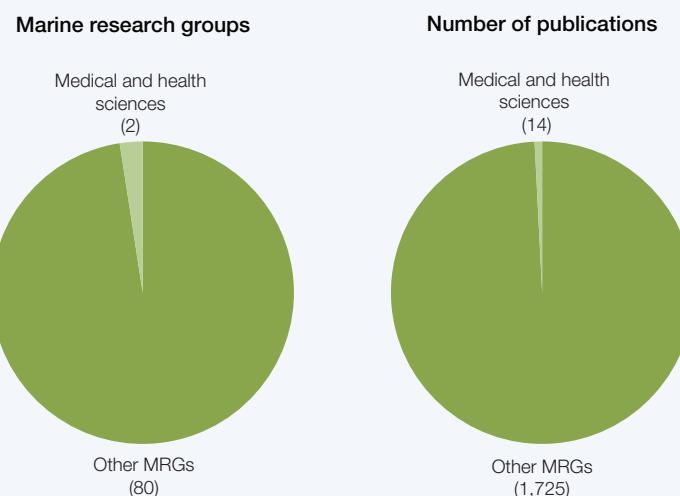


Figure 31. Number of MRGs in Flanders and Belgium active in the research domain of medical and health sciences as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research domain (Source: IMIS, VLIZ 2013).

The research domain of medical and health sciences includes several aspects ranging from research on the influence of toxic substances in the marine environment on human health (toxins in marine organisms, marine pollution, toxic algal blooms, etc.) over research on the effects of the sea on human well-being and health ('the blue gym'), to the extraction of medicine from marine organisms. On a European level, the potential of medicine of marine origins is emphasised in the communication on blue growth (COM (2012) 494). According to *Navigating the Future IV (European Marine Board, 2013)*²²⁶⁸⁷⁴, a further elucidation of the relationship between human health and the oceans (the risks as well as the remedies) constitutes one of the great challenges for future marine research.

The research of the MRGs (2, figure 31) in this domain is on the one hand focused on the discovery and characterisation of bioactive substances (toxins), in, *inter alia*, jellyfish, sea anemones and cone snails. This research is strongly connected to marine biotechnology, in the research domain of engineering and technology. On the other hand, research is performed on fish and shellfish as a nutrition source for omega-3 fatty acids and the toxicological risks related to the consumption of fish. This research is strongly linked to ecotoxicological research conducted within the research disciplines of biological sciences and fisheries and aquaculture (e.g. food packaging and food safety).

RESEARCH DOMAIN OF NATURAL SCIENCES: RESEARCH DISCIPLINE OF BIOLOGICAL SCIENCES

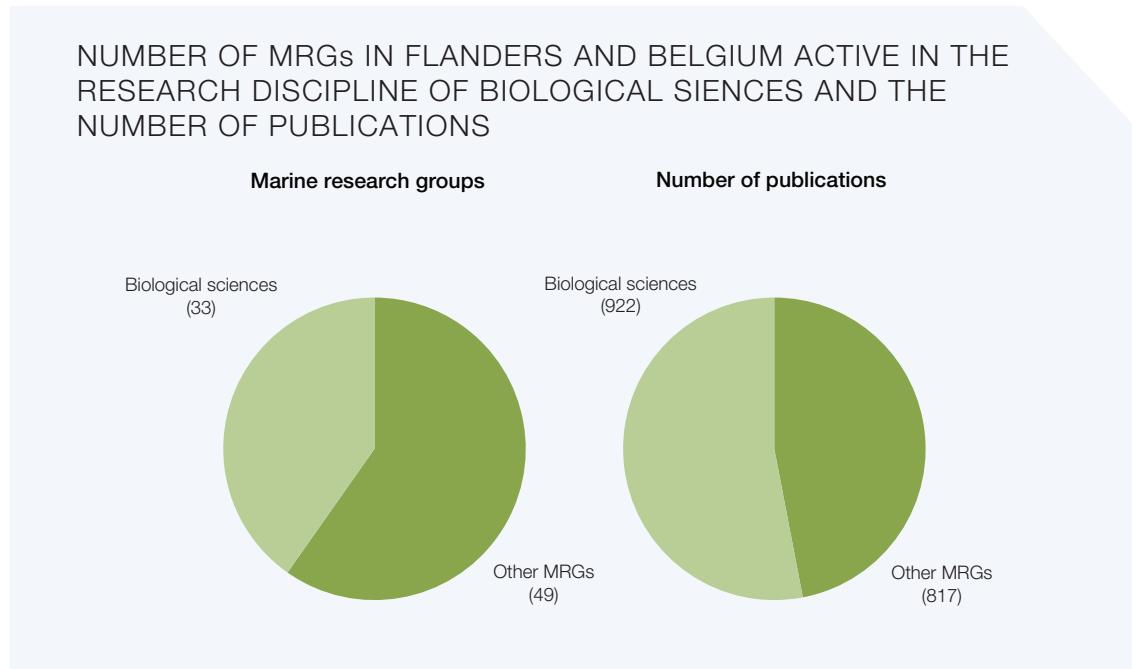


Figure 32. Number of MRGs in Flanders and Belgium active in the research domain of natural sciences – research discipline biological sciences, as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research discipline (Source: IMIS, VLIZ 2013).

The MRGs (33, figure 32) in Flanders and Belgium have strongly developed expertise in marine, estuarine and coastal biological research. The biological and ecotoxicological research in support of policy, primarily addresses the impact of human activities on the marine environment and marine organisms. In addition, there is research on the diversity, distribution and abundance of several marine organisms, ranging from marine mammals, seabirds, fish, and marine invertebrates to algae and micro-organisms. The interaction between these organisms and their abiotic environment is also studied in research on marine, estuarine and coastal ecosystems. The importance of present and future research on marine ecosystems and their societal benefits, resources from the deep sea, the impact of climate change, etc. is emphasised in *Navigating the Future IV (European Marine Board, 2013)*²²⁶⁸⁷⁴.

Several MRGs conduct policy-oriented marine biological research with regard to the impact of human activities on marine ecosystems in the BNS. In many cases, this concerns mandatory monitoring carried out in the framework of international conventions (e.g. the OSPAR Convention), European directives (*Marine Strategy Framework Directive*, *Water Framework Directive*, *Birds Directive*, *Habitats Directive*, etc.) or national legislation. The biological impact of human activities such as the disposal of dredged material, offshore sand extraction, artificial hard substrates, construction of offshore wind farms, introduction of invasive species, fisheries, etc. is studied and monitored. Furthermore, the condition of certain populations and habitats is monitored (cf. research on marine mammals, sea and coastal birds, and ecosystems research). The research in support of the *Common Fisheries Policy* is discussed in the research domain of agricultural and veterinary sciences.

Policy-oriented research is also conducted on the beach and dune areas, such as the inventory and mapping of certain key species, scientific support for management plans, quantification of the ecological effects of beach nourishments, and development of nature conservation and repair measures (see coastal ecosystems). Finally, MRGs conduct research to support policies for the Scheldt Estuary by means of ecosystem monitoring in the context of the *Water Framework Directive* and nature regeneration projects (see estuarine ecosystems).

In (eco-)toxicological research the effects of certain contaminants on marine organisms or the marine environment are modelled and monitored (see also the research discipline chemical sciences). Specific research is conducted on the effects of marine (micro)litter, endocrine disruptors, trophic transfer and bio-accumulation of contaminants in food chains, heavy metals in European sea bass and dogfish, the impact of metals and organic contaminants on microbial communities in marine sediments and the influence of pollutants such as PCBs on deep sea fish.

Some MRGs perform scientific research on the occurrence of **marine mammals** in the BNS. An important aspect of this research concerns the study of stranded marine mammals. The toxicokinetics and physiological effects of organic contaminants in marine mammals (seals, sea lions etc.) are also addressed.

The MRGs conduct research on different aspects of **sea and coastal birds**. This includes the study of the evolution of populations of coastal birds, bird counts in the BNS, food ecology of terns, interaction between the pelagic component and top predators in the food chain and the impact of human activities on coastal birds and sea bird populations.

Besides fisheries-related research (cf. research field agricultural and veterinary sciences), the MRGs also conduct fundamental research on different aspects of **fish**. This includes the development of an encyclopaedia on African brackish water fish (FishBase), the study of the phylogeography and distribution ecology of marine fish of the North East Atlantic Ocean and the Southern Ocean, genetic research of fish, archaeobiological studies (cf. research domain human sciences), host-parasite interactions and cospeciation, research on fish migration and migration bottlenecks, the development of ecological parameters for fish stocks, the study of the communication and hearing of bony fish, sound studies on clownfish, bioluminescence in sharks, etc. The different MRGs also conduct **evolutionary morphological research** on fish. Within this scope, the evolution of the features and function of certain parts in marine vertebrae are studied, such as the cranial morphology of Anguilliformes (eels), the skeleton and metabolism of Syngnathids (pipefish, seahorses), opercular malformations in sea bream, morphological studies of pearlfish, the development of sea bass larvae and the carapax of Teleostei (bony fish).

The MRGs have extensive expertise with regard to marine invertebrates such as Crustaceae, Mollusca, Nematoda, Annelida, Platyhelminthes, Echinodermata, and Cnidaria. The research concerning these invertebrates is, *inter alia*, used in biodiversity studies and studies on the impact of climate change on the functioning of ecosystems. In the case of the **Crustacea**, research topics include: the distribution of exotic Crustacea in estuarine waters in Belgium; the revision and synopsis of Amphipoda in the Southern Ocean; the study of the ecology, evolution and taxonomy of Copepoda; and the taxonomy, phylogeny and zoogeography of marine and brackish Ostracoda. With regard to **Mollusca**, research is conducted on molecular systematics, taxonomy, and population genetics. The MRGs host extensive expertise with regard to **Nematoda**. Both benthic as well as free-living species are studied in different ecosystems (cf. research on marine, estuarine and coastal ecosystems). In addition, research is performed on bioluminescence in pelagic ringworms (**Annelida**). In the case of the **Platyhelminthes**, the biodiversity, phylogeny and biogeography of free-living flatworms are studied. The study of **Echinodermata** includes research on taxonomy and biodiversity (zoogeography, systematics and bio-ecology) of echinoderms such as sea urchins, starfish, sea cucumbers and brittle stars. Furthermore, there is specific research on the bioluminescence in Echinoderms and the excretion of certain substances by sea cucumbers, sea urchins and brittle stars. With regard to **Cnidaria**, research focuses on the taxonomy and biogeography of sponges. The research on corals is addressed in the study of marine ecosystems. The MRGs also perform research on the formation of skeletal parts (**biomineralisation**) in marine invertebrates.

The MRGs have an extensive expertise in the field of **algology** (brown algae, green algae and micro-algae). Research is conducted on different aspects of algae such as sexual reproduction and speciation, evolutionary dynamics and biogeography, population structure, bacteria-algae interactions, spatial and temporal analysis of communities and species variability, taxonomy, genetics, and diversity. Resistant remains of micro-algae such as diatoms and dinoflagellate cysts are frequently used in palaeo-ecological research (see also research discipline of earth sciences). A large collection of live diatoms is kept and constitutes a part of the 'Belgian Coordinated Culture collections of Microorganisms'. Finally, there is extensive research on toxic algal blooms in the marine environment.

The **microbiological research** of the MRGs *inter alia* focuses on aquatic microbial ecology (phytoplankton, protozooplankton and bacteria) and identification and classification of new marine bacteria. In addition, research is conducted on marine methanotrophes by means of the development of reactors and the study of marine ecosystems such as mud volcanoes, ecosystems in the deep sea and coral reefs. Bacteria in intertidal sediments and endosymbiotic bacteria in green algae are also studied. Last but no least, viruses and microbial ecology of fish products are studied, which is related to the food safety studies in the research domain of agricultural and veterinary sciences.

The MRGs conduct research on diverse **marine ecosystems**. This includes the modelling of ecosystems, the study of the biodiversity in marine ecosystems, the study of ecosystems on sandbanks and the study of ecosystems in the deep sea, such as submarine canyons at continental slopes, cold-water corals, communities at seeps, mud volcanoes, hydrothermal sources, habitats in polar seas and deep-sea sediments. The ecology (parasites, coral

bleaching) and evolution of tropical coral reefs are also studied. The microbial communities and skeletogenesis in corals are discussed as well within this scope (see also the research on marine invertebrates and the microbiological research).

The research on **coastal ecosystems** is focused on coastal dunes and the beaches of the Belgian coast. It concerns research on the use of spiders and insects as bio-indicators in coastal dunes (implications for nature conservation and evaluation of the impact of nature management measures), the ecology and functioning of dune ecosystems (e.g. research on the blue grasshopper, spiders, marram grass, plant-arthropod interactions, etc.) and policy-oriented biological research (impact of sand nourishments, key species, support of management plans, preparation of nature conservation and recovery measures).

The MRGs also have extensive expertise in the field of **estuarine ecosystems**. This research primarily covers ecosystems in the Scheldt Estuary such as mudflats and salt marshes (bioturbation, nursery function, mudflats as a 'source of sink' of nutrients and silica, interaction between salt marshes and the sea, etc.) in which an ecosystem model for the Scheldt is being developed. In addition, policy-oriented biological research is conducted through ecosystem monitoring in the context of the *Water Framework Directive* and nature restoration projects (water birds, macrobenthos, habitats and ecotopes, nature development, ecosystem visions, methodology of basin management plans, non-indigenous species, integrated system monitoring, fish migration, fish stocks, etc.).

In the field of estuarine and coastal ecosystems, multidisciplinary research is carried out on different aspects of **mangroves**, ranging from the functioning of the ecosystem, over ecosystem management and interaction with adjacent coral reefs to the study of insects in mangroves.

In addition to the biodiversity research of specific ecosystems, the MRGs conduct **biodiversity research** on a higher level. Use is made of marine data centres and databases such as SCAR-MarBIN (the Antarctic Marine Biodiversity Information Network) and NeMys to collect information for this purpose (see also research domain of engineering and technology). The biodiversity research addresses the study of food webs in the sea, in which the role of functional biodiversity (primary producers, biomass, predators, key species, species diversity, nutritional relations, etc.) is examined.

RESEARCH DOMAIN OF NATURAL SCIENCES: RESEARCH DISCIPLINE CHEMICAL SCIENCES

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DISCIPLINE OF CHEMICAL SCIENCES AND THE NUMBER OF PUBLICATIONS

Marine research groups Number of publications

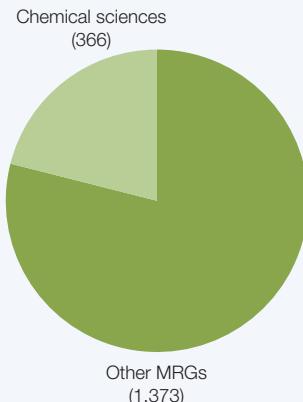
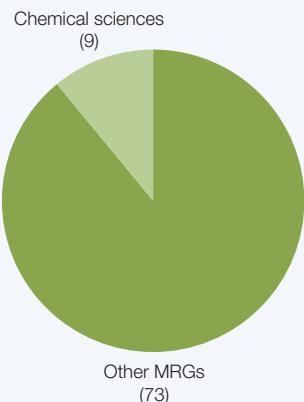


Figure 33. Number of MRGs in Flanders and Belgium active in the research domain of natural sciences - research discipline chemical sciences as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research discipline (Source: IMIS, VLIZ 2013).

The research of the MRGs (9, figure 33) in the research discipline of chemical sciences focuses on the development of chemical analysis methods, analysis of contaminants and the study of biogeochemical cycles and fluxes of certain chemical substances and chemical processes. This research discipline is important with regard to monitoring in the framework of different policy instruments and overlaps with the disciplines of earth sciences and biological sciences.

The MRGs conduct research on the development of new analysis and evaluation methods and the validation of the results. This research will lead to an improved knowledge of the marine environment by means of analytical chemical, physical and biochemical analyses and also contributes to certain monitoring activities in the context of the *OSPAR Convention*, the *European Water Framework Directive*, and the *Marine Strategy Framework Directive*. Reference materials for international ring tests are also being developed.

A significant part of the research discipline of chemical sciences is focused on the **analysis of chemical contaminants**. This includes the analysis of sediment, suspended material, water and biota. This research topic has applications in several areas, such as endocrine disruption in the Scheldt Estuary, analysis of micro-pollutants, food safety and authenticity/traceability of fish and shellfish (overlap with the research domain of agricultural and veterinary sciences) metabolism and transfer of marine toxins from algae to the environment and research on persistent organic pollutants (POPs such as PCBs, OPCs, PBDEs, etc.) in fish, eels, and marine mammals.

The MRGs study **several biogeochemical cycles and fluxes of different chemical substances**. This includes heavy metals, of which both the biogeochemical behaviour in the Scheldt Estuary and North Sea and the influx of these metals to the sea by rivers and the atmosphere are studied. Research is also carried out on marine biogeochemical cycles in different marine areas (sea ice in polar zones, continental slopes, etc.) and (eco-)systems (mangrove ecosystems, tropical estuaries, upwelling systems, etc.). Furthermore, biogeochemical fluxes of substances such as carbon methane, nitrogen, silica and phosphorus are studied. Within the scope of these studies, the MRGs also conduct research on a number of marine chemical processes, such as eutrophication, calcification, ocean acidification and (export) production in open oceans.

RESEARCH DOMAIN OF NATURAL SCIENCES: RESEARCH DISCIPLINE EARTH SCIENCES.

NUMBER OF MRGs IN FLANDERS AND BELGIUM ACTIVE IN THE RESEARCH DISCIPLINE OF EARTH SCIENCES AND THE NUMBER OF PUBLICATIONS

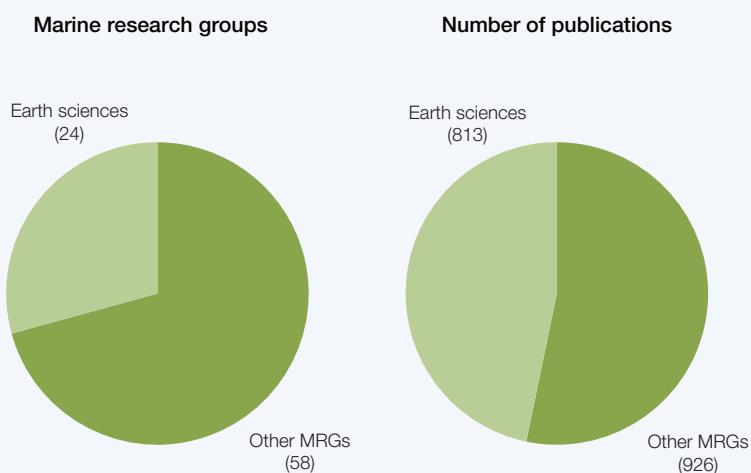


Figure 34. Number of MRGs in Flanders and Belgium active in the research domain of natural sciences – research discipline earth sciences as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research discipline (Source: IMIS, VLIZ 2013).

The research of the MRGs (24, figure 34) in the research discipline of earth sciences encompasses a broad spectrum of topics. It includes the study of hydrodynamic and sedimentary processes in the marine environment, the observation

and study of the seabed and the underlying sediments, ancient marine sediments on land, palaeontological studies and the geology of the coastal plain. Climate research is also discussed, although this is pre-eminently a multidisciplinary research field. In *Navigating the Future IV (European Marine Board, 2013)*²²⁶⁸⁷⁴, research on changes in the oceans within a changing earth system, polar ocean science and sustainable use of (deep-)sea resources are put forward as important challenges for (future) marine research.

Several MRGs conduct research on **hydrodynamic and sedimentary processes** in the Scheldt Estuary and the BNS. In addition to *in situ* measurements, hydrodynamic and sediment transport models are being developed for a range of applications, such as the monitoring of the effects of dredging and dumping of dredged materials (mud transport), evolution and degradation of pollution and marine meteorological predictions in order to simulate water levels and currents. In this context, an important overlap occurs with the research domain of engineering and technology (coastal protection, port structures, geomatics, etc.). Additionally, hydrodynamic, biogeochemical and sedimentary processes in oceans are modelled on a larger scale, often in relation to climate studies.

An important aspect in the study of the seabed concerns **observation techniques** to explore the seafloor. Besides sampling through grabs, box cores, sediment cores, etc., MRGs also have expertise in the use of seismic surveys, multibeam imaging, side scan sonar imaging and acoustic characterisation of the seabed. There is specific research on the propagation of sound waves in aquatic environments, acoustic tomography, the processing of sonar images to map the sea floor and the development of methods for the characterisation of shallow environments (estuaries and coastal waters). This research is related to the research domain of engineering and technology.

The MRGs study different aspects of the **seabed**, in which the mapping and characterisation of the seabed are strongly linked to benthic biological research (see also research discipline biological sciences). In the BNS a broad range of research topics is addressed such as research in support of a sustainable management of natural resources, evaluation of dumping sites, and morphological and marine geoarchaeological research. In addition, there is a strong international component in which research is conducted on the geology of continental slopes and the deep sea. The geological research of the oceans is *inter alia* focused on the geodynamics, stratigraphy and palaeo-oceanography of continental slopes, methane hydrates, cold seeps and mud volcanoes, cold-water corals and carbon mounds, and the reconstruction of deep-sea currents by means of detailed sedimentological studies. The geochemistry and petrology of the oceanic crust (plumes, subduction zones, etc.) are also studied in cores which were retrieved within the scope of the Integrated Ocean Drilling Program (IODP).

Besides the study of the seabed, ancient marine deposits on land are studied as well (see also palaeontology). The MRGs conduct research on **carbonate rocks** (in which diagenesis of marine carbonates is studied in detail) and specifically on **fossil coral reefs**, mounds and atolls, of which the basin dynamics, palaeogeography, sedimentology, palaeontology and geochemistry are elucidated.

The MRGs have considerable marine palaeontological expertise, on both macro- and micropalaeontology. The research mainly focuses on molluscs, ostracods, brachiopods, vertebrates, Precambrian eukaryotes, and microfossils such as dinoflagellate cysts, foraminifera, chitinozoa, pollen and spores, etc. This palaeontological research encompasses all geological eras, from the Precambrian to the Quaternary (Holocene), and has an international character. The research has several applications, such as taxonomy, morphology, osteology, geosphere-biosphere interactions, palaeo-ecology, palaeoclimatology, global and regional biostratigraphy and sequence stratigraphy, anthropobiology, archaeozoology and the evolution of Precambrian eukaryotes. The research on anthropobiology and archaeozoology is strongly linked to coastal archaeological research in the research domain of human sciences and the biological sciences (e.g. the identification of fish remains).

The **geological history of the coastal plain** is extensively studied by the MRGs, covering both the sedimentology of deposits and the palaeogeography of the coastline (sea level changes). This research is strongly linked to archaeological research in the coastal region, in the field of human sciences. Furthermore, this research focuses on the hydrogeology of the coastal plain, such as fresh and salt water distribution, management of ground water extraction, water quality and the impact of climate change on the hydrogeological situation in the coastal plain.

The **study of the climate** is a multidisciplinary research field strongly linked to biological and chemical sciences as well as to the research domain of engineering and technology (coastal protection). Within the research discipline of earth sciences, climate studies constitute an important part of the research on the seabed and sediment records, the geology of the coastal plain and palaeontological studies. The MRGs perform research on a range of aspects related to climate. Applied research is conducted on the impact of climate change and necessary adaptations for marine activities. Sea ice, the dynamics of ice sheets and their contribution to the sea-level rise are also studied. Ocean and

ice models are developed (LIM, SLIM, CART, etc.) in order to make long-term predictions with regard to climate and sea level changes. These models can also be used to reconstruct the former climate and to evaluate human impact on climate. Another important aspect of the climate research of MRGs is the study of biogeochemical cycles in oceans (link to chemical sciences), which is crucial to elucidate the role of oceans in the global climate and to gain insight in certain effects of climate change on oceans, such as ocean acidification.

RESEARCH DOMAIN OF SOCIAL SCIENCES

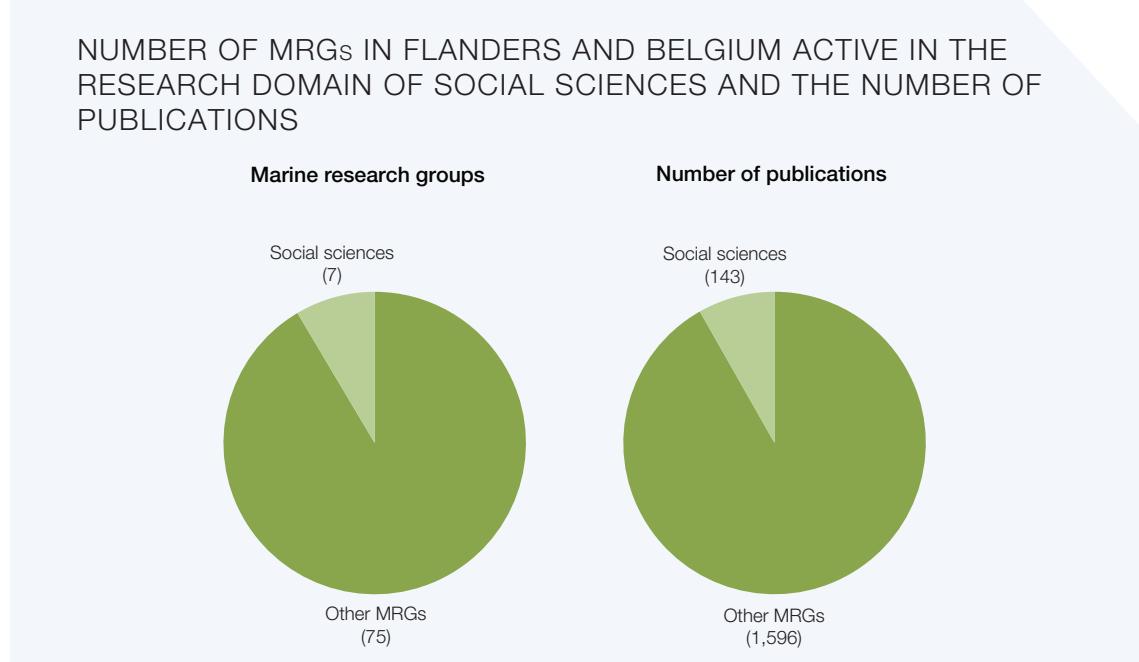


Figure 35. Number of MRGs in Flanders and Belgium active in the research domain of social sciences as well as the number of publications (peer-reviewed and VABB) published between 2008 and 2012 in this research domain (Source: IMIS, VLIZ 2013).

The research domain of social sciences includes a wide range of research topics such as economy, sociology, communication, political sciences and law. Specific research is carried out on several aspects of coastal, marine and maritime law, spatial planning at sea and in the coastal zone, and port and transport economy, as well as on specific aspects of the marine policy. Marine and coastal research is also disseminated to specific target groups. Safe and sustainable use of marine and coastal space and effective European marine science - policy interfaces are some of the crucial research topics identified in *Navigating the Future IV (2013)*²²⁶⁸⁷⁴ by the European Marine Board.

Several MRGs conduct research on specific topics in the context of coastal, marine and maritime law. The research topics include international law of the sea, the position of Belgium in the area of maritime law, international fisheries law, maritime boundaries, transport and maritime law, risks and consequences of human activities at sea (e.g. marine pollution), protection of the marine environment, piracy and boat refugees. There is also research on certain aspects of the marine policy, such as coastal zone management, marine spatial planning, port policy and fisheries policy.

In the context of spatial planning, a lot of research has been carried out concerning spatial planning at sea and in the coastal zone. Special attention has been paid to the response and adaptation to climate change.

The economic research of the MRGs is mainly aimed at ports and the associated transport sector. Several research topics are addressed, including competition and cooperation in the maritime and port sector, ports as nodes for logistic chains, productivity of terminals, economics of maritime transport, strategic planning in sea ports, traffic predictions, shipping networks and financing of port investments. Many of the aforementioned research topics are strongly linked with research on maritime law, marine policy and spatial planning. In addition, research is conducted on sustainable fish stock management and on the use of the fishing fleet to optimise the economic development of the fisheries sector.

In the field of **communication and outreach**, the conducted marine and coastal research is shared and explained to certain target groups such as education, the general public, policy makers and the industry.

2.5 Opportunities and challenges for marine research

KEY POINTS FOR MARINE RESEARCH IN EUROPE

In October 2010, more than 400 representatives of the European marine research community gathered during the EurOCEAN 2010 Conference in Ostend (Belgium). The *EurOCEAN conferences* offer a platform for developing a joint vision of marine research, both at the European and national level (figure 1). During the conference, the '*Ostend Declaration (2010)*'²⁰⁴⁸⁶⁷ was accepted unanimously. In this declaration, the international marine scientific community underlines:

- The critical role of the oceans in the earth and climate systems;
- The importance of coasts, seas and oceans and their ecosystems to our health and well-being;
- The increasing impacts of global environmental change on the marine environment and the significant socio-economic consequences of those impacts;
- The ongoing need for basic research to address major gaps in our fundamental knowledge of coasts, seas and oceans;
- The enormous opportunities for innovation, sustained wealth and job creation in new and existing maritime sectors such as aquaculture, renewable energy, marine biotechnology and maritime transport;
- The need to translate these messages to all sectors of society.

Europe emphasises the crucial role of science and technology in providing knowledge about the seas and oceans, in support of new opportunities and new technologies, sustainable management of ecosystems and natural resources and sustainable food, energy and health in the long term (**Marine research: the European context**).

During the *EurOCEAN 2010* Conference, the most important challenges and opportunities in the field of marine research were identified and specific measures for a focused response from the EU, the EU members and associated states were formulated. These measures address the growing need for coordinated action at the European level for joint planning and pooling of research resources and capacities (e.g. Horizon 2020, JPI-Oceans), infrastructure (e.g. European Ocean Observation System (EOOS), European Strategic Forum for Research Infrastructure (*ESFRI*)), and data systems (e.g. European Marine Observation and Data Network (*EMODnet*)). Furthermore, the measures deal with the importance of integrated and concrete co-operation with regard to marine research themes and agendas. The support of Member States to ensure structural funding for realising a marine research infrastructure and developing an integrated European Ocean Observation System (EOOS) is crucial. It is a strategic factor in the development of the European Research Areas (ERAs) both at the level of the regional seas and at a pan-European level. The upcoming programme Horizon 2020 and the Joint Programming Initiatives (JPIs) are also important consolidating factors for this purpose, in particular ERA-NETs and JPI-Oceans with formal representatives of 20 Member States. Together with the marine infrastructures of ESFRI and EOOS, they are some of the main components which constitute the backbone of the future ERA for marine research and technology. These goals and projects are also highlighted in *Navigating the Future IV*²²⁶⁸⁷⁴, the vision document of the European Marine Board (*EMB*), in which the main European marine research institutes, funding agencies and university consortia determine the key points for future marine research in Europe.

MARINE RESEARCH IN FLANDERS AND BELGIUM: DIVERSITY AND QUALITY

In Belgium, marine research is conducted by 82 different marine research groups (MRGs) of several universities and research institutes (**Inventory of marine research**). These MRGs have a research capacity of at least 1,000 scientists and specialised staff, which are active in the different marine research disciplines (**Qualitative analysis of marine research**). This corresponds to approximately 2% of the total R&D capacity in Belgium (all research fields in the private and public sectors) and 3.9% of the public R&D sector in Belgium (higher education and government) (Source: Overleggroep CFS/STAT, see **Inventory of marine research**).

The research capacity is mainly located at the universities, with 48 MRGs at the Flemish universities and 26 MRGs at the universities of the Wallonia-Brussels Federation. Together, they represent 90% of the MRGs in Belgium. With little over 500 staff members, Flemish universities employ about half of the Belgian marine researchers and specialised staff. The Flemish research institutes employ about 200 marine staff members (figure 10). Together, these Flemish MRGs account for 67% of the dedicated marine research capacity (staff) in Belgium.

From a thematic perspective, the core of Belgian marine research lies in the domain of natural sciences, with 70% of the MRGs and 77% of staff. This is in part explained by the long standing tradition of marine research in Belgium ([History of marine research](#)). Natural sciences are also well represented in the overview of the peer-reviewed journals in which the MRGs publish most frequently (figure 15, table 4). This is in line with the research capacity, but also related to the tradition in natural sciences of publishing in peer-reviewed journals (source: Web of Science, see [Methodology](#)).

The quality of marine research of the MRGs is internationally renowned. An analysis of recent (2008-2012) marine peer-reviewed publications of the MRGs shows that, on average, a publication is cited 1.86 times per year (figure 16; source Web of Science), while a dozen publications of the analysed subset have an average of more than 10 citations per year. Although the number of citations is not a direct indicator of quality, the number of citations does express a certain level of impact. It should be mentioned that, as a general rule, the average number of citations per year increases when publications have been registered in the WoS database for a longer period of time.

Besides the traditional research topics, the MRGs have a wide and diverse range of expertise in new research fields and applications. This diversity is reflected in the qualitative analysis as well as in the high number of journals: between 2008 and 2012, the MRGs published in 499 different peer-reviewed journals (table 4). The MRGs have extensive expertise which is directly related to the great challenges for future research in the fields of aquaculture and integrated multitrophic aquaculture systems, blue growth and blue technology, climate studies, offshore technologies for renewable energy, energy storage and transport, public health related to seas and oceans, and sustainable management of resources from the (deep) sea ([Navigating the Future IV \(European Marine Board, 2013\)](#)²²⁶⁸⁷⁴). Several of these new marine research topics are addressed by PhD studies at MRGs in universities and scientific institutes. The tax incentives and additional investments by IWT and FWO-Vlaanderen have generated an increase in the number of PhD candidates since 2000. It is a focus of the current policy to offer these temporary researchers a long-term perspective for an academic career, as a strategic action in view of the further development of the European Research Area ([Vlaamse beleidsnota Wetenschappelijk onderzoek en Innovatie \(2009-2014\)](#)²²⁹⁰⁰¹, policy document on scientific research and innovation (2009-2014) Flemish Government).

COMPARABILITY WITH MARINE RESEARCH INSTITUTES IN EUROPE

Unlike some of its neighbouring countries, Belgium does not have a dedicated national marine research centre and an associated research programme. Since 1976, the RBINS has a dedicated unit (Operational Direction Natural Environment, MUMM) that combines research, policy support and monitoring, for the BNS. Flanders, on the other hand, established a coordination and information platform for marine scientific research, the Flanders Marine Institute (Vlaams Instituut voor de Zee – VLIZ), in October 1999. VLIZ is also a focal point for marine and coastal research and serves as an international contact point.

Table 11. MRGs in Flanders and Belgium in comparison to national research centres (staff, publications and budget) (source: Scopus literature database, VLIZ 2013).

EUROPEAN MARINE RESEARCH INSTITUTES	STAFF	PUBLICATIONS, ANNUAL AVERAGE 2008-2012	BUDGET (MILLION EUROS)	NUMBER OF PUBLICATIONS/STAFF
Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)	1593	407	213 (2010)	0.26
Alfred Wegener Institut (AWI)	>900	430	> 100 (2012)	0.46
National Oceanography Centre NOC Southampton	550	173	53 (2012)	0.31
Royal Netherlands Institute for Sea Research (NIOZ)	370	195	30 (2013)	0.53
MRGs Belgium	1075	372	-	0.35
MRGs Flanders	725	261	-	0.36

Compared to the larger marine research institutes in neighbouring countries, MRGs in Flanders and Belgium are - in terms of marine research capacity (staff) - similar to the capacity of the national marine institutes (table 11). When considering scientific output, Belgian and Flemish MRGs are comparable to the national marine institutes, both in the absolute number of peer-reviewed publications and relative to the number of employees. For the purpose of this comparison with foreign national marine institutes, the Scopus Database was consulted for scientific output by means of the 'affiliation search' query module. However, some footnotes should be taken into account: the specific assignments and mandates of research centres largely determine to what extent scientists can devote their staff time to effective research. For example the federal and Flemish research institutes tend to focus on generating knowledge output which is not necessarily suitable for peer-reviewed publications, such as the monitoring and evaluation of policy objectives and formulating policy advice. On the other hand, a considerable amount of staff time of researchers from academic and non-academic institutes may be spent on educational objectives and capacity building.

AN INTENSIVE INTERNATIONAL COOPERATION

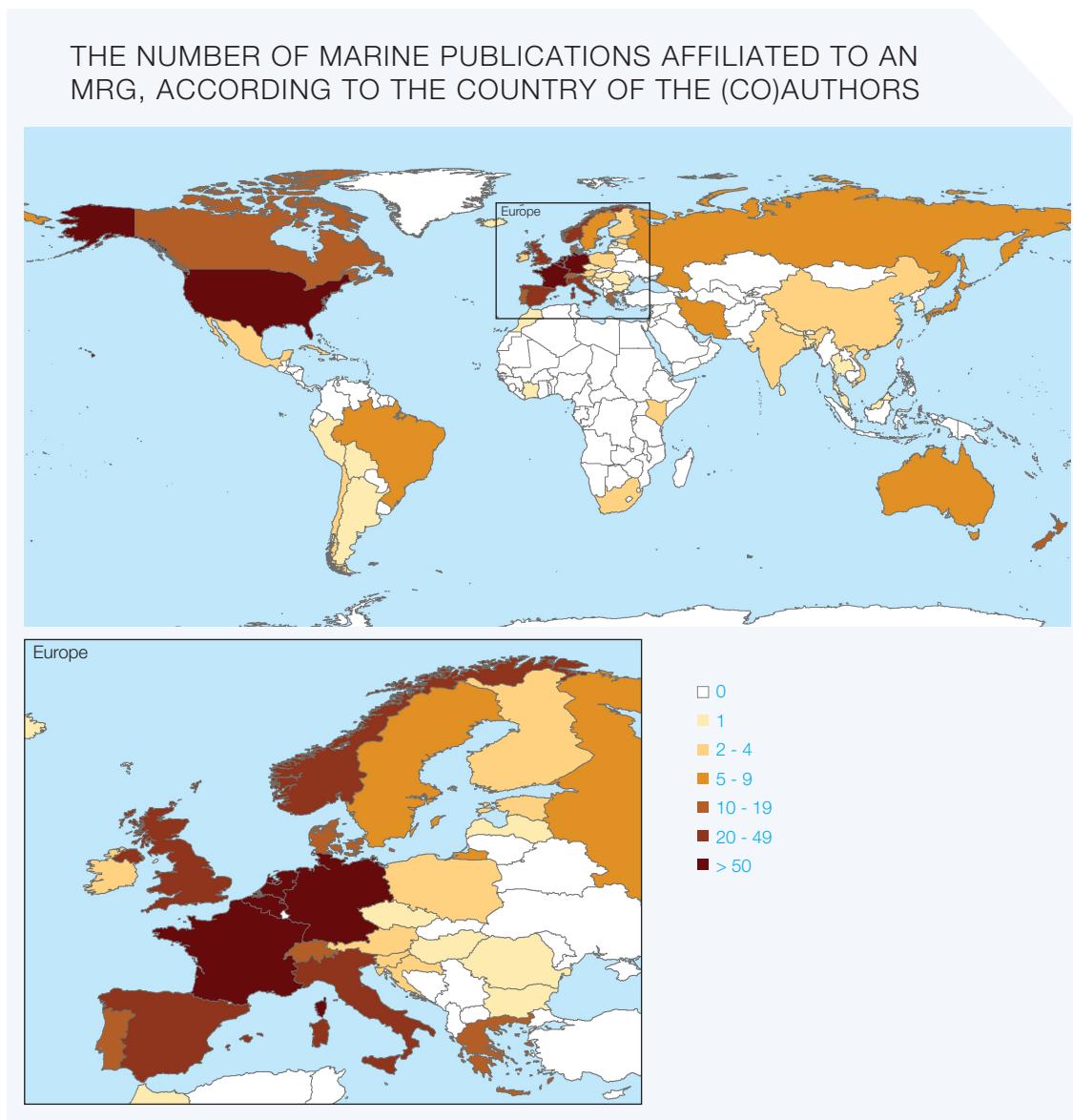


Figure 36. Geographical representation of the number of marine peer-reviewed and VABB publications affiliated to an MRG, by country of affiliation of the (co)authors (geographic representation of partnerships based upon peer-reviewed publications, 2010) (Source: IMIS, VLIZ 2013).

MRGs cooperate with international networks and foreign experts for most of their research. This is demonstrated by the partnerships in European projects (e.g. FPs), but also from bilateral or individual cooperations with foreign experts and (co)authors for publications. Of the inventoried marine peer-reviewed and VABB publications of the Belgian MRGs in 2010, 68% involved cooperation with foreign (co)authors of 57 different nationalities (figure 22 and figure 36).

This strong co-operation with foreign research institutes and integration in international research networks and programmes is also illustrated by the use of foreign research vessels. The scientific output of 2010 contains references to 41 different research vessels from 15 different countries (figure 24). Ensuring permanent access to this international research infrastructure is crucial for maintaining and developing the expertise in marine research in Flanders and Belgium. The current research infrastructure in Flanders and Belgium plays an important role in this context: besides the application for regional and local research, this infrastructure is also used within the framework of international cooperation and exchange.

The international character of the conducted marine research is also demonstrated by an analysis of the MRG publications (peer-reviewed and VABB) between 2008 and 2010. 70% of the conducted research focuses on study areas with an international character (European and worldwide); 30% of the research is regional (BNS, coastal zone and adjacent estuaries, Southern Bight of the North Sea).

THE NEED FOR AN INTEGRATIVE PLATFORM IN A FRAGMENTED AND DIVERSE LANDSCAPE

The marine research landscape in Flanders and Belgium is fragmented and diverse. The marine research community relies on complex funding mechanisms and has unique characteristics. An analysis of the peer-reviewed and VABB publications indicates that there is good cooperation between MRGs within universities, between MRGs of Flemish universities and federal institutes, and between MRGs of Flemish universities and Flemish scientific institutes. Even though there is no instrument available yet to measure inter- or multidisciplinary research, a preliminary analysis shows that cooperation occurs between MRGs from a wide range of research disciplines. There is an increasing need for a multidisciplinary approach to effectively address the present and future priorities in marine research and the societal challenges associated with the seas and oceans (*Navigating the Future IV (European Marine Board, 2013)* 226874). The federal science policy has been stimulating cooperation between research groups in Belgium within the North Sea research programmes since 1997. Furthermore, interdisciplinary research has been supported through the funding of projects for interdisciplinary networks. The research programme BRAIN-be emphasises the importance of this interdisciplinary research and networking.

The importance of marine research will continue to grow over the next few decades and the MRGs will need central logistical support to face the current challenges. Hence, the marine research community will benefit from joining forces by means of a supporting, networking and integrating platform. VLIZ aims at a well-connected marine research community and stimulates collaboration between research groups, administrations, the federal level, neighbouring countries, the European Union, multilateral organisations and other interested parties. In this regard, VLIZ can function as a facilitator for the communication between policy makers and scientists by (1) helping to identify the needs of marine research in terms of supporting and informing policy; (2) providing scientific data and information to policy makers and the broad range of marine experts; and (3) disseminating marine knowledge. VLIZ maps the expertise of Flemish and Belgian research groups and connects this expertise in a coordinated way at a local and international level. These efforts increase the visibility of marine research locally as well as abroad, stimulate participation in international and regional activities and alignment with different policy levels.

FLANDERS AS AN INTERNATIONAL ACTOR IN MARINE RESEARCH

In the Flemish policy document on Scientific Research and Innovation (2009-2014) (*Vlaamse beleidsnota Wetenschappelijk onderzoek en Innovatie (2009-2014)* 229001), the minister for Innovation, Ingrid Lieten, aligns the key policy issues with the international and European challenges. The current coalition agreement of the Flemish government (*Flemish government 2009*) reconfirms the commitment to the objective of *Pact 2020* to spend 3% of the GDP on research and development activities (*Andries et al. 2012* 229004). Central to this policy are excellence in scientific research and education as well as a good interaction between science and industry to translate research products and applications to the market. For a small region as Flanders, the importance to increase the scale in order to intensify the participation in the European Research Area (JPI, EIT, Horizon 2020) cannot be overestimated. This

increase in scale is aimed at the level of aligning information providers and policy organisations as well as at the level of research infrastructure.

Since 2005, the Flemish government has supported the UNESCO/IOC project office ([IODE Project Office](#)) by means of structural funding (0.54 million euro per year) as well as by providing office space in Ostend, local staff and operational funds. Through UNESCO as implementing agency, the Flanders-UNESCO Science Trust Fund (FUST) contributes an additional 1.53 million euro per year, of which approximately 60% (0.9 million euro) is dedicated to marine and coastal programmes and projects. With this support, Flanders contributes to the development of international coordination in oceanography, capacity building and the promotion of sustainable use and development of coastal zones worldwide.

The [Hercules Foundation](#) of the Flemish government provides funding for medium to large-scale research infrastructure for fundamental and strategic research in all scientific disciplines. [ESFRI](#) maps the needs for pan-European research infrastructures of EU Member States and also acts as a consultation platform between Member States to realise these infrastructures. Flanders takes part in five projects in the ESFRI framework ([Hercules Foundation](#)), two of which are relevant for marine research: the Integrated Carbon Observation System ([ICOS](#)) and the E-Science European Infrastructure for Biodiversity and Ecosystem Research ([Lifewatch](#)).

Concerning the use of large infrastructures on a European scale, the Flemish marine research community is represented in the European Network of Marine Research Institutes and Stations ([MARS](#)) and in the European Research Vessels Operators ([ERVO](#)).

Besides physical components, research infrastructure also comprises collections and databases. Flanders participates actively in international networks for marine information management (e.g. [EURASLIC](#), [IAMSPLIC](#), [ASFA](#), [IODE](#)) and data standardisation and integration (e.g. [SMEBD](#), [ERMS](#), [WoRMS](#), [OBIS](#), [SeaDataNet](#), [GLOSS](#), [IODE](#)).

In 2012, European commissioner for Maritime Affairs and Fisheries, Maria Damanaki, decided to accept the offer of Flemish minister Ingrid Lieten to host the central secretariat of the European Marine Observation and Data Network ([EMODnet](#)) at the Innovocean site in Ostend. EMODnet is part of the European initiative "Marine Knowledge 2020" (COM (2010) 461). The Flemish government annually reserves 180,000 euro to support the EMODnet secretariat through VLIZ. This way, Flanders contributes significantly to the Europe 2020 objectives.

The European Marine Board ([EMB](#)) was established in 1995 to enhance the coordination between European marine research organisations – both research performing and research funding entities – and to develop a strategy for marine research in Europe. Since 2006, the secretariat of this European forum for marine science is located in Ostend. The Flemish agency FWO-Vlaanderen, the Walloon agency FNRS, and BELSPO (federal level) are the Belgian members in EMB (FWO-Vlaanderen is represented by VLIZ).

From the start of JPI-Oceans, Flanders and Belgium have joined in its development. Furthermore, the Flemish government attributes an annual contribution of 200,000 euro to support JPI-oceans and since 2011 VLIZ seconded a staff member to the JPI-Oceans secretariat. In 2012, the Coordination and Support Action (CSA) Oceans was established under FP7, bringing together eleven partners from nine different countries to cooperate on the operability of JPI-Oceans. In the CSA Oceans project, VLIZ is responsible for communication and outreach.

These concerted efforts increase the visibility of the marine research abroad and stimulate participation in international activities within the framework of integrated cooperation in research. Besides internationalisation, new research potential is being developed through increased participation in interregional cooperation.

Notwithstanding the decentralisation of marine research in Flanders and Belgium, the research community has been able to position itself both on a regional and an international level. The scientific capacity for multidisciplinary work is present in a broad range of marine research domains and disciplines. When the opportunity for multidisciplinary work presents itself in the future, the MRGs will be ready to respond. Communication, coordination and cooperation for necessary services are crucial in this regard. Through cooperation, the marine research community in Flanders and Belgium will increase its visibility and presence in national and international forums. This collectivity is also necessary to develop a coherent vision on scientific questions as well as on technological and infrastructural needs in an international and European context. Structural support for these partnerships – also towards the industry – offers a permanent added value for the foundations of our knowledge society and for responding to the great challenges of current and future marine research.

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
OSPAR-Convention	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 (adopted in 1992)	1992	
Bucharest Convention	The Bucharest Convention on the Protection of the Black Sea against Pollution (adopted in 1992)	1992	
Barcelona Convention	The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (adopted in 1995)	1995	
	<i>Convention on the Protection of the Underwater Cultural Heritage</i>	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 the 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
Regulations			
Common Fisheries Policy	Council Regulation on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy	2002	2371
	Council Regulation amending Regulation (EC) No 1543/2000 establishing a Community framework for the collection and management of the data needed to conduct the common fisheries policy	2007	1343
Other (Decisions, Communications, White Papers, etc.)			
	Communication from the Commission (COM): Towards a European research area	2000	6
	Communication from the Commission - More research for Europe - Towards 3% of GDP	2002	499
Integrated Maritime Policy	Communication from the Commission (COM): An Integrated Maritime Policy for the European Union	2007	575
	Communication from the Commission (COM): 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 (COM): Building a sustainable future for aquaculture A new impetus for the Strategy for the Sustainable Development of European Aquaculture {SEC(2009) 453} {SEC(2009) 454}	2009	162
	Communication from the Commission (COM): Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain {SEC(2009) 1341}	2009	538
	Communication from the Commission (COM): MARINE KNOWLEDGE 2020 marine data and observation for smart and sustainable growth	2010	461
	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Horizon 2020 - The Framework Programme for Research and Innovation	2011	808
	Communication from the Commission (COM): 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	
	Proposal for a directive of the European Parliament and of the Council (COD) establishing a framework for maritime spatial planning and integrated coastal management	2013	133
	Communication from the Commission (COM): Action Plan for a Maritime Strategy in the Atlantic area Delivering smart, sustainable and inclusive growth	2013	279

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
Laws	
Bijzondere wet van 8 augustus 1980	Bijzondere wet tot hervorming der instellingen
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
Decrees	
Decreet van 30 april 2009	Decreet betreffende de organisatie en financiering van het wetenschaps- en innovatiebeleid